Field Crops

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PEST MANAGEMENT GUIDE

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Keys to the Proper Use of Pesticides

1. Read the label on each pesticide container before each use. Follow the printed instructions to the letter; heed all cautions and warnings; note precautions about residues.

2. Store pesticides in the containers in which you bought them. Put them where children and animals cannot get to them - preferably locked-up and away from food, feed, seed, and other materials that may become harmful if contaminated.

3. Dispose of empty pesticide containers properly.

See your physician if symptoms of illness occur during or after the use of pesticides.

Disclaimer

Commercial products are named in this publication for informational purposes only. Virginia Cooperative Extension does not endorse these products and does not intend discrimination against other products which also may be suitable.

NOTICE:

Because pesticide labels can change rapidly, you should read the label directions carefully before buying and using any pesticides.

Regardless of the information provided here, you should always follow the latest product label when using any pesticide. If you have any doubt, please contact your local Extension agent, VDACS pesticide investigator, or pesticide dealer for the latest information on pesticide label changes.

See Chapter 1 - Regulations and Basic Information **for pesticide handling information.**

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7 Author Contact List

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Safe and Effective Use

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Introduction

The Pest Management Guide Series

The Virginia Pest Management Guide (PMG) series lists options for management of major pests: diseases, insects, nematodes, and weeds. These guides are produced by Virginia Cooperative Extension and each guide is revised annually. PMG recommendations are based on research conducted by the Research and Extension Division of Virginia Tech, in cooperation with other land-grant universities, the USDA, and the pest management industry.

These guides are not a comprehensive control plan for all pests in Virginia. However, they do provide management tactics for major pest problems. For specific recommendations beyond the scope of these guides, please contact the Extension specialist(s) associated with the particular commodity or specialty area.

Chemicals listed in the PMG's are registered by the U.S. Environmental Protection Agency (EPA) and the Virginia Department of Agriculture and Consumer Services (VDACS). When used in accordance with label directions, residues should be within tolerance limits set by the EPA. Pesticide users must follow label directions with regard to application site(s), rates of application, number of applications, and minimum time interval between application and harvest. Violation of label directions may result in unsafe residues, fines to the applicator and grower, crop seizure, and loss of public confidence and product marketability.

Use pesticides only on labeled sites, and follow all label directions to the letter!

How To Get Help with a Pest or Pesticide Management Problem

The first rule in solving any problem is to identify the cause before you seek a solution. This is especially true for pest management. You MUST identify the pest before you make any attempt to control it. If you need assistance with pest identification, contact your local Extension office. Extension offices are located in local county or city governmental units throughout Virginia. The agents and staff members of these units are dedicated professionals. They are part of a unique alliance between the United States Department of Agriculture, Virginia's land-grant universities, and local government. Local Extension offices are listed in the telephone directory. There is also a complete list of all Virginia Cooperative Extension offices at www.ext.vt.edu/offices/ on the Internet.

If a pest is especially difficult to identify or if you need more information, your agent will send a specimen and/or samples to Virginia Tech. Services available include: the Plant Disease Diagnostic Clinic, the Insect Identification Laboratory, the Weed Identification Laboratory, the Soil Testing Laboratory, and the Forage Testing Laboratory. One or more of these services may help to solve pest—or pesticide—management problems.

Alternative Pest Controls

Pest management includes more than the use of pesticides. Virginia agriculture employs a number of non-chemical methods. Alternative controls are an integral part of any production system. However, where chemical controls are necessary, they must be used in such a way as to provide for a safe food supply, a clean and healthy environment for humans and wildlife, and a productive and profitable agricultural industry.

Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is an ecological approach to pest control, based on the life cycle and habitat of the pest. It combines all appropriate pest management techniques into a single, unified program or plan. The goal of any IPM program is to reduce pest populations to an acceptable level in a way that is practical, cost-effective, and safe for people and the environment.

Virginia Tech has developed a number of specific IPM programs with precise monitoring (scouting) tactics and thresholds. Each is based on scientific studies of local pest populations and the crops/sites these pests damage. Specific IPM protocols take time and resources to generate; as a result, there is not a prescribed program for each and every pest + site combination

in the commonwealth. However, an experienced pest manager can apply IPM principles to any situation by: identifying the pest; learning about its life cycle, basic needs, and the environmental conditions that influence its population size and activity; assessing pest population size and distribution by monitoring (scouting); deducing what attracted or brought the pest to the site; acquiring accurate information about management tactics, both chemical and non-chemical; and making long-term plans to prevent or suppress this pest in years to come. For more information about IPM, contact your local Extension agent.

Pesticide Management in Virginia

Virginia Cooperative Extension offers educational programs for the public in pest management and pesticide safety. Examples are commodity production meetings and pesticide safety workshops, including pesticide applicator training and recertification.

Issues and programs such as farmworker protection, recordkeeping, endangered species protection, food and water quality, and re-registration of pesticides often result in additional state and federal regulations affecting pesticide users. In Virginia, the Virginia Pesticide Control Act and regulations promulgated under the act affect growers and commercial pesticide applicators. State and federal pesticide laws and regulations are enforced by the Virginia Department of Agriculture and Consumer Services, Office of Pesticide Services.

Growers and applicators are responsible for meeting all requirements imposed by state and federal agencies. For more information about programs, laws, and regulations, contact your local Extension office and/or VDACS/OPS.

Pesticide Applicator Certification

In Virginia, most commercial pesticide users, all aerial applicators, and growers who use restricted-use pesticides must be certified. The Virginia Pesticide Control Act and regulations drafted under the act define "pesticide use" as actual application, supervision of an application, or commercial recommendation of a pesticide. This includes the routine activities that are part of a pesticide application, such as mixing, loading, clean-up, and disposal. Handling, transfer, or transport after the manufacturer's original seal is broken is considered "use." (Pesticide handling typically managed by persons other than the mixer/loader/applicator, such as long-distance transport, long-term storage, or ultimate disposal, is not considered part of routine use.)

Before preparing for certification, you must first decide if you plan to become a Private Applicator, Commercial Applicator, or Registered Technician. Private and Commercial Applicators must be certified in one or more categories, based on the type(s) of pesticide use planned.

Types of Pesticide Applicators

Two general types of certified pesticide applicator are recognized by the Commonwealth of Virginia. Each is described below. Persons engaged in several sorts of pesticide-related activities may need to be certified as both a private and a commercial applicator.

Private Applicator

A certified applicator who uses or supervises the use of any restricted-use pesticide (RUP) to produce an agricultural commodity. Applications must be made on property owned or rented by the user or his/her employer; or, if applied without compensation other than trading of personal services between producers of agricultural commodities, on the property of another person. Noncertified applicators employed by agricultural producers may use RUPs only when under the direct supervision of a certified Private Applicator. Direct supervision, in this case, means the RUP is used by a competent person who is acting under the instructions and control of a certified Private Applicator. The certified Private Applicator is responsible for the actions of the uncertified farmhand. The certified Private Applicator who is in charge of the pesticide use must either be in close proximity to the pesticide user or within telephone or radio contact.

Commercial Applicator

A person using any pesticide for any purpose on the job other than as described for a Private Applicator (production of an agricultural commodity on property the grower owns or leases). Most commercial applicators must be certified. There are two certification options: Commercial Applicator or Registered Technician.

Certified Commercial Applicator

A person who has fulfilled the competency requirements set for Commercial Applicators in Virginia to use or supervise the use of any pesticide for any purpose or on any property on the job other than as described for a Private Applicator.

Certified Registered Technician

An individual who performs services similar to those of a certified Commercial Applicator. Such a person has completed training and demonstration of those competency standards required for Registered Technicians but not the requirements for Commercial Applicator certification. (Registered Technician trainees receive general pesticide safety training and job-specific instruction in pesticide use.) Registered Technicians may use general-use pesticides without supervision. They may use restricted-use pesticides under the direct supervision of a certified Commercial Applicator. Registered Technicians who work for hire must work for a licensed Pesticide Business.

Pesticide Applicator Training Manuals

Pesticide applicator training manuals are sold by Virginia Tech. Orders can be placed online: *http://vapesticidemanuals.com/*. Alternatively, government purchase orders can be arranged by email: vcedistributioncenter@vt.edu

Certification procedures differ for Private Applicators, Commercial Applicators, and Registered Technicians. For the most up-to-date information about certification requirements, categories, initial certification procedures, and how to keep a certificate in force, contact your local Extension office, Virginia Tech Pesticide Programs, or VDACS Office of Pesticide Services.

Pesticide Laws, Regulations, and Restrictions

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) has been amended several times since it was passed in 1947. The amendments to this act are some of the most significant laws affecting American agriculture.

The 1972 amendment is known as the Federal Environmental Pesticide Control Act (FEPCA). FEPCA stipulates that the use of any pesticide inconsistent with its labeling is prohibited; that violations of FEPCA by growers, applicators, and dealers can result in heavy fines and imprisonment; that pesticides must be classified for either general use or for restricted use; that anyone using or purchasing restricted-use pesticides must be certified by their state of residency; that pesticide manufacturing plants must be inspected by the EPA; that states may register pesticides on a limited basis for special local needs; that all pesticides must be registered by the EPA; that all product registrations must be backed by scientific evidence to control the pests on the label; not injure people, crops, animals, or the environment; and not result in illegal residues in food and feed when used according to label directions.

A 1978 amendment was designed to improve the registration processes. It stipulates that efficacy data can be waived and that generic standards can be set for active ingredients rather than for each product. Re-registration of older products is required to make certain that scientific data exists to back them. Pesticides can be given a conditional registration prior to full registration. Registrants can use supporting data supplied from other companies if paid for. Trade secrets are to be protected. States have primary enforcement responsibility for both federal and their own state pesticide laws and regulations. States can register pesticides under a Special Local Needs (SLN or 24C) label. Finally, the phrase "to use any registered pesticide in a manner inconsistent with its labeling" was defined in detail.

It is illegal to use a pesticide in any way not permitted by the labeling. A pesticide may be used only on the plants, animals, or sites named in the directions for use. You may not use higher rates or more frequent applications. You must follow all directions for use, including directions concerning safety, mixing and loading, application, storage, and disposal. You must wear the specified personal protective equipment. Pesticide use directions and label instructions are not advice, they are legal requirements. Persons who derive income from the application, recommendation, sale, or distribution of pesticides CANNOT make recommendations which call for uses inconsistent with labeling.

However, federal law does allow you to use some pesticides in ways not specifically mentioned in the labeling. You may: apply a pesticide to control a pest not listed on the label (as long as the application is made in accordance with label directions); use any appropriate equipment or method of application not specifically prohibited by the label; mix two or more pesticides if not prohibited by one or more labels and all the dosages are at or below the label rate; and mix a pesticide or pesticides with fertilizer if the mixture is not prohibited by the labeling.

A major change to FIFRA, provided by a 1988 amendment, requires EPA to accelerate the re-registration of all pesticide products registered prior to 1978. As a result, some older pesticide registrations and/or product uses are being dropped.

The Food Quality Protection Act (FQPA) of 1996 amends both the Federal Food, Drug, and Cosmetic Act (FFDCA) and FIFRA. FQPA provides a unified, comprehensive health-based plan for pesticide residues. Because it requires the EPA to consider pesticide use and safety data in new ways, it will result in significant changes in U.S. pesticide use patterns.

In 2006, EPA initiated a program to re-evaluate all pesticide registrations on a regular cycle. Re-registration and the FQPA will affect pesticide availability and labels.

The Virginia Pesticide Control Act

The Virginia Pesticide Control Act is enforced by the Virginia Department of Agriculture and Consumer Services (VDACS). The act and regulations which support it affect pesticide use in Virginia. Information concerning regulatory changes affecting pesticide use is available from Virginia Tech, VDACS Office of Pesticide Services, and your local Extension office.

Responsibilities of Pesticide Applicators in Virginia

I. Follow the Pesticide Label

The pesticide label is a legal agreement between the Environmental Protection Agency (EPA), the product manufacturer, and the user. Pesticide product labels provide instructions for all stages/phases of use. Applicators must read, understand, and follow label directions carefully. Pesticides may not be applied to any site not listed on the product label. Materials may not be applied more often, or at rates higher, than the label directs. Pesticide applicators must follow all label directions for transport, mixing, loading, application, storage, and disposal of pesticide products and containers. State and federal laws prohibit the use of any pesticide in a way that is not consistent with its label. There are state and federal penalties for violations.

II. Adhere to Certification Requirements

Pesticide use means actual application and/or supervision of an application. "Use" includes the routine activities that are part of a pesticide application, such as mixing, loading, cleanup, and disposal. Handling, transfer, or transport after the manufacturer's original seal is broken is considered "use." (Pesticide handling typically managed by persons other than the mixer/loader/applicator—such as long-distance transport, long-term storage, or ultimate disposal—is not considered part of routine use.)

Private Applicators:

- In Virginia, a private applicator is a person engaged in producing an agricultural commodity on private property (owned, rented, or leased by the producer).
- Growers using restricted-use pesticides (RUP) must be certified or work under the direct supervision of a certified private applicator.

Commercial Applicators:

- The Virginia Pesticide Control Act defines a person who, as part of his or her job duties, uses or supervises the use of any pesticide for any purpose (other than production of agricultural commodities on private land) as a commercial pesticide applicator.
- Certification options for commercial applicators:
  - registered technician
  - commercial applicator
- Certification requirements depend on the commercial applicator class and scope of pesticide use. In addition, The Virginia Business License Regulation requires that people who make recommendations for-hire be certified. There are four classes of commercial applicator:
  - *Government employees* must be certified to use any pesticide for any purpose.
  - *For-hire* commercial applicators must be certified to use any pesticide for any purpose, and to make recommendations for hire (ex. as a crop consultant).
  - *Not-for-hire* commercial applicator certification requirements vary. People who do not work for hire but do use pesticides on the job must be certified if:
    - Using restricted-use pesticides, or
    - Using pesticides on the sites in the following list:

- on any area open to the public at the following establishments:
  - * Educational institutions,
  - * Health-care facilities,
  - * Day-care centers, or
  - * Convalescent facilities;
- where open food is stored, processed or sold; or
- on any recreational land over five acres.

- *Inactive* status is a way to maintain certified applicator status while not employed as a pesticide user.

The Virginia Department of Agriculture and Consumer Services (VDACS) is responsible for the certification of applicators and for all enforcement aspects of the Virginia Pesticide Control Act and its regulations.

Certificates may be suspended or revoked if the holder, in the eyes of VDACS, presents a substantial danger or threat of danger to public health and safety or to the environment. A suspension may be issued on an emergency basis, and a certificate may be revoked after a hearing has taken place. If a person's certificate is revoked, he or she may not reapply for Virginia certification for two years.

Persons who have a history of repeat violations of any federal, state, or local pesticide law may not apply for certification. In addition, persons who have had a Virginia applicator certificate revoked may not be granted certification within a two-year period following that action. However, persons in either of these circumstances may petition for certification.

III. Keep Your Certificate in Force

A. Renewal of Certificates

Commercial: Commercial applicator certificates must be renewed every two years. They expire June 30 of the second year after issue. VDACS Office of Pesticide Services will send each commercial applicator a renewal notice when it is time to renew. Return the notice with the $70 renewal fee on or before June 30 to avoid a $14 penalty. No late renewals will be accepted after August 29. (See the last paragraph in this section for special conditions for certified applicators who work for federal, state, or local government.)

Applications for renewal will not be processed unless the applicator has met the requirements for recertification credit in the proper category or categories (see section B, which follows). If you allow your certificate(s) to lapse by more than 60 days, you must retest in both the core material and the specific category or categories to reinstate your certificate(s).

All applicators must inform the VDACS-OPS/Certification, Licensing, Registration, and Training Section if their mailing address or employment status changes.

Commercial applicators who work for hire will not be issued renewed certificates unless they have, or work for someone who has, a valid Virginia pesticide business license.

Government applicators do not have to pay application and renewal fees. For this reason, VDACS Office of Pesticide Services does not send renewal notices to government employees who are certified Commercial Applicators and Registered Technicians. Government employee applicators who have met their recertification requirements will receive their renewed certificates automatically.

Private: Private applicator certificates are automatically renewed biennially at recertification. There is no fee. Private applicator certificates expire on December 31, two years following issue. Late renewals will not be accepted after March 1.

B. Recertification

Private and commercial applicators and registered technicians must participate in an ongoing pesticide education program. At a minimum, commercial applicators and registered technicians must attend at least one fully approved

recertification session, per category, every two years. Private applicators must accumulate three credits per category every two years before their certificate expires. Applicators may accumulate up to four years of recertification credit. Persons who fail to recertify will not be able to renew their certificates.

Virginia Cooperative Extension (VCE), pesticide-related trade and professional organizations, and others offer recertification courses. A listing of all Virginia-approved courses may be obtained from:

Virginia Cooperative Extension offices or
Virginia Tech Pesticide Programs (VTPP) Unit:
www.vtpp.ext.vt.edu/ (private applicator courses; searchable database)

VDACS/OPS/Certification, Licensing, Registration, and Training Unit:
http://www.vdacs.virginia.gov/pesticide-applicator-training.shtml (commercial applicator courses)

Program availability varies by time of year and by category. Most courses are offered between September and March. Applicators are advised to keep in touch with Virginia Cooperative Extension and/or professional organizations to avoid missing recertification opportunities.

Certified applicators based out of state may be able to become certified and recertify in Virginia by reciprocity. Contact the Virginia Department of Agriculture and Consumer Service Office of Pesticide Services for more information.

Failure to maintain a certificate, either due to failure to respond to the renewal notice or failure to recertify, will result in expiration. Persons who allow their certificate(s) to lapse (for more than 60 days) must retest.

Applicators must inform VDACS/OPS if their address changes.

IV. Supervise Employees

A. Registered Technicians by Commercial Applicators

Certified commercial applicators must provide on-the-job training, instruction, and supervision of registered technicians employed by them or assigned to them by their employer. Registered technicians may use restricted-use pesticides only under the direct supervision of a commercial applicator. The supervising commercial applicator must either be physically present or be where the registered technician may contact the applicator by telephone or radio. Certified applicators are responsible for the work of registered technicians under their supervision and must provide the registered technicians with clear, specific instructions on all aspects of pesticide use. A registered technician may apply general-use pesticides unsupervised.

Uncertified persons may apply pesticides commercially while in training to become registered technicians *only* when under the direct, *on-site* supervision of a properly certified commercial applicator.

B. Uncertified Handlers by Private Applicators

Uncertified but competent persons may apply restricted-use pesticides in the production of agricultural commodities on private property when under the direct supervision of a certified private applicator. The certified private applicator is responsible for the actions of the uncertified person.

Direct supervision means the act or process by which the application of a pesticide is made by a competent person acting under the instructions and control of a certified applicator who is responsible for the actions of that person. The certified applicator must be accessible to the applicator by being nearby or within reach by telephone or radio.

V. Handle Pesticides Safely

Although there are no specific storage and disposal regulations in Virginia, unsafe use/handling/storage/disposal practices can be cited under the enforcement regulation: 2 VAC 20-20-10 through 20-220 (VAC is the Virginia Administrative Code).

Provisions to Note:

Handling and Storage:

"No person shall handle, transport, store, display, or distribute pesticides in a manner which may endanger humans or the environment, or food or feed or other products…"

Disposal:

"No person shall dispose of, discard, or store any pesticide or pesticide containers in a manner that may cause injury…or pollute…"

Application Equipment:

"…must…be in good working order…dispense the proper amount of material…be leakproof…have cutoff valves and backflow prevention…"

Service Container Labeling:

Containers other than the original registrant's or manufacturer's containers used for the temporary storage or transportation of pesticide concentrates or end-use dilutions must have abbreviated labeling for identification.

A. Pesticide Concentrate:

1. If the pesticide to be temporarily stored or transported is a concentrate to be further diluted, the container shall bear a securely attached label with the following information:
    a. Product name or brand name from product label;
    b. EPA registration number from the product label;
    c. Name and percentage of active ingredient(s) from the product label; and
    d. Appropriate signal word; i.e., Poison, Danger, Warning, Caution (from the product label).
2. The above labeling is required for concentrate service containers, regardless of container type, size, or capacity. (Note: If possible, keep pesticides in their original container.)

B. Pesticide End-Use Dilutions or End-Use Concentrates:

1. If the pesticide to be temporarily stored or transported will be applied without further dilution, its container must bear a securely attached label with the following information:
    a. Product name (brand name from product label) preceded by the word "Diluted" or "End-Use Concentrate";
    b. EPA registration number from the concentrate product label;
    c. Name of active ingredient(s) and percentage(s) of end-use dilution; and
    d. Appropriate signal word; i.e., Poison, Danger, Warning, Caution (from the product label).
2. Exemptions: abbreviated service container labeling is not required for:
    a. End-use dilution containers not exceeding 3 gallons liquid or 3 pounds dry capacity, when such containers are used as application devices; i.e., hand-held sprayers, dusters, puffers, etc.
    b. Containers used by farm-supply dealers for the temporary storage or transportation of pesticide concentrate or end-use dilution, provided that sales invoices or delivery tickets adequately identifying the pesticide(s) accompany each shipment or delivery.
    c. Farm concentrate or end-use dilution containers or application equipment used for the temporary storage or transportation of such pesticides for agricultural use.
    d. Aircraft-mounted containers used for temporary storage or transportation of concentrate or end-use dilution pesticides, provided that aircraft logs or other documents on board adequately identify the pesticide(s).

VI. Keep Accurate Records

A. Commercial Applicators

Virginia regulations require all commercial applicators to keep records of all pesticide applications. These records must be maintained for two years following the pesticide use. Commercial applicator records must contain the following information:

1. Name, address, and telephone number (if applicable) of the treatment site property owner, and address/location of the application site, if different;

2. Name and certification number of the person making or supervising the application;

3. Date of application (day, month, year);

4. Type of plants, crops, animals, or sites treated;

5. Principal pest(s) to be controlled;

6. Acreage, area, or number of plants or animals treated;

7. Identification of pesticide used:

   -Brand name or common name of pesticide used, and

   -EPA product registration number;

8. Amount of pesticide concentrate and amount of diluent (water, etc.) used, by weight or volume, or the volume and concentration applied to a structure as defined in #6; and

9. Type of application equipment used.

Commercial applicators and WPS compliance:

Commercial applicators who apply pesticides to agricultural commodities on farms, forests, nurseries, and greenhouses should be sure their record data elements conform to those required by both the **Worker Protection Standard (WPS)** and the **Food, Agriculture, Conservation, and Trade (FACT) Act**, also known as the 1990 Farm Bill.

- If a grower hires a commercial applicator to apply an RUP, the commercial applicator is responsible for making and maintaining the application records required by the FACT Act.
- If a grower with farm-worker or pesticide-handler employees hires a commercial applicator to apply any pesticide, the commercial applicator must provide the grower with information about the application in advance. This is necessary so that the grower can comply with WPS notification, restricted-entry, and record-keeping requirements.

A sample commercial applicator record-keeping form follows at the end of this section.

B. Private Applicators

The Food, Agriculture, Conservation and Trade (FACT) Act of 1991, also known as the 1990 Farm Bill, requires certified private pesticide applicators to record applications of restricted-use pesticides (RUPs). RUP applications made by a private applicator must be recorded within 14 days and maintained for a period of two years. Private Applicator records must contain the following nine data elements:

1. The restricted-use pesticide brand or product name;

2. The EPA registration number;

3. The total amount of the restricted-use pesticide product applied;

4. The month, day, and year of application;

5. The location of the treated area;

6. The crop, commodity, stored product, or site to which the restricted-use pesticide was applied;

7. The size of area treated;

8. The name of the certified applicator who applied or supervised the application of the restricted-use pesticide; and

9. The certificate number of the person named in number 8, who made or supervised the application.

Records of spot-treatments may require less information. A spot application is a treatment of an area totalling less than one-tenth of an acre made on the same day. For spot applications record:

1. Brand or product name;

2. EPA registration number;

3. Total amount applied;

4. Month, day, and year of application; and

5. Location of treated area, designated as a "spot application" (with a brief but concise description of the site).

Recording the name and certificate number of the certified private applicator who made or surpervised the RUP spot treatments is recommended, although it is not required by federal law.

(Note: ***Nursery and greenhouse RUP applications do NOT qualify as spot treatments. Greenhouses and nurseries must record all required recordkeeping data elements.*****)**

Certified applicators are required to make records available, upon request, to any Federal or State agency that deals with pesticide use or any health or environmental issue related to the use of restricted-use pesticides. In addition, medical professionals need access to records in the event of an exposure.

The certified applicator who applies a RUP is responsible for making and maintaining the application records required by the FACT Act. However, if a grower hires a commercial applicator to apply a RUP, the commercial applicator is responsible for the FACT Act recordkeeping.

The FACT Act requires commercial applicators to provide a copy of a restricted-use pesticide application record to the person for whom the application was made within 30 days of the application. However, if a private applicator has employees, he/she should obtain the record information prior to any for-hire application — RUP or not — to ensure compliance with WPS posting and notification requirements.

The Federal Worker Protection Standard (WPS) also involves some recordkeeping. Growers who employ field workers or pesticide handlers must display pesticide use and safety information at a central location. WPS requires growers who employ agricultural workers to make, maintain, and post pesticide application records. WPS application records must be kept for every pesticide used on the farm, not just for those that are restricted-use. Growers must post information about each application for 30 days after the expiration of the restricted-entry interval (REI). In addition, this information must be kept on file for two years. A WPS application list must record:

1. Brand or product name;

2. EPA registration number;

3. Active ingredient(s) of the product used;

4. Location of the treated area;

5. Time and date of the application; and

6. Restricted entry interval for the pesticide (duration and expiration).

WPS application information and safety data sheets (SDSs) must be displayed at a central location within 24 hours of the end of an application, and before workers enter the treated area. Application information and SDSs must be posted for 30 days after the restricted-entry interval (REI) expires—and kept on file for two years following. On-file application information and SDSs must be available to workers, handlers, designated/authorized representatives (identified in writing), or treating medical personnel upon request.

Additionally, employers will be required to keep records of WPS training. Please keep in touch with your local Extension agent for the latest information on record keeping. Your agent will also know about WPS and other pesticide laws and regulations affecting agricultural producers. A sample record-keeping form for producers follows at the end of this section.

Table 1.1 - Private/Grower Pesticide Application Record for _____

USDA records of restricted-use pesticide applications must be kept for two years. WPS requires pesticide application information and Safety Data Sheets for all pesticides to be posted in a central area no later than 24 hours after an application is completed. Application and hazard information must be displayed continuously until 30 days after the last applicable restricted-entry interval or until workers or handlers are no longer on the establishment, whichever is earlier. WPS information must be retained for two years after expiration of the REI.

Application [3]Date(s) (day/month/year) and [1]Time		[3]Crop/ Commodity or Site Treated	[3]Location and Description of Treated Area	[3]Brand or Product Name	[1]Active Ingredient Common Name	[3]EPA Registration Number	[2]# of Units or Acres Treated	[2]Total Amount of Product Used (oz., lb., pt., qt., gal.)	[2]Applicator Information: (Name & Certificate No.)	[1]Restricted-entry Interval (REI)	
[1]Start	[1]Finish									Duration (# of hours)	Expiration (date/ time)

[1]Required for Worker Protection Standard
[2]Required for Federal Pesticide Recordkeeping Requirements, USDA
[3]Required for Worker Protection Standard and Federal Pesticide Recordkeeping Requirements

Prepared by Virginia Cooperative Extension and VDACS (Virginia Department of Agriculture and Consumer Services), Office of Pesticide Services, 2016.

Table 1.2 - Commercial Applicator Pesticide Application Record

Note: The Commonwealth of Virginia requires commercial applicator records of pesticide applications to be kept for two years.

Name, Address, and Telephone Number of Property Owner	Address and Location of the Application Site (if different than recorded in left column)	Certified Applicator's Name and Certificate Number	Date: (Month, Day, Year)	Type of Plants, Crops, Animals, or Sites Treated	Principal Pest to be Controlled	Acreage, Area, or Number of Plants or Animals Treated	Brand or Common Name of Pesticide	EPA Product Registration Number	Total Amount of Product *and* of Diluent (if used)	Type of Application Equipment

Prepared by Virginia Cooperative Extension and VDACS (Virginia Department of Agriculture and Consumer Services) Office of Pesticide Services, 2006.

VII. Report Pesticide Accidents

Pesticide accidents or incidents that constitute a threat to any person, to public health or safety, and/or to the environment must be reported. Telephone notification is required within 48 hours. A written report describing the accident or incident must be filed within 10 days of the initial notification.

Telephone contacts and written reports should be directed to:

Virginia Department of Agriculture and Consumer Services
Office of Pesticide Services/Enforcement and Field Operations
P. O. Box 1163, Richmond, VA 23218
(804) 371-6560

In the event of an emergency release, notify local authorities immediately, and contact the Virginia Department of Emergency Management (VDEM) Operations Center at 1-800-468-8892 or (804) 674-2400.

If the accident or incident involves a spill which may pose a threat to people and/or the environment, the applicator should contact VDACS/OPS to determine whether the release is governed under SARA Title III (the Community Right-to-Know Law). The chemical hazard and the volume of the released chemical determine reporting under SARA Title III, which involves notifying the National Response Center at 1-800-424-8802.

VIII. Obtain a Pesticide Business License

Certified commercial applicators working *for hire* must have a pesticide business license or work for someone who does. Registered technicians working *for hire* must work for a properly licensed pesticide business.

The Virginia Department of Agriculture and Consumer Services is responsible for all enforcement aspects of the Virginia Pesticide Control Act and its regulations. Business licenses may be suspended or revoked if the holder, in the eyes of VDACS, presents a substantial danger or threat of danger to public health and safety or to the environment.

IX. Ensure Financial Responsibility

The commercial applicator *for hire,* or his/her employer, must provide VDACS with evidence of financial responsibility protecting persons who may suffer legal damages as a result of use of any pesticide by the applicator. The coverage must provide for liability that may result from the operation of a pesticide business and for liability relating to completed operations (for businesses that *apply* pesticides). The Commonwealth insures Virginia's state employees for activities performed as official job duties.

Sources of Information

Questions regarding federal and state pesticide regulations, the legal responsibilities of pesticide users, and certificate/license status:

Virginia Department of Agriculture and Consumer Services (VDACS)
Office of Pesticide Services (OPS)
P.O. Box 1163
Richmond, VA 23218

(804) 786-3798
www.vdacs.virginia.gov/pesticides.shtml

Questions regarding federal and state pesticide regulations, legal responsibilities of pesticide users, pesticide management techniques, and sources of approved preparatory training sessions and recertification workshops:

Virginia Cooperative Extension (VCE)
Virginia Tech Pesticide Programs (MC 0409)
302 Agnew Hall
460 West Campus Drive
Virginia Tech
Blacksburg, VA 24061

(540) 231-6543
www.vtpp.ext.vt.edu/ or *vtpp.org*

Pest management information available from Virginia Tech:

Department of Entomology: *www.ento.vt.edu*

Department of Plant Pathology, Physiology, and Weed Science: *www.ppws.vt.edu/*

The Hazard Communication Standard

As of May 23, 1988, all employers must adhere to restrictions under the OSHA Hazard Communication Standard. This standard is a worker right-to-know law, which requires employers to train and inform all workers who may be exposed to hazardous chemicals in the workplace. The new law especially targets operations, including agricultural operators, with 10 or more employees. These employers must file a Hazard Communication Plan in their offices and inform their employees of the content of this plan. These employers must obtain and file Safety Data Sheets (SDS) for all chemicals used by their employees. In addition, employers must provide training on the information in the plan, the SDS, and chemical labeling to each employee who may be potentially exposed to a chemical hazard. This training is very specific to each operation and therefore must be conducted by the employer. Also, when new chemical hazards are introduced into the workplace, the employer must provide new training to protect the employee.

For agricultural operators with fewer than 10 employees, it is not necessary to develop and file a Hazard Communication Plan. However, SDS and Labeling should be maintained, and employees must be informed of proper use and safe handling according to the SDS and labeling information. For more information on the standard, contact your local Extension office or the Virginia Department of Labor and Industry.

Community Right To Know (SARA Title III)

The Superfund Amendments and Reauthorization Act of 1986 (SARA Title III) was drafted to require industries and others producing or storing hazardous chemicals to provide communities with the identity and amounts of chemicals located in their vicinity. The law also addresses the need for communities to establish emergency response plans to follow in the event of an emergency.

Section 302 requires a facility to send a one-time written notification to the Virginia Emergency Response Council (VERC) and its jurisdictional local Emergency Planning Committee (LEPC) if the presence of an Extreme Hazardous Substanee (EHS) at the facility, at any time, exceeds or equals the threshold planning quantity (TPQ) for that material. For more information, visit this section of the Virginia Department of Environmental Quality website: VAEmergencyResponsePlanningOrganizations.aspx (Navigation: DEQ, Programs, Air, Air Quality Planning & Emissions, SARA Title III, VA Emergency Response & Planning Organizations.)

The amount of formulated product that may be stored but not reported depends on the active ingredient itself and percent active ingredient in the product. If a product was 10 percent active ingredient and the TPQ was 10 pounds, then you could store up to 100 pounds of the formulated product before you would be required to report to local authorities.

In the event of a spill, contact local authorities immediately. For help with spill management, contact the Virginia Department of Emergency Management's Operations Center at (800) 468-8892 or (804) 674-2400. Spills that pose a threat to people and/or the environment must be reported to VDACS Office of Pesticide Services at (804) 371-6560. If the spill is of a reportable quantity (information available from VDACS), then contact the National Response Center (800) 424-8802.

Worker Protection Standard for Agricultural Pesticides

The EPA's Worker Protection Standard for Agricultural Pesticides (WPS) was developed to protect workers and pesticide handlers from exposures to agricultural pesticides, thus reducing the risks of pesticide poisonings and injuries. The WPS targets workers who perform hand-labor operations in agricultural fields, nurseries, greenhouses, and forests treated with pesticides. It also affects employees who handle pesticides (mix, load, apply, etc.) for use in those locations. Labels of pesticides used in agricultural plant production, nursery/greenhouse operations, and forestry refer to WPS requirements.

WPS has requirements referenced ***(but NOT explained in detail)*** on pesticide labels. You will find general information about WPS in the Virginia Core Manual: *Applying Pesticides Correctly.* For comprehensive information, consult the EPA manual: *The Worker Protection Standard for Agricultural Pesticides – How to Comply.* In addition, a WPS *Summary Guide* produced by VDACS Office of Pesticide Services is available on the agency's website. It provides a great deal of compliance assistance information, including a self inspection checklist. If you have questions about the WPS, please contact your local Extension agent or call the Virginia Department of Agriculture and Consumer Services/Office of Pesticide Services at (804) 786-4845.

Groundwater Restrictions

The EPA and Congress have placed special emphasis on protection of water resources. Water quality programs are being implemented in education and research programs throughout the country. Federal and state efforts to protect groundwater are resulting in revised pesticide product label instructions and new use restrictions. Applicators should expect a continued emphasis on protection of water supplies.

As an applicator and landowner, you must adhere to label restrictions and should follow the best management practices in handling pesticides. Particular attention should be given to prevention of spills, backsiphoning, and disposal of pesticides. Applicators can do much to prevent contamination by following label directions and maintaining and calibrating application equipment. In Virginia, it is against the law to use equipment in poor repair or to fill tanks directly from a water source without an anti-siphon device in use on the spray equipment.

For more information on anti-siphon devices, sometimes referred to as back-flow preventers, contact your local water authority. ***(Note: most check valves do not qualify as "anti-siphon" devices because they do not break the siphon.)***

Endangered Species Pesticide Use Restrictions

Under the authority of the Endangered Species Act and FIFRA, the U.S. Fish and Wildlife Service and the EPA may restrict pesticide use where such use jeopardizes a federally listed threatened or endangered species.

The EPA's Endangered Species Protection Program (ESPP) is designed to protect federally listed endangered and threatened species from exposure to pesticides. The program's goal is to ensure that pesticide use does not adversely affect the survival, reproduction, and/or food supply of listed species.

The agency will inform users of enforceable use limitations by means of ESPP Bulletins. Bulletins will provide product users with information about geographically-specific pesticide use restrictions. Bulletins will be referenced on pesticide product labels and available on the internet at *www.epa.gov/espp* or by calling 1-800-447-3813. (Internet search tip: At the main ESPP page, click on "Bulletins Live!" to view pesticide use limitations for a specific county or active ingredient.)

Applicators using a product with an ESPP reference on the label must check for—and access—a bulletin no more than 6 months prior to applying this pesticide. Failure to follow label-referenced bulletin instructions and provisions, whether or not that failure results in harm to a listed species, is subject to enforcement under the misuse provisions of FIFRA and state law.

Note that not all pesticide active ingredients will have restrictions, and not all pesticide uses are banned in restricted areas.

Please observe pesticide labeling for changes and keep up to date on this topic. Information is available through your local Extension office or the Virginia Department of Agriculture and Consumer Services.

Guidelines for Disposal of Pesticides and Empty Containers

Always dispose of pesticides and empty containers so they pose no hazard to humans or the environment. Follow label directions and consult your local Extension agent if you have questions. The best solution to the problem of what to do with excess pesticide is to avoid having any. Waste minimization strategies include:

- Buy only the amount needed for a year or a growing season.
- Minimize the amount of product kept in storage.
- Calculate how much diluted pesticide you will need for a job, and mix only that amount.
- Apply pesticide with properly calibrated equipment.
- Use all pesticides in accordance with label instructions.
- Purchase pesticide products packaged in such a way as to minimize disposal problems, or packaged in containers that have legal disposal operations available in your area.

The best disposal option for excess usable pesticide is to find a way to apply the material as directed by the label. Please note that the total amount of active ingredient applied to a site, including all previous applications, must not exceed the rate and frequency allowed by the labeling.

Other pesticide waste disposal options include:

- Follow valid label disposal directions.
- Return product to the dealer, formulator, or manufacturer.
- Participate in a federal indemnification program for canceled/suspended products.
- Employ a professional waste-disposal firm.
- Participate in a state or local "clean day," such as the Virginia Pesticide Control Board-sponsored Pesticide Disposal Program.

Pesticide wastes that cannot be disposed of right away should be marked to indicate the contents and then stored safely and correctly until legal disposal is possible.

EPA container and containment regulations require registrants to place instructions for container cleaning on product labels. In addition, users should read the label to learn if a container is refillable or non-refillable. One-way, non-refillable containers will have guidelines for proper cleaning and disposal.

Federal law (FIFRA) requires pesticide applicators to rinse "empty" pesticide containers before discarding them. Pesticide containers that have been properly rinsed can be handled and disposed of as non-hazardous solid waste. However, the containers of some commonly used pesticides are classified as hazardous waste if not properly rinsed. Proper disposal of hazardous waste is highly regulated. Improper disposal of a hazardous waste can result in high fines and/or criminal penalties.

A "drip-drained" pesticide container contains product. Immediate and proper rinsing generally removes more than 99 percent of container residues. Properly rinsed pesticide containers pose minimal risk to people and their environment.

There are two methods for proper rinsing:

- Triple Rinsing, and
- Pressure Rinsing.

Pesticide containers should be rinsed as soon as they are emptied. So, the time to rinse is during mixing/loading. If containers are rinsed as soon as they are emptied, the rinse water (rinsate) can be added to the spray tank. This avoids the problem of rinsate disposal and makes sure that nothing is wasted. If containers are rinsed immediately, residues do not have time to dry inside. Dried residues are difficult (or impossible!) to remove. Never postpone container rinsing!

Be sure to wear protective clothing when rinsing pesticide containers. See the product label for information on what to wear.

Pesticide Phone Sales – Buyers Beware

Telephone solicitation of pesticides is a chronic problem for growers and applicators in Virginia. As a general rule, applicators should be wary about buying pesticide products "sight unseen." Here is a general description of problems often associated with telephone sales offers:

1. The product actually contains a very low percentage of pesticide active ingredient per unit volume. So, it is actually quite expensive to use on a per-area basis.
2. Often, weed control products contain a small proportion of herbicide formulated with diesel fuel or some other petroleum product. These are generally not recommended and not usable in many situations.
3. The product name is similar to the trade name of another well-known pesticide product or sounds like one from a major pesticide manufacturer's line.
4. The solicitor gives an EPA establishment number but not an EPA registration number. In many cases, this is because the product is not registered with EPA.
5. The product is not registered with VDACS, despite being offered for sale in the commonwealth. This is an illegal practice.

If the potential buyer wishes to follow up on a telephone sales solicitation, he/she should ask for the following information: company name, address, and telephone number; name of salesperson; product name; product registration number; percent active ingredient(s) per unit volume; use site(s); and use rate(s). It is wise to ask for a copy of the label and product MSDS before making a commitment to purchase. If a telephone salesperson does not provide the information you request, the "bargain" is better passed by.

Information given over the telephone can be verified, and the claims for the product can be compared to industry standards or known performance data for the product's active ingredient(s). To check federal and state product registrations, call:

VDACS/Office of Pesticide Services (804) 786-3798 or VCE/Virginia Tech Pesticide Programs (540) 231-6543

If you receive what you suspect to be an improper sales offer, you're encouraged to get as much information as possible and make a complaint to VDACS Office of Pesticide Services by calling (804) 786-3798.

Based on the difficulties associated with telephone solicitations, pesticide users are advised to buy from established dealers and from sellers they know.

Pesticide Use Precautions

Efficient and economical control of insects, plant diseases, and weeds is a factor in the production of all crops. Both management costs and losses resulting from inadequate control can reach tremendous proportions. The use of today's pesticides requires a great degree of precision. In some instances, rates are given in ounces per acre. This requires that pesticide users know how to calibrate equipment and follow detailed directions on product labels.

All pesticides should be used with care. The following suggestions will help minimize the likelihood of injury (from exposure to such chemicals) to people, animals, and non-target plants and animals.

Read the Label: Before buying and applying pesticides, always read all label directions. Follow them exactly when you handle and apply the product. Notice warnings and cautions before opening the container. Repeat the process every time, no matter how often you use a pesticide. The label directions for pesticides often change. Apply materials only on crops specified, at the rate(s) and times indicated on the product label.

Store Pesticides Properly: A suitable storage site for pesticides protects:

• People and animals from accidental exposure.

• The environment from accidental contamination.

• Stored products from damage (from temperature extremes and excess moisture).

• The pesticides from theft, vandalism, and unauthorized use.

All pesticides should be stored under lock and key, outside the home. Storage facilities should be well-ventilated and well-lit. Pesticide storage areas should be located away from water sources such as ponds or wells. However, a supply of clean water for decontamination is recommended. Use non-porous materials for flooring and shelving. It is important to arrange materials in the storage site so cross-contamination does not occur. Do not store pesticides with food, feed, seed, or fertilizer. An emergency plan should be worked out with local authorities, notifying them of the contents of pesticide storage facilities. If susbstantial quantities of highly toxic pesticides are stored, you must notify (according to law) your local Emergency Response Council. Proper records should be maintained to provide an up-to-date list of contents at all times. Always store pesticides in their original containers and keep them tightly closed. Never keep pesticides in unmarked containers.

Avoid Physical Contact with Pesticides: Never smoke, eat, chew tobacco, or use snuff while handling or applying pesticides. Use the protective clothing and equipment the label requires. Protect your eyes from pesticides at all times. Avoid inhaling sprays or dusts. Do not spill pesticides on skin or clothing. If they are accidentally spilled, remove contaminated clothing immediately and wash exposed skin thoroughly. Wash hands and face and change to clean clothing after applying pesticides. Wash protective clothing, separate from the family laundry, each day, before re-use. Do not spray with leaking hoses or connections. Do not use the mouth to siphon liquids from containers or to blow out clogged lines, nozzles, etc. **See a doctor if symptoms of illness occur during or after the use of pesticides.** A list of Poison Control Centers located in and around Virginia is included in this guide.

Apply Pesticides Carefully: Successful pest control requires application of the correct amount of pesticide uniformly over a targeted area. Pesticide application is a precise operation requiring reliable, properly calibrated equipment. For example, many herbicides have narrow ranges of selectivity. At the suggested rates of application, they will generally control weeds without damaging the crop, but at a slightly higher rate they may damage or kill the crop.

Dispose of Pesticides Correctly: All pesticides should be disposed of according to container directions. All empty containers should be triple rinsed (or equivalent), crushed, and disposed of as directed by the product label. Rinsate should be placed in the spray tank at the time of mixing. Leftover diluted pesticides should be used according to label directions. Leftover concentrates should be disposed of according to EPA guidelines only after exhausting other options. Amounts of chemicals that do not qualify for disposal under these guidelines must be disposed of by an approved hazardous-waste handler.

Protect Pets, Fish, and Wildlife: To protect fish and other wildlife, do not apply pesticides to streams or areas where drainage may be expected to enter waterways unless the product is labeled for use in such areas. Incorporate all granular pesticides into the soil to prevent birds and other animals from eating particles. Scout fields for dead animals and birds before and after application. Remove any carcasses to prevent poisoning of birds-of-prey and scavengers. Report any wildlife poisonings to the Virginia Department of Game and Inland Fisheries. Be aware of bee cautions; see section to follow on protecting honeybees from pesticides.

Cover food and water containers when treating around livestock or pet areas. Do not discard leftover materials into drainage channels. Confine chemicals to the property and crop being treated.

Prevent Drift: Drift can be a problem with any pesticide. However, herbicide drift is the most commonly encountered cause of pesticide damage to susceptible crops. No pesticide can be applied by either aerial or ground equipment without some drift. Spray drift is influenced by a number of factors, including, droplet size, environmental conditions, and equipment configuration and operation.

To minimize particle drift, application should be made as close to the ground as possible using spray nozzles which produce large droplets and eliminate “fines.” In some instances, spray additives may be used to reduce drift.

Some highly volatile herbicide products are capable of causing injury to off-target plants by movement in the vapor phase after the spray has dried. Use low-volatility formulations and avoid making spray applications when the temperature is high and humidity is low to reduce the possibility of vapor drift.

The farmer and the applicator are liable for damages caused by particle drift or volatility.

Select Pesticide Products Wisely: Two or more pesticides may be equally effective in a given situation. Also, the same active ingredient may be available in a variety of formulations. Your selection of a pesticide and its formulation will be determined by the:

1. Site/crop to be treated.
2. Pest species involved.

3. Product availability.
4. Equipment availability.
5. Hazards to humans, domestic animals, wildlife, and desirable plants.
6. Time of application.
7. Relative total costs of materials and application.

All recommended rates of application are based on the amount of active ingredient in a given product. Many commercial products vary in the percentage of active ingredient. The label will give the exact amount of active ingredient in the container and the amount of product to be used in a given area.

To make an accurate cost comparison, it is wise to calculate the cost per area. In general, concentrated products are more economical. However, they may require more handling (measuring, mixing, and loading) than ready-to-use products.

Poisonings

The procedure to be followed ***in case of suspected poisoning****:*

(1) Call a physician immediately. If a doctor is not available, take the exposed person to the nearest hospital emergency room along with the product label and safety data sheet. (If you take a label affixed to a product container, do not carry it in the passenger compartment of a vehicle.)

(2) If necessary, the attending physician will call the nearest poison control center for further information on toxicity of the suspected agent, treatment, and prognosis. The EPA publication *Recognition and Management of Pesticide Poisonings* is an invaluable resource and can be viewed, downloaded, or ordered online.

(3) You may call a poison control center for information. However, don't delay seeking medical attention.

NOTE: This information is correct to the best of our knowledge. Listings below were checked for this revision. Please note that this information is subject to change. You should confirm locations and phone numbers of nearby emergency contacts now rather than at the time of a poisoning incident.

Poison Information and Treatment Resources For Virginians

National Poison Control Center

Toll-Free Number for all U.S.: (800) 222-1222

Calls to this number will be routed to the closest Regional/Area Poison Control Center.

Website for the American Association of Poison Control Centers is: www.aapcc.org/

Regional Poison Control Center

Provides 24-hour information and consultation services by Poison Information Specialists and board-certified Medical Toxicologists. Located in a hospital equipped for all toxicologic (poison) emergencies.

CHARLOTTESVILLE, VA.
Blue Ridge Poison Center
University of Virginia Health Systems
Jefferson Park Place
1222 Jefferson Park Avenue
Charlottesville, VA 22908
(800) 222-1222 or (800) 451-1428
https://med.virginia.edu/brpc/

Area Poison Control Centers

Hospitals with staff who will provide poison information by telephone. Hospitals equipped for most toxicologic emergencies.

WASHINGTON, D.C.
National Capital Poison Center
3201 New Mexico Ave., NW, Suite 310
Washington, DC 20016
(800) 222-1222
www.poison.org/

CHARLESTON, W.V.
West Virginia Poison Center
3110 MacCorkle Ave., SE
Charleston, WV 25304
(800) 222-1222
www.wvpoisoncenter.org/

RICHMOND, VA.
Virginia Poison Center
Virginia Commonwealth University Medical Center, VCU Health System
1250 East Marshall Street
PO Box 980522 - Richmond, VA - 23298-0522
(800) 222-1222 or (804) 828-9123
(Calls from Central and Eastern Va. only)
www.virginiapoison.org or www.vapoison.org

A complete list of Poison Control Centers is available on the World Wide Web at www.aapcc.org/

Pesticide Information Directory

This directory is intended for use by persons who need assistance with general and emergency pesticide-related information. We hope that it will save time and money by directing you to the proper government and industry sources.

The pages that follow include **Emergency Information, General Information, and Industry Associations**. In the blank lines provided, please take time to list your local phone numbers for these sources. In the case of an emergency, it might save a life, as well as possible added expense and inconvenience. Keep a copy of this guide, with this directory section marked, near your phone and/or in your service vehicle for future reference.

Emergency Information

Poisonings For Treatment:	If poisoned, have someone take you immediately to your nearest emergency room with the label of the container.	
My Nearest Poison Control Center Is Located At:	The blanks below are supplied for recording the name and telephone number of the nearest poison control center. Please refer to the Regional and Area Poison Control Centers listed previously in this section.	
	_____	
	_____	
	_____	
Phone number	_____	
Spills accidents and other related emergencies	CHEMTREC (for assistance) Chemical Transportation Emergency Center Industry assistance with clean-up procedures, etc.	*(800) 262-8200* *chemtrec.com/*
Accidents or **Incidents** that constitute a threat to any person, public safety and health, or the environment must be reported to:	Virginia Department of Agriculture and Consumer Services Office of Pesticide Services Field Operations	(804) 371-6560
For Assistance with Spills and Emergencies Take time to write your local emergency numbers in the space provided.	State Police	_____
	Fire Department	_____
	Ambulance	_____
	Virginia Department of Emergency Management (VDEM) **Emergency Operations Center** *pio@vdem.virginia.gov* - E-mail monitored during regular business hours. *http://www.vaemergency.gov/aboutus/locationscontact-us*	(804) 897-6500 (Mon-Fri) 8:15am-5pm **(804) 674-2400** **(800) 468-8892** 24 hours / day
	Local Emergency Services Coordinator	_____
	Local Emergency Response Council	_____

General Information

General Information about pest identification and management and about pesticide safety and use patterns	**Virginia Tech** Your Local Extension Office *www.ext.vt.edu/offices.html* Virginia Tech Pesticide Programs (0409) Blacksburg, VA 24061 *www.vtpp.ext.vt.edu/* or *vtpp.org*	 (540) 231-6543
Regulatory Information including certificate or license status	**Virginia Dept. of Agriculture and Consumer Services** Office of Pesticide Services 102 Governor Street P.O. Box 1163 Richmond, VA 23218 *www.vdacs.virginia.gov/pesticides.shtml*	(804) 786-3798
Community Right-to-know Environmental Programs	**Department of Environmental Quality** 629 East Main Street P.O. Box 1105 Richmond, VA 23218 *http://www.deq.virginia.gov.*	(804) 698-4000 (800) 592-5482
EPA Cooperator for general pesticide information	**National Pesticide Information Center (NPIC)** Ag. Chemistry Extension Oregon State University 310 Weniger Hall Corvallis, OR 97331-6502 *npic.orst.edu/*	(800) 858-7378 M-F 11:00 am – 3:00 pm ET
Animal Poisonings Assistance	**Va.-Md. Regional College of Veterinary Medicine** 265 Duck Pond Drive Virginia Tech (0442) Blacksburg, VA 24061 *www.vetmed.vt.edu/* **ASPCA Animal Poison Control Center** $65.00 consultation fee, credit cards accepted University of Illinois at Urbana-Champaign College of Veterinary Medicine 2001 S. Lincoln Ave. Urbana, IL 61802 *aspca.org/pet-care/animal-poison-control*	(540) 231-4621 (hospital) Ask your veterinarian to call on your behalf (888) 426-4435
RCRA & Superfund Industry Assistance Hotline	**EPA - Resource Conservation Recovery Act** (Superfund regulations) *www.epa.gov/rcra*	(800) 424-9346
Toxicology Information	**Virginia Dept. of Health** Division of Environmental Epidemiology/Toxicology Program 109 Governor Street P.O. Box 2448 Richmond, VA 23218 *www.vdh.virginia.gov/*	(804) 864-8127 (toxic substance information)
EPA Safe Drinking Water Hotline	For information on drinking water regulations and pesticides in drinking water. *www.epa.gov/safewater/*	(800) 426-4791 M-F 10:00 am-4:00 pm
Hazard Communication/OSHA Compliance Information	**Virginia Dept. of Labor & Industry** 600 East Main Street Suite 207 Richmond, VA 23219 *www.doli.virginia.gov/*	(804) 371-2327 M-F 8:15 am – 5:00 pm

Industry Associations

Croplife America 1156 15th St., N.W. Washington, DC 20005	(202) 296-1585 *www.croplifeamerica.org/*
Virginia Crop Production Association, Inc. (VCPA) 6442 Cross Keys Road Mt. Crawford, VA 22841	(540) 234-9408 *www.vacropproduction.com*
Responsible Industry for a Sound Environment (RISE) 1156 15th Street, N.W., Suite 400 Washington, DC 20005	(202) 872-3860 *www.pestfacts.org/*
National Pest Management Association (NPMA) 10460 North Street Fairfax, VA 22030	(703) 352-6762 (800) 678-6722 *www.pestworld.org/* (consumer info.) *www.npmapestworld.org* (PMPs)
Virginia Pest Management Association (VPMA) 102 Bell Road Fredericksburg, VA 22405 P. O. Box 7161 Fredericksburg, VA 22404-7161	(540) 374-9200 (877) 875-8722 *www.vpmaonline.com/*
National Association of Landscape Professionals (NALP) 950 Herndon Parkway, Suite 450 Herndon, VA 20170	(800) 395-2522 (703) 736-9666 *www.landscapeprofessionals.org*
Virginia Turfgrass Council (VTC) P.O. Box 5989 Virginia Beach, VA 23471	(757) 464-1004 *www.vaturf.org/*
Virginia Nursery and Landscape Association 383 Coal Hollow Road Christiansburg, VA 24073-6721	(800) 476-0055 (540) 382-0943 *www.vnla.org/*

This directory neither endorses the groups listed nor intends to exclude those not listed. To be included in future revisions contact Rachel Paarson, Virginia Tech Pesticide Programs, 302 Agnew Hall (0409) Virginia Tech, Blacksburg, VA 24061, telephone: (540) 231-4639.

Protective Clothing and Equipment

Dermal exposures account for most of all handler exposures that occur during liquid spray applications. Wearing protective clothing will prevent pesticides from coming into contact with the skin. Any body covering will provide some protection, because dermal absorption is reduced to some degree by a fabric barrier. Protective clothing may be classified according to the part of the body it protects; i.e., feet (boots and shoes), hands (gloves), eyes (goggles and faceshields), head (hats and hoods), and trunk and arms and/or legs (jackets, shirts, pants, coveralls, overalls, and raincoats).

Because of its comfort, conventional work clothing is worn most often. Wearing cotton clothing with a stain-repellent finish provides some protection from dusts and spray mists. However, cotton fabric will provide little or no protection from accidental spills of concentrated pesticides.

Use chemical-resistant garments when handling pesticide concentrates and applying liquids. Adjust work habits and take precautions to prevent heat exhaustion.

Cleaning/Laundering Recommendations

Laundering Information for Pesticide-contaminated Clothing - Before laundering, read the pesticide label. Key words on all pesticide labels identify the toxicity of the product: **DANGER POISON** (highly toxic), **WARNING** (moderately toxic), and **CAUTION** (slightly toxic). Wear waterproof gloves when handling pesticide-contaminated clothing and equipment.

1. **Cotton or Denim Fabric** - Hold and wash contaminated clothing separately from the family wash. Pesticide residues may be transferred from contaminated clothing to other clothing in a hamper, and clothing worn when handling pesticides requires extra washing steps.

Note: Regular laundering will not clean fabric contaminated with highly toxic and/or concentrated pesticide. Clothing saturated with either should be discarded, after slashing/cutting to make the item unusable.

Pre-treating contaminated clothing before washing will help remove pesticide particles from the fabric. This can be done by:

1. Pre-soaking in a suitable container.
2. Pre-rinsing with agitation in an automatic washing machine.
3. Spraying/hosing garments outdoors.
4. Pretreating soiled areas with heavy-duty liquid detergent or a stain-removal product.

Clothing worn while using slightly toxic pesticides may be effectively laundered in one machine washing. It is strongly recommended that multiple washings be used on clothing worn while applying more toxic pesticides. Also, multiple wash cycles are recommended for protective clothing treated with starch or water/stain repellents.

When machine-washing, use a full tank of hot water. Choose heavy-duty liquid detergent. Heavy-duty detergents are particularly effective in removing oily soils (the kind emulsifiable concentrate formulations make). In addition, their performance is not affected by water hardness. Increasing the amount of detergent used is recommended, especially if the fabric has been treated with a stain/water repellent finish.

If several garments are contaminated, wash only one or two garments in a single load. Wash garments contaminated by the same pesticide(s) together. Use a full water level to allow the water to thoroughly flush the fabric.

Clothing exposed to pesticides should be laundered daily. It is much easier to remove pesticides from clothing by daily laundering than attempting to remove residues that have accumulated over a period of time.

Pesticide carry-over to subsequent laundry loads is possible because the washing machine may retain residues, which are then released in following loads. Rinse the washing machine with an "empty load," using hot water, the same detergent, and machine settings and cycles used for laundering contaminated clothing.

Line drying is recommended for these items. Many pesticides break down when exposed to heat and sunlight. Line drying eliminates the possibility of residues collecting in the dryer.

When dry, apply fabric starch or stain repellent on clothing.

2. **Vinyl-coated fabric, neoprene, or rubber** - This type of outer protective clothing should be pan-washed in warm water using a good detergent. Double or triple washing of heavily contaminated outer protective clothing is desirable. Rinse through two water changes and hang up to air dry. Wash after each use.
3. **Gloves and boots** should be rinsed before taking them off, then pan-washed inside and out using a good detergent with several rinses. Remember, gloves must be clean inside because the inner surface will be in contact with your skin. Wash rubber boots the same as gloves.
4. **Respirators** require special care. Wash inside with a cloth, detergent, and warm water. Change filters according to instructions on the original container. Keep the respirator in a plastic bag, original container, or some other suitable container when it is not being used. Keep the respirator properly adjusted to your face. Filters and prefilters should be kept sealed in a plastic bag when not in use.
5. **Goggles** should be washed with a mild detergent so as not to scratch the lens.

Give all of your protective clothing and equipment the best of care. They may save your life.

Chemical Resistance

Many pesticide labels require the use of specific personal protective equipment (PPE) — clothing and devices that protect the body from contact with pesticides or pesticide residues. Some labels call for **chemical-resistant** PPE — items that the pesticide cannot pass through during the time it takes to complete the task. The labels of a few pesticides, such as some fumigants, prohibit the use of chemical-resistant PPE. Please refer to specific product labels for details.

Most chemical-resistant PPE items are plastic or rubber. But not all these materials are equally resistant to all pesticides and under all conditions.

Three factors affect a material's chemical resistance: the exposure time, the exposure situation, and the chemical properties of the pesticide product to which the material is exposed.

Unless the pesticide label directs otherwise, do not use items that are made of — or lined with — absorbent materials such as cotton, leather, or canvas. These materials are not chemical-resistant, and they are difficult or impossible to clean after a pesticide gets on them. Even dry formulations can move quickly through woven materials and may remain in the fibers.

Look for PPE items whose labels state that the materials have been tested using American Society for Testing Materials (ASTM) test methods for chemical resistance, such as test method F739-91. Footwear — and in most cases, gloves — should be at least 14 mils thick.

Pesticides can leak through stitching holes and gaps in seams. For chemical resistance, PPE should have sealed seams.

Any waterproof material is resistant to dry and to water-based pesticides.

Dry pesticides include dusts, granules, pellets, wettable powders, dry flowables (water-dispersible granules), microencapsulated products, soluble powders, and some baits. Water-based pesticides include soluble powders and some solutions.

The type of material that is resistant to non-water-based liquid pesticides depends on the contents of the formulation.

Liquid pesticides that are not water-based may be emulsifiable concentrates, ultra-low-volume and low-volume concentrates, flowables, aerosols, dormant oils, and invert emulsions. Common solvents are xylene, fuel oil, petroleum distillates, and alcohol.

Choosing Chemical-Resistant PPE

Materials are not listed on label.

If the pesticide label requires the use of chemical-resistant PPE but does not indicate the types of materials that are resistant to the product, select sturdy barrier-laminate, butyl, or nitrile materials. Then watch for signs that the material is not resistant to the product. If it is not, it may:

• Change color.

• Become soft or spongy.

• Swell or bubble.

• Dissolve or become jelly-like.

• Crack or develop holes.

• Become stiff or brittle.

If any of these changes occur, discard the item and choose another type of material for the task.

Chemical-Resistance Category Listed on Label.

If the pesticide label specifies the PPE materials that **must** be worn when using the product, follow those instructions.

Some labels may list **examples** of PPE materials that are highly resistant to the product. The label may say, for example: "Wear chemical-resistant gloves, such as barrier laminate, butyl, nitrile, or viton." You may choose PPE items made from any of the listed materials.

Pesticide labels sometimes specify a chemical-resistance category (A through H) for PPE to use when working with the product. This allows you to consult an EPA chemical-resistance chart (see below) for PPE material options.

Table 1.3 - EPA Chemical Resistance Category Selection Chart

For use when PPE section on pesticide label lists chemical resistance category

Selection Category Listed On Pesticide Label	Type Of Personal Protectlve Material							
	Barrier Laminate ≥ 14 mils	Butyl Rubber ≥ 14 mils	Nitrile Rubber ≥ 14 mils	Neoprene Rubber ≥ 14 mils	Natural Rubber[1]	Polyethylene	Polyvinyl Chloride (PVC) ≥ 14 mils	Viton ≥ 14 mils
A (dry and water-based formulations)	high	high	high	high	high	high	high	high
B	high	high	slight	slight	none	slight	slight	slight
C	high	high	high	high	moderate	moderate	high	high
D	high	high	moderate	moderate	none	none	none	slight
E	high	slight	high	high	slight	none	moderate	high
F	high	high	high	moderate	slight	none	slight	high
G	high	slight	slight	slight	none	none	none	high
H	high	slight	slight	slight	none	none	none	high

[1]Includes natural rubber blends and laminates

HIGH: Highly chemical resistant. Clean or replace PPE at end of each day's work period. Rinse off pesticides at rest breaks.
MODERATE: Moderately chemical resistant. Clean or replace PPE within an hour or two of contact.
SLIGHT: Slightly chemical resistant. Clean or replace PPE within ten minutes of contact.
NONE: No chemical resistance. Do not wear this type of material as PPE when contact is possible.

When choosing an appropriate material, consider the dexterity needed for the task and whether the material will withstand the physical demands of the task. The PPE will protect you if:

- the item is in good condition, and no punctures, tears, or abrasions allow pesticide to penetrate the material, and
- pesticide does not get inside the PPE through careless practices, such as allowing pesticide to run into gloves or footwear or putting the PPE on over already-contaminated hands or feet.

Highly Resistant PPE

A rating of **high** means that the material is highly resistant to pesticides in that category. PPE made of this type of material can be expected to protect you for an 8-hour work period. The outside of the PPE, especially gloves, should be washed at rest breaks — about once every 4 hours. Highly resistant PPE is a good choice when handling pesticides, especially concentrates, for long periods of time.

Moderately Resistant PPE

A rating of **moderate** means that the material is moderately resistant to pesticides in that category. PPE made of this type of material can be expected to protect you for 1 or 2 hours. After that, replace the PPE with clean chemical-resistant PPE or thoroughly wash the outside of the PPE with soap and water. Moderately resistant PPE may be a good choice for pesticide handling tasks that last only a couple of hours.

Slightly Resistant PPE

A rating of **slight** means that the material is only slightly resistant to pesticides in that category. PPE made of this type of material can be expected to protect you for only a few minutes after exposure to the pesticide product. Slightly resistant PPE is not a good choice for most pesticide handling tasks.

Inexpensive disposable gloves or shoe covers, such as those made from polyethylene, may be useful for such brief tasks as:

• Adjusting contaminated parts of equipment.

• Unclogging or adjusting nozzles.

• Opening pesticide containers.

• Moving open pesticide containers or containers with pesticides on the outside.

• Handling heavily contaminated PPE.

• Climbing in and out of cabs or cockpits where the outside of the equipment is contaminated.

• Operating closed systems.

These disposable PPE items should be used only once, for a very short-term task, and then discarded. At the end of the task, it is a good idea to wash the outside of the gloves or shoe covers first, and then remove them by turning them inside out. Discard them so they cannot be reused.

Table 1.4 - Tables of Weights and Measures

Weights:
28.35 grams = 1 ounce
16 ounces = 1 pound = 453.6 grams
1 pint of water = 1.04 pounds
1 gallon of water = 8.34 pounds
1000 micrograms = 1 milligram
1000 milligrams = 1 gram = 0.035 ounce avoirdupois
1000 grams = 1 kilogram = 2.2 pounds

Volume And Liquid Measure:
3 teaspoons = 1 tablespoon = 14.8 cubic centimeters (cc)
2 tablespoons = 1 fluid ounce = 29.6 cc
8 fluid ounces = 16 tablespoons = 1 cup = 236.6 cc = 1/2 pint
2 cups = 32 tablespoons = 1 pint = 473.1 cc = 16 fluid ounces
2 pints = 64 tablespoons = 1 quart = 946.2 cc = 0.946 liter
4 quarts = 256 tablespoons = 1 gallon = 3785 cc
1 gallon = 128 fluid ounces = 231 cubic inches = 3785 cc
1 milliliter (ml) = 1 cubic centimeter = 0.034 fluid ounces
1000 milliliters = 1 liter = approximately 1 quart, 1 fluid ounce
1 liter of water = 1 kilogram
1 bushel soil = 1.25 cubic feet

Land Measure:
43,560 square feet = 1 acre = 0.404 hectare
1 mile = 5280 feet = 1609.35 meters
10 millimeters = 1 centimeter = 0.3937 inches
100 centimeters = 1 meter = 39.37 inches

Length Of Row Required For One Acre:

Row Spacing	*Length or Distance*
24 inch	7260 yards = 21,780 feet
30 inch	5808 yards = 17,424 feet
36 inch	4840 yards = 14,520 feet
40 inch	4356 yards = 13,069 feet
42 inch	4149 yards = 12,446 feet
48 inch	3630 yards = 10,890 feet

Table 1.5 - Abbreviations For Pesticide Formulations

A	=	Aerosol	M	=	Microencapsulated
B	=	Bait	P	=	Pellet
C	=	Concentrate	RTU	=	Ready to Use
D	=	Dust	S	=	Solution
DF	=	Dry Flowable (see WDG)	SP	=	Soluble Powder
E or EC	=	Emulsifiable Concentrate	ULV	=	Ultra Low Volume
F	=	Flowable	W or WP	=	Wettable Powder
G	=	Granule	WDG	=	Water Dispersible Granule (see DF)
H/A	=	Harvest Aid	WS	=	Water Soluble
IE	=	Invert Emulsion	WSP	=	Water Soluble Packet
LC	=	Liquid Concentrate			

Calibration Tables And Information

Table 1.6 - Travel Speed Chart

Time Required in Seconds to Travel			
Miles per Hour	**100 ft**	**200 ft**	**300 ft**
1	68	136	205
2	34	68	102
3	23	46	68
4	17	34	51
5	14	27	41
6	11	23	34
7	10	20	29
8	9	17	26
9	8	15	23
10	7	14	21

1 mph = 88 feet per minute
1 mph = 1.466 feet per second
Speed in mph = Number of 35-inch steps per minute/30

Table 1.7 - Equivalent Quantities of Liquid Materials (Emulsifiable Concentrates, Etc.) for Various Quantities of Water

Water	Quantity of Material					
100.0 gal[1]	0.5 pt	1.0 pt	2.0 pt	3.0 pt	4.0 pt[1]	5.0 pt
50.0 gal	4.0 fl oz	8.0 fl oz	1.0 pt	24.0 fl oz	1.0 qt	2.5 pt
5.0 gal	0.4 fl oz (1.0 tbsp)[2]	0.8 fl oz	1.6 fl oz	2.4 fl oz	3.2.0 fl oz	4.0 fl oz
1.0 gal[1]	0.08 fl oz (0.5 tsp)[2]	0.16 fl oz (1.0 tsp)[2]	0.32 fl oz (2.0 tsp)[2]	0.48 fl oz (3.0 tsp)[2]	0.64 fl oz[1]	0.8 fl oz (5.0 tsp)[2]

[1]Example: If 4 pints of a liquid concentrate is recommended to 100 gallons of water, 4 teaspoonsful of the chemical to 1 gallon of water will give a mixture of approximately the same strength.

[2]Approximate figure.

Table 1.8 - Pounds of Active Ingredients per Gallon, Pounds per Pint of Liquid, and the Number of Pints for Various per Acre Rates

Pounds of Active ingredients in one gallon of commercial product	Pounds of active ingredients per pint[1]	Pints of commercial product needed each acre to give the following pounds of active ingredient					
		0.25 lb/A	0.50 lb/A	0.75 lb/A	1.0 lb/A	1.50 lb/A	2.0 lb/A
2.00	0.25	1.00	2.00	3.00	4.00	6.00	8.00
2.64	0.33	0.75	1.50	2.25	3.00	4.50	6.00
3.00	0.375	0.67	1.33	2.00	2.67	4.00	5.33
3.34	0.42	0.60	1.20	1.80	2.40	3.60	4.80
4.00	0.50	0.50	1.00	1.50	2.00	3.00	4.00
6.00	0.75	0.33	0.67	1.00	1.33	2.00	2.67

[1]1 pint = 16 liquid ounces.

Table 1.9 - Available Commercial Materials in Pounds Active Ingredients per Gallon Necessary to Make Various Percentage Concentrate Solutions

Pounds of active ingredients in one gallon of commercial product	Pounds of active ingredients per pint[1]	Liquid ounces of commercial product per one gallon of solution to make:				
		1/2%	1%	2%	5%	10%
2.00	0.25	2.68	5.36	10.72	26.80	53.60
2.64	0.33	2.02	4.05	8.10	20.25	40.44
3.00	0.375	1.78	3.56	7.12	17.80	35.58
3.34	0.42	1.59	3.18	6.36	15.90	31.96
4.00	0.50	1.34	2.67	5.33	13.34	26.69
6.00	0.75	0.89	1.78	3.56	8.90	17.79

[1]Based on 8.34 pounds per gallon (weight of water).

Table 1.10 - Converting Pounds Active Ingredients per Acre to Smaller Units for Small Plots

Liquid

Cubic centimeters (ml) per 100 square feet necessary to apply the following pounds of active ingredients per acre

	Concentrate lbs/A															
lbs/gal	**1/8**	**1/4**	**1/2**	**3/4**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
8.00	0.14	0.27	0.54	0.81	1.08	2.16	3.24	4.32	5.40	6.48	7.56	8.64	9.72	10.80	11.88	12.96
7.00	0.16	0.31	0.62	0.93	1.24	2.48	3.72	4.96	6.20	7.44	8.68	9.92	11.16	12.40	13.64	14.88
6.66	0.16	0.33	0.65	0.99	1.30	2.60	3.91	5.21	6.51	7.80	9.10	10.40	11.70	13.03	14.30	15.60
6.00	0.18	0.36	0.72	1.10	1.45	2.89	4.34	5.78	7.23	8.70	10.15	11.60	13.05	14.46	15.95	17.40
5.00	0.22	0.44	0.87	1.31	1.74	3.47	5.21	6.94	8.68	10.44	12.18	13.92	15.66	17.35	19.14	20.88
4.00	0.27	0.54	1.09	1.64	2.17	4.34	6.51	8.68	10.85	13.02	15.19	17.36	19.53	21.69	23.87	26.04
3.33	0.33	0.65	1.31	1.97	2.61	5.21	7.82	10.42	13.03	15.66	18.27	20.88	23.49	26.06	28.71	31.32
3.00	0.36	0.72	1.45	2.16	2.89	5.78	8.67	11.56	14.45	17.34	20.23	23.12	26.01	28.90	31.79	34.68
2.50	0.43	0.87	1.74	2.61	3.47	6.94	10.41	13.88	17.36	20.82	24.29	27.76	31.12	34.71	38.17	41.64
2.00	0.54	1.09	2.17	3.25	4.34	8.68	13.01	17.35	21.69	26.04	30.38	34.72	39.06	43.38	47.74	52.08
1.00	1.08	2.17	4.34	6.51	8.68	17.35	26.03	34.71	43.39	52.08	60.76	69.44	78.12	86.76	95.48	104.16

Dry

Grams per 100 square feet necessary to apply the following pounds of active ingredient per acre

% Active ingredients	**lbs**										
	1/2	**3/4**	**1**	**2**	**3**	**4**	**5**	**7.5**	**10**	**20**	**50**
100.0	0.52	0.78	1.04	2.08	3.12	4.15	5.19	7.79	10.39	20.77	51.94
90.0	0.58	0.87	1.15	2.31	3.46	4.62	5.77	8.66	11.54	23.08	57.71
80.0	0.65	0.97	1.30	2.60	3.90	5.19	6.49	9.74	12.98	25.97	64.92
75.0	0.69	1.04	1.38	2.77	4.15	5.54	6.92	10.39	13.85	27.70	69.25
50.0	1.04	1.56	2.08	4.15	6.23	8.31	10.39	15.58	20.77	41.55	103.87
25.0	2.08	3.12	4.15	8.31	12.46	16.62	20.77	31.16	41.55	83.10	207.75
22.5	2.31	3.46	4.62	9.23	13.85	18.46	23.08	34.62	46.17	92.33	230.83
20.0	2.60	3.90	5.19	10.39	15.58	20.77	25.97	36.37	51.94	103.87	259.69
18.5	2.81	4.21	5.61	11.23	16.84	22.46	28.07	42.11	56.15	112.30	280.74
12.5	4.15	6.23	8.31	16.62	24.93	33.24	41.55	62.32	83.10	166.20	415.50
10.0	5.19	7.79	10.39	20.77	31.16	41.55	51.94	77.91	103.87	207.75	519.37
7.5	6.92	10.39	13.85	27.70	41.55	55.40	69.25	103.87	138.50	277.00	692.50
5.0	10.39	15.58	20.77	41.55	62.32	83.10	103.87	155.81	207.75	415.50	1038.74
4.0	12.98	19.48	25.97	51.94	77.91	103.87	129.84	194.76	259.69	519.37	1298.43
2.0	25.97	38.95	51.94	103.87	155.81	207.75	259.69	389.53	519.37	1038.74	2596.86
1.0	51.94	77.91	103.87	207.75	311.62	415.50	519.37	779.06	1038.74	2077.49	5193.72

Table 1.11 - Determination of Product Rate per Acre from Active Ingredient Rate

(Liquid Formulations)

Active Ingredient per gallon					
Active Rate lb/A	**1.5 lb**	**2.0 lb**	**3.0 lb pt/A**	**4.0 lb**	**6.0 lb**
0.25	1.33	1.0	0.83	0.5	0.33
0.5	2.67	2.0	1.33	1.0	0.67
1.0	5.33	4.0	2.67	2.0	1.33
2.0	10.67	8.0	5.33	4.0	2.67
3.0	16.00	12.0	8.00	6.0	4.00
4.0	21.33	16.0	10.67	8.0	5.50
5.0	27.00	20.0	13.33	10.0	6.67

Table 1.12 - Determination of Product Rate per Acre from Active Ingredient Rate

(Dry Formulations)

Percentage of Active Ingredient in Product										
Active Rate lb/A	**5**	**10**	**20**	**25**	**50**	**65**	**70**	**75**	**80**	**90**
	lb/A									
0.25	5.0	2.5	1.2	1.0	0.5	0.37	0.36	0.32	0.3	0.28
0.5	10.0	5.0	2.5	2.0	1.0	0.75	0.72	0.65	0.6	0.55
1.0	20.0	10.0	5.0	4.0	2.0	1.50	1.40	1.30	1.2	1.10
2.0	40.0	20.0	10.0	8.0	4.0	3.00	2.90	2.60	2.4	2.20
3.0	60.0	30.0	15.0	12.0	6.0	4.50	4.30	3.90	3.6	3.30
4.0	80.0	40.0	20.0	16.0	8.0	6.00	5.80	5.20	4.8	4.40
5.0	100.0	50.0	25.0	20.0	10.0	7.50	7.20	6.50	6.0	5.50

Calibration of Boom Sprayers

Be sure to calibrate your sprayer properly. NEVER exceed the labeled rate. Using too much pesticide is illegal and may injure your crop. Using too little may result in little or no pest control. Pressure, nozzle orifice size, spacing of nozzles, and speed all affect the application rate. Be sure that all of your spray equipment is in good working order and your sprayer is configured properly.

Large-area Method

1. Measure and stake off one acre (43,560 sq ft) in the field to be treated.
2. Fill sprayer tank with water.
3. Maintain constant pressure and speed while spraying the acre. Mark pressure, throttle, and gear settings.
4. Measure the amount of water used. The amount of water necessary to refill the tank is equal to gallons per acre applied.
5. Make up the spray solution with the correct amount of chemical, based on the amount of water applied per acre.
6. Make the application at pressure, throttle, and gear settings used in calibrating.

"Ounce" Method

1. Mark off a test course, based on the chart below.
   (Measure nozzle spacing for booms; row spacing for directed and band rigs.)
2. Fill your tank half full (average weight). Set the throttle for spraying. Get a running start. Drive the test course three times while operating the equipment under field conditions. Record driving times (# of seconds) for each trial.
3. Calculate the average time in seconds required to drive the measured distance.
4. Run the equipment for the average time it took to drive the course, using the same settings (RPMs, pressure). Catch output during that time in a container marked in ounces. (If you are using a boom sprayer, catch the output from one nozzle. If you are using a directed/band rig, catch the spray from all nozzles per row for the prescribed time.)
5. Output in ounces = gallons per acre (GPA) applied.

Table 1.13 - "Ounce" Method Distances

Row Width or Nozzle Spacing (inches)	Distance (feet)	Row Width or Nozzle Spacing (inches)	Distance (feet)
48	85	30	136
46	89	28	146
44	93	24	170
42	97	20	204
40	102	18	227
38	107	15	272
36	113	10	408

This method works because the test course is 1/128th of an acre, and an ounce is 1/128th of a gallon — the proportions are the same.

A word of caution: Be sure to use the right nozzle (and pressure) for the job. Check ALL nozzles (or sets of nozzles, in the case of banding/directed applications) to be sure the pattern and output from each one (or each set) is the same. To check pattern, use a tray designed for this purpose or spray a hard surface and observe how the wetted area dries. Check output with a flow meter, or by catching the output from each for a short time (ex. 10 seconds). Replace any nozzles that do not match the pattern and flow rate of the one(s) you used in the calibration test.

For more information and/or for guidance on calibration methods for other types of equipment, contact your local Extension agent.

Chemical Information Chart

This section contains a chart listing commonly used pesticides (chemical name/trade name), their manufacturers, their actions, and their acute toxicity rating (oral LD_{50}). Pesticides which have been canceled are given only as a reference to their toxicity and should not be used.

This list is for information purposes only and is not meant to endorse or exclude any manufacturers or their products. The names are correct to the best of our knowledge. If mistakes were made, they were unintentional. Please notify the authors if corrections or additions are needed for the next edition.

Names

The common chemical name is the approved name given a pesticide by the American National Standards Committee. An active ingredient may have many trade names, given to a pesticide by the manufacturers/producers.

Action

The specific actions of the pesticides listed are abbreviated as follows:

A	- acaricide	IGR	- insect growth regulator
Anti	- antibiotic	M	- molluscicide
Av	- avicide	Mi	- miticide
B	- bactericide	N	- nematicide
F	- fungicide	PGR	- plant growth regulator
Fum	- fumigant	R	- rodenticide
H	- herbicide	Rep	- repellent
H A	- harvest aid (defoliant)	T	- termiticide
I	- insecticide	V	- vertebrate control

Toxicity

Toxicity is the quality, state, or degree of being poisonous. The toxicities listed here are oral. Oral LD_{50} (mg/kg) is the dosage in milligrams per kilogram of body weight required to kill 50 percent of test animals when given as a single dose by mouth. A milligram/kilogram (mg/kg) is equal to 1 part per million (1 lb in 500 tons). The lower the LD_{50}, the higher the toxicity. Dermal LD_{50} ratings are in most cases higher (lower in toxicity) than oral ratings.

When registering pesticides, the Environmental Protection Agency (EPA) uses acute LD_{50} values to determine the toxicity category, words, and symbols that must be placed on the label. For this purpose the test animals are usually mice, rats, or rabbits. The letters LD stand for lethal dose.

Table 1.14 - Toxicity Categories

Toxicity Category	Signal Words* Required on Label by EPA	Oral LD_{50} (mg/kg)	Probable Lethal Adult Human Dose
I Highly Toxic	DANGER and POISON, plus skull and crossbones symbol	0 to 50	A few drops to 1 teaspoon
II Moderately Toxic	WARNING	50 to 500	1 teaspoon to 2 teaspoons
III Slightly Toxic	CAUTION	500 to 5,000	1 ounce to 1 pint (1 pound)
IV Almost non-toxic	CAUTION	more than 5,000	1 pint (1 pound)

***Please note:** certain products may use signal words which do not correlate with LD_{50} ratings due to some special property of the chemical. For example, chlorothalonil has a very low toxicity (LD_{50} 10,000 mg/kg) yet has DANGER and WARNING signal words on many of its formulations, due to a possibility of an extreme allergic reaction in some people. Also, toxicity (LD_{50}) is relative to the concentration of active ingredient in question and the body weight of the victim.

All LD_{50} ratings listed here are for technical grade compounds; however, pesticide products are not sold as 100 percent concentrations. To find the LD_{50} for a specific pesticide product – which takes into account the toxicity of the active ingredients, its concentration, and all other components in the formulation – consult the MSDS. Remember that, if misused, any pesticide can be highly toxic to humans, domestic animals, and wildlife.

Restricted-Use Pesticides (1)

Those active ingredients having some or all products designated as **restricted use** are marked with a **superscript one** (1) in Table 1.15. Products that are restricted usually have a higher toxicity, concentration, or other property which makes them more hazardous than products which are designated for general use. Refer to the product label as a guide. Applicators must be certified to use or purchase restricted-use pesticides. Contact your local Extension agent for information on how to become a certified applicator.

Table 1.15 - Chemical Information Chart

Common Name or Designation (1=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
abamectin[1]	Agri-Mek, Avid, various	I/Mi	Syngenta, various	300
acephate	Orthene, various	I	Amvac, BASF, various	866-945
acetamiprid	Assail, Tristar	I	United Phosphorus, Cleary	314-417
acetic acid	vinegar	H	various	331
acetochlor	Breakfree, Confidence, Degree, Harness, Surpass	H	Dow AgroSciences, DuPont, Monsanto	2,953
acifluorfen	Blazer, Storm	H	United Phosphorus	2,025
Agrobacterium radiobacter	Galltrol-A	B	AgBioChem	low toxicity
alachlor[1]	Bullet, Intrro, Lariat, Micro-Tech	H	Monsanto	~1,000
aldicarb[1]	Meymik, Temik	I	Ag Logic, Bayer	1
allethrin	various	I	various	680-1,000
allyl isothiocyanate	Dominus	Rep	Engage Agro USA	151
aluminum phosphide[1]	Phosfume, Phostoxin, Weevil-Cide	Fum	Degesch, Douglas, United Phosphorus	0.3
ametryn	Evik	H	Syngenta	1,110
ametoctradin	Orvego, Zampro	F	Bayer	> 2,000
amicarbazone	Xonerate	H	Arysta	> 2,000
aminocyclopyrachlor	Method	H	Bayer	> 5,000
4-aminopyridine[1]	Avitrol	Av	Avitrol Corp	20-29
aminopyralid	Milestone	H	Dow AgroSciences	> 5,000
amitraz[1]	Apivar	H	Arysta	800
ancymidol	A-Rest, Abide	PGR	Fine Americas, Sepro	4,500
asulam	Asulox	H	United Phosphorus	5,000
atrazine[1]	Aatrex	H	Syngenta, various	3,080
avitrol[1]	Avitrol	AV	Avitrol Corp.	20
azadirachtin	Amazin, Aza-Direct, Azatin, Azatrol, Ecozin, Ornazin	IGR, I, F, Rep	Amvac, Certis, Gowan, Olympic, PBI Gordon, Sepro	> 5,000
azoxystrobin	Abound, Dynasty, Headway, Heritage, Quadris	F	Syngenta, various	> 5,000
Bacillus cereus	Pix Plus	PGR	Arysta	> 5,000
Bacillus firmus	Nortica, Vovito	N	Bayer	> 5,000
Bacillus licheniformis	Roots Ecoguard	F	Novozymes	> 5,000
Bacillus pumilus	Ballad Plus, Sonata, Yield-Shield	F	Bayer	> 5,000

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
Bacillus sphaericus	Fourstar, Vectolex, Vectomax, Spheratax	I	Advanced Microbiologics, Fourstar, Valent	> 5,000
Bacillus subtilis	Companion, Serenade, Rhapsody	F	AgraQuest, Growth Products	> 5,000
Bacillus thuringiensis	DiPel, various	I	various	> 5,000
Beauveria bassiana	balEnce, Botaniguard, Mycotrol, Naturalis	I	Jabb, LAM, Troy Biosciences	> 5,000
benefin (benfluralin)	Balan, Team	H	Dow AgroSciences, various	> 10,000
bensulide	Prefar	H	Gowan, various	770
bentazon	Basagran, Rezult	H	Arysta, BASF, various	1,100
bifenazate	Acramite, Floramite, Sirocco	Mi	Chemtura, OHP	> 5,000
bifenthrin[1]	Talstar, various	I	FMC, various	54.5
bispyribac-sodium	Tradewind, Velocity	H	Valent	4,111
BLAD	Fracture	F	FMC	> 5,000
borax	various	I	various	4,500-6,000
Bordeaux Mixture	Copper/Sulfur	F	various	low toxicity
boric acid	various	I	various	low toxicity
boscalid	Emerald	F	BASF	> 2,000
brodifacoum	Final, Talon, various	R	Bell Labs, Syngenta, various	0.27
bromacil	Hyvar, various	H	Bayer, various	5,200
bromadiolone	Contrac, various	R	Bell Labs, various	0.56-0.84
bromethalin	Assault, Fastrac, various	R	Bell Labs, various	2.0
bromoxynil	Buctril, various	H	Bayer	190
buprofezin	Applaud, Talus, various	IGR	Nichino, Sepro	180-400
butralin	Butralin	H, PGR	Chemtura	890-1,540
capsaicin	Hot Sauce, various	Rep	various	> 2,500
captan	Captan, various	F	various	9,000
carbaryl	Sevin, various	I/Mi	various	850
carbendazim	Fungisol, Imisol	F	J.J. Mauget	> 15,000
carbofuorfen	Acifluorfen 2, Avalanche, Levity	H	various	> 5,000
carboxin	Vitavax	F	various	3,820
carfentrazone-ethyl	Aim, various	H	FMC, various	> 5,000
chlorantraniliprole	various	I	DuPont, Syngenta, various	> 5,000
chlorethoxyfos[1]	SmartChoice	I/Mi	Amvac	1.8-4.8
chlorfenapyr	Phantom, Pylon	I/Mi	BASF	441
chlorimuron ethyl	Cemax, Classic	H	Agsurf, DuPont	4,102
chlormequat chloride	Citadel, Cycocel, Chlormequat	PGR	various	> 5,000
chlorophacinone[1]	Rozol	R	Liphatech	3.15
chloropicrin[1]	Tri-Pic	Fum	Triest	250
chlorothalonil	Bravo, Chloronil, various	F	Syngenta, various	> 10,000
chlorpropham	Shield, various	H, PGR	Aceto Ag, Decco	3,800

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
chlorpyrifos[1]	Dursban, Lorsban	I	Dow AgroSciences, various	135-163
chlorsulfuron	Telar	H	Bayer	5,545
chlorthal	Dacthal	H	Amvac	3,000
cholecalciferol	Agrid 3, Terad 3	R	Bell	352
clethodim	Envoy, Select, Volunteer	H	Valent, various	1,630
clofentezine	Apollo, Ovation	Mi	Makhteshim-Agan, Everris	> 5,200
clomazone	Command	H	FMC	2,077
clopyralid	Lontrel	H	Dow AgroSciences	> 4,300
cloransulam-methyl	FirstRate	H	Dow AgroSciences	> 5,000
clothianidin	Arena, Belay, Poncho	I	BASF, Valent	> 5,000
copper chelate	Cutrine, various	H(aq)	Applied Biochemists	0.50-2.00
copper hydroxide	Kocide, various	F/B	DuPont, Sepro, various	1,000
copper sulfate	Bluestone, various	H(aq), F/B	various	470
coumaphos[1]	Checkmite +, Co-Ral	I/A	Bayer, Mann Lake	56-230
m-cresol	Gallex	B	Agbiochem	242
creosote[1]	coal tar	F/I	various	885
cyantraniliprole	Exirel, Ference, Fortenza, Mainspring, Verimark, Zyrox	I	DuPont, Syngenta	> 5,000
cyazofamid	Ranman, Segway	F	various	> 5,000
cyclanilide	Finish, Stance, Terminate	PGR	Bayer, NuFarm	> 5,000
cycloate	Ro-Neet	H	HelmAgro	2,000-3,190
cyflufenamid	Torino	F	Gowan	> 5,000
cyflumetofen	Nealta, Sultan	Mi	BASF	> 2,000
cyfluthrin[1]	Tempo, Tombstone, various	I	Bayer, Loveland, various	400
(gamma-) cyhalothrin[1]	Declare, Proaxis	I	Cheminova	50
(lambda-) cyhalothrin[1]	Demand, Karate, Warrior, various	I	Syngenta, various	79
cymoxanil	Curzate, Tanos	F	DuPont	1,100
cypermethrin[1]	Ammo, Demon, Fastac	I	various	250-4,150
cyproconazole	Alto	F	Syngenta	1,020
cyprodinil	Vangard	F	Syngenta	> 2,000
cyromazine	Citation, Trigard	IGR	Syngenta	3,387
2,4-D	various	H/PGR	various	300-700
2,4-DB	various	H	various	370-1,500
DCPA	see chlorthal	—	—	—
daminozide	B-Nine, Dazide	PGR	various	8,400
dazomet	Basamid, various	Fum	various	520
decanol	Royaltac, various	PGR	various	18,000
deet	OFF, various	Rep	SC Johnson, various	8,500

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
deltamethrin	Deltadust, Deltagard, various	I/Mi	Bayer, various	> 5,000
diazinon[1]	Diazion	I	various	1,250
dicamba	Banvel, Engenia, Vanquish, various	H	BASF, Syngenta, various	1,707-6,764
dichlobenil	Casoron	H	various	> 3,160
1,3-dichloropropene[1]	Telone	Fum	Dow AgroSciences	250-500
dichlorvos	Vapona, various	I	various	56-80
diclofop-methyl[1]	Hoelon, Illoxan	H	Bayer	563
diclosulam	Strongarm	H	DowAgroSciences	> 5,000
dicrotophos[1]	Bidrin, Inject A Cide	I	Amvac, Mauget	22
difenacoum	various	R	various	<1
difenoconazole	Dividend, Inspire	F	Syngenta	1,453
difethialone	Generation, Hombre, various	R	Liphatech	1-7
diflubenzuron[1]	Advance, Dimilin	IGR, T	BASF, Chemtura	> 4,640
diflufenzopyr-sodium	no stand-alone products	H	BASF	> 5,000
dikegulac sodium	Augeo, Atrimmec, Pinscher	PGR	various	18,000-31,000
dimethoate	Dimethoate	I	various	290-325
dimethomorph	Forum, Stature	F	BASF	3,900
dinotefuran	Venom	I	Valent	2,804
diphacinone	various	R	various	3
diquat dibromide	Diquat, Enforcer, Reward, Weedtrine-D	H	various	231
disulfoton[1]	Di-Syston	I	Bayer	12.7
dithiopyr	Dimension, various	H	Dow AgroSciences, various	3,600
diuron	Karmex	H	various	3,400
dried blood	various	Rep	various	low toxicity
egg solids	various	Rep	various	34,600
emamectin[1]	Enfold, Proclaim	I	Syngenta	76-89
endosulfan	Thionex	I	Makhteshim Agan	40
endothall	Aquathol, Hydrothal	H/H(aq)	United Phosphorus	51
EPTC	Eptam	H	Gowan	1,630
esfenvalerate[1]	Asana, various	I	Valent, various	75-458
ethaboxam	Intego	F	Valent	> 5,000
ethalfluralin	Curbit, Sonalan, Strategy	H	Dow AgroSciences, Loveland	> 10,000
ethephon	Cerone, Ethrel, Florel	PGR	Bayer, various	4,000
ethofenprox	Zenivex	I	Wellmark	> 40,000
ethofumesate	Ethotron, Poa Constrictor, Prograss	H	Bayer, United Phosphorus	6,400
ethoprop (ethoprophos)[1]	Mocap	I/N	Amvac	62

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
etoxazole	Beethoven, Tetrasan, Zeal	Mi, IGR, Mi	BASF, Valent	> 5,000
etridiazole	Banrot, Terrazole, Truban	F	various	1,077
famoxadone	Tanos	F	DuPont	> 5,000
fatty acid salts/soaps	various	I/Mi, H, PGR, Rep	various	50 - > 5,000
fenamidone	Fenstop, Reason	F	Bayer, OHP	> 5,000
fenazaquin	Magister, Magus	Mi	Gowan	134
fenbuconazole	Indar	F	Dow AgroSciences	> 2,000
fenbutatin-oxide (hexakis)[1]	Meraz, Vendex	Mi	United Phosphorus	2,630
fenhexamid	Captevate, Decree, Elevate	F	Arysta, Sepro	> 2,000
fenoxaprop-p-ethyl	Acclaim, Double Check, Tacoma	H	Bayer, Loveland, Winfield	4,670
fenpropathrin[1]	Danitol, Tame	A/I	Valent	70
fenpyrazamine	Protexio	F	Valent	> 2,000
fenpyroximate	Akari, Portal	I/Mi	Nichino, Sepro	480
fentin hydroxide[1]	Agri-Tin, Super Tin	F/I/Mi	NuFarm, United Phosphorus	160
ferbam	Ferbam	F	Taminco	> 17,000
ferric sodium EDTA	Slug and Snail Killer	M	various	low toxicity
fipronil[1]	Frontline, Regent, Termidor	I/Mi/T	Bayer, BASF	336
flazasulfuron	Katana	H	PBI Gordon	> 5,000
flonicamid	Aria, Beleaf	I	FMC	> 2,000
florasulam	Defendor	H	Dow AgroSciences	> 5,000
fluazifop-P-butyl	Fusilade	H	Syngenta, various	3,680
fluazinam	Omega, Secure	F	Syngenta	> 5,000
flubendiamide	Belt, Synapse, Tourismo, Vetica	I	Bayer, Nichino	> 2,000
flucarbazone-sodium	Finesse, Everest, Sierra	H	Arysta, DuPont, Syngenta	> 5,000
fludioxonil	Maxim, Medallion	F	Syngenta	> 5,000
fluensulfone	Nimitz	N	Makhteshim Agan	> 2,000
flufenacet	Axiom, Define	H	Bayer	589-1,617
flumetralin	Prime +, various	PGR	Syngenta, various	> 5,000
flumetsulam	Python	H	Dow AgroSciences	> 5,000
flumiclorac-pentyl	Action, Resource	H	Amvac, Valent	> 5,000
flumioxazin	Broadstar, Clipper, Gangster, Payload, SureGuard, Valor	H/H(aq)	Valent	> 5,000
fluometuron	Cotoran, Shotaran	H	various	6,416-8,900
fluopicolide	Adorn, Presidio, Stellar	F	Valent	> 5,000
fluopyram	Ilevo	F/N	Bayer	> 2,000
fluoxastrobin	Aftershock, Disarm, Evito	F	Arysta, Loveland	> 5,000

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
flupyradifurone	Sivanto	I	Bayer	> 2,000
fluridone	Avast, Sonar	H (aq)	Alligare, Sepro	> 10,000
fluroxypyr	Position, Starane, Vista	H	Dow AgroSciences	> 2,405
flurprimidol	Cutless, Topflor	PGR	Sepro	709-914
fluthiacet-methyl	Cadet	H	FMC	> 5,000
flutolanil	Moncoat, Prostar	F	Bayer, Nichino	> 10,000
flutriafol	Fortix	F	Arysta	1,140
fluvalinate	Apistan, Mavrik	I	Wellmark	260-280
fluxopyroxad	Systiva, Xzemplar	F	BASF	> 2,000
folpet	Fungitrol	F	International Specialty Products	> 10,000
fomesafen	Sinister	H	Helena	1,250-2,000
formic acid	Mite-Away	Mi	Nod Apiary Products	110
fosamine ammonium	Krenite	H	Bayer	10,200
fosetyl-Al	Aliette, various	F	Bayer, various	5,800
furfural	Multiguard Protect	F/N	Agriguard	65
gibberellic acid	GibGro, ProGibb	PGR	various	630
Gliocladium virens	Soil Gard	F	Certis	low toxicity
glufosinate-ammonium	Finale, Ignite, Liberty, Rely, Remove, various	H	Bayer, various	1,620-2,000
glyphosate	Accord, Rodeo, Roundup, various	H	Dow AgroSciences, Monsanto, various	4,050-5,600
halosulfuron-methyl	Sandea, Sedgehammer, various	H	Monsanto, Nufarm, various	1,287
harpin protein	Axiom, various	B, I, F, N, PGR	various	low toxicity
hexaflumuron	Shatter	T, IGR	Dow AgroSciences	> 5,000
hexazinone	Velossa, Velpar	H	DuPont, Helena	1,690
hexythiazox	Hexygon, Onager, Savey	Mi	Gowan	> 5,000
hydramethylnon	Amdro	I	various	1,131-1,300
hydroprene	Gentrol, various	IGR	various	> 34,600
IBA	Hormodin, various	PGR	various	100 (mice)
imazalil	Fungaflor	F	Whitmire	227-343
imazamox	Beyond, Clearcast, Raptor	H/ H(aq)	BASF, Sepro	> 5,000
imazapic	Cadre, Plateau	H	BASF, NuFarm	> 5,000
imazapyr	Arsenal, Chopper, Habitat, various	H	BASF, Sepro, SSI Maxim	> 5,000
imazaquin	Image	H	BASF	> 5,000
imazethapyr	Pursuit	H	BASF	> 5,000
imazosulfuron	Celero, League	H	Valent	> 5,000
imidacloprid	Admire, Advantage, Merit, various	I/A	Bayer, various	450
imiprothrin	see metaflumizone	---	---	---

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
indaziflam	Alion, Esplanade, Marengo, Specticle	H	Bayer, OHP	> 2,000
indoxacarb	Advion, Avaunt, Steward	I	DuPont	268-1,732
iodosulfuron	Autumn	H	Bayer	2,678
ipconazole	Acceleron, Rancona, Vortex	F	Bayer, Chemtura, Monsanto	> 5,000
iprodione	Eclipse, Rovral, various	F	FMC, Sipcam Agro, various	3,500
isoxaben	Gallery	H	Dow AgroSciences	> 10,000
isoxaflutole	Balance	H	Bayer	> 5,000
kasugamycin	Kasumin	F	Arysta	> 5,000
kinoprene	Enstar	IGR	Wellmark	4,900-5,000
kresoxim-methyl	Sovran	F	BASF	> 5,000
lactofen	Cobra, Phoenix	H	Valent	> 5,000
linuron	Linex, Lorox	H	Tessenderlo Kerley	1,500-4,000
magnesium phosphide[1]	Fumi-Cel, Fumi-Strip, Magtoxin	Fum	Degesch	0.3
malathion	Malathion, various	I	various	1,375-2,800
maleic hydrazide	MH-30, various	H/PGR	various	6,950
mancozeb	Dithane, Fore, Manzate, various	F	various	> 5,000
MCPA	MCPA, various	H	various	700-800
mecoprop	MecoMec, various	H	PBI/Gordon, various	930
mefenoxam	see metalaxyl-M	—	—	—
mefluidide	Embark	H/PGR	PBI/Gordon, various	> 4,000
mepiquat chloride	various	PGR	various	464
mepiquat pentaborate	Pentia	HA/ PGR	BASF	500
mesotrione	Callisto, Tenacity	H	DuPont, Syngenta	> 5,000
metaflumizone	Altrevin, Siesta	I	BASF	1,800
metalaxyl-M (mefenoxam)	Apron, Subdue	F	various	1,040
metaldehyde	Deadline, various	M	various	630
metam-sodium[1]	Vapam, various	Fum	Amvac, various	1,800
metconazole	Caramba, Metlock, Quash, Tourney	F	BASF, Valent	660
methamidophos[1]	Monitor	I	Bayer	17
methiocarb[1]	Mesurol	I/M/Rep	Gowan	15-35
methomyl[1]	Lannate, Nudrin, various	I/N	DuPont, various	17-24
methoprene	Altosid, various	IGR	Wellmark Intl., various	34,600
methoxyfenozide	Intrepid, Troubadour	I	Dow AgroSciences, Helena	> 5,000
methyl anthranilate	various	Rep	various	> 5,000
methyl bromide[1]	Bromo-O-Gas, Metabrom, Meth-O-Gas	Fum	Great Lakes, various	200 (vapor)
metiram	Polyram	F	Loveland	> 10,000

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
metolachlor	Cinch, Dual, Pennant , various	H	DuPont, Syngenta, various	2,780
metrafenone	Vivando	F	BASF	> 5,000
metribuzin	Metribuzin, Sencor, Tricor	H	Bayer, various	1,100-2,300
metsulfuron-methyl	Ally, Cimarron, Escort, various	H	Bayer, DuPont, various	> 5,000
mineral oil	Dormant Oil, various	I/Mi	various	low toxicity
MSMA	MSMA, Target	H	Drexel, Luxembourg	1,700
myclobutanil	Eagle, Laredo, various	F	Dow AgroSciences, various	1,600-2,290
NAA	Dip'nGrow, Pomaxa, RootMaster	PGR	Valent, various	1,000
NAD	Amid-Thin, Rootone	PGR	Amvac, Bayer	1,000
naled	Dibrom, Trumpet	I	Amvac	430
naphthalene	"moth balls"	Fum/I /Rep	various	50-500
napropamide	Devrinol	H	United Phosphorus	5,000
neem	see azadirachtin	—	—	—
nicarbazin	Ovocontrol	Av	Innolytics, LLC	10,000
nicosulfuron	Accent	H	DuPont	> 5,000
norflurazon	Solicam	H	Tessenderlo Kerley	> 9,400
Nosema locustae	Nolo Bait	I, M & R	M&R Durango	low toxicity
novaluron	Diamond, Pedestal, Rimon	I	Chemtura, Makhteshim Agan	> 5,000
noviflumuron	Recruit	T, IGR	Dow AgroSciences	> 5,000
oryzalin	Surflan, various	H	United Phosphorus, various	> 10,000
oxadiazon	Ronstar, various	H	Bayer, various	> 8,000
oxamyl[1]	Vydate	I/N	DuPont	5.4
oxydemeton-methyl[1]	MSR	I, Mi	Gowan	65-75
oxyfluorfen	Goal, various	H	Dow AgroSciences, various	> 5,000
oxytetracycline	Mycoject, Mycoshield, Treetech	F	various	low toxicity
paclobutrazol	Bonzi, Cambistat, Piccolo, Profile, Trimmit	PGR	various	5,346
paradichlorobenzene	"moth balls"	I/Rep	various	500-5,000
paraquat[1]	Gramoxone, various	H	Syngenta, various	150
pendimethalin	Pendulum, Prowl, various	H	BASF, Scott's, various	1,250
penoxsulam	Galleon, Sapphire	H/H(aq)	Dow AgroSciences, Sepro	> 5,000
pentachloronitrobenzene	Blocker, Terraclor, Turfcide	F	Amvac	1,650-12,000
penthiopyrad	Fontelis, Velista, Vertisan	F	DuPont	> 5,000
permethrin[1]	Ambush, Pounce, various	I	Amvac, FMC, various	4,000
phenmedipham	Spin Aid	H	Bayer	> 4,000
phenothrin	Bedlam, various	I	MGK, various	> 5,000
phorate[1]	Thimet	I	Amvac	2-4
phosmet	Imidan	I	Gowan	147-316

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
phosphine gas[1] (hydrogen phosphide)	Eco_2Fume, $VAPORPH_3OS$	I/Mi, Fum	Cytec Ind.	0.3
phostebupirim[1]	Aztec[1] (w/cyfluthrin)	I	Bayer	2.9-3.6
picaridin	Cutter, Off, various	Rep	S.C. Johnson, various	4,743
picloram[1]	Tordon K, various	H	Dow AgroSciences, various	8,200
picoxystrobin	Approach	F	DuPont	> 5,000
pinoxaden	Axial	H	Syngenta	> 5,000
piperalin	Pipron	F	Sepro	2,500
piperonyl butoxide	(used as a synergist)	I	various	> 7,500
polybutene	Hot Foot, various	Rep	various	low toxicity
polyoxin D	Affirm, Endorse, Ph-D, Veranda	F	Arysta	> 5,000
potassium bicarbonate	Armicarb, Kaligreen, Milstop	F	various	500-5,000
primisulfuron-methyl	Beacon	H	Syngenta	5,050
prodiamine	Barricade, various	H	Syngenta, various	> 5,000
prohexadione calcium	Anuew, Apogee, Kudos	PGR	BASF, Cleary, Fine	> 5,000
prometon	Pramitol, various	H	various	2,980
prometryn	Caparol, CottonPro	H	Syngenta, Makhteshim Agan	5,235
pronamide[1] (propyzamide)[1]	Kerb	H	Dow AgroSciences	5,620-8,350
propamocarb hydrochloride	Banol, Previcur, Proplant	F	Bayer, Lesco, Sipcam	8,600
propargite	Omite	Mi	Chemtura	2,200
propiconazole	Alamo, Banner, Tilt, various	F	Syngenta, various	1,517
propoxur	Invader, various	I/Mi	FMC, various	95-104
propyzamide[1]	see pronamide	—	—	—
prosulfuron	Peak	H	Syngenta	4,360
prothioconazole	Proline	F	Bayer	> 6,200
pymetrozine	Endeavor, Fulfill	I/Mi	Syngenta	5,820
pyraclostrobin	Cabrio, Headline, Insignia	F	BASF	> 5,000
pyraflufen-ethyl	Edict, Venue	H, HA	Nichino	> 5,000
pyrethrum	Pyrethrins	I	various	584-900
pyridaben	Nexter, Sanmite	I/Mi	Gowan	820-1,350
pyridalyl	Overture	I	Valent	> 5,000
pyrimethanil	Scala	F	Bayer	4,149
pyriproxyfen	Distance	IGR	Valent	4,733
pyrithiobac-sodium	Pyrimax, Pysonex, Staple	H	Agsurf, DuPont, Makhteshim Agan	4,000
pyroxasulfone	Zidua	H	BASF	> 2,000
pyroxsulam	GR1, PowerFlex	H	Dow AgroSciences, DuPont	> 2,000
quinclorac	Facet, various	H	BASF, various	> 2,610
quinoxyfen	Quintec	F	Dow AgroSciences	> 5,000

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
quizalofop-p-ethyl	Assure II, Targa	H	DuPont, Gowan	1,182-1,210
resmethrin[1]	Scourge	I	Bayer, various	> 2,500
rimsulfuron	Matrix, various	H	DuPont, various	> 5,000
rotenone[1]	CFT Legumine, Prenfish, Prentox	V	Central Garden & Pet Co.	132-1,500
saflufenacil	Detail, Integrity, Sharpen, Treevix	H	BASF	> 2,000
sethoxydim	Poast, Rezult, various	H	BASF, various	2,676-3,200
siduron	Tupersan, various	H	various	> 7,500
silica/silicon dioxide	various	I	various	3,160
simazine	Princep, various	H	Syngenta, various	> 5,000
sodium bentazon	Basagran, Rezult B, various	H	Arysta, BASF, various	1,100-2,063
sodium chlorate	Defol, various	H	Drexel, various	1,200
sodium chloride	TABLE SALT	---	Morton, various	3,320
sodium cyanide[1]	M-44	V	USDA-APHIS-WS	6.4
sodium fluoroacetate[1]	1080	V	USDA-APHIS-WS	0.22
spinetoram	Delegate, Radiant	I	Dow AgroSciences	> 5,000
spinosad	SpinTor, Tracer, various	I/Mi	Dow AgroSciences, various	> 5,000
spiromesafen	Forbid, Judo, Oberon	I/Mi	Bayer, OHP	> 2,500
spirotetramat	Kontos, Movento	I	Bayer, OHP	> 2,000
starlicide[1]	Compound DRC-1339, Starlicide Complete	Av	USDA-APHIS-WS, VIrbac AH	1,770
streptomycin sulfate	Agri-Mycin, various	F	various	> 10,000
sulfentrazone	Authority, Spartan, various	H	FMC, various	2,855
sulfometuron-methyl	Oust, various	H	Bayer, various	> 5,000
sulfosulfuron	Certainty, Outrider	H	Monsanto	> 5,000
sulfoxaflor	Closer, Transform	I	Dow AgroSciences	1,000
sulfur	Thiolux, various	F, I/Mi	various	low toxicity
sulfuryl fluoride[1]	Profume, Vikane, Zythor	Fum	Dow AgroSciences, Ensystex II	100
tebuconazole	various	F	various	4,000
tebufenozide	Confirm, Mimic	I	Gowan, Valent	> 5,000
tebupirionfos[1]	see phostebupirim[1]	—	—	—
tebuthiuron	Spike, various	H	Dow AgroSciences, various	579
tefluthrin[1]	Force, Precept	I/Mi	Monsanto, Syngenta	20-35
tembotrione	Laudis	H	Bayer	> 2,000
temephos	Abate	I	Clarke	8,600-13,000
terbacil	Sinbar	H	Tessenderlo Kerley	> 5,000
terbufos[1]	Counter	I	Amvac	1.6
tetrachlorvinphos	Rabon	I/Mi	Bayer, various	4,000-5,000
tetraconazole	Domark, Mazinga	F	Isagro, Sipcam Agro	1,248
tetramethrin	various	I	various	4,640

Table 1.15 - Chemical Information Chart (cont.)

Common Name or Designation ([1]=restricted use)	Trade Names Other Names	Action	Company	Acute LD_{50} Values for White Rats-Oral (mg/kg) Technical
thiabendazole	Mertect	F	Syngenta	3,810
thiacloprid	Calypso	I	Bayer	621
thiamethoxam	Actara, various	I/Mi	Syngenta, various	1,563
thiencarbazone-methyl	no stand-alone products	H	Bayer	> 2,000
thidiazuron	Ginstar, various	HA	Bayer, various	> 5,000
thifensulfuron-methyl	Harmony, various	H	DuPont, various	> 5,000
thiophanate methyl	3336, Spectro, Topsin	F	Cleary, various	7,500
thiram	Spotrete, various	F/Rep	Cleary, various	780
tolclofos-methyl	Rizolex	F	Valent	5,000
tolfenpyrad	Apta, Hachi-Hachi, Torac	I	Nichino, Sepro	260-386
topramezone	Armezon, Frequency, Impact, Pylex	H	Amvac, BASF	> 2,000
triadimefon	Bayleton, various	F	Bayer, various	317-568
triadimenol	Baytan	F	Bayer	700-1,200
tribenuron-methyl	Express	H	DuPont	> 5,000
tribuphos (tribufos)	DFT 6, Folex 6, Vestage	HA	Amvac, Loveland, Red Eagle	250
trichlorfon	Dylox	I	Bayer	560-630
Trichoderma harzianum	Rootshield, Turfshield	F	Bioworks	low toxicity
triclopyr	Garlon, various	H	Dow AgroSciences, various	713
trifloxystrobin	Compass, Flint, Gem	F	Bayer, OHP	> 4,000
trifloxysulfuron-sodium	Envoke, Monument	H	Syngenta	> 5,000
triflumizole	Procure, Terraguard, Viticure	F	Chemtura	2,230
trifluralin	Preen, Treflan, various	H	Dow AgroSciences, various	> 10,000
trinexapac-ethyl	Primo, various	PGR	Syngenta, various	> 5,000
triticonazole	Trinity	F	BASF	> 5,000
uniconazole	Concise, Sumagic	PGR	Fine, Valent	2,020
vinclozolin	Curalan, Touche	F	BASF	> 10,000
warfarin	Rodex	R	Bell, Hacco, various	186
zinc phosphide[1]	various	R	Bell, Hacco, various	45.7
ziram	Ziram	F	United Phosphorus, Taminco	1,400
zoxamide	Gavel, Zing, Zoxium	F	Gowan	> 5,000

Protecting Honey Bees

James Wilson, Extension Apiculturist, Virginia Tech Department of Entomology

Honey bees are a valuable service to apiculture and agriculture not only because they produce honey and beeswax, but they are the most important pollinators of cultivated crops. Pesticide poisoning of honey bees, and other beneficial insects, can be a serious problem. Every effort should be made to minimize the exposure of honey bees to pesticides in treated areas.

A Note on Protecting Pollinators in Virginia

Federal guidelines mandate that each state develop a plan for the mitigation of pesticide exposure to managed pollinators in their own state. This mandate came through the United States Environmental Protection Agency and was directed to the pesticide regulatory office of each state. The Virginia Department of Agriculture and Consumer Services (VDACS) has fulfilled that role here. Through 7 regional listening sessions, input from approximately 450 stakeholders, 169 written comments from producers, beekeepers, professional pesticide applicators, and other stakeholders, VDACS developed a representative advisory committee of stakeholders and drafted a plan. The plan is known as the "Voluntary Plan to Mitigate the Risk of Pesticides to Managed Pollinators" and was finalized in May of 2017.

This voluntary plan encourages an increase in communication between pesticide applicators and the managers of pollinators in an effort to reduce the potential for damaging pesticide exposure. Since this plan is voluntary there are additional guiding documents for the majority of involved stakeholders. This plan has been adopted by the Commonwealth of Virginia and can be found in its entirety at the 1st link provided below. A specific list of best management practices appropriate for this pest management guide is provided below. Virginia has employed a communications tool to encourage access and communication between beekeepers and insecticide applicators. This tool is known as Bee Check. For more information on this tool and how you may use it to help prevent the exposure of bees to pesticides please visit *http://www.vdacs.virginia.gov/pdf/BeeCheck-Fact-Sheet.pdf*, or *http://www.vdacs.virginia.gov/plant-industry-services-beekeeping-apiary-inspection.shtml*. Questions and comments should be directed to VDACS with the contact information given below.

Virginia is currently developing a strategy for managing all pollinators. This strategy is focused on identifying the strengths and weaknesses of the conservation and pollinator management efforts in Virginia. Once identified, this plan will outline how we can best manage Virginia's resources for pollinators. Future developments with that plan will be made available by VDACS, and updated here accordingly.

Virginia's Voluntary Plan to Mitigate the Risk of Pesticides to Managed Pollinators

http://www.vdacs.virginia.gov/pdf/BMP-plan.pdf

Best Management Practices:

Agricultural Commercial Applicators: *http://www.vdacs.virginia.gov/pdf/BMP-Ag-Commercial-Applicator.pdf*

Agricultural Producers: *http://www.vdacs.virginia.gov/pdf/BMP-Ag-Producer.pdf*

VDACS Pesticide Resources:

The Virginia Pesticide Database: *http://www.kellysolutions.com/VA/pesticideindex.htm*

The Office of Pesticide Services: *http://www.vdacs.virginia.gov/pesticides.shtml*

VDACS Contact Point:

Liza Fleeson Trossbach, Program Manager
Office of Pesticide Services
liza.fleeson@vdacs.virginia.gov
804.371.6559

Keith Tignor, State Apiarist
Office of Plant Industry Services
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804.786.3515

Causes of Honey Bee Poisoning

1. The majority of honey bee poisoning occurs when pesticides are applied to crops in bloom. This includes crop plants such as sweet corn, which is routinely sprayed when in tassel. Honey bees do not pollinate corn; however, they will collect pollen from corn tassels and transport it back to the honey bee hive.
2. The application of pesticides to fields with weeds in bloom. The spring application of pesticides to alfalfa fields with flowering weeds is a particular problem in Virginia.
3. The drift of toxic sprays or dusts to adjoining crops or weeds in bloom.
4. The contamination of flowering ground-cover crops in orchards treated with pesticides.
5. The contamination of water or dew on foliage and flowers. This includes the water collected by honey bees for drinking and cooling the honey bee hive.
6. The application of systemic pesticides and the potential contamination of nectar and pollen collected by foraging honey bees. The use of neonicotinoid pesticides (e.g., clothianidin, imidacloprid, and thiamethoxam) is a concern for honey bee poisoning; although, there is a need for more research evidence.

The most serious poisonings result with honey bees that collect pesticide-contaminated pollen or nectar and transport these materials to the honey bee hive. Pesticide dusts (e.g., Sevin) and encapsulated pesticides are especially dangerous. These pesticides can adhere to foraging honey bees, be transported to the hive, and stored for long periods of time. Such pesticides may cause honey bee mortality in the hive for several months.

Ways to Reduce Honey Bee Poisoning

1. Contact beekeepers with honey bee hives near areas to be treated with pesticides that are hazardous to honey bees.
2. Do not apply pesticides that are toxic to honey bees on crops in bloom.
3. Use pesticides that are less toxic to honey bees when such choices are consistent with pest control recommendations (e.g., see table of relative pesticide toxicities).
4. Choose the least hazardous pesticide formulations when possible. Pesticide dusts and encapsulations are more toxic than sprays of the same material. Pesticides applied as wettable powder sprays tend to have longer residual effects (and are more toxic) than the emulsifiable concentrate sprays. Granular applications of pesticides are typically the safest method of treatment in areas with honey bee hives.
5. Avoid drift of toxic pesticide sprays onto ground-cover plants, weeds, and crops in nearby fields.
6. Control weeds in fields and avoid direct pesticide applications to flowering weeds when possible. Mow before pesticide application, if orchards have ground-cover plants in bloom.
7. Apply pesticides in the late evening or early morning when honey bees are not actively foraging. This is important with crops such as corn, since pollen is released in the morning. The evening application of pesticides to such crops are less hazardous and will reduce the unintentional poisoning of honey bees..
8. Do not apply pesticides if temperatures are expected to be unusually low following pesticide treatment. Pesticide residues can remain toxic to honey bees for longer periods of time under low temperature conditions.
9. Avoid the direct application of pesticides over honey bee hives.
10. Allow beekeepers an option to move or confine honey bee hives that are near areas to be treated with pesticides, if there is a potential for honey bee loss.

Relative Toxicity of Pesticides to Honey Bees by Laboratory and Field Tests

Group I. Highly Toxic

Severe losses may be expected if these pesticides are used when honey bees are present at treatment time or within a day *thereafter*.

Abamectin

Acramite (bifenazate)

Actara, Centric, Platinum, Helix, Cruiser, Adage (thiamethoxam)

Acephate

Admire, Advantage, Gaucho, Merit, Premise, Touchstone (imidacloprid)

Advantage

Ambush (permethrin)

Ammo (Fury) (>.025 lb/A) (cypermethrin)

Apollo, Ovation (clofentezine)

Asana (esfenvalerate)

Avaunt (Advion) (indoxacarb)

Avid (avermectin)

Baygon (propoxur)

Baythroid (cyfluthrin)

Bidrin (dicrotophos)

Capture, Annex, Brigade (bifenthrin)

Carzol

Clutch (clothianidin)

Commodore (lambda-cyhalothrin)

Comply (fenoxycarb)

Curacron (profenofos)

Cygon (dimethoate)

Cymbush

Danitol (fenopropathin)

Dasanit (fensulfothion)

DDVP (dichlorvos)

Decis (decamethrin)

Delegate, Radiant (spinetoram)

Denim (emamectin benzoate)

Dibrom (naled)

Diazinon (spectracide)

Dimecron (phosphamidon)

Dinotefuran

Dursban, Eradex (chlorpyrifos)

Endigo

Envidor (spirodiclofen)

Ethyl guthion (azinphos-ethyl)

Flagship (thiamethoxam)

Fipronil

Furadan F (carbofuran)

Gardstar (permethrin)[1]

Guthion (azinphos-methyl)

Imidan (phosmet)

Karate

Lannate D (methomyl)

Lindane

Lorsban (chlorphyrifos)

Malathion

Matacil (aminocarb)

Mesurol (methiocarb

Monitor (methamidophos)

Nexter (pyridaben)

Nudrin (methomyl)

Orthene (acephate)

Parathion

Pay Off (flucythrinate)

Phosphamidon

Pirimiphos-methyl (Execute, Actellic)

Poncho, Titan, Clutch, Acceleron, Arena, Belay, Celero (clothianidin)

Pounce (permethrin)

Prallethrin

Proaxis (gamma-cyhalothrin)

Proclaim (emamectin)

Provado (imidacloprid)

Pydrin (fenvalerate 0.1 lb/A)[2]

Pylon, Phantom (chlorfenapyr)

Pyramite

Rebelate (dimethoate)

Resmethrin

Scout (tralomethrin)

Sevin (carbaryl)[3]

Sniper

Spectracide

Steward (indoxacarb)

Sumithion (fenitrothion)

Supracide (methidathion)

Swat (bonyl)

Synthrin (resmethrin)

Talstar

Tameron (methamidophos)

Tefluthrin (Force)

Temik (aldicarb)

TEPP

Tralomethrin (Saga)

Trimax

Vapona (dichlorvos)

Venom (dinotefuran)

Warrior (lambda-cyhalothrin)

Zectran (mexacarbate)

Zephyr (Agri-Mek) (abamectin)

Zeta-cypermethrin

[1]Can be applied to ground in front of honey bee hives for the control of small hive beetles.
[2]Can be applied in the late evening at rate of 0.1 lb/A or less.
[3]Some formulations of Sevin XLR are rated as moderately toxic to honey bees.

Group II. Moderately Toxic

These can be used around honey bees if dosage, timing, and method of application are correct, but should not be applied directly on honey bees in the field or at the honey bee hive.

Abate (temophos)
Acramite, Floramite (bifenazate)
Assail (acetamiprid)
Banol (carbanolate)
Bolstar (sulprofos)
Calypso (thiacloprid)
Carzol (formetanate)
Chlordane
Ciodrin (crotoxyphos)
Coumaphos[1] (Agridip, Asunthol)
Counter (terbufos)
Decis, Battalion (deltamethrin)
Di-Syston (disulfoton)
Dyfonate (fonofos)
Elgetol (dinitrocresol)
endrin
Esteem (pyriproxyfen)
Ethodan (Ethion)
Larvin (thiocarb)
Metasystox (demeton-s-methyl)
Metasystox R (oxydemeton-methyl)
Mocap (ethoprop)
Oil sprays (superior type)
Rimon, Pedestal (novaluron)
SpinTor, Conserve SC, Entrust, Success (spinosad)
Spirotetramet (Movento)
Systox (demeton)
Trigard (cyromazine)
Thimet (phorate)[2]
Thionex (endosulfan)
Trithion, Thiodan (carbophenothion)
Vydate (oxamyl)

[1]Checkmite (coumaphos) strips can be used in honey bee hives to treat for varroa mites and small hive beetles.
[2]Thimet EC should only be applied during late evening.

Group III. Relatively Nontoxic

These can be used around honey bees with a minimum of injury; safest if applied in the evening or early morning.

Acaraben (chlorobenzilate)
Acarol (bromopropylate)
Agri-Mek (avermectin)
Allethrin
Altosid (methoprene)
Amitraz
Apollo, Ovation (clofentezine)
Applaud, Centaur (buprofezin)
Aza-direct (azadirachtin)
Baam (amitraz)
Bacillus thuringiensis (Accoate, Biotrol, Dipel, Thuricide)
Birlane (chlorfenvinphos)
Calypso (thiacloprid)
Chlorantraniliprole
Chloroparacide (chlorbenside)
Confirm, Mimic (tebufenozide)
Cyd-X (CM granulovirus)
Cyrolite
Delnav (dioxathion)
Demize (D-Limonene)
Dessin (dinobuton)
Dimilin (diflubenzuron)
Dinocap (Karathane)
Dylox (trichlorfon)
Endeavor (Pymetrozine)
Ethrel (ethephon)
Esteem (pyriproxyfen)
Flonicamid
Fujimite, Akari (fenpyroximate)
Fulfill (pymetrozine)
Fundal, Galecron (chlordimeform)
Heliothis polyhedrosis virus
Herculex
Hexygon
Intrepid (methoxyfenozide)
Isomate
Kanemite (acequinocyl)
Kelthane (dicofol)
Mach 2
(halofenozide)
Mavrik (tau-fluvalinate)[1]
Methoxychlor (Marlate)
Mitac (amitraz)
Morocide (binapacryl)
Murvesco (fenson)
Neemix, Align (azidirachtin)
Neotran
Nicotine
Omite (propargite)
Ovotran (ovex)
Pentac (dienochlor)
Plictran [mitacid] (cyhexatin)
Pynamin
Pyrellin (rotenone/ pyrithrin)
Pyrethrum (natural)
Rotenone
Ryania
Sabadilla
Saphos (menazon)
Savey, Onager (hexythiazox)
Shuttle
Smite (sodium azide)
Spiromesifen (Oberon, Forbid)
Spur (fluvalinale)
Sucrocide (sucrose octano-ate esters)
Surround (kaolin)
Talus (buprofezin)
Tedion (tetradifon)
Tetram
Tetrasan
Torak (dialifor)
Trigard (cyromazine)
Vendex (fenbutatin oxide)
Yieldgard
Zeal, Secure (etoxazole)

[1]*tau*-Fluvalinate is used in Apistan strips to treat honey bee hives for varroa mites. It is illegal to use Mavrik in honey bee hives.

Fungicides

As a general rule, fungicides are safe to use around honey bees.

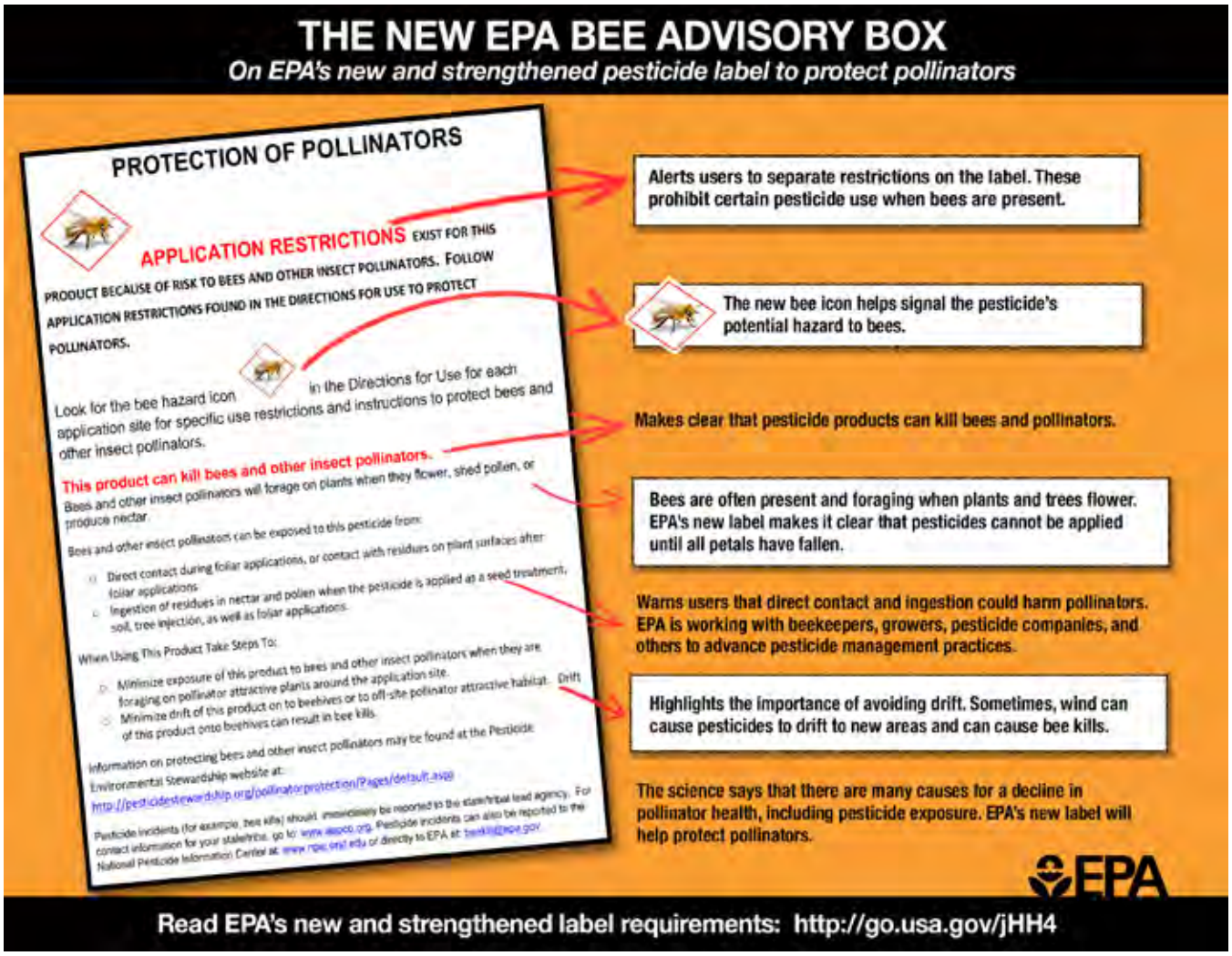
Afugan (pyrazophos)
Arasan (thiram)
Bayleton (triadimefon)
Benlate (benomyl)
Bordeaux mixture
Boscalid (emerald, endura, pristine)
Bravo (chlorothalonil)
Captan
Carbendazim (Fungisol, Polyphase)
Copper oxides
Copper oxychloride sulfate
Copper sulfate
Cupric hydroxide (Kocide)
Cyprix (dodine)
Cyprodinil
Daconil (chlorothalonil)
Dessin (dinobuton)
Difenoconazole
Difolatan (captafol)
Dithane D-14 (nabam)
Dithane M (maneb, manzeb)
Dithane Z (zineb)
Du-Ter (fentin hydroxide)
Dyrene (anilazine)
Ferbam
Fluoxastrobin
Glyodin
Hinosan (edifenphos)
Indar (butrizol)
Iprodoine[2]
Karathane
Lesan (fenaminosulf)
Maneb
Mancozeb
Morestan (oxythioquinox)
Morocide (binapaeryl)
Myclobutanil
Mylone (dazomet)
Phygon (dichlone)
Plantvax (oxycarboxin)
Polyram (metriam)
Propiconazole[1] (Alamo, Banner)
Pyraclostrobin[2]
Pyrimethanil[1] (Philabuster, Penbotec)
Ridomil
Rovral (iprodione)[2]
Sulfur
Syllit (dodine)
Terraguard[1], Procure (triflumizole)
Tetraconazole (Domark, Eminent)
Thiram
Thylate
Vinclozolin[2]
Vitavax (carboxin)
Zineb

[1] May increase the toxicity of neonicotinoid pesticides to honey bees if used together.
[2] May cause loss of honey bee larvae. Use with caution where honey bees are foraging.

Herbicides, Defoliants and Desiccants

2,4-D
2,4-DB
2,4-DP (dichlorprop)
Alachlor
Alanap (naptalam)
Alopex (clofop-isobutyl)
Amiben (chloramben)
Amitrol
Ammate
Atrex (atrazine)
Avenge (difenzoquat)
Balan (benefin)
Banvel (dicamba)
Basagran (bentazon)
Betanal AM (bentanex)
Bladex (cyanazine)
Blazer (acifluorfen)
cacodylic acid
Cambilene (2,3,6-TBA)
Caparol (prometryn)
Chloro-IPC (chlorpropham)
Cotoran (fluometuron)
Daconate (MSMA)
Dalapon
Diquat
DSMA
Dual (metolachlor)
Endothall (endothall)
Eptam
Evik (ametryn)
Evital (norflurazon)
Exhalt 800
Folex (desmedipham)
Garlon (triclopyr)
Glyphosate
Gramoxone (paraquat)
Herbisan (EXD)
Hoelon (diclofop-methyl)
Hyvar (bromacil)
IPC (propham)
Karmex (diuron)
Kerb (proamide)
Lasso (alachlor)
Lorox (linuron)
MCPA
Methar, DSMA
Milogard (propazine)
Modown (bitenox)
MSMA
Mylone (dazomet)
Nortron (ethofumesate)
Oxyfluorfen[1]
Paarlan (isopropalin)
Paraquat
Pendimethalin[1] (Prowl)
Phenmedipham (Betanal)
Pramitol (prometone)
Princep (simazine)
Probe (methazole)
Propanil[1]
Prowl (pendimethalin)
Pyramin (chloridazon)
Ramrod (propachlor)
Randox
Ronstar (oxadiazon)
Sancap (dipropetryn)
Sencor (metribuzin)
Sinbar (terbacil)
Surflan (oryzalin)
Sutan (butylate)
Telvar (monuran)
Tolban (profluralin)
Tordon (picloram)
Treflan (trifluralin)[1]
Vegadex
Zorial (norflurazon)

[1] Slightly toxic to honey bees


THE NEW EPA BEE ADVISORY BOX
On EPA's new and strengthened pesticide label to protect pollinators
PROTECTION OF POLLINATORS
APPLICATION RESTRICTIONS EXIST FOR THIS PRODUCT BECAUSE OF RISK TO BEES AND OTHER INSECT POLLINATORS. FOLLOW APPLICATION RESTRICTIONS FOUND IN THE DIRECTIONS FOR USE TO PROTECT POLLINATORS.
Look for the bee hazard icon in the Directions for Use for each application site for specific use restrictions and instructions to protect bees and other insect pollinators.
This product can kill bees and other insect pollinators.
Bees and other insect pollinators will forage on plants when they flower, shed pollen, or produce nectar.
Bees and other insect pollinators can be exposed to this pesticide from:
Direct contact during foliar applications, or contact with residues on plant surfaces after foliar applications
Ingestion of residues in nectar and pollen when the pesticide is applied as a seed treatment, soil, tree injection, as well as foliar applications.
When Using This Product Take Steps To:
Minimize exposure of this product to bees and other insect pollinators when they are foraging on pollinator attractive plants around the application site.
Minimize drift of this product on to beehives or to off-site pollinator attractive habitat. Drift of this product onto beehives can result in bee kills.
Information on protecting bees and other insect pollinators may be found at the Pesticide Environmental Stewardship website at:
http://pesticidestewardship.org/pollinatorprotection/Pages/default.aspx
Pesticide incidents (for example, bee kills) should, immediately be reported to the state/tribal lead agency. For contact information for your state/tribe, go to: www.aapco.org. Pesticide incidents can also be reported to the National Pesticide Information Center at: www.npic.orst.edu or directly to EPA at: beekill@epa.gov
Alerts users to separate restrictions on the label. These prohibit certain pesticide use when bees are present.
The new bee icon helps signal the pesticide's potential hazard to bees.
Makes clear that pesticide products can kill bees and pollinators.
Bees are often present and foraging when plants and trees flower. EPA's new label makes it clear that pesticides cannot be applied until all petals have fallen.
Warns users that direct contact and ingestion could harm pollinators. EPA is working with beekeepers, growers, pesticide companies, and others to advance pesticide management practices.
Highlights the importance of avoiding drift. Sometimes, wind can cause pesticides to drift to new areas and can cause bee kills.
The science says that there are many causes for a decline in pollinator health, including pesticide exposure. EPA's new label will help protect pollinators.
EPA
Read EPA's new and strengthened label requirements: http://go.usa.gov/jHH4

Livestock Area Fly Control

Eric R. Day, Extension Entomologist, Virginia Tech

Fly Control in Milk Rooms

Warning: Extremely small amounts of pesticide residues can be detected in milk. For all practical purposes, the tolerance level for pesticide residues in milk is ZERO. Moreover, the presence of such residues in milk is virtually always illegal. To avoid pesticide residues in milk, dairy producers are cautioned to use ONLY those pesticides that are labeled for use in dairy operations. The following steps are suggested for managing flies in milk rooms:

(a) Use good sanitation and only labeled insecticides in dairy barns to reduce the number of flies entering the milk room.

(b) Use tight screens (14-16 mesh per inch) in good repair on milk room doors and windows. Screens made of copper, aluminum, bronze, plastic, or rust-resisting materials are best.

(c) Use sticky flypaper, sex pheromone sticky paper (Fly Stik with Muscalure), or sticky foil flypaper with flies printed on it to attract other flies.

(d) Dichlorvos (Vapona) resin strips work best in controlling flies if windows and doors are kept closed. Replace strips when they become ineffective.

(e) **Use only labeled** space spray treatments in milk rooms when the above strips do not give adequate fly control. Avoid contaminating milking utensils, cans, bulk tanks, and containers. Remove these items from the milk room or completely cover them before spraying.

General Fly Control Methods for Livestock

Sanitation

Good sanitation practices are the basis for all fly control programs and can account for as much as 75% toward the prevention of fly breeding. **Sanitation should be the first line of defense against house flies and other filth-breeding fly species.** Under optimum conditions, house flies can complete their life cycle (egg to adult) in as few as 9 days. By adhering to a strict manure management program throughout the period of greatest fly activity (i.e., the spring and summer months) it is possible to disrupt the life cycles of these pests.

(a) Remove all manure from livestock pens as frequently as possible. Pens with calves or bulls require special attention and should be cleaned once or twice a week. Remember, a clean livestock barn has fewer fly problems.

(b) Manure that has been removed should be spread thinly on fields or other large outside areas to facilitate rapid drying. This will help kill developing fly eggs and larvae. Another option is to stack the manure and cover **completely** with black plastic.

(c) Eliminate silage seepage areas, wet litter, manure stacks, old wet hay or straw bales, and other organic matter accumulations that may attract flies on the farm. Wet feed remaining at the ends of mangers also will breed flies.

(d) Provide proper drainage in barnyards. Use clean gravel and other fill to eliminate low spots in livestock yards. Proper tiling can reduce wet barnyards.

(e) Drag pastures with wire mesh to break up large piles of droppings.

To be successful in controlling flies it is important that producers implement a control program that best fits their particular operation. Reliance on a single practice or pesticide product is not the best approach to achieving effective and economical pest control. A better approach is to combine routine sanitation with a variety of pesticide strategies such as baits, residual sprays, space sprays, and larvicides whenever flies are a problem. Do not wait for heavy fly populations to build up. It is much easier and less expensive to prevent fly populations from increasing at the beginning of the season than to attempt to control them after they have reached unacceptable density levels. As fly populations begin to increase, take time and treat as needed.

Residual Sprays

The next line of defense is residual sprays applied to the outside and inside of buildings. Other practices such as the application of larvicides, space sprays, and baits should be considered supplementary to sanitation and residual sprays. Residual sprays are applied to walls, ceilings, partitions, stanchions, posts, and other fly resting places. These sprays are much more effective in stanchion barns than in loose-housing, open barns where landing and resting surfaces are minimal. Also, barn surfaces vary in the amount of spray that should be applied to them. Smooth surfaces require less spray than rough, porous surfaces. Thoroughly wet the surface to the point of runoff at low pressures of 80-100 pounds per square inch. Avoid contaminating feed, drinking water, milk, milking utensils, and milk rooms. The importance of ***following directions exactly according to the label*** cannot be stressed enough when using any pesticide.

Long-Term Residual Treatments

(a) Fenvalerate [10%]. This product is labeled for use only in swine or horse buildings as a premise spray. Mix 1 quart product in 10 gal water and apply at the rate of 1 gal of spray per 750 sq ft. Remove animals before spraying. Keep animals out of treated buildings for at least 4 hours. ***Do not*** allow feed or drinking water to become contaminated.

(b) Permethrin [25%]. ***This product is not labeled for use in milk rooms.*** Mix 6.67 oz product in 10 gal water and apply at the rate of 1 gal of spray per 1,000 sq ft. ***Do not*** make direct applications to animals, feed, or drinking water.

(c) Permethrin [10%]. Mix 1 qt product in 25 gal water and apply at the rate of 1 gal of spray per 750 sq ft. Can be used in barns, dairies, feedlots, stables, and poultry houses.

(e) Tetrachlorvinphos [50%]. Follow directions according to label. Remove calves and lactating animals before spraying. Keep them out of treated buildings for at least 4 hours. ***Do not*** allow feed or drinking water to become contaminated. Can be used in dairy barns, poultry houses, swine buildings, and other animal buildings.

(f) Lambda-cyhalothrin

(g) Malathion, various formulations. See label for directions.

(h) Beta-cyfluthrin, various formulations. See label for directions.

(i) Gardona, various formulations. See label for directions.

(j) Pyrethrins

(k) Spinosad

(l) Bifenthrin

Medium-Term Residual Treatments

(a) Deltamethrin [0.02%]. Controls stable flies, horn and face flies, house flies, deer flies, mosquitoes, and gnats in livestock and horse facilities. Apply thoroughly to surfaces until wet. Apply as needed, but not more than once per week. Do not spray animals or humans. Do not contaminate feed or drinking water. ***Do not use in milk room or milking parlor.***

Short-Term Residual Treatments

(a) Dichlorvos [43.2%]. Make up a 0.5% solution by mixing 1 gal product in 100 gal water and apply diluted spray as an overall premise application. Particular attention should be given to areas where flies congregate. Animals may be present during treatment. ***Do not*** allow feed, water or foodstuffs, milk or milking utensils to become contaminated. Apply to cattle feedlots, stockyards, holding pens, and corrals.

(b) Naled [58%]. Follow directions according to label.

(c) Pyrethrins [0.1%] and piperonyl butoxide [1.0%]. Follow directions according to label. Apply as a space spray for quick knockdown and kill of house flies, stable flies, and horn flies in barns, milk rooms, and dairies.

(d) Pyrethrins [0.5%] and piperonyl butoxide [4.0%]. Controls stable flies and other flies, mosquitoes, fleas, and wasps in

livestock, dairy, hog, and poultry facilities. Close all windows and doors and apply at a rate of 2 to 3 seconds/1,000 cubic feet of area. Do not remain in treated area. Thoroughly vent treated area after 15 minutes.

Bait Treatments

Although fresh baits will help control flies, results may be poor if fly breeding is excessive. It is suggested that baits be applied following the removal of all floor litter and manure. For best control, use baits liberally and repeat as needed. It may be necessary to increase amounts when flies are breeding heavily, but check label for proper use directions for any bait product. Baits are most effective when used in conjunction with other control measures. Do not use bait in areas where animals can slip and fall or where children may come in contact with the bait.

(a) Methomyl [1%]. No mixing required. Bait can be used only around the outside of feed lots, broiler houses, livestock barns, and on walkways in caged layer houses. Scatter bait (do not put in piles) at rate of approximately 0.25 lb per 500 sq ft of fly feeding area, keeping 1- to 2-inch intervals between particles. ***Do not*** allow food-producing animals to have access to treated areas. ***Do not*** allow contamination of feed or drinking water.

(b) Methomyl [1%] and (Z)-9-Tricosene [0.025%]. See label for use directions.

Space Treatments

Space sprays or aerosols can be effective for rapid knockdown and kill of adult flies. It is important to reduce air movement as much as possible. Follow directions according to label.

(a) Pyrethrins [0.1%] and piperonyl butoxide [1.0%]. Before spraying, close doors and windows. Apply as a fog or fine mist, directing spray toward ceiling and upper corners until area is filled with mist. Use about 0.5 oz solution per 1,000 cu ft. Allow mist to settle on animals. Leave room closed for 5 minutes after treatment, remembering to ventilate area before reoccupying. Repeat as needed. Wash teats of dairy animals before milking. Avoid breathing fumes by wearing mask or respirator of a type recommended by the U.S. Bureau of Mines.

(b) Dichlorvos [23.4%]. Apply by fogging or misting at rate of 1 quart of 0.5% solution per 8,000 cu ft. Reduce air movement as much as possible before applying. ***Do not*** use in areas where animals have received a direct application within 8 hours. ***Do not*** allow feed, water, milk, or milking utensils to become contaminated.

(c) Dichlorvos resin strips. Suspend from ceiling as directed on label. Use 1 strip per 1,000 cu ft. These strips work best in closed rooms. ***Do not*** place over water or feed. Keep strips away from animals and children.

(d) Spinosad [2.46%]. Dilutable spray for control of stable and house flies on animal premises, including in and around poultry, beef, dairy, horse, swine, and sheep premises. ***Do not*** apply product in milking parlor or milk room. Mix 20 oz product per 5 gal water and apply at a rate of 1 gal solution per 500-1,000 sq ft. ***Do not*** use in overhead sprinkler system. Refer to label for more directions.

Larvicides

Oral Treatments

The use of oral larvicides such as cyromazine, tetrachlorvinphos, and diflubenzuron [9.7%] , is not legal in all states. These feed additives and boluses often are not the answer to fly control unless used very extensively. All manure must be treated within an area in order to effectively reduce the fly population. In many cases the area must be very large because flies rapidly move from one herd to the next over large geographic regions.

Oral larvicides work by preventing the development of flies in manure. They are not effective against existing adult flies, and should be used in conjunction with a regular manure sanitation practice. Supplemental fly control often is needed where flies breed in manure from untreated animals or other organic sources.

(a) Cyromazine [1%]: See Poultry section.

(b) Diflubenzuron [9.7%]. This product is a controlled-release bolus for beef and dairy cattle that aids in the suppression of house and stable flies. Administer 1/2 bolus to cattle weighing 300-550 lb, and 1 bolus to cattle weighing 550-1,100 lb or more. ***Do not*** administer to cattle weighing less than 300 lbs. NEVER administer more than 1 bolus to any animal.

(c) Tetrachlorvinphos [97.3%]. Follow directions according to label. For beef cattle and lactating dairy cattle, feed at the rate of 70 mg product/100 lb of body weight. Start feeding in early spring before flies begin to appear, and continue through the summer and fall until cold weather restricts fly activity.

Manure Treatments

(a) Tetrachlorvinphos [23%] and dichlorvos [5.3%]. Mix 1 gal product in 25 gal water and apply at the rate of 1 gal of spray per 100 sq ft of droppings. Repeat at 7- to 10-day intervals until droppings begin to cone up, then treat only "hot spots" (small areas found to have large numbers of maggots). Can be used in poultry and livestock facilities. ***Do not*** spray animals directly. ***Do not*** contaminate feed or drinking water.

(b) Tetrachlorvinphos [50%]. Apply at the rate of 1 gal of 1% solution per 100 sq ft of poultry droppings, manure piles, etc. Repeat every 7-10 days until control is achieved. ***Do not*** spray animals directly. ***Do not*** contaminate feed or drinking water.

Mineral Mixtures and Feed Additives

(a) S-Methoprene [10.5% and other formulations]. The Al in Altosid Cattle Custom Blending Premix is an insect growth regulator (IGR) that interrupts the development of the horn fly (and possibly other species of filth-breeding flies) in the manure of treated cattle. Begin use in the spring before horn flies appear on cattle and continue feeding until cold weather restricts horn fly activity. Product is safe for beef and dairy cattle, including breeding cattle, lactating cattle, and calves. Product can be fed up to slaughter and to lactating dairy cows without withholding milk. Refer to label for details on proper feed to weight blending ratios.

Perimeter Area Treatments

(a) Citric Acid and crystalized propanetricarboxylic acid [100%]. Apply 1/8 cup per sq ft of treatment area. Treatment area should have a moderately salted appearance after application. Apply every 7 days during fly season. See label for specific area applications.

Poultry Area Fly Control

Eric R. Day, Extension Entomologist, Virginia Tech

There are several species of flies commonly found around caged layer poultry houses. The most common species are the house fly and the lesser house fly. Other annoying flies are blow flies (which breed on bird carcasses, broken eggs, and other garbage), soldier flies, fruit flies, gnats, and rat tailed maggots.

The house fly is by far the most important problem in caged layer operations. Not only are they a nuisance but they also are carriers of diseases. With the spread of non-farm residences into rural areas near poultry operations, egg producers are faced with increasing pressures from non-farm residents and health officials to control house flies. Also, the shift to large poultry operations has resulted in heavy concentrations of manure, a major source of fly breeding. According to workers in Georgia, as many as 1000 flies can develop in one pound of suitable breeding media. They are difficult to control, especially when the population becomes extremely high. A dedicated effort involving integrated pest management (IPM) will be needed to maintain house flies at a low level.

Fly Biology

All flies pass through four life stages: egg, larva (maggot), pupa, and adult. During its life cycle, which is about 30 days, a house fly female can lay up to 1000 eggs. These eggs are deposited on moist manure or any type of moist rotten or decaying organic matter. The eggs hatch in 10-12 hours and the maggots move into the wet manure. Fly maggots mature in 4-5 days under warm moist conditions. Pupation occurs in the drier parts of manure with the adult flies emerging in 3-5 days. Under ideal conditions a house fly can complete its life cycle in 9-14 days. The life cycle can be much longer in cooler temperatures. Although capable of movement up to several miles, house flies normally move no more than one half to three quarters of a mile from their breeding sites.

An IPM Program to Control House Flies

Step 1. Population Monitoring

It is essential to know as early as possible which houses are the major sources of fly breeding. The simplest and quickest method of taking quantitative fly counts is the moving tape method. A roll of ordinary sticky fly tape is carefully extended full length and held by the top loop so that the cardboard carton is almost touching the floor. The operator then walks at a normal pace up and down a standardized number of rows (at least 2 full rows) holding the tape by his or her side and slightly in front. At the end of the circuit, the number of flies that have stuck on the tapes is counted and recorded on a chart. These counts should be made in each house twice a week. Population increases and decreases can then be seen and compared from each house. The problem houses can thus be determined early enough to begin supplemental control measures before the fly population gets out of control. The producer also has quantitative evidence of the progress of his or her IPM program to present to interested neighbors or health officials.

The producer has to judge, based on the population dynamics in each house, when to apply supplementary control measures (**treatment threshold**). This decision is based on application costs and the nuisance situation to the surrounding residents.

Step 2. Sanitation and Manure Management

Inside: Manure is usually removed once a year in high-rise egg houses. It is allowed to cone up under the cages and kept as dry as possible. If at all possible, this manure should be removed during the cooler months of the year. Do not disturb the manure during the summer months. When it is spread on fields it is important to scatter the manure thinly so that the eggs and larvae are killed by drying. It is best to plow or disk it under immediately after spreading. In shallow pit houses, frequent removal of manure once or twice a week reduces fly breeding. It is important to make sure that spilled manure is not left in wet piles around the disposal equipment and in areas that the disposal equipment does not reach. If manure has to be stored, be sure to cover it completely with a heavy grade of black plastic. Cover the edges of the plastic with soil to prevent house flies from entering. House fly eggs need relative humidity levels of 90% or higher to develop successfully.

Flies normally breed in wet manure (above 40% moisture). **Leaking waterers are a major source of wet manure.** Thousands of house flies can breed in just one leaking water spot. Daily inspection and repair of all leaking waterers is essential. Provide abundant cross ventilation by the use of fans above the cages and in the manure pits, especially in hot weather.

Outside: All garbage, leaking feed, spilled manure, bird carcasses, eggs, and miscellaneous trash should be removed regularly. Vegetation, weeds, and grass should be kept trimmed around the houses. Junk, trash, and rusting equipment which provide resting sites for flies should be removed. Install proper eave troughs and down spouts on houses to carry rain water away from buildings. Provide proper drainage in poultry yards and roadways.

Step 3. Biological Control

Natural fly predators (insects and mites that actively feed on fly eggs and larvae) and parasites (small, stingless wasps that lay their eggs in and kill the pupae of house flies) can build up in manure accumulations. They can significantly reduce house fly breeding. Biological control is more effective if the sanitation and manure management as listed in Step 2 is conscientiously applied. In high-rise houses, never clean out a house completely of manure. Leave at least a fourth of the manure undisturbed so that the natural enemies can survive and move into the new manure. Biological control is not as effective in shallow-pit houses; however, if manure is kept dry, the natural enemies are more effective.

Several commercial companies sell parasites for release in poultry houses. These parasites are supposed to be self-propagating in the process of controlling flies; however, quality control of these commercially available parasites is quite variable. Often, only a small percentage of the parasites are actually alive by the time the producer receives them. Producers intending to use these parasites are advised to set aside a small sample of them to check for emergence before releasing them in the houses.

A specific biological control program for house flies in high-rise poultry houses has been developed for Virginia. A predaceous fly larva, Hydrotaea aenescens, is mass-reared and released, resulting in a low house fly population with a reduced need for chemical control.

Step 4. Chemical Control

Insecticides should be used to supplement steps 2 (sanitation) and 3 (biological control). Insecticides can be used to attract and kill those flies that survived the larval stages. They should be applied so that they will not contact and kill house fly predators and parasites. Other insecticides can be used as an emergency control measure when fly populations threaten to overwhelm IPM control measures.

Fly Baits: These are designed to kill flies that have escaped the natural enemies in the manure and should be a regular part of the house fly IPM program. They are inexpensive and simple to use. They should be put out at the beginning of the fly season and renewed at least once a week through warm weather. Baits should be placed in containers (i.e., egg cartons) or glued onto cardboard panels so they will not fall into the manure pits.

Contact Sprays: If the moving tape counts indicate that the fly population in a house is threatening to overwhelm the natural controls, contact sprays can be used. As the name implies, these sprays kill flies on contact and are effective as a quick knock down treatment. Contact spray insecticides have a short residual life and will not prevent a later reinfestation. Do not spray in the manure pits or directly on the birds, eggs, feed, or water.

Residual Sprays: These insecticides have a longer residual life and can be used both inside and outside where flies congregate. In darkness, flies tend to "roost" on the upper walls and ceilings of layer houses, so residual insecticides should be concentrated in these areas. Because insecticide resistance is possible, residual sprays should be applied only to problem houses and areas where the moving tape counts indicate that the population growth is becoming serious.

Step 5. Feed-Through Larvicides

When the moving tape counts indicate that the fly population is about to explode, or when equipment failure has caused a temporary build up of wet spots in the manure, application of larvicides in the feed is a practical option. It should be applied until the tape counts indicate that the flies have been significantly reduced.

These syrphid fly larvae live in highly polluted water such as livestock lagoons, polluted abandoned fish pools, foul pools, and streams associated with barnyards. The maggots are able to live in the water if sufficient solids are present as food. The adult flies resemble honey bees and are often seen "hovering" near the ground in the barnyard vicinity. Because the rattailed maggot breeds and feeds in highly polluted water, an effort must be made to keep the lagoon in optimum condition. Usually, the lagoon becomes "out-of-balance" when the water level is not in proper relationship with the solids. Never allow accumulations of manure above the water line, either floating or sticking to the sides, because these conditions promote fly development. Keep the banks steep and the weeds under control.

Use loose soil and construct a soil barrier between the milk house and the rattailed maggot source. As maggots migrate to the soil barrier, they will dig into it to pupate rather than move into the milk house.

Try to agitate the pit contents frequently during the spring and summer by pumping the pits routinely (at least once a week) to disrupt maggot development. Always maintain a waterline above the manure solids. Clean out the pit contents on a routine basis, if possible.

Usually the occurrence of rattailed maggots is a management problem directly related to improper care of the lagoon or a poorly constructed lagoon. The Environmental Protection Agency (EPA) is very concerned with run-off and over-flow leading to pollution. It is very important to coordinate with agricultural designers and Health Department officials before constructing new liquid manure tanks and lagoons. Plans are available from these agencies for constructing tanks to prevent manure seepage and polluted waters, thereby avoiding a rattailed maggot problem.

Table 2.1 - Some Commercial Insecticides Registered for Control of House Flies in Poultry Houses

Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information
Fly Baits	
Methomyl [1%]	Ready-to-use bait.
Contact Sprays	
Pyrethrins [0.1% - 0.6%] + Piperonyl Butoxide [1% 6%]	Ready-to-use oil spray; apply as mist or fog. Spray at a rate of 1-2 seconds per 1,000 cubic feet. Close windows and doors for 15 min. or double dosage if area can't be closed.
Dichlorvos [43.2%]	Mix with water as instructed on label, apply as mist or fog.
Tetrachlorvinphos [50%] walls and ceilings	Mix with water as instructed on label, apply to inside or outside
Permethrin [5.7% to 25%]	Check label for specific application instructions.
Tetrachlorvinphos [23%] and Dichlorvos [5.3%]	Check label for specific application instructions.
Dibrom 37% EC	Check label for specific application instructions.
Stirophos	Check label for specific application instructions.
Imidacloprid	Check label for specific application instructions.
Sevin	Check label for specific application instructions.
Feed-Through Larvicides	
Cyromazine [1%] ton of feed. Follow directions according to label.	**feed to egg-laying hens only.** Mix 1 lb product per

Rattailed Maggots (Syrphid Fly Larvae)

Frequently during the warm summer months, rattailed maggots are reported as a nuisance pest migrating from livestock lagoons and manure pits. These insects are not a problem as long as they remain in the liquid manure pit. However, they have been known to move out of the pit or lagoon in large numbers contaminating livestock feed, accumulating in electrical boxes causing short circuits, and congregating in stacks of egg cartons and other unwanted places. The maggots migrate in search of drier places in which to pupate.

Rattailed maggots, known as the larval or immature stage of syrphid flies, are about 1 1/4 inches long. The body portion is about 3/4 inch long and the tail portion (breathing tube) is about 1/2 inch long. These maggots are white in color and semi-transparent with the body portion being an elongated, oval, cylindrical shape. What appears to be a long tail is actually a breathing tube. The adult rattailed maggots resemble bumble bees but are actually flies that cannot sting.

These syrphid fly larvae live in highly polluted water such as livestock lagoons, polluted abandoned fish pools, foul pools, and streams associated with barnyards. The maggots are able to live in the water if sufficient solids are present as food. The adult flies resemble honey bees and are often seen "hovering" near the ground in the barnyard vicinity. Because the rattailed maggot breeds and feeds in highly polluted water, an effort must be made to keep the lagoon in optimum condition. Usually, the lagoon becomes "out-of-balance" when the water level is not in proper relationship with the solids. Never allow

accumulations of manure above the water line, either floating or sticking to the sides, because these conditions promote fly development. Keep the banks steep and the weeds under control.

Use loose soil and construct a soil barrier between the milk house and the rattailed maggot source. As maggots migrate to the soil barrier, they will dig into it to pupate rather than move into the milk house.

Try to agitate the pit contents frequently during the spring and summer by pumping the pits routinely (at least once a week) to disrupt maggot development. Always maintain a waterline above the manure solids. Clean out the pit contents on a routine basis, if possible.

Usually the occurrence of rattailed maggots is a management problem directly related to improper care of the lagoon or a poorly constructed lagoon. The Environmental Protection Agency (EPA) is very concerned with run-off and over-flow leading to pollution. It is very important to coordinate with agricultural designers and Health Department officials before constructing new liquid manure tanks and lagoons. Plans are available from these agencies for constructing tanks to prevent manure seepage and polluted waters, thereby avoiding a rattailed maggot problem.

Asian Longhorned Tick

The Asian Longhorned Tick, *Haemaphysalis longicornis*, is a recently recognized tick in Virginia and other states in the eastern United States. If you suspect that you have this tick please submit a sample to the Insect Identification Lab or a State Veterinarian to have it confirmed. Populations can build up into extreme numbers and impact animal health. For information see:

https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/ENTO/ento-282/ENTO-282.pdf

Table 2.2 - Special section for Longhorned Tick Control on Poultry

Control Method for Ticks	Active Ingredients *Sold under various trade names*	Insecticide Mixing and Application Information	Precautions
Dip wash	Permethrin	Wet feathers through to skin and air dry.	Check label, some versions are ready to use and some require dilution.
Emulsifiable concentrate spray	Permethrin	Spray/soak plumage, skin, and vent.	Wear protective clothing when making applications.
Ready to use dust or spray	Permethrin	Spot treat legs, tail, wings & comb. For dust, treat at the rate 1 lb. per 100 birds, make sure vent area is treated.	Wear protective clothing. If using dust, include a NIOSH approved respirator.

Beef External Parasites

Eric R. Day, Extension Entomologist, Virginia Tech

Beef External Parasite Control

Longhorned Tick Control for Cattle

The Longhorned Tick, *Haemaphysalis longicornis*, is a recently recognized tick in Virginia and other states in the eastern United States. If you suspect that you have this tick please submit a sample to the Insect Identification Lab or a State Veterinarian to have it confirmed. Populations can build up into extreme numbers and impact animal health. For information see:

https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/ENTO/ento-282/ENTO-282.pdf

Table 2.3 - Special section for Longhorned Tick Control on Cattle

Control Method for Ticks	Active Ingredients *Sold under various trade names*	Insecticide Mixing and Application Information	Precautions
Pour On	Permethrin	Head, neck, and on top line of back.	Check label some versions are ready to use and some require dilution.
EC Spray for Beef and non-lactating dairy cattle	Permethrin	Emulsifiable concentrate spray.	Beef & non-lactating dairy cattle.

Table 2.4 - Dust Bags

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
horn flies, lice (aids in control of face flies)	Coumaphos [1%] Dust Permethrin [0.25%] Dust Gardona (lis-isomir)	No mixing is necessary. Install burlap bags or commercial ready-to-use bags of dust in areas where animals must come in contact. Keep bags in place during winter months to aid in control of lice. DUST BAGS MUST HANG 4-6 INCHES BELOW TOPLINE OF CATTLE.	Do not contaminate feed or water.

Table 2.5 - Hand Dusting

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
horn flies, face flies, lice	Tetrachlorvinphos [3%]	Read label before use. Wear rubber gloves and apply approximately 2.0 oz of dust to the upper portions of the back, neck, and poll, and to the face as an aid in the control of face flies. Rub in lightly to carry the dust beneath the hair.	Do not contaminate feed or water. Wear protective clothing and gloves as recommended on the label.
	Permethrin [0.25])	Apply 2.0 oz (6.0 tbsp) of dust per animal by shaker can. Repeat as necessary.	Do not contaminate water, food or feed by storage or disposal. Keep container sealed when not in use. Wear protective clothing and gloves as recommended on the label.
	Malathion Dust [4%]	For horn flies: apply 4 tbsp on the back and neck. Repeat at 10-14 day intervals. Dust calves lightly. For lice and ticks: dust animal thoroughly. Repeat treatment after 2-3 weeks if needed.	Do not treat calves under 1 month of age. Do not contaminate water. Wear protective clothing and gloves as recommended on the label.
	Coumaphos [1%]	No mixing is necessary. Apply not more than 2.0 oz per animal. Dust evenly into the hair over the head, neck, shoulders, back, and tailhead. Repeat as necessary but not more than once every 10 days.	Do not contaminate feed or water. Wear protective clothing and gloves as recommended on the label.
	Zeta-Cypermethrin [0.075%] + Piperonyl Butoxide [0.15%]	Check label for specific application instructions.	

Table 2.6 - Backrubbers[1] and Facerubbers

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
face flies, horn flies, stable flies, house flies, black flies, mosquitoes, eye gnats, mange mites	Permethrin [11%] (Atroban 11% EC) Permethrin [10%] Permethrin [5.7%] and others	Follow directions according. to labels. Use only #2 diesel oil or any approved backrubber base oil.	Read and adhere to all precautions on labels. Do not use motor oil or waste oil on backrubbers. Keep rubbing device charged. Results improve daily with forced use.
face flies, horn flies	Coumaphos Dichlorvos [5.3%] Phosmet [11.6%] Permethrin [7.4%] + Piperonyl Butoxide [7.4%] Gardona (cis-isomer)	Follow directions according to label. Use only #2 diesel oil or any approved backrubber base oil.	Read and adhere to all precautions on labels. Do not use motor oil or waste oil on backrubbers.

[1]Backrubbers will suppress cattle lice, but usually do not result in complete control.

Table 2.7 - Sprays

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
face flies, horn flies, grubs[1], lice, screwworms, ticks	Coumaphos Pyrethrin	Follow directions according to label. Apply spray at high pressure so as to wet the skin. Use only between August 1 and November 1 for grub control.[1] Do not use after November 1 unless animals are known to be grub-free, because paralysis or suffocation may result.	Do not apply to sick animals or those less than 3 months old. Do not apply in conjunction with oral drenches or internal medications.
horn flies, lice, ticks	Tetrachlorvinphos [50%]	For horn flies and lice, mix 4.0 lbs product in 75.0 gal water. For ticks mix 4 lb product in 50.0 gal of water. Apply as coarse spray. Use 0.5-1.0 gal of spray per animal depending on size and thickness of hair coat.	Do not contaminate feed or water.
horn flies, lice, lone star ticks, face flies (aids in control)	Tetrachlorvinphos [23%] and Dichlorvos [5.3%]	Check label for proper dilution for each pest. Apply as coarse spray. Use between 0.5-1.0 gal of spray/animal depending on size and hair coat.	Do not treat more often than every 10 days. Do not contaminate feed or water.
face flies, horn flies, stable flies, lice, ticks	Permethrin [11%] Permethrin [10%]	Check labels for specific application instructions.	Do not contaminate feed or water.
Permethrin [5.7%] face flies, horn flies, lice	(Ectiban EC) and others Permethrin [7.4%] + Piperonyl Butoxide [7.4%]	Check label for specific application information.	Can be applied topically to livestock and their premises. Check label for precautions.
horn flies, lice, ticks, sarcoptic mange horn flies, lice	Phosmet [11.6%] (Liquid Insecticide) Spinosad [2.46%]	See label for specific mixing and rate information Refer to label for specific mixing and rate information.	Do not contaminate feed or water. Does not control cattle grubs. Do not make more than 5 consecutive treatments with this product. Do not apply more than once every 7 days. Do not apply within 2 days of slaughter.

[1]Cattle grubs - dips and sprays - Do not apply to sick, convalescent, or stressed animals or animals less than three months old. Do not dip or spray animals for 10 days before or after shipping or weaning, or after exposure to contagious or infectious diseases. Do not apply in conjunction with oral drenches, or with internal medications such as phenothiazine, or with natural or synthetic pyrethroids or their synergists, or with other organic phosphates. Do not apply in a confined, non-ventilated area. Destruction of *Hypoderma* larvae (cattle grubs) at the period when these grubs are in vital areas may cause undesirable host-parasite reactions including the possibility of fatalities. Killing *Hypoderma lineatum* when it is in the tissue surrounding the gullet may cause salivation and bloat; killing *H. bovis* when it is in the vertebral canal may cause staggering or paralysis. These reactions are not specific to treatment with Ivomec, but can occur with any successful treatment of grubs. Cattle should be treated either before or after these stages of grub development. Consult your veterinarian or Extension entomologist concerning proper timing of treatment.

Table 2.8 - Pour-ons[1]

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
horn flies, face flies	Lambda-Cyhalothrin [1.0%]	Ready to use. Apply down backline at rate of 0.33 oz/ animal up to 600 lbs of body weight. For animals weighing more than 600 lbs use 0.5 oz/animal.	Do not apply to face of animal. Non-systemic, will not control cattle grubs. Repeat as needed, but not more than once every 2 weeks and not more than 4 times within 6 months. Two treatments at 14- day intervals are recommended for control of sucking lice.
	Permethrin [10.0 %]	Ready to use. Apply from poll down neck to shoulders and along midline of back. Use 0.125 oz/250 lbs of body weight.	Non-systemic, will not control cattle grubs. Repeat as needed, but not more often than once every 2 weeks.
	Spinosad [2.46%]	Ready to use. Apply along back and down face. See label for complete use directions.	Repeat as needed, but not more than once every 2 weeks. Do not make more than 5 consecutive treatments with this product. Do not apply more than once every 7 days. Do not apply within 2 days of slaughter.
lice	Permethrin [1.0%]	Ready to use. Apply along back and down face. Use 0.5 oz/100 lbs of body weight, up to 5 oz/animal.	Repeat as needed, but not more than once every 2 weeks.
	Cyfluthrin [1.0%]	Rates for horn flies and face flies: 4 oz<400 lb body wt 8 oz 400 to 800 lb body wt 12 oz >800 lb body wt Rates for biting and sucking lice: 8 oz<400 lb body wt 16 oz 400 to 800 lb body wt 24 oz>800 lb body wt	Does not control cattle grubs.
	Permethrin [1.0%] + Piperonyl Butoxide [1.0%]	Apply at rate of 0.5 oz/100 lb of body wt up to maximum dosage of 5 oz/animal.	Repeat as needed, but not more often than once every 2 weeks. Check label for additional precautions.

[1]Do not use any pour-ons for lice control between Nov. 1 and Feb. 1. **Apply all pour-on grub treatments after Aug. 1 but no later than Nov. 1.**

[2]Destruction of *Hypoderma* larvae (cattle grubs) at the period when these grubs are in vital areas may cause undesirable host-parasite reactions including the possibility of fatalities. Killing *Hypoderma lineatum* when it is in the tissue surrounding the gullet may cause salivation and bloat; killing *H. bovis* when it is in the vertebral canal may cause staggering or paralysis. These reactions are not specific to treatment with Ivomec, but can occur with any successful treatment of grubs. Cattle should be treated either before or after these stages of grub development. Consult your veterinarian or Extension entomologist concerning proper timing of treatment.

Refrain from smoking or eating when handling. Wash hands after using. Keep this and all drugs out of reach of children.

Table 2.8 - Pour-ons[1] (cont.)

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
lice (cont.)	Spinosad [2.46%]	Ready to use. Apply along back and down face. See label for complete use directions.	Repeat as needed, but not more than once every 2 weeks. Do not make more than 5 consecutive treatments with this product. Do not apply more than once every 7 days. Do not apply within 2 days of slaughter.
	L-cyhalothrin	See label.	0 days to slaughter.
Avoid using products with grubicidal activity in Virginia from Nov. 1 to Feb. 1.[2]			
grubs, horn flies, lice, sarcoptic mange, chorioptic mange See footnote[2]	Eprinomectrin	Use 1.0 ml of product for each 22.0 lb of body weight. Apply along backline in a narrow strip extending from the withers to tailhead.	When used according to label, no pre-slaughter withdrawal period is required.

[1]Do not use any pour-ons for lice control between Nov. 1 and Feb. 1. **Apply all pour-on grub treatments after Aug. 1 but no later than Nov. 1.**

[2]Destruction of *Hypoderma* larvae (cattle grubs) at the period when these grubs are in vital areas may cause undesirable host-parasite reactions including the possibility of fatalities. Killing *Hypoderma lineatum* when it is in the tissue surrounding the gullet may cause salivation and bloat; killing *H. bovis* when it is in the vertebral canal may cause staggering or paralysis. These reactions are not specific to treatment with Ivomec, but can occur with any successful treatment of grubs. Cattle should be treated either before or after these stages of grub development. Consult your veterinarian or Extension entomologist concerning proper timing of treatment.

Refrain from smoking or eating when handling. Wash hands after using. Keep this and all drugs out of reach of children.

Table 2.9 - Spot-ons

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
ear ticks, screwworm	Coumaphos [5%]	Shake well. Squeeze container to release dust in short bursts of light clouds. Hold nozzle 2-4 inches from area to be treated and apply a light, even coat around the area.	For screwworm, treat infested wounds with light but thorough coverage. For ear ticks, dust into the area and also treat adjacent head area.

Table 2.10 - Mineral Mixtures and Feed Additives

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
face flies, horn flies, house flies, stable flies	Tetrachlorvinphos [7.6%] Gardona (cis-isomer) Diflubenzuron	Follow directions according to label. Start feeding in early spring before flies begin to appear, and continue throughout the summer and fall until cold weather restricts fly activity.	Check label for precautions.
horn flies (and possibly other species of filth-breeding flies)	s-Methoprene [10.5%]	Refer to label for details on proper feed to weight blending ratios.	S-Methoprene is an insect growth regulator (IGR) that interrupts the development of the horn fly (and possibly other species of filth-breeding flies) in the manure of treated cattle. Begin use in spring before horn flies appear on cattle and continue feeding until cold weather restricts horn fly activity. Product is safe for beef and dairy cattle, including breeding cattle, lactating cattle, and calves. Product can be fed up to slaughter and to lactating dairy cows without withholding milk.

Table 2.11 - Ear Tags

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
face flies, horn flies	**Pyrethroid Class Tags** Beta-Cyfluthrin insecticide, Cyfluthrin insecticide, Cypermethrin insecticide & Piperonyl Butoxide synergist, Permethrin insecticide, Permethrin insecticide & Piperonyl Butoxide synergist, Lambda-Cyhalothrin insecticide & Piperonyl Butoxide synergist	Follow directions according to labels. Apply with recommended applicator.	Carefully read instructions to avoid ear damage. Remove tags before slaughter.
	Organophosphate Class Tags Diazinon, Coumaphos	Follow directions according to labels. Apply with recommended applicator.	Carefully read instructions to avoid ear damage. Remove tags before slaughter.
	Pyrethroid & Organophosphate Class Tags Cypermethrin & Chlorpyrifos insecticide & Piperonyl Butoxide synergist, Lambda-Cyhalothrin & Pirimiphos-methyl insecticide, Permethrin and Chlorpyrifos insecticide & Piperonyl Butoxide synergist	Follow directions according to labels. Apply with recommended applicator.	Carefully read instructions to avoid ear damage. Remove tags before slaughter.

Table 2.12 - Injectables[1]

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
lice (sucking): (Linognathus vituli), (Haematopinus eurysternus), (Solenopotes capillatus) grubs: (Hypoderma bovis), (H. lineatum) mange mites: (Psoroptes ovis), (Sarcoptes scabiei) See footnote[1]	Ivermectin [1%] Dectomax [1%]	Ivermectin should be given only by subcutaneous injection at the recommended dose level of 200 mcg ivermectin/kg of body weight. Each 10 mg of ivermectin is sufficient to treat 110 lb (50 kg) of body weight. Use of a 16 gauge, 1/2 to 3/4" needle is suggested. Inject under the loose skin in front of or behind the shoulders.	Do not treat cattle within 35 days of slaughter. This product is not for intravenous or intra- muscular use. Animals should be appropriately restrained to achieve the proper route of administration. Use sterile equipment and sanitize the injection site by applying a suitable disinfectant. Clean, properly disinfected needles should be used to reduce potential injection-site infections.

[1]Observe cattle for injection site reactions. Reactions may be due to clostridial infection and should be aggressively treated with appropriate antibiotics.

Ivermectin is highly effective against all stages of cattle grubs. However, proper timing of treatment is important. For most effective results, cattle should be treated as soon as possible after the end of the heel fly (warble fly) season.

Destruction of *Hypoderma* larvae (cattle grubs) at the period when these grubs are in vital areas may cause undesirable host-parasite reactions including the possibility of fatalities. Killing *Hypoderma lineatum* when it is in the tissue surrounding the gullet may cause salivation and bloat; killing *H. bovis* when it is in the vertebral canal may cause staggering or paralysis. These reactions are not specific to treatment with ivermectin, but can occur with any successful treatment of grubs. Cattle should be treated either before or after these stages of grub development. Consult your veterinarian or Extension entomologist concerning proper timing of treatment.

Cattle treated with ivermectin after the end of the heel fly season may be retreated with ivermectin during the winter for internal parasites, mange mites, or lice without danger of grub-related reactions. **A planned parasite control program is recommended**.

Transitory discomfort has been observed in some cattle following subcutaneous administration. A low incidence of soft-tissue swelling at the injection site has been observed. These reactions have disappeared without treatment. Divide doses greater than 10 ml between two injection sites to reduce occasional discomfort or site reaction. Protect from light.

CAUTION: Ivermectin injection for cattle has been developed specifically for use in cattle and reindeer only. This product should not be used in other animal species because severe adverse reactions, including fatalities in dogs, may result.

Refrain from smoking or eating when handling. Wash hands after using. Keep this and all drugs out of reach of children.

Table 2.13 - Bolus

Pests	Active Ingredient [Percent A.I. in Product]	Insecticide Mixing and Application Information	Precautions
face flies, horn flies, house flies, stable flies	Diflubenzuron [9.7%]	This product is a controlled-release bolus for beef and dairy cattle that aids in the suppression of house and stable flies. Administer 1/2 bolus to cattle weighing 300-550 lb, and 1 bolus to cattle weighing 550-1,100 lb or greater.	Do not administer to cattle weighing less than 300 lb. Never administer more than 1 bolus to any animal.

When to Treat for Cattle Grubs

Proper timing of treatment is important when using systemic grubicide pour-ons and spot-ons on beef and non-lactating dairy cattle. For most effective results, cattle should be treated for grubs after the end of heel fly activity in September. Host-parasite reactions such as bloat, salivation, staggering and paralysis may sometimes occur when cattle are treated while the common cattle grub, Hypoderma lineatum, is in the gullet, or while the northern cattle grub, H. bovis, is in the area of the spinal cord. Therefore, avoid using products with grubicidal activity on cattle in Virginia from Nov. 1-Feb. 1.

Follow Instructions on the Label

If it is impossible to determine the origin of the cattle, and thus the exact stage of the grubs is unknown, it is recommended that the cattle receive only dry hay or a maintenance ration of low energy feed a couple of days before and during the treatment period. This lessens the likelihood of severe bloat, which may occur in cattle on full feed when the common grub is killed in the gullet.

When to Treat for Cattle Lice

Systemic pour-ons and spot-ons for lice control on beef and non-lactating dairy cattle are convenient. Grub treatment before the November cutoff date often will not take care of cattle lice problems. Louse eggs are not as susceptible to insecticides as the lice themselves and therefore animals should be re-examined about three weeks after treatment to determine if viable lice eggs have hatched and reinfested the herd.

Do not use grubicides such as coumaphos (Co-Ral), famphur (Warbex - registration cancelled), fenthion (Tiguvon or Spotton – registration cancelled) or phosmet (Prolate) from November through January on cattle not previously treated for grubs due to possible host-parasite reactions. After February 1, grub larvae have migrated from the spinal canal, or esophagus, and usually encyst in the back; cattle may then be treated safely with grubicides. It is then safer to treat for lice to minimize the host-parasite reaction.

For cattle previously treated for grubs, a second treatment later in the season may become necessary should lice become a problem. The second treatment usually should not be applied sooner than 35 days after the first treatment. Be sure to follow instructions on the label for any safety precautions.

Systemic spot-ons and pour-ons that kill lice but not grubs can be applied anytime throughout the fall and winter months. Be sure to follow instructions on the label for any safety precautions.

Dairy External Parasites

Eric R. Day, Extension Entomologist, Virginia Tech

Insecticides should be applied with extreme caution to cows or calves in poor health. This means light applications of safer materials. Extremely small amounts of pesticide residues can be detected in milk. For all practical purposes, the tolerance level for pesticide residues in milk is ZERO. Moreover, the presence of such residues in milk is virtually always illegal. To avoid pesticide residues in milk, dairy producers are cautioned to use ONLY those pesticides that are labeled for use in dairy operations.

Longhorned Tick Control for Cattle

The Longhorned Tick, *Haemaphysalis longicorni*s, is a recently recognized tick in Virginia and other states in the eastern United States. If you suspect that you have this tick please submit a sample to the Insect Identification Lab or a State Veterinarian to have it confirmed. Populations can build up into extreme numbers and impact animal health. For information see:

https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/ENTO/ento-282/ENTO-282.pdf

Table 2.14 - Special section for Longhorned Tick Control on Dairy Cattle

Control Method for Ticks	Active Ingredients *Sold under various trade names*	Insecticide Mixing and Application Information	Precautions
Pour On	Permethrin	Ready to use version. Apply from poll down neck and along midline of back.	Check label some versions are ready to use and some require dilution. Repeat as needed, but not more than once every 2 weeks.
EC Spray for Beef and non-lactating dairy cattle	Permethrin	Emulsifiable concentrate spray.	Beef & non-lactating dairy cattle.

Table 2.15 - Dust Bags[1]

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
horn flies, lice (aids in control of face flies)	Coumaphos [1%] Dust Gardona Permethrin Rabon	No mixing is necessary. Install burlap bags of dust in doorway where cattle leave milking barn or enter loafing barn. Keep in place during winter months to aid in control of lice.	Do not contaminate feed or water. Wear protective clothing and gloves as recommended on the label.

[1]Closed-mesh bags must be used to prevent waste of dust.

Table 2.16 - Backrubbers[1] - Lactating Cows

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
face flies, horn flies, stable flies	Permethrin [11%]	Dilute 1.0 pt product/10.0 gal #2 diesel oil.	Use only #2 diesel oil or any other approved backrubber base oil. Do not use motor oil or waste oil. Keep rubbing device charged. Results improve with daily forced use. Install backrubbers where cattle leave the milking barn.
	Permethrin [10%]	Mix 1.0 qt product/20.0 gal #2 diesel oil.	
	Permethrin [5.7%]	Mix 1.0 qt product/10.0 gal #2 diesel oil.	
	Cumophos	1.25 cups/gal #2 diesel oil	
face flies, horn flies, lice	Permethrin [7.4%] + Piperonyl Butoxide [7.4%]	Mix 2.1 oz/gal mineral oil. Results improve with daily forced use.	

[1]Backrubbers will suppress cattle lice, but usually do not result in complete control.

Table 2.17 - Hand Dusting - Lactating Cows

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
face flies, horn flies, lice	Tetrachlorvinphos [3%] Dust	Follow directions according to label. Wear rubber gloves to apply. Apply approximately 2 oz dust to the upper portions of the back, neck and poll, and to the face as an aid in the control of face flies. Rub in lightly to carry the dust beneath the hair.	Do not contaminate feed or water.
	Permethrin [0.25%]	Apply 2 oz (6.0 tbsp) of dust/animal by shaker can. Repeat as necessary.	Do not contaminate water, food or feed by storage or disposal. Keep container sealed when not in use.
horn flies, lice	Coumaphos [1%] Dust	No mixing is necessary. Apply not more than 2.0 oz/animal. Dust evenly into the hair over the head, neck, shoulders, back, and tail-head. Repeat as necessary.	Do not contaminate feed or water.
	Zeta-Cypermethrin [0.075%] + Piperonyl Butoxide [0.15%]	See label for specific application instructions.	

Table 2.18 - Wetting Sprays - Lactating Cows

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
face flies, horn flies, horse flies, house flies, stable flies, lice, mites, ticks	Permethrin [11%]	Mix 1.0 pt product in 25.0 gal water. Apply 1-2 qts of coarse spray/ animal over entire body surface.	Spray lactating dairy animals only after milking is completed. Do not contaminate feed or drinking water.
face flies, horn flies, stable flies, ticks	Permethrin [5.7%]	Mix 1.0 qt product in 25.0 gal water. Apply 1-2 qts spray/ animal over entire body surface.	
lice	Permethrin [5.7%]	Mix 1.0 quart product in 100 gal water.	A second application is recommended 2-3 weeks later.
	Coumaphos [25%]	Mix 1.0 lb product in 100 gal water. Apply spray to run-off.	
face flies, horn flies, horse flies, stable flies, lice, mites, ticks, etc.	Permethrin [10%]	Mix 1.0 quart product in 200 gal water. Apply spray to thoroughly cover animal.	For lice and mites a second application is recommended 2-3 weeks later.
face flies, horn flies, lice	Permethrin [7.4%] + Piperonyl Butoxide [7.4%] Pyrethrin	Check label for specific application instructions.	Can be applied topically to lactating dairy animals and their premises. Check label for precautions.
horn flies, lice	Spinosad [2.46%]	For lactating and non-lactating beef and dairy cows. Refer to label for specific mixing and rate information.	Do not make more than 5 consecutive treatments with this product. Do not apply more than once every 7 days. Do not apply within 2 days of slaughter.

Table 2.19 - Mist Sprays - Lactating Cows

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
horn flies, stable flies	Synergized pyrethrins	Apply 1.0-2.0 oz of product directly to animal once daily, preferably in morning.	If other mist sprays are used on lactating dairy cattle, please read label carefully.
face flies, horn flies, stable flies	Dichlorvos [40.2%]	Dilute 5.0 oz product in 2.0 gal water. Apply 1.0- 2.0 oz of diluted solution/animal daily as a fine mist. Thoroughly cover all parts of the animal, including the legs, but do not wet the skin.	Do not contaminate feed or drinking water. Do not apply in combination with trichlorfon. Do not apply to calves under 6 months.

Table 2.20 - Injectables - Males and Females Not of Breeding Age[1]

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
lice (sucking): *Linognathus vituli,* *Haematopinus eurysternus,* *Solenopotes capillatus* grubs: *Hypoderma bovis,* *H. lineatum*	Ivermectin [1%]	Ivermectin should be given only by subcutaneous injection at the recommended dose level of 200 mcg ivermectin/kilogram of body weight. Each 10 mg of ivermectin is sufficient to treat 110 lb (50 kg) of body weight. A 16 gauge, 1/2 to 3/4" needle is suggested. Inject under the loose skin in front of or behind the shoulders.	Do not treat cattle within 35 days of slaughter. **Because a withdrawal time in milk has not been established, do not use in female dairy cattle of breeding age**. This product is not for intravenous or intramuscular use. Animals should be appropriately restrained to achieve the proper route of administration. Use sterile equipment and sanitize the injection site by applying a suitable disinfectant. Clean, properly disinfected needles should be used to reduce the potential for injection-site infections.

[1]Ivermectin - Observe cattle for injection-site reactions. Reactions may be due to clostridial infection and should be aggressively treated with appropriate antibiotics.

Ivermectin is highly effective against all stages of cattle grubs. However, proper timing of treatment is important. For most effective results, cattle should be treated as soon as possible after the end of the heelfly (warble fly) season.

Destruction of *Hypoderma* species larvae (cattle grubs) at the period when these grubs are in vital areas may cause undesirable host-parasite reactions including the possibility of fatalities. Killing *Hypoderma lineatum* when it is in the tissue surrounding the gullet may cause salivation and bloat; killing *H. bovis* when it is in the vertebral canal may cause staggering or paralysis. These reactions are not specific to treatment with ivermectin, but can occur with any successful treatment of grubs. Cattle should be treated either before or after these stages of grub development. Consult your veterinarian or Extension entomologist concerning proper timing of treatment.

Cattle treated with ivermectin after the end of the heelfly season may be retreated with ivermectin during the winter for internal parasites, mange mites, or lice without danger of grub-related reactions. A planned parasite control program is recommended.

Transitory discomfort has been observed in some cattle following subcutaneous administration. A low incidence of soft-tissue swelling at the injection site has been observed. These reactions have disappeared without treatment. Divide doses greater than 10 ml between two injection sites to reduce occasional discomfort or site reaction.

Protect from light.

CAUTION: Ivermectin injection for cattle has been developed specifically for use in cattle and reindeer only. This product should not be used in other animal species because severe adverse reactions, including fatalities in dogs, may result.

Refrain from smoking or eating when handling. Wash hands after using. Keep this and all drugs out of reach of children.

Table 2.21 - Bolus

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
face flies, horn flies, house flies, stable flies	Diflubenzuron [9.7%]	Administer 0.5 bolus to cattle weighing 300-550 lb, and 1 bolus to cattle weighing 550- 1,100 lb or more. Follow directions according to label.	Do not administer to cattle weighing less than 300 lb. Never administer more than 1 bolus to any animal.

Table 2.22 - Pour-ons - Lactating Cows[1]

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
horn flies, lice	Permethrin [10.0%]	Ready to use. Apply from poll down neck to shoulders and along midline of back. Use 0.125 oz/250 lbs of body weight.	Non-systemic, will not control cattle grubs. Repeat as needed, but not more often than once every 2 weeks.
	Spinosad [2.46%]	Ready to use. Apply along back and down face. See label for complete use directions.	Repeat as needed, but not more than once every 2 weeks. Do not make more than 5 consecutive treatments with this product. Do not apply within 2 days of slaughter.
face flies, horn flies, lice	Permethrin [5.0%]	Apply 0.10 oz/100 lbs of body weight, up to a maximum of 1.01 oz/animal.	Non-systemic, will not control cattle grubs. Repeat as needed, but not more often than once every 2 weeks.
	Permethrin [1.0%]	Ready to use. Apply along back and down face. Use 0.5 oz/100 lbs of body weight, up to 5 oz/animal.	Repeat as needed, but not more than once every 2 weeks.
	Permethrin [1.0%] + Piperonyl Butoxide [1.0%]	Apply at rate of 0.5 oz/100 lb body weight up to a maximum dosage of 5 oz/animal.	Repeat as needed, but not more than once every 2 weeks. Check label for additional precautions.
	Cyfluthrin [1.0%]	**Rates for horn flies and face flies:** 4 oz <400 lb body wt 8 oz 400 to 800 lb body wt 12 oz >800 lb body wt **Rates for biting and sucking lice:** 8 oz <400 lb body wt 16 oz 400 to 800 lb body wt 24 oz >800 lb body wt	Does not control cattle grubs.
	Diflubenzuron + Permethrin	See label.	
grubs, horn flies, lice sarcoptic mange, chorioptic mange	Ivomec Eprinex	Use 1.0 ml of product for each 22.0 lb body wt. Apply along backline in a narrow strip extending from the withers to tailhead.	When used according to label, neither a pre-slaughter withdrawal period nor a milk discard time is required.

[1]Avoid using products with grubicidal activity in Virginia from Nov. 1 to Feb. 1.

Table 2.23 - Pour-ons - Non-lactating Cows[1]

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
face flies, horn flies, lice	Permethrin [1.0%] + Piperonyl Butoxide [1.0%]	Pour along back at rate of 0.5 oz/100 lbs body wt up to a maximum of 5 oz/animal.	Repeat as needed, but not more than once every 2 weeks. Check label for additional precautions.
grubs[2], horn flies, lice sarcoptic mange, chorioptic mange	Eprinomectrin (Ivomec Eprinex)	Use 1.0 ml of product for each 22.0 lb body wt. Apply along backline in a narrow strip extending from the withers to tailhead.	When used according to label, neither a pre-slaughter withdrawal period nor a milk discard time is required.
horn flies, lice	Spinosad [2.46%]	Ready to use. Apply along back and down face. See label for complete use directions.	Repeat as needed, but not more than once every 2 weeks. Do not make more than 5 consecutive treatments with this product. Do not apply within 2 days of slaughter.

[1]Please read label carefully if other pour-ons for grub control are used on non-lactating dairy cattle.

[2]Avoid using products with grubicidal activity in Virginia from Nov. 1 to Feb. 1.

Table 2.24 - Ear Tags

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
face flies, horn flies	**Pyrethroid Class Tags** Beta-Cyfluthrin insecticide, Cyfluthrin insecticide, Cypermethrin insecticide & Piperonyl Butoxide synergist, Permethrin insecticide, Permethrin insecticide & Piperonyl Butoxide synergist, Fenvalerate insecticide	Follow directions according to labels and apply with recommended applicator.	Carefully read instructions to avoid ear damage. Remove tags before slaughter.
	Organophosphate Class Tags Pirimiphos-Methyl, Coumaphos, Diazinon Chlorpyrifos insecticide & Piperonyl Butoxide synergist		
	Pyrethroid & Organophosphate Class Tags Cypermethrin insecticide & Chlorpyrifos insecticide & Lambda-cyhalothrin, Piperonyl Butoxide synergist, Permethrin insecticide & Chlorpyrifos insecticide & Piperonyl Butoxide synergist		
	Tags From Other Classes Avermectin B1		

Table 2.25 - Mineral Mixtures and Feed Additives

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
face flies, horn flies, house flies, stable flies	Tetrachlorvinphos [7.6%] Diflubenzuron	Follow directions according to label. Start feeding in early spring before flies begin to appear, and continue throughout the summer and fall until cold weather restricts fly activity.	Check label for precautions.
horn flies (and possibly other species of filth-breeding flies)	s-Methoprene [10.5%]	Refer to label for details on proper feed to weight blending ratios.	The Ai in Altosid Cattle Custom Blending Premix is an insect growth regulator (IGR) interrupts the development of the horn fly (and possibly other species of filth-breeding flies) in the manure of treated cattle. Begin use in spring before horn flies appear on cattle and continue feeding until cold weather restricts horn fly activity. Product is safe for beef and dairy cattle, including breeding cattle, lactating cattle, and calves. Product can be fed up to slaughter and to lactating dairy cows without withholding milk.

Swine External Parasites

Eric R. Day, Extension Entomologist, Virginia Tech

Table 2.26 - Sprays

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
lice	Coumaphos [25%]	Mix 2.0 lbs product in 100 gal water. Apply to point of run-off.	Check label for details.
	Tetrachlorvinphos [50%]	Dilute 4.0 lbs in 50.0 gal water. Apply as a coarse spray, using 1-2 qts/animal.	Repeat in 2 weeks if necessary.
lice, mange mites, ticks	Amitraz [12.5%]	Mix 1 can (760-ml = 25.7 oz) in 50.0 gal water (equivalent to 0.5 oz product/gal spray solution). Use solution within 6 hr of mixing. Spray entire pen area at 70-150 psi. Spray all animals to run-off and thoroughly treat jowl, legs, inside the ears, and underside of body. If necessary, make second application in 7-10 days for mites and 10-14 days for lice.	Remove feed from pen and cover drinking bowls. Remove and destroy bedding. Hose out feces and excess feed. **Do not apply to swine within 3 days of slaughter. Do not treat animals more than 4 times per year.**
lice, mange mites	Fenvalerate [10%]	Mix 1.0 qt product in 50.0 gal water. Wet entire animal with up to 8.0 oz of spray.	Do not apply within 1 day of slaughter.
	Phosmet [11.6%][1]	Mix 1.0 qt product in 25.0 gal water. Apply to run-off. Repeat if necessary after 14 days.	Check label for details. Do not apply within 1 day of slaughter. Do not apply to sick, convalescent or stressed animals. Do not apply to suckling pigs.
	Permethrin [11%] Stirofos Piperonyl Butoxide + Pyrethrins s-Methoprene	Follow directions according to labels.	Check labels for precautions.

[1]Do not use this product in conjunction with other cholinesterase-inhibiting drugs, pesticides, or chemicals.

Table 2.27 - Dusts

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
lice	Coumaphos [1%]	No mixing is necessary. Ready-to-use. Do not use more than 1.0 oz of product/ animal.	Do not use more frequently than once every 10 days. Wear protective clothing and gloves as recommended on the label.
	Tetrachlorvinphos [3%][1]	Use 3-4 oz/animal. Repeat as necessary, but not more often than once every 14 days. In severe infestations, both animals and bedding should be treated. Use 1.0 lb/150.0 sq ft of bedding.	Check label for details. Wear protective clothing and gloves as recommended on the label.
	Permethrin [0.25%]	Apply up to 1.0 oz (3.0 tbsp) of dust to the head, shoulders, and neck. Repeat as necessary, but not more than once every 10 days.	Do not contaminate water, food or feed by storage or disposal. Keep container sealed when not in use.

[1]Do not use this product in conjunction with other cholinesterase-inhibiting drugs, pesticides, or chemicals.

Table 2.28 - Pour-ons

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
lice, mange mites	Amitraz [2%] Fenualerate Fenthion Permethrin	Requires specially designed dosing gun. Apply proper dosage (consult chart on label) to the inside of each ear and along the midline of the back.	Restrain animals. Do not treat within 7 days of slaughter. Retreat in 7 to 10 days, if necessary. Check label for details.

Table 2.29 - Injectables

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
sucking lice (*Haematopinus suis),*	Ivermectin [1%] (Ivomec)	Ivomec should be given only by subcutaneous injection at the recommended dose level of 300 mcg ivermectin/ kgm of body wt. Each ml of Ivomec contains 10 mg of ivermectin, sufficient to treat 75 lb (33 kg) of body weight. Use of a 16- or 18-gauge 1/2 to 3/4" needle is suggested. The recommended route of administration is by subcutaneous injection in the neck, behind the ear. Use aseptic technique.	This product has been developed for use in swine only. Do not treat swine within 18 days of slaughter. This product is not for intravenous or intra-muscular use. Restrain animal to achieve the proper route of administration. Use sterile equipment and sanitize the injection site by applying a suitable disinfectant. Clean, properly disinfected needles should be used to reduce potential injection-site infection. Protect product from light. Keep this and all drugs out of reach of children.
mange mites *(Sarcoptes scabiei* var. *suis)*			

Table 2.30 - Oral Treatments

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
lice	Gardonia Tetrachlorvinphos	See label.	See label.

Longhorned Tick Control for Swine

The Longhorned Tick, *Haemaphysalis longicornis*, is a recently recognized tick in Virginia and other states in the eastern United States. If you suspect that you have this tick please submit a sample to the Insect Identification Lab or a State Veterinarian to have it confirmed. Populations can build up into extreme numbers and impact animal health. For information see:

https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/ENTO/ento-282/ENTO-282.pdf

Table 2.31 - Special section for Tick Control on Swine

Control Method for Ticks	Active Ingredients *Sold under various trade names*	Insecticide Mixing and Application Information	Precautions
Dip, Sponge, or Spray	Permethrin	Back and shoulders.	No treatments 1 week before shipping.

Sheep External Parasites

Eric R. Day, Extension Entomologist, Virginia Tech

Table 2.32 - Sprays or Dips[1]

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
lice, sheep keds	Permethrin [7.4%] + Piperonyl Butoxide [7.4%], Cumaphos, Diazinon	Check label for specific application instructions.	Can be applied topically to sheep and their premises. Check label for precautions.
	Fenvalerate [10%]	Mix 1.0 qt product in 100 gal water. Wet animal with up to 1.0 qt of solution.	For use only on non-lactating sheep or goats. Repeat application in 30 days if necessary. Do not apply more than 2 times in spring and 2 times in fall. Do not apply within 2 days of slaughter.
lice, mites, sheep keds, ticks	Permethrin [11%]	Mix 1.0 pt product in 25.0 gal water. Apply 1-2 qt of coarse spray/ animal over entire body surface.	Do not contaminate feed or drinking water. Check label for details.
lice, sheep keds, ticks, fleeceworms	Coumaphos [25%]	Follow directions according to label.	Repeat as necessary but not within 15 days of slaughter.
fleeceworms	Permethrin	Follow directions according to label.	See label.

[1]May be applied as a spray or dip.

Do not apply to sick, convalescent, or stressed livestock, or to any animals less than 3 months old except in Federal and State eradication programs. Do not treat animals for 10 days before or after shipping or weaning, or after exposure to contagious and infectious diseases except in Federal or State eradication programs. Do not spray in confined non-ventilated area.

Animals must be wet thoroughly to penetrate wool for control of lice next to the skin. Dipping is the most reliable method of eliminating lice on sheep.

Table 2.33 - Pour-ons

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
lice, sheep keds	Fenvalerate [10%]	Mix 4.0 oz product in 1.5 gal of water. Apply up to 4.0 oz of solution down midline of back 1-2 times in the spring.	For use only on non-lactating sheep and goats. Repeat application in 30 days if necessary. Do not apply more than 2 times in the fall pest season. One application after shearing is usually adequate for sheep ked control. Do not apply within 2 days of slaughter. Repeat as needed, but not more than once every 2 weeks.
	Permethrin [1.0%] & Piperonyl Butoxide synergist [1.0%]	Apply 0.25 oz/50 lbs of body weight, up to maximum of 3 oz/animal.	
	Permethrin [1.0%]	Ready to use. Apply along back. Use 0.25 oz/50 lbs of body weight, up to 3 oz/animal.	
	Permethrin [1.0%] + Piperonyl Butoxide [1.0%]	Apply at rate of 0.25 oz/50 lb body weight up to a maximum dosage of 3 oz/animal.	Repeat as needed, but not more than once every 2 weeks. Check label for additional precautions.
face flies, horn flies, lice, sheep keds	Permethrin [5%]	Apply 0.05 oz/50 lbs body weight, up to 0.61 ml/animal.	Repeat as needed, but not more than once every 2 weeks

Table 2.34 - Dust

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
lice, sheep keds, ticks	Zeta-Cypermethrin [0.075%] + Piperonyl Butoxide [0.15%]	Check label for specific application instructions.	Check label for precautions. Wear protective clothing and gloves as recommended on the label.

Scabies

Sheep scabies is a disease caused by mange mites. Virginia has been declared free of this disease for several years. Nevertheless, scabies may occur occasionally on sheep in areas that have been declared free of the disease. Scabies suspected on sheep in Virginia should be reported immediately to your county Extension office or to representatives of the State Veterinarian's office of the Virginia Department of Agriculture and Commerce, Richmond, Virginia. Inspection and diagnosis is a free service. If scabies is positively identified, the necessary treatment will be applied without charge by the Virginia Department of Agriculture and Consumer Services.

Longhorned Tick Control for Sheep and Goats

The Asian Longhorned Tick, *Haemaphysalis longicornis*, is a recently recognized tick in Virginia and other states in the eastern United States. If you suspect that you have this tick please submit a sample to the Insect Identification Lab or a State Veterinarian to have it confirmed. Populations can build up into extreme numbers and impact animal health. For information see:

https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/ENTO/ento-282/ENTO-282.pdf

Table 2.35 - Special section for Longhorned Tick Control on Sheep and Goats

Control Method for Ticks	Active Ingredients *Sold under various trade names*	Insecticide Mixing and Application Information	Precautions
Spot-on	Permethrin	Back and shoulders.	For animals older then 1 month.
Dip vat	Permethrin	Concentrate, diluted as per label instructions.	Wet fleece, hair-coat, through to the skin.
Pour On	Permethrin	Head, neck, and on top line of back.	Check label some versions are ready to use and some require dilution.
Dip	Permethrin	Hand soak or sponge.	
Emulsifiable concentrate spray	Permethrin	Treat head, neck, and along top-line.	
Ready to use spray	Permethrin	Spot treat by spraying directly onto ticks.	
Aerosol spray	Permethrin	Spray onto ticks in and out-side the ears.	
Backrubber	Permethrin	Use where sheep congregate.	Keep applicator fully charged.

Horse External Parasites

Eric R. Day, Extension Entomologist, Virginia Tech

Research conducted in Virginia indicates that petroleum jelly applied in the ears of horses will provide up to 4 days protection from black flies.

Table 2.36 - Oral

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
bots	Ivermectin [1.87%]	Administer paste with single oral syringe at the dose rate of 91 mcg/lb. Each weight marking on the plunger delivers enough paste to treat 250 lb. It is important to know your horse's weight in order to calculate the proper dosage.	Refrain from smoking or eating when handling. Avoid contact with the eyes. Wash hands thoroughly after administration. Do not contaminate ground water. Swelling and itching reactions sometimes occur with severe infections. Consult a veterinarian if condition does not improve.
	Ivermectin [10 mg]	For liquid, 10 mg will treat a 1,100 lb horse. Read label for step-by-step instructions.	

Table 2.37 - Sprays and Wipe-ons

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
horn flies, lice, screwworms, ticks	Coumaphos [25%]	For horn flies and lice, mix 2 lb product in 100 gal water. To control ticks mix 4.0 lbs product in 100 gal water. To control screwworms mix 8.0 lbs product in 100 gal water.	Check label for precautions. Do not contaminate feed or water.
face flies, horn flies, house flies, stable flies	Fenvalerate [10%]	Mix 1.0 qt product in 25.0 gal water. Apply 8.0 oz as light spray with attention to head and legs. Repeat as necessary.	Do not treat animals intended for slaughter.
deer flies, horn flies, house flies, horse flies, mosquitoes	Tetrachlorvinphos [1%] + Pyrethrins [0.09%] + Piperonyl Butoxide [0.18%] + Repellent [0.8%]	No mixing is necessary. Available in ready-to-use form. Apply 1.0-2.0 oz/animal as a wipe-on or spray to evenly cover the flanks, belly, and back of the horse or pony.	Do not allow product to come in contact with eyes. More frequent applications may be necessary if the legs are exposed to high grass and water. Do not treat slaughter animals. Repeat as necessary on perspiring animals.
face flies, house flies	Tetrachlorvinphos [1%] + Pyrethrins [0.09%] + Piperonyl Butoxide [0.18%] + Repellent [0.8%]	Apply 1.0-2.0 oz/animal as a wipe-on preferably to the head area. Pay particular attention to area around the nostrils and eyes.	Do not allow product to come in contact with eyes. Do not treat slaughter animals. Repeat as necessary on perspiring animals.

Table 2.37 - Sprays and Wipe-ons (cont.)

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
stable flies	Tetrachlorvinphos [1%] + Pyrethrins [0.09%] + Piperonyl Butoxide [0.18%] + Repellent [0.8%]	Apply 1.0-2.0 oz/animal as a wipe-on or spray to the legs and flanks, leaving no unprotected area. More frequent application may be necessary if the legs are exposed to high grass or water. Repeat as necessary on perspiring animals.	Do not allow product to come in contact with eyes.
biting gnats	Tetrachlorvinphos [1%] + Pyrethrins [0.09%] + Piperonyl Butoxide [0.18%] + Repellent [0.8%]	Apply 1.0-2.0 oz/animal as a wipe-on preferably to the head, neck, belly, and forelegs. Be sure to apply to the inside surfaces of the ears.	Check label for details. Do not allow product to come in contact with eyes. Repeat as necessary on perspiring animals.
horse flies, house flies, stable flies, face flies, horn flies, deer flies, gnats , mosquitoes, lice, deer ticks	Cypermethrin [0.15%] + Pyrethrins [0.2%] + Piperonyl Butoxide [1.6%] + Butoxypoly-propylene glycol [5%]	Shake well before using. Shampoo and rinse dirty horses thoroughly. Wait until coat is dry before applying. For horse's face, always apply as a wipe. Use clean, absorbent cloth, towel or sponge. Spray or wipe entire body while brushing against the lay of the coat. Apply liberally. Reapply every 5-7 days initially, then every 10-14 days, and reapply each time animal is washed or exposed to heavy rain.	Wear rubber gloves or mittens when applying as a wipe. Avoid getting spray in horses eyes, nose or mouth.
lice, stable flies, horn flies, face flies, deer flies, eye gnats, ticks	Permethrin [7.4%] + Piperonyl Butoxide [7.4%] Dichlorvos Synthrin s-Methoprene Cyphenothrin	Can be applied topically to horses. Check label for specific application instructions	Check label for precautions.
black flies	petroleum jelly	Apply to the inside of the ears.	

Table 2.38 - Hand Dusting

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
horn flies, lice, ticks	Zeta-Cypermethrin [0.075%] + Piperonyl Butoxide [0.15%]	Check label for specific application instructions.	Wear protective clothing and gloves as recommended on the label.
horn flies, lice	Permethrin [0.25%] (horse lice duster)	Ready to use. Apply 2.0 oz dust per animal to the head, neck, shoulders, and back and tailhead.	Avoid getting dust in the animal's eyes. Wear face mask respirator when applying dust formulations. Wear protective clothing and gloves as recommended on the label.

Longhorned Tick Control for Equids

The Longhorned Tick, *Haemaphysalis longicornis*, is a recently recognized tick in Virginia and other states in the eastern United States. If you suspect that you have this tick please submit a sample to the Insect Identification Lab or a State Veterinarian to have it confirmed. Populations can build up into extreme numbers and impact animal health. For information see:

https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/ENTO/ento-282/ENTO-282.pdf

Table 2.39 - Special section for Longhorned Tick Control on Equids

Control Method for Ticks	Active Ingredients *Sold under various trade names*	Insecticide Mixing and Application Information	Precautions
Spot-on	Permethrin	Head, neck, and on top line of back and where ticks are found.	Check label some versions are ready to use and some require dilution.
Spot On	Permethrin	Head, neck, and on top line of back and where ticks are found.	Safe for foals older than 3 months.
Ready to use spray	Permethrin	Head, neck, and on top line of back and where ticks are found.	Spot treat legs, tail, mane, and ears.
Aerosol spray	Permethrin	Ready to use.	Spray onto ticks in and outside the ears.
Backrubber	Permethrin	Use where horses congregate or loaf.	Keep applicator fully charged.
Dip	Permethrin	Hand soak or sponge.	Wet to skin, drip dry, avoid face.
Garment/cover	Permethrin	Leg or blanket covering.	Deterrent.
Wipe-on	Permethrin	Use mitt.	Safe for foals older than 3 months.

Poultry External Parasites

Eric R. Day, Extension Entomologist, Virginia Tech

Table 2.40 - Caged Layer Treatments

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
northern fowl mite[1]	Permethrin [5.7%]	Mix 1 qt product in 25.0 gal of water. Apply 1.0 gal of diluted spray/100 birds. Be sure to treat vent area thoroughly.	Check label for precautions and apply only to animals listed on label.
lice, mites	Tetrachlorvinphos [50%]	Mix 8.0 lb product in 100 gal of water. Apply at a rate of 1.0 gal solution/100 birds. Spray, vent, and fluff areas from below. Repeat when necessary. For northern fowl mite, use a power sprayer at 100-125 psi.	Do not repeat more often than once every 14 days. Treat roosters carefully and individually to avoid reinfestation of breeding flocks.
	Tetrachlorvinphos [23%] & Dichlorvos [5.3%]	Mix 1.0 gal product in 50.0 gal of water. Apply 1.0 gal of solution/100 birds under high pressure (no less than 100-125 psi) to the vent and fluff areas from below.	Repeat as needed but not more often than once every 14 days. Treat roosters carefully and individually to avoid reinfestation of breeding flocks.
lice, mites	Cumaphos	3.0-6.0 oz/5 gal of water.	3.0-oz rate for mites. 6.0-oz rate for lice.
	Sevin	Mix 4.0 oz/5 gal of water. Use 1 gal/100 birds.	Check label for precautions. Wear protective clothing and gloves as recommended on the label.
lice, mites	Piperonyl + Pyrethrins s-Methoprene	See label.	Check label for precautions. Wear protective clothing and gloves as recommended on the label.

[1]This treatment will aid in the control of adult house flies.

Table 2.41 - Litter Treatment

Pests	Insecticide Active Ingredient [Percent A.I. in Product]	Mixing and Application Information	Precautions
lice, mites (including northern fowl mite), litter beetles	Tetrachlorvinphos [50%]	Mix 4.0 lbs product in 50.0 gal of water. Apply 1.0-2.0 gal of spray/100 square feet. Can be used as a dry dust. Use 0.75 oz product/100 sq ft. Use a rotary, mechanical or electrostatic duster.	Wear a face mask when applying.
lice, mites	Sevin, Dichlorvos, Tetrachlorvinphos	Follow label	Check label for precautions. Wear protective clothing and gloves as recommended on the label.

Longhorned Tick Control for Poultry

The Longhorned Tick, *Haemaphysalis longicornis*, is a recently recognized tick in Virginia and other states in the eastern United States. If you suspect that you have this tick please submit a sample to the Insect Identification Lab or a State Veterinarian to have it confirmed. Populations can build up into extreme numbers and impact animal health. For information see:

https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/ENTO/ento-282/ENTO-282.pdf

Table 2.42 - Special section for Longhorned Tick Control on Poultry

Control Method for Ticks	Active Ingredients *Sold under various trade names*	Insecticide Mixing and Application Information	Precautions
Dip wash	Permethrin	Wet feathers through to skin and air dry.	Check label some versions are ready to use and some require dilution.
Emulsifiable concentrate spray	Permethrin	Spray/soak plumage, skin, and vent.	Wear protective clothing when making applications.
Ready to use dust or spray	Permethrin	Spot treat legs, tail, wings & comb. For dust, treat at the rate 1 lb. per 100 birds, make sure vent area is treated.	Wear protective clothing. If using dust, include a NIOSH approved respirator.

Disease and Nematode Management in Field Crops

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General Considerations

Disease and nematode control are essential components of crop management for maximizing yield potential. However, the need for and best tactics for disease and nematode control vary by crop, field, and year, and an ***integrated*** approach to management is necessary to minimize unnecessary inputs and maximize profits to the grower. Integrated disease and nematode management combines multiple approaches including cultivar selection, cultural practices such as crop rotation, and judicious use of pesticides based on disease advisories, economic thresholds, and/or scouting. The following points should be considered when making disease and nematode management decisions:

- **Susceptibility of crop variety to disease and/or nematodes.** Varieties have a high turnover rate so check with your local extension office or seed dealer for current information on which varieties have some level of resistance. Be aware of the specific diseases and nematodes your variety is susceptible or resistant to.
- **Yield potential and commodity price.** If yield potential or price received is low, you do not have much to gain and pesticide applications are less likely to be profitable.
- **Previous crop and cropping system (e.g. no till).** Many pathogens are able to survive on crop residues. Tillage and rotation to non-host crops helps bury and decompose this residue. Keep in mind that some require a living plant host and must move in from warmer regions each year (e.g. some rusts). Crop parasitic nematodes need a plant host to reproduce, so nematodes with a narrow host range can be controlled by rotating to a non-host.
- **Crop growth stage and timing of fungicide applications.** Diseases are more likely to impact yield at particular growth stages of the crop (typically during development of the grain) so timing fungicide applications accordingly is key.
- **Proper pathogen and nematode identification.** Field crops can be affected by a variety of fungi, bacteria, viruses, and nematodes. Each type of pathogen requires a different approach for disease management. Many abiotic issues including compaction, drought, nutrient deficiencies, and chemical damage can appear similar to some diseases. Proper identification of biotic and abiotic problems impacting the crop are key to avoiding ineffective or unnecessary chemical applications.
- **Disease and nematode pressure.** Are diseases present at amounts that require intervention? Scout fields regularly to maximize profits. Future nematode management decisions can be based on economic damage thresholds if crop parasitic nematode populations are quantified at harvest.
- **Weather.** Temperature and humidity greatly influence the onset and development of disease. Even if the crop is susceptible and a pathogen is present, the risk of yield loss to disease may be low if environmental conditions are not conducive pathogen growth and reproduction. Warm, humid conditions are favorable for many foliar diseases in our region. In some cases, the micro-climate within a field may be conducive for disease development even when ambient conditions are relatively dry, especially when high plant populations and a dense canopy are present in a field.

All of these factors should be considered before making plant disease and nematode management decisions, especially before applying a fungicide or nematicide that may or may not be needed. **Diseases and nematodes are most effectively managed by integrating several of the following practices:**

1. **Adapted, disease and nematode resistant cultivars** - produce plants able to resist disease and nematode attack. Every variety has a disease and nematode resistance "package" that provides levels of resistance or tolerance to specific pests. This information can be obtained from seed dealers, commercial companies, and University variety trials such as those conducted at Virginia Tech and The University of Delaware. Some diseases and nematodes cannot be managed with resistance, and not every variety has adequate resistance to all potential pests. However, growers who do not consider resistance when selecting varieties are taking a considerable and likely a costly, risk.
2. **Rotation** - avoid build up of pathogens and nematodes by not continually planting the same crop in the same fields year after year. Rotation reduces the amount of residue, and therefore the amount of some pathogens, in fields. Rotation also is essential for reducing populations of some plant parasitic nematodes.

3. **Sanitation** – use tillage when possible and manage weeds. Deep tillage (not disking) buries plant pathogens, favoring their decomposition and reducing their ability to reach the plant and cause damage. However, many pathogens are "regional" and therefore disking one field may not have any impact on disease if nearby fields contain ample residue. In addition, the widespread use of conservation or no-till agriculture prohibits the use of tillage, making it impractical in many cases.
4. **Planting date** - avoid pathogens or reduce the infection period by avoiding early planting. This is particularly effective in managing seedling diseases.
5. **Seed bed preparation and balanced fertility** - provide good seed to soil contact and fertility to promote vigorous plant stands. Healthy plants are likely to be less stressed and less prone to some diseases and damage from parasitic nematodes.
6. **Good quality, disease-free seed** - promote healthy, vigorous seedling development. In addition, some diseases can move in or on seed. Using clean, certified seed can help reduce the development of these diseases and maximize stands.
7. **Chemical control** - judicious use of fungicides and nematicides is necessary is some cropping situations. If pathogen or nematode pressure is high, chemical control may be needed to protect crop yields.

This section includes lists of fungicides and nematicides that are currently registered for use in field crops in the region. The information in this section is provided as a guide to available products but does not substitute for or supersede the information found on the pesticide label of a specific product. Trade names are included to aid in the identification of the specific active ingredient of a pesticide known to be effective. No discrimination against a similar product is intended or implied by omission. Mention of a commercial product does not constitute an endorsement by the authors or by their respective Extension Services. Consult the pesticide label for any changes in rate, timing, handling, or registration. Use pesticides only as directed.

Corn and Sorghum Diseases

Seed and Seedling Diseases of Corn and Sorghum

Seed treatment for corn continues to be a highly effective and inexpensive disease management tool for early-season seed and soilborne problems. In particular, because corn yield depends on plant population, seed treatments help to protect the yield potential by reducing stand losses from early-season diseases. As a result all major brands of hybrid seed are sold already treated. Similarly, hybrid sorghum production also benefits from seed treatments, as nontillering types depend on emergence to achieve optimum plant populations. Treating sorghum seed is also important for preventing the development of certain seedborne smut diseases and the systemic form of downy mildew and for reducing the introduction of and damage caused by sorghum ergot. Hybrid sorghum seed, like corn, is therefore sold already treated.

Foliar Diseases of Corn

A few chemical control measures are registered for foliar diseases of corn. However, they are generally not necessary when resistant hybrids and proper crop rotations are employed. Occasionally, when a highly susceptible hybrid is planted no-till into corn stubble and favorable conditions develop for a disease such as gray leaf spot, an economic return on a fungicide can be realized. Use resistant hybrids, especially in continuous no-till production systems. Many disease causing organisms are harbored in infested corn debris; thus, they are more readily available to infect corn in systems where debris remains on the soil surface and is allowed to build up. Foliar fungicides do not directly control stalk rots. However, lodging due to stalk rotting can be reduced through the management of foliar diseases. Hybrids with resistance to leaf diseases or susceptible hybrids treated with a fungicide are less likely to have severe stalk rotting. Hybrids with good "stay green" characteristics are also less likely to have severe stalk rotting. Foliar fungicide use in the absence of foliar disease pressure or risk is not recommended.

Gray Leaf Spot, Southern Corn Leaf Blight, and Northern Corn Leaf Blight

Three economically important blighting diseases of corn in Virginia and the mid-Atlantic region are gray leaf spot (*Cercospora zeae-maydis*), southern corn leaf blight (*Bipolaris maydis*), and northern corn leaf blight (*Setosphaeria turcica*). Gray leaf spot is recognized by its characteristically long rectangular lesions (1/8 - 1/4 inch wide and 1/2 to 2 1/2 inches in length). These lesions typically show a grayish cast when the fungus is sporulating. As the disease progresses from the lower leaves upward and the disease becomes more severe, lesions may coalesce and cause the death of the entire leaf. (See Virginia Cooperative Extension Fact Sheet: Grayleaf Spot Disease of Corn, Pub. No. 450-612, at *http://pubs.ext.vt.edu/450/450-612/450-612.html)*. Northern corn leaf blight lesions are long (2 - 6 inches), wide (1 - 1.5 inches), and elliptical or boat-shaped. Lesions are tan to

gray-green and may show faint concentric rings of spores on the lesion surface. Southern corn leaf blight lesions are elongated between veins, tan, and up to 1 inch long with parallel margins. Southern leaf blight is favored by warmer weather compared to northern leaf blight and gray leaf spot.

Yield Loss

Foliar diseases are most damaging when leaves are blighted at or just after silking stage. At this critical time it can cause severe yield reduction. Early blighting of the leaves above the ear leaf on susceptible hybrids has led to severe yield losses often exceeding 50% in experimental plots in Virginia. Blighting that does not occur until the R5 (dent) growth stage results in very little grain loss. Premature stalk death and lodging is enhanced by severe leaf blighting and leads to difficulty in mechanically harvesting. Hybrids that are more resistant and slow to blight may prevent significant yield reduction.

Epidemiology

An understanding of the epidemiology of these foliar fungal pathogens is helpful in understanding why the disease has increased in intensity, severity, and distribution over the past 25 years. *C. zeae-maydis* and other fungal pathogens overwinter in the debris of previously diseased corn plants remaining on the soil surface. In spring, conidia (spores) are produced and disseminated to corn plants by wind and splashing rain. These conidia require several days of high relative humidity to germinate and infect corn leaves. Several weeks may be required for the development of mature lesions on leaves. Conidia for secondary spread are produced from two to four weeks after initial leaf infection. No till or minimal till production systems serve as overwintering sources for the fungus and provide the primary inoculum to produce severe levels of foliar disease in the next season.

Management of Gray Leaf Spot, Southern Corn Leaf Blight, and Northern Corn Leaf Blight

In conventional tillage systems, burying residue through tillage will significantly reduce disease pressure for the subsequent corn crop. Growers utilizing a minimal tillage system should promote residue decomposition by sizing residue, turbo tilling, or lightly discing fields. Avoid planting into unworked corn residue. Growers should continue to use conservation tillage methods wherever practical, but consider planting different crops in rotation with corn in their farming system. A one- or two-year rotation away from corn will help reduce inoculum levels of these fungal pathogens. However, infested (diseased) corn debris on adjacent fields may be plentiful enough to initiate significant disease losses on moderately- to highly-susceptible hybrids. Growers with a history of gray leaf spot in their fields are encouraged to select one or more of the newer gray leaf spot resistant hybrids. Selection should be based on yield potential and standability under gray leaf spot pressure.

Common and Southern Rust

Common and Southern rusts can occasionally cause yield loss in the mid-Atlantic region. The fungi causing rusts require a living host to survive and reproduce and as a result do not survive the winter months. Each growing season these pathogens must blow into the mid-Atlantic from central America and parts of the deep south. Damage is dependent on when these diseases arrive relative to the growth stage of corn. Arrival of either disease before the R3 (milk) growth stage could result in significant yield loss under the appropriate conditions. Rusts are characterized by orange pustules that occur on foliage. When these pustules are rubbed against hands or clothing they will leave an orange to brown, rusty color (hence the name rust). Common rust pustules are often ellipsoid, cinnamon brown, and can be found on both the upper and lower surfaces of the leaf. In contrast, Southern rust forms round, brown to orange pustules that are found predominantly on the upper leaf surface. Pustules may also be found on husks and stalks. Disease development of common rust is favored by moderate temperatures (42-77°F) whereas Southern rust prefers warmer weather (77-82°F). Hot temperatures limit the development of common rust and causes pustules to become inactive. As a result, Southern rust typically arrives later in the growing season (July-August) compared to common rust.

Yield Loss

Rusts are most damaging when they reach the ear leaf or above by R3. Estimates for yield losses vary, but range from 3-8% for each 10% of total leaf area infected by the R5 (dent) growth stage.

Management of Rusts

Selection of hybrids with good resistance is the primary means of managing both rusts. In 2008, a race of Southern rust was identified that was able to overcome a Southern rust resistance gene. Fungicides applied preventatively can help to manage rusts; however, optimal timings likely differ for the two diseases. Movement of Southern rust can be monitored on the ipmPIPE website (scr.ipmpipe.org).

Stalk Rots

Stalk rots are the most common and devastating diseases/disorders affecting corn. These diseases are insidious, and often growers are unaware of their effects until harvest. Low levels of stalk rot occur in nearly every corn field in the mid-Atlantic, and severity and incidence varies from year to year. Losses of over 50% can occur in severe cases.

Stalk rot pathogens decay the central pith, which weakens the stalk. One can envision a healthy stalk being a solid rod of plant tissue. A rotted stalk is no more than a tube with decaying pith loosely packed inside. Thus, corn suffering from stalk rot may easily lodge when exposed to windy conditions. Initial symptoms of stalk rots include premature wilting and ear drop. As the disease progresses stalks senesce rapidly and turn brown to grey.

Factors that Favor Stalk Rots

Carbohydrate Stress

Carbohydrate stress in corn can be caused by either limits to photosynthesis or over-commitment of carbohydrate resources to the ear. The following are generalizations. For more detailed information refer to agronomy texts or primary literature.

Limitation to photosynthesis can be caused by numerous factors. The most important factors impacting stalk rots in corn are foliar diseases, insect damage, cloud cover, high plant density, and nutrient and water deficiencies. Disease and insect damage reduce the amount of photosynthetic area, thereby reducing the overall carbon budget. As levels of damage to foliage by pathogens and pests increase, so too does the amount of stalk rot. Cloud cover and high planting density reduce the amount of light accessible to foliage and therefore photosynthetic rate. High planting densities also can limit access to water and nutrients, which reduce photosynthetic rate through other mechanisms.

Hybrid characteristics such as a large cob size and high kernel numbers may predispose plants to stalk rots. This is because the aforementioned factors increase the amount of "pull" the cob has on the plant carbon budget. After flowering the carbohydrates, produced through photosynthesis in the ear leaf, are preferentially diverted to the ear. However, if the ear leaf cannot meet the demands of grain fill, carbohydrates are mobilized from the root and stalk. Without a sufficient carbohydrate supply the production of chemicals for defense of plant tissues is reduced, resulting in increased levels of infection by stalk rotting pathogens. For this reason many of the stalk-rotting pathogens are opportunistic, and disease is caused by whatever organism happens to be in the vicinity when carbohydrate stress occurs

Fertility

Limited access to nutrients critical to photosynthesis can cause carbohydrate stress and increase stalk rots. Although there is variability in terms of specific nutrients and diseases, in general, stalk rots increase when nutrients are lost during the growing season. Conversely, over fertilization can cause excessively lush growth. Lush growth is often structurally weak and easily invaded by fungi.

Water

Limitations to water impact the amount of gaseous carbon that moves to the foliage from the atmosphere. Plants contain tiny openings in the foliage and stems that allow gas exchange. When water is plentiful, these openings open. When water is deficient, these openings close, which limits the amount of carbon that enters the plant leaf and therefore the amount of carbohydrates available for grain fill, plant defense, etc. Therefore, any factor that limits the ability of the plant to access water may ultimately predispose the plant to stalk rot. Excessively wet conditions can leach nitrogen from the soil and stress roots, facilitating fungal infection.

Hybrid Genetics

Hybrids differ in their susceptibility to stalk rots. In general, hybrids with low ratings of stalk strength or those that produce exceptionally large ears tend to be more prone to stalk rots than those with strong stalks and smaller ears. Hybrids also can differ in their water and nutrient use profiles, which as mentioned previously, impact the carbon budget of the plant.

Management

Management of stalk rots should include the use of: 1) hybrids with resistance to stalk rot pathogens and/or high ratings of stalk strength and stay green characteristics; 2) a balanced fertility program based on the environment, population, and hybrid; 3) programs to control foliar diseases and insects; 4) irrigation to avoid drought stress.

Fungicide Efficacy for Control of Corn Diseases

The Corn Disease Working Group (CDWG) has developed the following information on fungicide efficacy for control of major corn diseases in the United States. Efficacy ratings for each fungicide listed in the table were determined by field testing the materials over multiple years and locations by the members of the committee. Efficacy ratings are based upon level of disease control achieved by product, and are not necessarily reflective of yield increases obtained from product application. Efficacy depends upon proper application timing, rate, and application method to achieve optimum effectiveness of the fungicide as determined by labeled instructions and overall level of disease in the field at the time of application. Differences in efficacy among fungicide products were determined by direct comparisons among products in field tests and are based on a *single application* of the labeled rate as listed in the table. **Table includes systemic fungicides available that have been tested over multiple years and locations. The table is not intended to be a list of all labeled products**[1]. Efficacy categories: NR=Not Recommended; P=Poor; F=Fair; G=Good; VG=Very; Good; E=Excellent; NL = Not Labeled for use against this disease; U = Unknown efficacy or insufficient data to rank product.

Table 3.1 - Fungicides for management of foliar diseases in corn

Class	Active ingredient (%)	Product/Trade name	Rate/A (fl oz)	Anthracnose leaf blight	Common rust	Gray leaf spot	Northern leaf blight	Southern rust	Harvest Restriction [2]
QoI Strobilurins Group 11	Azoxystrobin 22.9%	Quadris 2.08 SC, Multiple Generics	6.0 - 15.5	VG	E	E	G	G	7 days
	Pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0 - 12.0	VG	E	E	VG	VG	7 days
	Picoxystrobin 22.5%	Aproach 2.08 SC	3.0 – 12.0	VG	VG-E	F-VG	VG	G	7 days
DMI Triazoles Group 3	Propiconazole 41.8%	Tilt 3.6 EC, Multiple Generics	2.0 - 4.0	NL	VG	G	G	F-G	30 days
	Prothioconazole 41.0%	Proline 480 SC	5.7	U	VG	U	VG	G	14 days
	Tebuconazole 38.7%	Folicur 3.6 F, Multiple Generics	4.0 - 6.0	NL	U	U	VG	F-G	36 days
	Tetraconazole 20.5%	Domark 230 ME, Multiple Generics	4.0 – 6.0	U	U	E	U	G	R3 (milk)
Mixed mode of action	Azoxystrobin 13.5% Propiconazole 11.7%	Quilt Xcel 2.2 SE, Multiple Generics	10.5 - 14.0	VG	VG-E	E	VG	VG	30 days
	Benzovindiflupyr 2.9% Azoxytrobin 10.5% Propiconazole 11.9%	Trivapro	13.7	U	U	E	VG	E	30 days
	Cyproconazole 7.17% Picoxystrobin 17.94%	Aproach Prima 2.34 SC	3.4 – 6.8	U	U	E	VG	G-VG	30 days
	Flutriafol 19.3% Fluoxastrobin 14.84%	Fortix 3.22 SC, Preemptor 3.22 SC	4.0 -6.0	U	U	E	VG-E	VG	R4 (dough)

Table 3.1 - Fungicides for management of foliar diseases in corn (cont.)

Fungicide(s)				Anthracnose leaf blight	Common rust	Gray leaf spot	Northern leaf blight	Southern rust	Harvest Restriction [2]
Class	Active ingredient (%)	Product/Trade name	Rate/A (fl oz)						
Mixed mode of action	Pyraclostrobin 13.6% Metconazole 5.1%	Headline AMP 1.68 SC	10.0 - 14.4	U	E	E	VG	G-VG	20 days
	Pyraclostrobin 28.58% Fluxapyroxad 14.33%	Priaxor 4.17 SC	4.0 – 8.0	U	VG	VG	VG-E	G	21 days
	Trifloxystrobin 32.3% Prothioconazole 10.8%	Stratego YLD 4.18 SC	4.0 - 5.0	VG	E	E	VG	G-VG	14 days
	Azoxystrobin 9.35% Tetraconazole 7.48%	Affiance 1.5 SC	10.0 - 17.0	U	U	U	G-VG	G	7 days

[1]Additional fungicides are labeled for disease on corn, including contact fungicides such as chlorothalonil. Certain fungicides may be available for diseases not listed in the table, including Gibberella and Fusarium ear rot. Applications of Proline 480 SC for use on ear rots requires a FIFRA Section 2(ee) and is only approved for use in Illinois, Indiana, Iowa, Louisiana, Maryland, Michigan, Mississippi, North Dakota, Ohio, Pennsylvania, and Virginia.

[2]Harvest restrictions are listed for field corn harvested for grain. Restrictions may vary for other types of corn (sweet, seed or popcorn, etc.), and corn for other uses such as forage or fodder. Many products have specific use restrictions about the amount of active ingredient that can be applied within a period of time or the amount of sequential applications that can occur. Please read and follow all specific use restrictions prior to fungicide use. This information is provided only as a guide. It is the responsibility of the pesticide applicator by law to read and follow all current label directions. Reference to products in this publication is not intended to be an endorsement to the exclusion of others that may be similar. Persons using such products assume responsibility for their use in accordance with current directions of the manufacturer. Members or participants in the CDWG assume no liability resulting from the use of these products.

Nematode Diseases of Corn

Cultural practices, in particular rotation with non-host crops or fallow, are the most effective nematode management tactics. The length of rotation needed depends on nematode population level and species. Only when these practices are not feasible should chemical control measures be considered. Fumigant nematicides are not recommended. Non-fumigant nematicides will suppress populations and reduce infection but will not provide full-season control. Seed treatments have early season activity against nematodes. Until more independent test information is available, expect seed treatment control of nematodes to be shorter-lived than soil treatments. Nematode infestations are not uniformly distributed in fields. Therefore, plan to treat problem sites rather than whole fields. Base the need for a nematicide on the results of a soil test for the presence and level of plant parasitic nematodes and on the site history. The best time to collect samples for nematode testing is fall, immediately after harvest. Before deciding to use a nematicide, consult your county Extension office for information on proper soil sampling procedures for nematode testing and for information on threshold levels. Nematode testing is available for a fee through Virginia Cooperative Extension and some commercial soil testing laboratories.

Table 3.2 - Corn Nematicides

Nematodes	Active ingredient	Trade name	Application rate per acre	PHI (days)	Remarks
Southern root-knot, stubby-root, sting, lesion, lance, and stunt	terbufos	Counter 20G	5.0-6.5 oz	7	Apply at planting in seed furrow or 8 in. band over row and incorporate in soil. Use of ALS herbicides on corn treated with Counter may cause crop injury.
	clothianidin + *Bacillus firmus*	Poncho/ Votivo	2.7 fl oz/80,000 seeds	-	Must be applied to seed by commercial liquid application equipment for suppression of insect pests and nematodes
	abamectin + thiamethoxam	Avicta Duo	Rate based on seed count per bag	-	Application only in Syngenta-certified corn seed treatment facilities having closed transfer and application systems.
	Burkholderia rinojensis	BioST Nematicide 100	8 oz/100 lb seed	-	Also provides protection against soil dwelling insects.

Foliar, Stalk, and Grain Diseases of Sorghum

Diseases impacting sorghum grain production in the mid-Atlantic include anthracnose, stalk rots, and head mold. *Colletotrichum sublineolum*, the causal agent of sorghum anthracnose, infects vegetative portions of the plant (leaf, stalk), the panicle, and the grain, and significant yield losses to this disease have been documented. Stalk rots, caused by fungi including *C. sublineolum* and *Fusarium* spp., can interfere with grain filling and cause lodging of the sorghum plant. Head mold of sorghum, caused by various fungi including mycotoxin-producing *Fusarium* spp., reduces grain mass and quality, has the potential to result in mycotoxin contamination of the grain, and may result in further grain deterioration during storage. Best management practices for controlling fungal diseases of sorghum include selection of resistant hybrids, maintaining soil fertility, and timely harvest so that fungal deterioration and mycotoxin contamination of grain is less likely to occur. Sorghum anthracnose can be controlled with foliar applications of the registered fungicides listed below.

Table 3.3 - Foliar applied fungicides for sorghum

Active ingredient	Fungicide trade name	Application rate per acre	PHI (days)	Remarks
Azoxystrobin	Quadris, Multiple Generics	6.0-15.5	14	Group 11 fungicides. To reduce the development of fungi resistant to this group of fungicides, do not apply more than two sequential applications of this or other group 11 containing fungicide per season.
Azoxystrobin + Propiconazole	Quilt, Xcel, Multiple Generics	10.5-14.0	21	Group 11 fungicides. To reduce the development of fungi resistant to this group of fungicides, do not apply more than two sequential applications of this or other group 11 containing fungicide per season.
Picoxystrobin	Aproach	6.0-12.0	Do not apply after flowering.	Group 11 fungicides. To reduce the development of fungi resistant to this group of fungicides, do not apply more than two sequential applications of this or other group 11 containing fungicide per season.
pyraclostrobin	Headline SC	6.0-12.0	Apply no later than 25% flowering.	Group 11 fungicide. Do not make more than one application per year.
fluxapyroxad + pyraclostrobin	Priaxor	4.0 – 8.0	21	Do not make more than one application. Do not apply more than 8 fl oz/A per season.
fluxapyroxad + pyraclostrobin + propiconazole	Nexicor	7.0-13.0	21	Group 11 fungicide. Do not make more than one application per year.
Fluoxastrobin	Evito 480 SC	2.0-4.0	21	Group 11 fungicide. Do not make more than two applications per season with a minimum interval of 14 days between applications. Do not apply more than 8 fl oz/A per season.

Soybeans

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Managing Seed and Seedling Diseases of Soybeans

There are several pathogens that can kill seedlings and reduce soybean stands. Seedling diseases that may be problematic in mid-Atlantic soybeans include *Rhizoctonia* spp., *Fusarium* spp., and on occasion, *Pythium* spp. In general, environmental conditions that reduce germination and emergence increase the risk for seedling blights.

Scouting: Examine at least one site per 10 acres of field every week until 3-4 weeks after emergence.

Management: Plant soybeans when the daily soil temperatures at the 4 inch depth average at least 65 F or more. Avoid compaction and improve drainage when practical. Consider seed treatments for seed lots that have less than 85 percent germination (by the warm germination test). There are many commercial seed treatments available that may help with stand establishment, and can help improve stands in some circumstances. Treat seed with a fungicide if germination is lower than 85 percent. Seed with germination below 75 percent generally should not be treated or used for seed. Many of the newer seed treatments have low use rates and must be applied by certified seed treatment applicators. Consult with your chemical or seed salesperson or agricultural supply dealer for product information. Hopper-box or slurry applications are still available. Remember, once seed are treated, they cannot be used for food, feed, or oil.

Fungicide Efficacy for Control of Soybean Seedling Diseases

The members of the Identification and Biology of Seedling Pathogens of Soybean project funded by the North Central Soybean Research Program and plant pathologists across the United States have developed the following ratings for how well fungicide seed treatments control seedling diseases of soybeans in the United States. Efficacy ratings for each fungicide active ingredient listed in the table were determined by field-testing the materials over multiple years and locations by the members of this group, and include ratings summarized from national fungicide trials published in Plant Disease Management Reports (and formerly Fungicide and Nematicide Tests) by the American Phytopathological Society at http://www.apsnet.org. Each rating is based on the fungicide's level of disease control, and does not necessarily reflect efficacy of fungicide active ingredient combinations and/or yield increases obtained from applying the active ingredient.

The list includes the most widely marketed products available. It is not intended to be a list of all labeled active ingredients and products. Additional active ingredients may be available, but have not been evaluated in a manner allowing a rating. Products listed are the most common products available as of the release date of the table; all available products may not be listed. Additional active ingredients may be included in some products for insect and nematode control, however; only active ingredients for pathogen control are listed and rated.

Many active ingredients and their products have specific use restrictions. Read and follow all use restrictions before applying any fungicide to seed, or before handling any fungicide-treated seed. This information is provided only as a guide. It is the applicator's and users legal responsibility to read and follow all current label directions. Reference in this publication to any specific commercial product, process, or service, or the use of any trade, firm, or corporation name is for general informational purposes only and does not constitute an endorsement, recommendation, or certification of any kind by members of the group, or by the North Central Soybean Research Program. Individuals using such products assume responsibility for their use in accordance with current directions of the manufacturer. Efficacy categories: E = Excellent; VG = Very Good; G = Good; F = Fair; P = Poor; NR = Not Recommended; NS = Not Specified on product label; U = Unknown efficacy or insufficient data to rank product. Please note: Efficacy ratings may be dependent on the rate of the fungicide product on seed. Contact your local Extension plant pathologist for recommended fungicide product rate information for your area.

Table 3.4 - Fungicide Efficacy for Control of Soybean Seedling Diseases

Fungicide active ingredient	Pythium sp.[1.]	Phytophthora root rot	Rhizoctonia sp.	Fusarium sp.[1,3]	Sudden death syndrome (SDS) (Fusarium virguliforme)	Phomopsis sp.
Azoxystrobin	P-G	NS	VG	G	NR	P
Carboxin	U	U	G	U	NR	U
Chloroneb	U	P	E	P	NR	P
Ethaboxam	E	E	U	U	U	U
Fludioxonil	NR	NR	G	F-VG	NR	G
Fluopyram	NR	NR	NR	NR	VG	NR
Fluxapyroxad	U	U	E	G	NR	G
Ipconazole	P	NR	F-G	F-E	NR	G
Mefenoxam	E[2]	E	NR	NR	NR	NR
Metalaxyl	E[2]	E	NR	NR	NR	NR
PCNB	NR	NR	G	U	NR	G
Penflufen	NR	NR	G	G	NR	G
Prothioconazole	NR	NR	G	G	NR	G
Pyraclostrobin	P-G	NR	F	F	NR	G
Sedaxane	NR	NR	E	NS	NR	G
Thiabendazole	NR	NR	NS	NS	P	U
Trifloxystrobin	P	P	F-E	F-G	NR	P-F

[1.] Products may vary in efficacy against different *Fusarium* and *Pythium* species.
[2.] Areas with mefenoxam or metalaxy insensitive populations may see less efficacy with these products.
[3.] Listed seed treatments do not have efficacy against *Fusarium virguliforme*, causal agent of sudden death syndrome.

Table 3.5 - Seed treatment products containing seedling disease fungicides

Product/Trade name	Active ingredient
Acceleron	DX-612 Fluxapyroxad DX-309 Metalaxyl DX-109 Pyraclostrobin
Allegiance FL	Metalaxyl
Allegiance LS	Metalaxyl
Apron XL LS	Mefenoxam
ApronMaxx RFC	Fludioxonil Mefenoxam
ApronMaxx RTA	Fludioxonil Mefenoxam
Catapult XL	Chloroneb Mefenoxam
CruiserMaxx	Fludioxonil Mefenoxam
CruiserMaxx Advanced or Cruiser Maxx Plus	Fludioxonil Mefenoxam

Table 3.5 - Seed treatment products containing seedling disease fungicides (cont.)

Product/Trade name	Active ingredient
CruiserMaxx Advanced Vibrance	Fludioxonil
	Mefenoxam
	Sedaxane
Dynasty	Azoxystrobin
EverGol Energy SB	Metalaxyl
	Penflufen
	Prothioconazole
ILeVO	Fluopyram
Inovate Pro	Ipconazole
	Metalaxyl
Intego	Ethaboxam
Maxim 4FS	Fludioxonil
Mertect 340 F	Thiabendazole
Prevail	Carboxin
	Metalaxyl
	PCNB
Trilex 2000	Metalaxyl
	Trifloxystrobin
Vibrance	Sedaxane
Warden CX	Fludioxonil
	Mefenoxam
	Sedaxane
Warden RTA	Fludioxonil
	Mefenoxam

Managing Foliar, Stem, and Pod Diseases of Soybeans

Foliar fungicides are tools that protect yields from plant pathogenic fungi. Research indicates that foliar applied fungicides do not always increase soybean yields in the mid-Atlantic and may not be economical in the absence of disease.

Scouting: Scout fields for foliar disease at 7 to 14 day intervals from growth stage R1 (flowering) up to R6 (full seed) for early detection of disease and effective timing of fungicide sprays.

Management: Plant varieties with resistance or tolerance to common foliar diseases. Fungicides may be needed to protect yield if a variety is susceptible to disease, disease pressure is high, and/or weather conditions are conducive for disease development (e.g. warm and wet/humid). Fungicides are more likely to be beneficial and economical for soybeans that are grown for seed production, as seed quality can be protected from moderate infestations and/or late season diseases.

Vegetative Growth Stages: Current data indicate that fungicide applications are not needed in the early vegetative growth stages. Spraying just prior to crop flowering (R1) may be prudent if a disease is increasing. Fungicide applications are not recommended after the crop reaches the full pod (R6) growth stage.

R1-R5 Reproductive Stages: Foliar, pod, and stem diseases are most prevalent, and increase most rapidly, during crop reproductive-growth stages. Foliar fungicides may or may not be needed to protect soybean yield. Decisions of whether or not to apply foliar fungicides should be based on susceptibility of the planted variety to disease, disease pressure, weather conditions, and cropping system (see introduction for more information on integrated disease management). In the absence of a need for

disease control at growth stages R1-R2, the most likely stages for disease to impact yield would be stages R3, R4, or R5. Consecutive applications of either strobilurins or triazoles alone should never be made due to resistance concerns. For example, resistance to QoI (Group 11) fungicides has been reported in frogeye leaf spot in Virginia and other states where soybean is grown. Refer to fungicide labels for specific directions and restrictions.

R6 and later: Spraying at late-growth stages is not recommended due to lack of yield response. In addition, many fungicides have days-to-harvest (preharvest) intervals or growth-stage restrictions. Refer to fungicide labels for specific directions and restrictions.

Fungicides for Managing Soybean Diseases

The North Central Regional Committee on Soybean Diseases (NCERA-137) has developed the following information on foliar fungicide efficacy for control of major foliar soybean diseases in the United States. Efficacy ratings for each fungicide listed in the table were determined by field-testing the materials over multiple years and locations by the members of the committee. Efficacy ratings are based upon level of disease control achieved by product, and are not necessarily reflective of yield increases obtained from product application. Efficacy depends upon proper application timing, rate, and application method to achieve optimum effectiveness of the fungicide as determined by labeled instructions and overall level of disease in the field at the time of application. Differences in efficacy among fungicide products were determined by direct comparisons among products in field tests and are based on a single application of the labeled rate as listed in the table, unless otherwise noted. Table includes systemic fungicides available that have been tested over multiple years and locations. The table is not intended to be a list of all labeled products. Efficacy categories: NR = Not Recommended; P = Poor; F = Fair; G = Good; VG = Very Good; E = Excellent; NL = Not labelled for use against this disease; U = Unknown efficacy or insufficient data to rank product efficacy.

Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases

Fungicide(s)				Arial web blight	Anthracnose	Brown spot	Cercospora leaf blight[2]	Frogeye leaf spot[3]	*Phomopsis/ Diaporthe* (Pod and stem blight)	Soybean rust	White mold[4]	Harvest Restriction[5]
Class	**Active ingredient (%)**	**Product/Trade name**	**Rate/A (fl. oz)**									
QoI Strobilurins Group 11	Azoxystrobin 22.9%	Quadris 2.08 SC[6], Multiple Generics	6.0-15.5	VG	VG	G	P	P	U	G-VG	P	14 days
	Fluoxastrobin 40.3%	Aftershock 480 SC Evito 480 SC	2.0-5.7	VG	G	G	P	P	U	U	NL	R5 (beginning seed) 30 days
	Picoxystrobin	Aproach 2.08SC	6.0-12.0	VG	G	G	P	P	U	G	G[8]	14 days
	Pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0-12.0	VG	VG	G	P	P	U	VG	NL	21 days
DMI Triazoles Group 3	Cyproconazole 8.9%	Alto 100 SL	2.75–5.5	U	U	VG	F	F	U	VG	NL	30 days
	Flutriafol 11.8%	Topguard 1.04SC	7.0–14.0	U	VG	VG	P-G	VG	U	VG-E	F	21 days
	Propiconazole 41.8%	Tilt 3.6EC Multiple Generics[6]	2.0-4.0	P	VG	G	NL	F	NL	VG	NL	R5 (beginning seed)
	Prothioconazole 41.0%	Proline 480SC[7]	2.5-5.0	NL	NL	NL	NL	G-VG	NL	VG	F	21 days
	Tetraconazole 20.5%	Domark 230ME Multiple Generics	4.0–5.0	NL	VG	VG	P-G	G-VG	U	VG-E	F	R5 (beginning seed)
MBC Thiophanates Group 1	Thiophanate-methyl	Topsin-M Multiple Generics	10.0–20.0	U	U	U	F	VG	U	G	F	21 days
SDHI Carboximides Group 7	Boscalid 70%	Endura 0.7 DF	3.5 – 11.0	U	NL	VG	U	P	NL	NL	VG	21 days

Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases (cont.)

Fungicide(s)				Aerial web blight	Anthracnose	Brown spot	Cercospora leaf blight[2]	Frogeye leaf spot[3]	*Phomopsis/ Diaporthe* (Pod and stem blight)	Soybean rust	White mold[4]	Harvest Restriction[5]
Class	**Active ingredient (%)**	**Product/Trade name**	**Rate/A (fl. oz)**									
Mixed mode of action	Azoxystrobin 18.2% Difenconazole 11.4%	Quadris Top 2.72 SC	8.0 – 14.0	U	U	G-VG	P-G	VG	U	VG	NL	14 days
	Azoxystrobin 19.8% Defenoconazole 19.8%	Quadris Top SBX 3.76 SC	7.0 – 7.5	U	U	U	U	G-VG	U	U	U	14 days
	Azoxystrobin 7.0% Propiconazole 11.7%	Quilt 1.66 SC Multiple Generics[6]	14.0 – 20.5	U	U	G	F	F	U	VG	NL	21 days
	Azoxystrobin 13.5% Propiconazole 11.7%	Quilt Xcel 2.2 SE	10.5 - 21.0	E	VG	G	F	F	U	VG	NL	R6
	Pyraclostrobin 28.58% Fluxapyroxad 14.33%	Priaxor 4.17 SC	4.0 – 8.0	E	VG	E	P-G	P-F	U	VG	P	21 days
	Pyraclostrobin 28.58% Fluxapyroxad 14.33% Tetraconazole 20.50%	Priaxor D 4.17 SC 1.9 SC	4.0 (each compo-nent)	U	U	VG	U	G-VG	U	U	P	21 days R5 (begin-ning seed)
	Trifloxystrobin 32.3% Prothioconazole 10.8%	Stratego YLD 4.18 SC[8]	4.0 – 4.65	VG	VG	VG	F	F	U	VG	NL	21 days
	Cyproconazole 7.17% Picoxystrobin 17.94%	Aproach Prima 2.34 SC	5.0-6.8	U	U	VG	P-G	G	U	U	NL	14 days

Table 3.6 - Foliar Fungicide Efficacy for Control of Foliar Soybean Diseases (cont.)

Fungicide(s)				Aerial web blight	Anthracnose	Brown spot	Cercospora leaf blight[2]	Frogeye leaf spot[3]	*Phomopsis/ Diaporthe* (Pod and stem blight)	Soybean rust	White mold[4]	Harvest Restriction[5]
Class	**Active ingredient (%)**	**Product/Trade name**	**Rate/A (fl. oz)**									
	Flutriafol 19.3% Fluoxastrobin 14.84%	Fortix SC Preemptor SC	4.0-6.0	U	U	G	P-G	VG	U	U	U	R5 (beginning seed)
	Trifloxystrobin 32.3% Prothioconazole 10.8%	Stratego YLD 4.18 SC[8]	4.0-4.65	VG	VG	VG	F	F	U	VG	NL	21 days
	Tetraconazole 7.48% Azoxystrobin 9.35%	Affiance 1.5 SC	10.0-14.0	U	VG	VG	F	G	U	U	U	14 days R5
	Benzovindiflupyr 2.9% Propiconazole 11.9% Azoxystrobin 10.5%	Trivapro	13.7-20.7	E	U	VG	P-G	F-G	G	VG-E	NL	14 days R6

[1]Multiple fungicides are labeled for soybean rust only, powdery mildew, and Alternaria leaf spot, including tebuconazole (multiple products) and Laredo (myclobutanil). Contact fungicides such as chlorothalonil may also be labeled for use.
[2]Cercospora leaf blight efficacy relies on accurate application timing, and standard R3 application timings may not provide adequate disease control. Fungicide efficacy may improve with earlier or later applications. Fungicides with a solo or mixed QoI or MBC mode of action may not be effective in areas where QoI or MBC resistance has been detected in the fungal population that causes Cercospora leaf blight.
[3]In areas where QoI-fungicide resistant isolates of the frogeye leaf spot pathogen are NOT present, QoI fungicides may be more effective than indicated in this table.
[4]White mold efficacy is based on an R1-R2 application timing, and lower efficacy is obtained at an R3 application timing, or if disease symptoms are already present at the time of application.
[5]Harvest restrictions are listed for soybean harvested for grain. Restrictions may vary for other types of soybean (edamame, etc.) and soybean for other uses such as forage or fodder.
[6]Multiple generic products containing this mode of action may also be labeled in some states.
[7]Proline has a supplemental label (2ee) for soybean, only for use on white mold in IL, IN, IA, MI, MN, NE, ND, OH, SD, WI. A separate 2ee for NY exists for white mold.
[8]Stratego YLD has a supplemental label (2ee) for white mold on soybean only in IL, IN, IA, MI, MN, NE, ND, OH, SD, WI.
Many products have specific use restrictions about the amount of active ingredient that can be applied within a period of time or the amount of sequential applications that can occur. Please read and follow all specific use restrictions prior to fungicide use. This information is provided only as a guide. It is the responsibility of the pesticide applicator by law to read and follow all current label directions. Reference to products in this publication is not intended to be an endorsement to the exclusion of others that may be similar. Persons using such products assume responsibility for their use in accordance with current directions of the manufacturer. Members or participants in the NCERA-137 group assume no liability resulting from the use of these products.

Managing Nematodes in Soybean

Scouting and sampling: Scout every other week from flowering (R1) through maturity. Affected plants often occur in circular patches, in sandy soils, and raised areas of the field. Symptoms include stunting, wilting, yellowing of leaf margins, and reduced nodulation of roots. In severe cases plants may die. In order to determine if nematodes are present, growers should collect soil samples and have them assessed by a nematode diagnostic lab. Consult your local Extension office for more information on proper sampling procedures for nematode testing. Once nematodes are identified and quantified, management decisions can be made based on whether or not nematode populations present in the field exceed economic risk thresholds.

Table 3.7 - Nematode Economic Damage Thresholds for Soybeans (per 500 cm^3 soil)

	LOW	MODERATE	HIGH
Soybean cyst larvae	0-20	20-60	>60
Cysts	0	-	>1
Soybean cyst eggs	0-500	500-4,000	>4,000
Lance	0-300	300-1,000	>1,000
Lesion	0-100	100-500	>1,000
Ring	0-200	200-700	>700
Root-Knot	0-50	50-170	>170
Spiral	0-1000	>1,000	-
Sting	0-10	10-20	>20
Stubby Root	0-90	>90	-
Stunt	0-300	300-1,000	>1,000

Low = nematodes are unlikely to cause crop damage.
Moderate = borderline populations in which crop damage may occur if other factors stress the crop
High = populations likely to cause crop damage and significant yield loss

Prevention and Sanitation: Sanitation measures should be implemented that prevent the spread of nematodes. Equipment, especially tillage equipment, will spread nematodes from one field to another. Reducing tillage has been an effective means of control. All equipment should be cleaned thoroughly after coming out of a field known to be infected with nematodes.

Rotation: Crop rotation is the best option for reducing nematodes. However, many nematodes can survive, reproduce and/or increase in numbers in other crops. For rotation to work, the rotational crop must not be a host to that particular nematode. Unfortunately, soybeans host nearly all damaging species. Use the table below to help choose good rotational crops.

Table 3.8 - Acceptable Rotations Using Common Crops Grown in Virginia for Several Nematode Species

Nematode	Corn	Cotton	Peanut	Soybean	Perennial grass forage
Soybean Cyst	Yes	Yes	Yes	No	Yes
Dagger	Yes	Yes	No	No	Yes
Lance	No	No	Yes	No	No
Lesion	No	No	No	No	Yes
Ring	No	Yes	No	No	No
Northern Root- Knot	Yes	Yes	No	No	Yes
Southern Root-Knot	No	No	Yes	No	Yes
Spiral	Yes	Yes	Yes	No	Yes
Sting	No	No	No	No	Yes
Stubby Root	No	No	No	No	No
Stunt	Yes	Yes	Yes	No	Yes

*Note that no indicates that the crop is not a good rotational crop and “yes” indicates the crop is a poor or non-host for the indicated nematode and therefore a good choice for a rotational crop.

Resistant Varieties: Use of resistant or tolerant varieties, when available, is an effective strategy for managing nematodes. One year of a rotation to a non-host crop may not reduce nematode populations below economic thresholds. Depending on the nematode species and one's crop rotation, variety selection may be the only option. Integrating a resistant variety with effective rotation will result in a greater response than just one tactic. Before purchasing seed review local reports of cultivar performance and characteristics for the region. Most soybean varieties have soybean cyst nematode resistance and a few have root-knot nematode resistance. Check seed-company guides or contact your seed provider for a list a nematode resistance and other traits.

Chemical control: The use of nematicides should be considered as a last resort due to economic factors and performance inconsistencies. Thus, growers should not rely solely on nematicides or seed treatments to control nematode populations. Seed treatments are generally applied to seed by commercial liquid application equipment and the rate is based on the seed count per bag.

Table 3.9 - Nematode seed treatments for soybean

Product	Nematode	Activity	Nematicide a.i.
Avicta Complete Beans	Root knot, soybean cyst, others	Fungicide Insecticide Nematicide	Abamectin
ILeVO	Root knot, soybean cyst, others	Fungicide Nematicide	Fluopyram
Clariva	Soybean cyst	Biological nematicide	*Pasteuria*
Poncho/VOTiVO	Root knot, soybean cyst	Biological nematicide	*Bacillus firmus*
BioST Nematicide 100	Root knot, soybean cyst, sting, others	Biological nematicide/ insecticide	*Burkholderia rinojenses*

Small Grains

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Small Grain Diseases

Disease management is critical for those interested in maximizing small grains yields and grain quality. Many diseases attack small grains in the mid-Atlantic and several significantly impact yields in disease favorable years. This section discusses how to manage diseases growers and consultants will encounter in mid-Atlantic small grains fields. Remember, management starts with accurate diagnosis. Contact your local Extension Agent, plant disease diagnostic clinic, or Extension Specialist for assistance with identifying and diagnosing issues in your small grains.

Table 3.10 - Effectiveness of Management and Cultural Practices on Diseases of Wheat

Diseases	Sanitation	Crop rotation	Planting date	Balanced fertility	Disease free seed	Resistant cultivars	Fungicide Seed	Fungicide Foliar	Insecticide Seed
Powdery mildew	-		2[1]	3	-	1	1	1	-
Leaf rust	-	-	3	-	-	1	3	1	-
Leaf and glume blotch	2	2	-	-	2	3	2	1	-
Tan spot	2	2	-	-	-	3	-	2	-
Loose smut	-	-	-	-	1	-	1	-	-
Head scab[2]	3	2	3	-	-	2	-	2	-
Take-all	2	1	3	3	-	-	-	-	-
Barley yellow dwarf	-	-	1	-	-	2	-	-	1
Wheat spindle streak	-	-	2	-	-	1	-	-	-
Wheat streak mosaic virus	1	2	-	-	-	-	-	-	-

[1]1 = highly effective; 2 = moderately effective; 3 = slightly effective; and - = no effect in reducing disease.

[2]Seed infested with the head scab fungus will produce weak seedlings that are prone to seedling blight. A fungicide seed treatment may be of some benefit if germination rates are acceptable. Scabby seed does not produce head-scabbed plants.

Table 3.11 - Effectiveness of Management and Cultural Practices on Diseases of Barley

Diseases	Sanitation	Crop rotation	Planting date	Balanced fertility	Disease free seed	Resistant cultivars	Fungicide Seed	Fungicide Foliar	Insecticide Seed
Covered smut	-	-	-	-	1[1]	2	1	-	-
Loose smut	-	-	-	-	1	2	1	-	-
Powdery mildew	-	-	2	3	-	1*	2	1	-
Leaf rust	-	-	2	-	-	1	3	1	-
Barley scald	1	1	-	-	-	1	-	1	-
Net blotch	1	1	-	-	-	1	2	1	-
Head scab[2]	1	2	3	-	-	-	-	2	-
Barley stripe	2	3	-	-	1	2	1	-	-
Barley yellow dwarf	-	-	2	-	-	1	-	-	1

[1]1 = highly effective; 2 = moderately effective; 3 = slightly effective; and - = no effect in reducing disease.

[2]Seed infested with the head scab fungus will produce weak seedlings that are prone to seedling blight. A fungicide seed treatment may be of some limited benefit if germination rates are acceptable. Scabby seed does not produce plants with head scab.

* The powdery mildew population has been shifting and some varieties that were previously resistant may now be suceptible to thie disease. An example of this occuring can be seen in Thoroughbred.

Managing Seed and Seedling Diseases of Small Grains

Some diseases such as loose smut, stinking smut, ergot, and some Fusarium diseases can be transmitted in or on seed. These diseases can potentially cause losses, although infrequently, in mid-Atlantic small grains. Fungicide seed treatments, properly applied, can be considered inexpensive stand establishment insurance. Seed treatments minimize losses from seed decay, seedling blights, and seed and soil borne diseases, and for small grains are the only means of combating the smut diseases. There are currently numerous seed treatment fungicides that are available for small grains. Many of these chemicals must be applied by certified seed treatment applicators. Consult with your chemical or seed salesperson or agricultural supply dealer for product information. Hopper-box or slurry applications are still available.

Foliar Fungicides in Small Grains

The North Central Regional Committee on Management of Small Grain Diseases (NCERA-184) has developed the following information on fungicide efficacy for control of certain foliar diseases of wheat for use by the grain production industry in the U.S. Efficacy ratings for each fungicide listed in the table were determined by field testing the materials over multiple years and locations by the members of the committee. Efficacy is based on proper application timing to achieve optimum effectiveness of the fungicide as determined by labeled instructions and overall level of disease in the field at the time of application. Differences in efficacy among fungicide products were determined by direct comparisons among products in field tests and are based on a single application of the labeled rate as listed in the table. Table 3.12 includes most widely marketed products, and is not intended to be a list of all labeled products.

Table 3.12 - Efficacy of Fungicides for Wheat Disease Control Based on Appropriate Application Timing

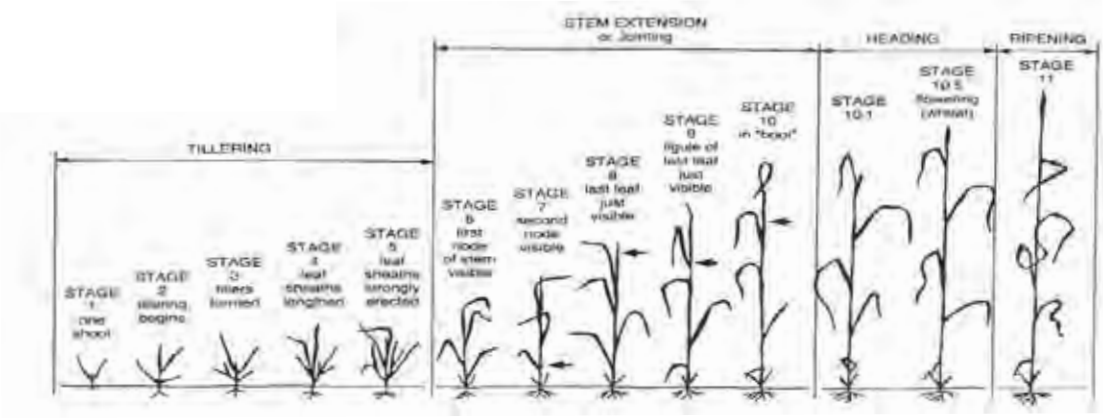
Fungicide(s)				Powdery mildew	Stagonospora leaf/glume blotch	Septoria leaf blotch	Tan spot	Stripe rust	Leaf rust	Stem rust	Head scab	Harvest Restriction
Class	Active ingredient(s)	Product	Rate/A (fl. oz)									
Strobilurin	Picoxystrobin 22.5%	Aproach SC	6.0 - 12	G[1]	VG	VG[2]	VG	E[3]	VG	VG	NL[4]	Feekes 10.5
	Fluoxastrobin 40.3%	Evito 480 SC	2.0 – 4.0	G	--	--	VG	--	VG	--	NL[4]	Feekes 10.5 and 40 days
	Pyraclostrobin 23.6%	Headline SC	6.0 - 9.0	G	VG[2]	VG[2]	E	E[3]	E	G	NL[4]	Feekes 10.5
Triazole	Metconazole 8.6%	Caramba 0.75 SL	10.0 - 17.0	VG	VG	--	VG	E	E	E	G	30 days
	Propiconazole 41.8%	Tilt 3.6 EC[5]	4.0	VG	VG	VG	VG	VG	VG	VG	P	Feekes 10.5.4
	Prothioconazole 41%	Proline 480 SC	5.0 - 5.7	--	VG	VG	VG	VG	VG	VG	G	30 days
	Tebuconazole 38.7%	Folicur 3.6 F[5]	4.0	NL	NL	NL	NL	E	E	E	F	30 days
	Prothioconazole19% Tebuconazole 19%	Prosaro 421 SC	6.5 - 8.2	G	VG	VG	VG	E	E	E	G	30 days
Mixed modes of action[6]	Metconazole 7.4% Pyraclostrobin 12%	TwinLine 1.75 EC	7.0 – 9.0	G	VG	VG	E	E	E	VG	NL[4]	Feekes 10.5
	Fluxapyroxad 14.3% Pyraclostrobin 28.6%	Priaxor	4.0 - 8.0	G	VG	VG	E	VG	VG	G	NL[4]	Feekes 10.5
	Fluoxastrobin 14.8% Pyraclostrobin 18.7% Propiconazole 11.7%	Nexicor EC	7.0-13.0	G	VG	VG	E	E	E	VG	NL[4]	Feekes 10.5
	Propiconazole 11.7% Azoxystrobin 13.5%	Quilt Xcel 2.2 SE[5]	10.5 - 14.0	VG	VG	VG	VG	E	E	VG	NL[4]	Feekes 10.5
	Prothioconazole 10.8% Trifloxystrobin 32.3%	Stratego YLD	4.0	G	VG	VG	VG	VG	VG	VG	NL[4]	Feekes 10.5 35 days
	Cyproconazole 7.17% Picoxystrobin 17.94%	Aproach Prima SC	3.4-6.8	VG	VG	VG	VG	E	VG	--	NR[4]	45 days
	Tebuconazole 22.6% Trifloxystrobin 22.6%	Absolute Maxx SC	5.0	G	VG	VG	VG	VG	E	VG	NL[4]	35 days
	Fluoxastrobin 14.8% Flutriafol 19.3%	Fortix	4.0 – 6.0	--	--	VG	VG	E	VG	--	NL[4]	Feekes 10.5 and 40 days
	Benzovindiflupyr 2.9% Propiconazole 11.9% Azoxystrobin 10.5%	Trivapro SE	9.4-13.7	VG	VG	VG	VG	E	E	VG	NL[4]	Feekes 10.5.4 and 14 days
	Prothioconazole 16.0% Trifloxystrobin13.7%	Delaro 325 SC	8.0	G	VG	VG	VG	VG	VG	VG	NL	Feekes 10.5 35 days

[1]Efficacy categories: NL=Not Labeled; NR=Not Recommended; P=Poor; F=Fair; G=Good; VG=Very Good; E=Excellent; -- = Insufficient data to make statement about efficacy of this product.
[2]Product efficacy may be reduced in areas with fungal populations that are resistant to strobilurin fungicides.
[3]Efficacy may be significantly reduced if solo strobilurin products are applied after stripe rust infection has occurred.
[4]Application of strobilurin products after heading may result in elevated levels of the mycotoxin deoxynivalenol (DON) in grain damaged by head scab.
[5]Multiple generic products containing the same active ingredients also may be labeled in some states.
[6]Products with mixed modes of action generally combine triazole and strobilurin active ingredients. Priaxor, Nexicor, and the Trivapro copack include carboxamide active ingredients.

Fungicides are not needed in every field every year and the use of fungicides may not always be profitable. Although some individuals claim that fungicides may boost yield in situations where diseases are absent, university research indicates this is not the case. Foliar fungicides are likely to be most profitable in 1) high yield settings (70+ bu/A); 2) fields where susceptible varieties are planted and scouting indicates threshold levels of disease are present; 3) the stage of crop growth is suitable for treatment; and 4) the forecast indicates that conditions will be favorable for continued disease development, in particular long periods of humid or rainy weather.

Scouting Small Grains for Disease

Scouting fields is an easy way to ensure that you are staying on top of yield-robbing diseases. Growers who scout their fields will benefit from scouting by 1) being able to make pesticide applications in a timely manner and 2) learning about the disease issues associated with a particular field or variety. This information can be used in future seasons to better maximize productivity. There are many diseases that can impact mid-Atlantic small grains, but seldom do they all attack at the same time. Specific diseases occur at certain times of the year when the environment is conducive or he plant growth stage is susceptible to disease.



Foliar Diseases

Powdery Mildew .....
Rusts .....
Leaf Blotch Complex .....
Tan Spot .....
Viruses .....

Head Diseases

Glume Blotch .....
Fusarium Head Blight .....
Loose Smut .....

Other

Take All .....
Root/crown rots .....

Scouting Calendar for Major Diseases of mid-Atlantic Small Grains

Diseases of Small Grains

Virus Diseases

Scouting: Examine fields at least once a month during active growing periods from Feekes 2 through Feekes 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Stunted, deformed plants. Foliage may be streaked or mottled. Leaf discoloration (red/orange). Entire fields are rarely affected. Instead look for single or small groups of plants in patches.

Diagnosis: Specialized tests that can be conducted by the Plant Disease Clinic or special testing services such as Agdia Inc.

Barley Yellow Dwarf

Barley yellow dwarf virus (BYDV) is the most widely distributed and destructive of the viral diseases that affect wheat. Symptoms of BYDV are often confused with various nutritional or non-biological disorders. Leaf discoloration induced by the virus infection typically ranges from shades of yellow to red and sometimes purple, especially extending from the leaf tip to the base and from the leaf margin to the mid-rib. Seedling infections have the greatest impact on yield. Plants infected in the fall may not survive the winter or are severely stunted and discolored when growth resumes in the spring. These diseased plants often occur in circular patches within the field. These patches are associated with the feeding and colonization by aphid vectors in the fall and early spring. Grain yields from such plants have been reduced by 30 to 35 percent in experimental plots in Virginia. The virus can be transmitted by more than 20 species of aphids (five species of which are known to occur in Virginia). The virus persists in small grains (barley, oats, rye, and wheat), in corn, and in over 80 species of perennial and annual grasses. The spread of this virus is entirely dependent on the activity of the aphid vectors. The environmental conditions that favor BYDV epidemics are cool temperatures (50˚ to 65˚F) with rainfall that supports wheat and grass growth as well as aphid reproduction and movement. Infections can occur throughout the season and are most abundant where high populations of aphids survive the winter. The leaf discoloration symptoms indicating virus infection develop within about two weeks of inoculation at temperatures between 65˚ to 70˚F. When infections occur at temperatures above 85˚F, symptoms do not develop.

Management: Plant after the Hessian fly-free date. Plant varieties tolerant to BYDV. Manage aphids in the fall via insecticide seed treatments. Foliar insecticides may provide some benefit if aphid populations increase past threshold levels in the fall, within a month of planting, or in early spring.

Wheat Spindle Streak Mosaic Virus (Wheat Yellow Mosaic)

Wheat spindle streak mosaic virus (WSSMV) is common in some fields in Virginia. Symptoms are typically expressed in leaves as yellow-green mottling with parallel dashes or streaks with tapered ends—hence the name wheat spindle streak. The virus is transmitted to wheat by a soil-borne fungus, *Polymyxa graminis*, which, in the absence of wheat, is associated with the roots of grassy weeds and other monocot crops (e.g., barley, corn, millet, rye, sorghum, etc.). Most significant infections take place during cool, wet periods in the fall. Often large areas of a field may be affected. Infection does not occur at temperatures above 68˚F. Thus, an increase in temperature allows the plant to outgrow the virus and may mask symptoms later in the growing season. The optimal temperature for symptom expression is between 48˚ and 55˚F. The earlier in the life of the wheat plant that infection occurs, the more severe the symptom expression. During cool spring conditions, the yellow spindle streaks may become necrotic. Affected plants may be mildly stunted and produce fewer tillers and seeds per head.

Management: Plant resistant wheat varieties. Plant after the Hessian fly-free date. Improve soil drainage and improve compaction in problem fields.

Wheat Streak Mosaic Virus

Wheat streak mosaic virus (WSMV) was observed for the first time in more than 25 years during the 2000 growing season. The incidence and severity of this disease depends on the environment, vector survival, distribution and frequency of volunteer wheat plants that serve as a source of virus and a haven for the vector, and wheat cultivar susceptibility. Symptoms of wheat streak mosaic virus typically appear in the spring. These symptoms can look very similar to wheat spindle streak caused by WSSMV. However, the field pattern of WSMV is related to the distribution and activity of the vector, the wheat curl mite, *Aceria tulipae*. As the wheat crop develops, plants affected with WSMV are typically severely stunted with yellow mottled and

streaked leaves. These yellow streaks are often seen as discontinuous dashes running parallel to the leaf veins. As the season progresses, plants affected and colonized by the curl mites may develop "leaf rolling." Leaves appear upright while the margins roll inward. This symptom of mite feeding looks like drought stress in the affected plants. WSMV symptoms tend to become more severe as the weather warms, and severely affected plants may produce sterile heads or die prematurely. The mite requires living hosts such as volunteer wheat or corn to survive and move to emerging wheat in the fall. Mites can then move to nearby or distant sources into wheat fields, feed on wheat, and can spread the virus.

Management: Eliminate volunteer wheat and corn before wheat emerges in the fall.

Foliar Diseases

Leaf Blotch Complex

Examine the following leaf positions at the indicated growth stage:

Flag-4 and Flag-5 for Zadoks growth stages 31 to 37 and Feekes growth stages 6 to 8 (jointing to flag leaf emergence)

Flag-3 for Zadoks growth stages 38 to 45 and Feekes growth stages 9 to 10 (flag leaf fully expanded to boot)

Flag-2 for Zadoks growth stages 46 to 59 and Feekes growth stages 10.1 to 10.5 (boot splitting to heading)

Scout fields weekly from Zadoks growth stage 31 through 59 (Feekes 6 through 10.5). Randomly select 10 locations within a wheat field. At each location, examine and record the number of indicator leaves out of ten main tillers with one or more leaf and glume blotch lesions. If 25 percent of the 100 indicator leaves in the field have one or more lesions, then a fungicide application may be beneficial.

Scouting: Examine fields at least every other week during active growing periods from Feekes 5 through Feekes 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

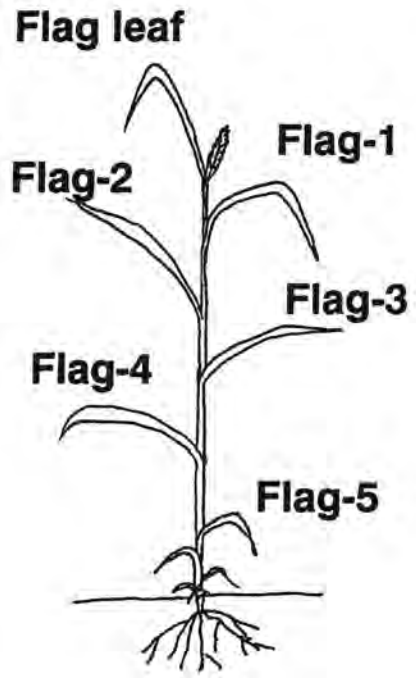


Fig 3.1 Determination of treatment threshold for septoria leaf and glume blotch in wheat.

General Symptoms: Lesions that may be blocky, oblong, or cats-eye in shape and surrounded by a thin yellow halo. *Septoria tritici* lesions tend to follow leaf veins and often contain multiple, black fungal structures within a lesion. Cream-colored cirri can be produced under extended periods of wet or humid weather. Lesions caused by *Stagonospora nodorum* are shaped like a cats-eye and contain very small, brownish colored fungal structures within the lesion. Lesions may be hard to see and can be embedded in the plant tissue. Cirri can also be produced under humid conditions but unlike *S. tritici*, they are salmon colored.

Diagnosis: May be diagnosed by trained individuals in the field with the aid of a hand lens. Confirmation through culturing or other techniques can be carried out by a Plant Diagnostic Clinic.

Description:
Leaf blotch complex is caused by two fungal diseases: *Stagonospora nodorum*, which also causes Glume Blotch, and *Septoria tritici*. Both diseases are residue- and seed-borne and develop first on lower leaves and move up the plant under favorable environmental conditions. *S. tritici* is a cool weather pathogen and is favored by high humidity and temperatures between 59-69°F. *S. nodorum* does best under warmer conditions (69-81°F) and humid weather. Epidemics of both diseases can originate from wind or rain dispersed spores, either from local or distal sources. Infection by *S. nodorum* tends to occur later in the stages of plant development. Both diseases can significantly reduce yields in susceptible varieties and under appropriate environmental conditions. Test weights may also be reduced.

Management: Plant resistant varieties. Varieties with resistance to Stagonospora leaf blotch may not be resistant to glume blotch and vice versa. Plant certified disease free seed and use recommended fungicide seed treatments. Destroy weeds and volunteer wheat or barley in fields prior to planting. If a susceptible variety is planted, foliar fungicides applied after flag leaf emergence can be beneficial if the disease is present and the environment conducive for further disease development.

Tan Spot

Scouting: Examine fields at least every other week during active growing periods from Feekes 5 through Feekes 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Tan spot is caused by *Pyrenophora tritici-repentis* and produces symptoms very similar to Leaf Blotch Complex. Tan spot lesions are cats-eyed shaped but unlike *S. nodorum*, lesions do not often coalesce. The lesions will have dark centers but do not have black or brown fungal structures within lesions.

Diagnosis: May be diagnosed by trained individuals in the field with the aid of a hand lens. Confirmation through culturing or other techniques can be carried out by a Plant Diagnostic Clinic.

Description: *Pyrenophora tritici-repentis* is a residue-borne organism that can infect wheat, barley, rye, and numerous other grassy hosts. Disease occurs over a wide temperature range, but symptoms are often more pronounced at later stages in crop growth. Depending on the variety, as few as 6 hours of leaf wetness may be needed for disease development. The disease spreads through the dissemination of spores in wind and rain.

Management: Same as for Leaf Blotch Complex

Powdery Mildew

Scouting: Examine fields at least every other week during active growing periods from Feekes 2 through Feekes 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: White fuzzy growth on stems and foliage of plants. Over time black pinhead-like structures can be observed in and on the white growth. Very old infections appear grey to brown.

Diagnosis: Easily identified with the naked eye in the field.

Description:
Blumeria graminis is common throughout the mid-Atlantic. The fungus overwinters in small grain stubble as well as overwintering wheat and barley. Powdery mildew is favored by cool temperatures (60-68°F) and high relative humidity (>90% RH). Unlike other foliar diseases, free water on the leaf surface may inhibit spore germination and infection. Disease progress ceases at temperatures above 77°F. Disease increases with nitrogen fertilization and lush growth. Spores of powdery mildew can be dispersed on air currents over large distances. Infection can cause lodging as well as yield losses resulting from foliar infection. Population shifts have overcome previously effective resistance genes in barley and this may occur in wheat.

Management: Plant resistant varieties. Avoid planting wheat or barley early in the fall. Avoid excessive nitrogen levels. Foliar fungicides, especially when a susceptible variety is planted and the disease is detected early in the growing season, may be beneficial in some years. Protection of the flag leaf is key.

Rusts (Stripe and Leaf)

Scouting: Examine fields every week during active growing periods from Feekes 2 through Feekes 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius. Consider a fungicide application for a high yield crop when rust covers 1 percent of upper, fully expanded leaves prior to heading, Fig 3.2.

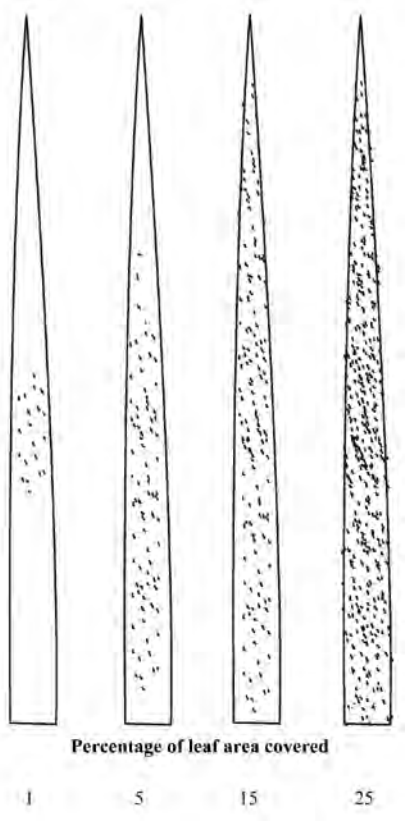


Fig 3.2
Percentage of leaf area affected by lef rust. (James, C. 1971. A Manual of Assessment Keys for Plant Diseases. Publication 1458. Canada Department of Agriculture.)

General Symptoms: Early infections appear as small yellow/orange spots on the foliage. Spots eventually develop into brown/orange raised pustules that will leave a brown/red rusty residue on fingers when pustules are rubbed between fingers. Leaf rust appears on the upper leaf surface and is generally brown in color. Stripe rust follows the leaf veins and is light orange in color.

Diagnosis: Easily identified with the naked eye in the field.

Description:
Puccinia recondita f.sp *tritici* (leaf rust) and *P. striiformis* f.sp *tritici* (stripe rust) occur frequently in the mid-Atlantic. These rusts may overwinter as mycelium in dormant wheat in the southernmost areas of the mid-Atlantic, particularly following a mild winter. More commonly, rusts blow in from the south and therefore arrive later in the growing season. Leaf rust does well under moderate temperatures (60-70°F) whereas stripe rust is favored by cool weather (50-60°F). Temperatures above 68°F inhibit stripe rust. Spores produced from pustules are wind distributed over large distances and are deposited by rain onto plants. When the environment is favorable, epidemics can develop rapidly and cause losses approaching 50% in susceptible varieties. Early season infections have the most impact on yield and can reduce root and tiller formation. Late season infections, which are common in many parts of the mid-Atlantic, are unlikely to cause significant yield reductions. New races of stripe rust have been identified that can better tolerate warm temperatures and ever-changing populations have overcome resistance in some varieties.

Management: Plant resistant varieties. Foliar fungicides applied before disease is present or reported in the area may be beneficial, particularly if a susceptible variety is planted. Avoid planting a variety in a subsequent year if stripe rust was detected in that variety the previous season.

Head Diseases

Glume Blotch

Scouting: Examine fields every week from Feekes 9 through Feekes 10.5. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Gray to brown spots form the chaff, typically starting on the upper ¾ of the glumes. Over time lesions can grow and brownish fungal structures form within gray centers of the lesion.

Diagnosis: Can be confused with other disorders such as bacterial diseases or chemical injury. Fungal structures are diagnostic but difficult to see without the aid of a hand lens.

Description:
Glume blotch is caused by *Stagonospora nodorum*, a component of Leaf Blotch Complex, which is described in the previous section.

Management: Plant resistant varieties. Varieties with resistance to Stagonospora leaf blotch may not be resistant to glume blotch and vice versa. Plant certified disease free seed and use recommended fungicide seed treatments. Destroy weeds and volunteer wheat or barley in fields prior to planting. Foliar fungicides applied before disease is present on the glumes may be beneficial if the environment is favorable for disease development.

Fusarium Head Blight

Scouting: Examine fields every week from Feekes' 10.5 to Feekes' 11. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Heads completely or partially bleached. Under humid conditions, masses or orange spores may be present at the base of infected kernels. Severely infected kernels may be shrunken, chalky, and shriveled. Infected heads may have elevated levels of deoxynivalenol (DON) a mycotoxin.

Diagnosis: Can be confused with other disorders such as insect injury, eyespot, or frost damage

Description:
Fusarium head blight (FHB) in the mid-Atlantic is caused predominantly by *Fusarium graminearum*. This is a reemerging disease that is likely to increase in incidence and severity due to widespread no-till and corn acres. This fungus overwinters in small grain or corn residue and produces spores under wet conditions (>70 % RH) and over a wide temperature range (60-85°F). Longer periods of wet weather are required for severe epidemics to occur under cool conditions. Approximately 70% of spores are ejected and carried long distances on wind currents and deposited at night. The remaining spores (30%), called macroconidia, are locally dispersed via rain splash. FHB only causes disease on heads and disease is most severe when appropriate conditions occur at or around flowering (Feekes' 10.5.1-yellow anthers observable at the center of heads). Once spores germinate, they can enter the head, resulting in kernel abortion and characteristic head bleaching. Depending on the environment, variety, and fungal strain, mycotoxins (DON and others) may be produced. Elevated levels of DON can result in dockage or rejection at the grain mill. Bleaching does not always indicate elevated DON levels in grain.

Table 3.13 Deoxynivalenol (DON) Advisory Levels Established by the FDA

Maximum Allowable DON Level (ppm)	Consumer
1	Humans
5	Swine and all animal species except cattle and poultry (Not to exceed 20% of the diet for swine and 40% for other animals
10	Ruminating beef and feedlot cattle older than 4 months and poultry (Not to exceed 50% of diet).

Management: Plant moderately resistant varieties with good tolerance to DON accumulation. DON management should be the focus when selecting a variety as DON levels do not correlate well with levels of bleaching, although bleached heads may indicate elevated levels of mycotoxins in a field. Research indicates that overall, the use of a locally adapted, moderately resistant variety can reduce DON by over 50% compared to susceptible varieties. Virginia Tech screens commercial and experimental wheat varieties for DON accumulation and growers should refer to these ratings when selecting a variety. The FHB fungus does not grow as well on soybean residue, so planting wheat after soybeans may help reduce local inoculum levels. Burial of residue through tillage may also help reduce local levels of inoculum. However, because the pathogen can be dispersed over long distances, local residue management may only have a minor effect on overall suppression of FHB and DON, particularly during severe epidemics. Staggering planting date may help reduce the likelihood that all fields will enter a susceptible stage when the environment favors FHB, although differences in flowering are likely to be subtle in warm environments. Several fungicides are available for suppression of FHB and DON. These products should be applied at least 10-15 gallons per acre at 35 psi with nozzles angled in a forward direction (30° optimal) if travelling above 10 mph in a ground rig. Aerial applicators should apply at 5 gallons per acre. The lowest labeled rate of a non-ionic surfactant may improve coverage of the head. Maximum product efficacy is obtained if fungicides are applied when plants have entered Feekes 10.5.1. Fungicides can be applied up to 6 days after the start of Feekes 10.5.1 without a notable drop-off in efficacy. Research trials indicate that currently, the best fungicides for suppression are Prosaro, Caramba and Proline. If applied properly these products reduce DON by approximately 45% compared to untreated controls. The use of moderately resistant varieties and recommended fungicides applied around Feekes 10.5.1 has been shown to reduce DON levels by 70% relative to untreated susceptible varieties in replicated national trials. The Fusarium Head Blight Prediction Center uses multiple sources of environmental weather data to determine the probability of FHB epidemics for wheat at a susceptible stage of growth (http://www.wheatscab.psu.edu/). This site can be used to help determine if a fungicide application is likely to be needed during the growing season. Remember, fungicide use alone is not likely to bring down DON levels to a manageable level if a susceptible variety is planted in an FHB-favorable year. Therefore, growers should integrate multiple practices to manage this disease.

Loose Smut

Scouting: Examine fields every week from Feekes' 10.5 until harvest. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Heads will contain a black/brown dusty mass of spores in the place of kernels and chaff. These spores eventually blow away, leaving a bare spike with a sooty appearance. Heads of infected tillers emerge from the boot earlier than healthy tillers and prior to heading diseased plants may appear darker than healthy plants.

Diagnosis: Easily identified in the field.

Description:
Loose smut is a disease that is infrequent in the mid-Atlantic, mostly as a result of seed treatment fungicides in wheat production systems. The disease is caused by the fungus, *Ustilago tritici* and yield losses can be significant in some situations. Spores of the fungus often enter the field on infested seed. After seed germination, the fungus grows within the plant without producing symptoms. When the head emerges the fungus invades the contents of the head, converting everything except the pericarp membrane and rachis to a mass of black fungal spores. Wind then disperses spores over long distances where they may land on flowering wheat or barley. Light rains and temperatures between 60 and 72°F favor germination of spores and infection. Once the fungus has established itself in the kernel it goes into dormancy. Infected seeds cannot be distinguished from infected seeds. The fungus only becomes active again when the infected kernel germinates.

Management: Plant certified disease-free seed. Utilize recommended seed treatment fungicides.

Other

Take-All

Scouting: Examine fields every other week from Feekes 5 through harvest. Scout at least 1 site per 10 acres of field. At each site observe plants within a 5-10 foot radius.

General Symptoms: Around head emergence leaves may become yellow and plants may be stunted or uneven. The most conspicuous symptom is premature white tillers. Take-all often occurs in patches but can also be uniform in distribution in some fields. The roots of infected plants will be brittle and rotten. If the outer leaf sheath is removed from the stem a shiny discoloration of the basal stem will be evident.

Diagnosis: Can be confused with other disorders such as head blight, sharp eyespot, frost injury, and insect damage. The shiny black appearance of the basal stem is diagnostic for the disease.

Description:

Take-all is caused by the fungus *Gaeumannomyces graminis*. This pathogen survives in fields on residue from infested small grains or grassy weeds. During the growing season, the fungus invades plant roots, compromising nutrient and water uptake. The pathogen is often most active in cool soils. Poorly drained soils, low soil fertility, and alkaline conditions may favor infection by *G. graminis*. Take-all is not often an issue due to the crop rotations that are commonly practiced in the mid-Atlantic.

Management: Rotation away from small grains for 2 years will reduce inoculum levels in the soil. Apply fertilizers and lime according to soil test recommendations. Minimize compaction and drainage issues.

On a related note, growers may have heard of a phenomenon known as, "Take-all decline." This has been observed in other regions where wheat monocultures are used extensively. In these cases, several years of wheat monoculture allows for the accumulation of antagonistic bacteria that compete with the pathogen for soil nutrients and resources.

Forage Crop Diseases

Hillary L. Mehl, Extension Plant Pathologist, Virginia Tech, Tidewater AREC

Disease management in perennial forage crops is based on planting locally adapted, disease-resistant cultivars and using good cultural practices to help reduce losses from diseases. Disease resistance ratings of alfalfa cultivars are compiled by the National Alfalfa & Forage Alliance and are updated annually. The list can be viewed on the web at http://www.alfalfa.org. You may download the list for free, or purchase a copy of the list for a nominal fee from the organization. Note that at this time no commercially available alfalfa cultivars have an acceptable level of resistance to Sclerotinia crown and stem rot.

Sclerotinia crown and stem rot is best managed by avoiding no-till seeding of new stands in the fall. Stand establishment of forage legumes may benefit from the use of seed-protectant fungicides, particularly in spring no-till seeding, when conditions slow the germination process. In general, cool, wet soil conditions favor seed decay and damping-off diseases. Most seed companies now sell alfalfa seed treated with a fungicide for damping-off management. However, most other forage crops are not commonly pretreated.

Table 3.14 - Major Diseases, Probability of Outbreaks and Recommended Minimum Level of Resistance for Alfalfa Cultivars to be Grown in the Mid-Atlantic

	Bacterial wilt	Verticillium wilt	Fusarium wilt	Anthrac-nose	Phyto-phthora root rot	Root-knot nematode	Aphano-myces root rot	Sclerotinia crown and stem rot	Leaf & stem spots
Outbreak probability	Low	Moderate	Moderate	Moderate	Moderate	Low	Unknown[3]	No-till fall seeding High	High
Recom-mended minimum resistance[1]	MR	MR	MR	R	R	Soil test[2]	MR	NA	NA

[1]Always get the highest level of resistance available whenever possible. Recommended minimums will not prevent serious losses in the event of a major outbreak.

[2]Nematode risk can be determined with a soil test prior to planting. When root-knot nematode is a threat and you must plant alfalfa, choose a variety with as high a level of resistance as you can find.

[3]Aphanomyces root rot has not been formally identified or surveyed for in the mid-Atlantic. It is, however, likely to be a problem. In general, plant cultivars that have at least an MR rating, except if planting in spring in which case select cultivars with at least an R rating.

Key: MR = moderately resistant, R = resistant, NA = resistance varieties not available.

Table 3.15- Fungicide Treatment

Crop	Disease	Active ingredient	Trade name	Remarks
Seed treatment fungicides				
Alfalfa and other forage legumes	Damping-off and early season Phytophthora root rot	Metalaxyl	Allegiance FL Acquire Belmont 2.7 FS Dyna-Shield Metalaxyl Metalaxyl 265 ST MetaStar ST Sebring 318 FS	Registered for application by commercial seed treaters only. Excellent control of Pythium damping-off.
Alfalfa, clover, and vetch	Seed decay and damping-off	Thiram	Protector-D	Control of Pythium damping-off is less effective than metalaxyl or mefenoxam. Apply seed treatment materials in a slurry or with commercial mist-type equipment. Follow instructions on label.
Soil treatment fungicides				
Alfalfa	Damping-off and early season Phytophthora root rot	Mefenoxam	Ridomil Gold SL Ultra Flourish	Soil treatment generally is not necessary if seed is treated with Allegiance or Apron. Consider soil treatment only where there is a history of Phytophthora, soil is heavy, cold and wet conditions are expected after seeding, and the variety is relatively susceptible. Most alfalfa seed is treated with Apron. Use the low rate of Ridomil with Apron-treated seed. Apply 1/4 to 1/2 pints per acre of SL formulation as a broadcast surface spray at planting in a minimum of 20 gallons of water per acre. Do not feed green forage or cut hay for 60 days following application.

Tobacco

Charles S. Johnson, Extension Plant Pathologist, Southern Piedmont AREC

Reliable and efficient control of tobacco diseases and nematodes **depends** upon accurate identification of the problems in each field and the simultaneous use of multiple disease management approaches (crop rotation, resistant varieties, sanitation, early stalk and root destruction, etc.).

Disease Management Practices

Crop Rotation

The use of the proper rotation crop can be **critical** to avoid losing yield and quality to diseases and nematodes. Tobacco following tobacco should be avoided.

Table 3.16 - Usefulness of Various Rotation Crops for Tobacco Disease Control[1]

Rotation Crop	Black Shank	Granville Wilt	Root-Knot Nematodes	Tobacco Cyst Nematodes	Tobacco Mosaic Virus	Black Root Rot
Fescue	H	H	H	H	H	H
Small grain	H	H	H	H	H	H
Lespedeza 'Rowan'	H	H	H	-	H	L
Soybean	H	H	L[2]	H	H	L
Corn	H	M	L	H	H	H
Sweetpotato	H	M	L[3]	-	H	H
Cotton	H	M	N	-	H	L
Milo	H	M	L	H	H	H
Peanuts	H	L	N	H	H	L
Pepper	H	N	N[4]	L	N	H
Potato, irish	H	N	L	L	H	H
Tomato	H	N	N[2]	N	N	M

[1]Adapted from Flue-Cured Tobacco Information, North Carolina Cooperative Extension Service. Ratings indicate the value of each rotation crop for reducing damage caused by each disease in the subsequent tobacco crop, and assume excellent weed control in each rotation crop; H = highly valuable, M = moderately valuable, L = Little value, N = no value – may be worse than continuous tobacco, - = unknown.

[2]However, root-knot resistant cultivars can be highly effective as rotation crops for managing root-knot nematodes on tobacco.

[3]Root-knot resistant sweetpotato cultivars are moderately effective rotation crops for tobacco.

[4]May be highly valuable for some species or races of root-knot nematodes

Early Stalk and Root Destruction

Helps reduce disease, insect, and weed infestation levels that will carry over into future tobacco crops. *Most effective when tobacco stalks and roots are destroyed immediately after final harvest.*

The following steps should be completed to gain maximum benefit: 1) **flue-cured** - cut stalks into small pieces with bushhog or similar equipment the day that harvest is completed in each field; 2) **all types** - disc or plow-out roots the day harvest is completed. Roots must be exposed to air for about 2 weeks to obtain maximum drying of roots; 3) after 2 weeks, re-disc field to provide additional root kill and to bury crop refuse; 4) plant a cover crop when root systems are killed and plant debris is buried.

Disease-resistant Varieties

Offer excellent control of most of the major diseases of tobacco. However, growers should consider the major disease problems and the level of infestation when selecting a resistant variety. In severe disease situations, disease control chemicals may also be required to obtain satisfactory results. The Virginia Cooperative Extension Tobacco Production Guides summarize the latest disease resistance information on the most current tobacco cultivars.

Disease Control in Tobacco Greenhouses

Disease causing organisms can enter a greenhouse in soil or plant debris. Entrances should be covered with asphalt, concrete, gravel, or rock dust. Footwear should be cleaned or disinfected before entering a greenhouse. Float bays should be re-lined with fresh plastic each year and be free of soil and plant debris. Greenhouse equipment should also be sanitized periodically. A 1:10 solution of household bleach and water is sufficient for these purposes, as are most disinfectants.

If tobacco mosaic (TMV) may have occurred in the previous year, greenhouse surfaces that may come in contact with plants should be disinfected. Such surfaces include side-curtains, center walkways, and the 2x6 boards that form the float bays. There is no need to spray the purline supports or the plastic covers over the greenhouse. *Relatively new float trays that may have been used when TMV may have been present should be washed and rinsed thoroughly before being steamed or otherwise sanitized of other pathogens.* Older trays should be discarded and replaced with new trays. Mosaic has a number of weed hosts (horsenettle, ground cherry) that should be removed from the vicinity of tobacco greenhouses.

Float trays should always be thoroughly cleaned and disinfected before fumigation. If float trays are to be sanitized by steaming, they should remain in aerated steam at 160º F to 175ºF for at least 30 minutes in order to minimize *Rhizoctonia* damping-off and sore shin, as well as *Pythium* damping-off.

Do not fill float bays with water from streams or ponds as these sources may be contaminated. Filling bays with water long before floating the trays can make *Pythium* problems worse. Be careful to avoid introducing disinfectants into water intended for plant uptake. Moving water from one greenhouse bay to another increases the chance of spreading water-borne pathogens like *Pythium*, and should be avoided.

To avoid spreading TMV, mower blades and decks should be sanitized with a 1:1 bleach and water solution between greenhouses and after each clipping. Plant debris left on trays after clipping is one of the primary causes of collar rot problems. Clippings, unused plants, and used media should be dumped at least 100 yards from the greenhouse.

Condensation on the underside of the greenhouse top and on leaf surfaces creates conditions that favor disease. This condensation results from a difference in temperature between the inside and outside of the greenhouse, particularly at sunset. **Increasing air exchange near dusk by temporarily lowering the side curtains will reduce such differences in air temperature. Ventilating the greenhouse with horizontal airflow fans will also help reduce potential condensation.** Minimize overhead watering and potential splashing of media from one tray cell to another. Correcting drainage problems in and around the greenhouse will also help avoid excess humidity.

Bacterial soft rot causes a slimy, watery rot of leaves and stems and can easily be confused with damage from collar rot. Greenhouse management practices that help minimize collar rot will also help prevent bacterial soft rot. Management practices for angular leaf spot and wildfire (two other diseases caused by bacteria) can also help reduce bacterial soft rot as a side effect.

Waiting to seed tobacco greenhouses and float beds until March, and eliminating any volunteer tobacco plants within these structures, should be an essential component of each grower's disease control plan. As a general rule, plants closely related to tobacco (tomatoes, peppers, etc.) should not be grown in greenhouses used for transplant production.

Diseases

Blue Mold

Unused tobacco transplants should be destroyed as soon as possible after transplanting has been completed. If possible, fields that seem to favor blue mold development (shady areas with poor air drainage) should be avoided. Fields should be irrigated early enough in the day that leaves can dry before nightfall. Suspected blue mold should be reported to Virginia Cooperative Extension. Most tobacco cultivars currently being planted are not resistant to tobacco blue mold. Dark-fired tobacco is generally less susceptible than flue-cured tobacco, which is generally less susceptible than burley tobacco, although burley cultivar KT 206LC has low-to-moderate resistance to blue mold. Burley tobacco cultivar TN 90LC is somewhat less resistant to blue

mold than KT 206LC. KT 204LC is less resistant than TN 90LC, but is less susceptible to blue mold compared to most other burley tobacco cultivars. A number of effective fungicides are available for controlling tobacco blue mold when it occurs, and several are relatively new, including Revus, Orondis Ultra, and Presidio.

Black Shank and Granville Wilt

Calculating and recording the percentage of diseased plants in each field at the end of each season can enable growers to evaluate the cost-effectiveness of their disease control program.

Severity Level	Black Shank or Granville Wilt
Low	Less than 1%
Moderate	1-5%
High	More than 5%

Black Shank

Caused by a fungus-like pathogen that lives in the soil and attacks tobacco roots and stalks. Disease losses can be minimized by planting highly resistant cultivars in fields that have been rotated in and out of tobacco production. The longer the interval between tobacco crops, the less black shank to be expected. This doesn't mean that black shank can't occur in fields that don't have a significant recent history of tobacco production. The pathogen can be introduced or moved from other fields (on field equipment, for example), and significant disease can develop if weather conditions during the growing season favor spread. Black shank-infested fields used to produce burley or dark-fired tobacco should be rotated out of tobacco for longer periods of time than normally used with flue-cured tobacco. **Tobacco cultivars possessing the *Php*** or ***Phl genes*** **are highly resistant to RACE 0 of the black shank pathogen, but vary in resistance to RACE 1. Because most tobacco fields in Virginia now contain mostly race 1 of the pathogen, tobacco cultivars should be chosen for their resistance to RACE 1. Current tobacco varieties are always at least as resistant to race 0 as they are to race 1, but many are much less resistant to race 1 than to race 0. If black shank is present in fields to be planted with tobacco, ALWAYS know the resistance to RACE 1 before selecting a variety.** Several highly effective black shank fungicides are also currently available, but don't forget that maximum use of a soil fungicide will not necessarily protect a variety with low black shank resistance against significant damage, particularly in fields where tobacco was planted the previous year. Consistently reliable black shank control, especially with less resistant tobacco cultivars, will likely require 2-3 fungicide applications during the growing season, starting at or near transplanting. Ridomil Gold and Orondis Gold 200 are labeled for application at or near transplanting. Follow-up field sprays should alternate to a black shank fungicide with a different mode of action (for example, Presidio). See Table 3.19 for these products and directions for their use. Pre-plant soil fumigation with a product containing chloropicrin may assist results from a black shank fungicide, but fumigation alone is not as effective against black shank as it is for the management of Granville wilt or nematodes.

Granville (Bacterial) Wilt

Caused by a soil-inhabiting bacterium that invades tobacco plants through roots and subsequently kills the entire plant. The pathogen can also invade tobacco plants through wounds caused by cultivation, mechanical topping, and mechanical harvest. For this reason, early, shallow cultivation and topping by hand can help reduce this disease in infested fields. Although symptoms are somewhat similar to those associated with black shank, intermediate symptoms of Granville wilt involve wilting on only one side of affected plants. Leaves of infected plants will tend to wilt more quickly (while still green) and take longer to yellow during curing than plants with black shank. Crop rotation (particularly with soybeans) and the use of resistant varieties are ***essential*** for Granville wilt control. Disease reduction and yield increases are generally much larger from the use of resistant varieties than from soil fumigation, but sometimes fields should be fumigated and a resistant variety planted when disease pressure is severe. However, Granville wilt-resistant varieties are not available in burley and dark-fired tobacco. These types of tobacco generally should ***not*** be planted in fields infested by the Granville wilt pathogen.

Nematodes

Nematodes are microscopic roundworms. Many live in soil and parasitize plant roots. Root-knot, lesion, and tobacco-cyst nematodes are important pests of all tobacco types grown in Southside Virginia. Because symptoms of nematode injury are often confused with other problems, nematodes may go undetected for years. However, plant-parasitic nematodes can *significantly* increase problems with root diseases such as bacterial wilt, black shank, and Fusarium wilt, even when nematode populations

are very low. The specific pesticides, rotation crops, and resistant varieties vary among the different types of nematodes that damage tobacco. A Nematode Assay Clinic at Virginia Tech provides a *Diagnostic Nematode Assay* and a *Predictive Nematode Assay*. The *Diagnostic Nematode Assay* determines if plant-parasitic nematodes are the cause of stunted or unthrifty plants. Plant roots should always accompany soil samples submitted for the assay. When nematodes are found to be the cause of problems, it is usually impractical to initiate control measures until the year following the diagnosis. The *Predictive Nematode Assay* focuses on sampling for nematodes in the fall to identify fields with damaging nematode populations so that control measures can be initiated before or at the time of planting. Any soil samples submitted for this assay should be obtained by a systematic sampling procedure. Each soil sample should represent an area no larger than 2 acres and should consist of at least 25 cores or subsamples taken 6 to 8 inches deep. Predictive nematode assay samples must be received by Virginia Tech by November 30 for results to be available by planting. Assay results indicate the presence or absence of economically significant nematode populations. If damaging nematodes are not found, the producer can choose to not use a nematicide. In addition, the type and number of nematodes will influence the choice of nematicide if one is needed. Contact your local Cooperative Extension agent for information on methods of collecting samples and interpreting assay results.

Lesion Nematodes

Early root and stalk destruction and crop rotation can significantly reduce populations of these nematodes. Use of a nematicide rated good (G) or excellent (E) may be profitable when a soil assay detects 50-100 lesion nematodes/500 cc of soil. A combination of crop rotation and soil fumigation should be used when populations of lesion nematodes are greater than 100 nematodes/500 cc of soil. Be aware that grass cover or rotation crops may not reduce lesion nematode populations to the same extent as for root-knot or tobacco cyst nematodes. Fall soil samples should be collected from soybean fields when tobacco is the intended crop in the following spring to ensure that damaging lesion nematode populations are not present.

Root-knot Nematodes

Root-knot nematodes are common in Virginia tobacco fields, and several types of root-knot can be present in damaging numbers in the same field. Most "root-knot resistant" tobacco cultivars are only resistant to races 1 and 3 of the southern root-knot nematode (*Meloidogyne incognita*), but other types or species are now common. Any root galling on a currently grown flue-cured tobacco cultivar indicates the presence of these other types of root-knot. Rotating tobacco with pasture grasses and small grains reduces populations of all types of root-knot, but be careful to rotate tobacco with root-knot resistant cultivars for row crops such as soybean. Forage legumes can increase root-knot nematode populations to damaging levels. Flue-cured tobacco cultivars CC 13, CC 33, CC 35, CC 37, CC 65, and PVH 2275 claim resistance to several types of root-knot. Consult the flue-cured tobacco production guide for more information on these varieties. A preplant nematicide may be necessary when root-knot populations are high, as indicated in the following table.

Table 3.17 - Interpreting Root-knot Nematode Infestation Levels

		Nematodes/500 cc of soil		
Risk of Crop Loss	**% Roots Galled**	**Fall Sample**	**Spring Sample**	**Control Options[1]**
Very Low	1-10	1-200	1-20	Practice crop rotation and/or plant a resistant variety.
Low	11-25	201-1,000	21-100	Use crop rotation in combination with a resistant variety or a nematicide rated 'G' or higher.
Moderate	26-50	1,001-3,000	101-300	Use crop rotation in combination with a resistant variety and a nematicide rated 'G' or higher.
High	Over 50	Over 3,000	Over 300	Increase rotation interval if at all possible. Use a resistant variety and a nematicide rated 'E'.

[1]Be aware that most "root-knot resistant" tobacco varieties are only resistant to the most common types of root-knot nematodes. **Risks of crop loss are high if galling on roots is greater than 20%**. Rotation intervals should be increased as long as possible and a soil nematicide or fumigant should be applied when this level of galling has been observed.

Tobacco-cyst Nematode (TCN)

Tobacco-cyst nematode (TCN) *(Globodera tabacum* subsp. *solanacearum)* is present in most tobacco-producing counties in Southside Virginia. Taking soil samples for a Predictive Nematode Assay of tobacco fields on a regular basis (before rotating a field to another crop) will help avoid detecting TCN populations "the hard way." **Varieties of flue-cured tobacco that possess the *Php* gene will reduce TCN populations to non-damaging levels after several years of use;** TCN populations will increase very quickly to damaging levels when fields are planted continuously with flue-cured tobacco cultivars without the *Php* gene. Crop rotation with corn, sorghum, small grains, or pasture grasses will also significantly improve TCN control, particularly when used in addition to TCN-resistant varieties.

Tobacco Mosaic Virus (TMV)

Anything that moves sap from diseased to healthy plants will also move TMV. TMV can spread via contaminated clipping mowers in the greenhouse and from manufactured tobacco products, old tobacco sheets, tobacco roots and stalks left in the soil from previous crops, and from weed hosts such as horse-nettle and ground cherry. Washing hands regularly with detergent can help reduce TMV incidence early in the season. Rogueing infected plants before layby will reduce spread of the virus within a field. TMV can be eliminated by faithful use of resistant varieties along with crop rotation and early root and stalk destruction. All burley varieties are resistant to TMV except HB 3307PLC, N 777LC, TN 86LC, and KT 215LC. Flue-cured tobacco cultivars CC 27, CC 37, CC 67, CC 304, GL 26H, NC 102, NC 297, PVH 2254, PVH 2275, and PVH 2310 are TMV-resistant. Traditional Virginia-type dark-fired tobacco cultivars (Shirey, for example) are susceptible to TMV, but newer varieties (other than KT D8LC, DT 538LC, DT 558LC, and PD 7309LC) are TMV-resistant. *TMV-resistant varieties should be planted in tobacco fields when 30 to 50 percent of the plants are infected with TMV by topping. If a TMV-resistant variety is planted in an infested field, the entire field should be planted with the resistant variety. Planting resistant and susceptible varieties together in TMV problem fields can result in significant crop losses due to a severe hypersensitive reaction in the resistant cultivar that can actually kill plants.*

Tomato Spotted Wilt Virus (TSWV)

Spread by various species of thrips from wild weed hosts to tobacco and other crops. Removing infected plants from a tobacco field will not reduce damage. Crop rotation does not reduce the incidence of TSWV. All commercial tobacco varieties are equally susceptible to the virus. Spraying foliar insecticides is also ineffective. However, application of insecticides containing imidacloprid or thiamethoxam prior to or at transplanting can significantly reduce the damage caused by TSWV to tobacco, as will preplant use of Actigard. Application of Actigard before transplanting, in addition to imidacloprid or thiamethoxam, significantly improves TSWV control compared to use of a single product. Be aware, however, that some risk of significant stunting has been associated with preplant use of Actigard. For this reason, do not apply Actigard before transplanting unless 10% to 15% of the tobacco crop is expected to become infected with TSWV. See the chapters on tobacco insect control in the production guides for burley, dark, and flue-cured tobacco for more specific information on use of imidacloprid or thiamethoxam.

Other Viruses

Tobacco etch virus (TEV), Tobacco vein mottling virus (TVMV), Cucumber mosaic virus (CMV), Peanut stunt virus (PSV), Potato virus Y (PVY), Alfalfa mosaic virus (AMV) - TVMV and TEV are the most common viruses found in burley tobacco, frequently occur together, and are often referred to as a virus complex. Other less common viruses found in the burley virus complex are AMV, CMV, and PSV. All of these viruses are transmitted by aphids that feed on infected weeds and then move into tobacco. Overwintering hosts of these viruses include horsenettle, ground cherry, curly dock (for TVMV), alfalfa (for AMV), and clovers for CMV and PSV. Symptoms of virus infections vary greatly depending on the virus involved, time of infection, and variety. Virus infected plants may show mosaic, vein clearing, stunt, chlorosis, vein banding, etch, and death of veins. The earlier the plants become infected the more severe the stunting, chlorosis, and necrosis. There are no known methods to prevent infection, nor are chemicals available to cure a virus-infected plant. Consult the KY, TN, VA and NC regional publication *2017-2018 Burley and Dark Tobacco Production Guide* (Virginia Cooperative Extension publication 436-050) for information on resistance to these viruses in currently-grown burley varieties.

Fusarium Wilt

Can become a serious problem. Plants are stunted, often wilted on one-side, and leaves or parts of leaves are significantly yellowed or chlorotic. Usually associated with nematode injury in flue-cured tobacco, but not necessarily in burley. Early destruction of tobacco stalks and roots and crop rotation (for as long as possible, but not with cotton or sweet potato) will also help reduce problems with Fusarium wilt. Soil fumigation using a product containing chloropicrin may be required where significant stand loss has occured.

Application Methods

The performance and safety of a chemical is dependent on following the proper application methods. Proper application procedures will avoid crop injury and poor disease control.

Preplant Incorporated (PPI)

Refer to section under weed control.

Foliar Spray (FS)

Greenhouse fungicide sprays should not begin until seedlings are at least the size of a dime. Use flat-fan, extended-range tips at approximately 40 psi to maximize results. Flat-fan spray tips and spray volumes of 25-50 gallons per acre should generally be used for field sprays targeting the soil surface. Foliar field sprays should apply spray volumes of at least 20 gallons/acre at layby, gradually increasing to 80-100 gallons of spray solution/acre at topping to maximize spray coverage as tobacco plants increase in size. Hollow cone or similar spray tips should be used for foliar field sprays to reduce spray droplet size to improve coverage of leaves. Spray pressures should generally range between 40 and 100 psi. Both the tops and bottoms of leaves need to be covered. The use of drop nozzles will significantly improve disease control after layby by improving spray coverage on bottom leaves, where foliar diseases are usually concentrated. Fungicides applied using air-blast sprayers should be mixed at a two-times concentration, but only half the spray volume (gal mix/acre) should be delivered compared to a hydraulic sprayer.

Fumigation

Labels for products that contain chloropicrin and metam sodium now require respirator fit-testing, full-face respirators (chloropicrin products only); completed "fumigant management plans" or FMPs *prior to application*; increased posting of treated areas, as well as buffer zones around fumigated fields; minimum distances between treated fields and "difficult to evacuate" sites (schools, etc.), 5-day "entry restricted periods" (ERPs) after soil fumigant application, completed "post-application summaries" within 30 days of application; and official notification requirements. Fumigant applicators must complete an EPA-approved training program in order to purchase and apply these products. This training isn't required for those who use products without chloropicrin or metam sodium, such as Telone II (containing only 1,3-dichloropropene). Further information on certified fumigant applicator training is available at https://www.epa.gov/soil-fumigants/soil-fumigant-training-certified-applicators.

Field Procedures - Performance of all or most field procedures must be documented in the GAP section of the FMP for chloropicrin products, Telone C-17, and metam sodium products. Soil should be in good seed bed condition, free of clods and undecomposed plant material, and with soil moisture at about 1/2 of field capacity when fumigants are applied. *If undecomposed plant material is present, plow down and allow to decompose before applying fumigant*. Soil temperature should be 50° to 80° F at the depth of injection. Fumigants can be applied by the following procedure: 1) **Row treatment** - inject the fumigant 6-8 inches deep with one chisel-type applicator in center of the row. In the same operation as fumigant application, seal the soil by bedding the fumigated row area with enough soil to bring the soil surface 14-16 inches above the point of infection; 2) **Broadcast treatment** - Space chisels 8 inches apart and inject fumigant 10 to 12 inches below the soil surface. Immediately seal in the fumigant with a roller, drag, disc, or similar equipment.

After fumigation, leave soil undisturbed for an 'exposure period' of 7-14 days. Cold, wet soil retards diffusion of fumigants and requires a longer exposure period. Soil should be aerated at the end of the exposure period. Planting is generally considered safe

when a residual odor of the fumigant is no longer detectable in the soil root zone. This condition is usually reached within 2-3 weeks of application, depending upon the specific soil fumigant used. *The following procedures can be used to hasten aeration, especially if rains or cold temperatures occur during the exposure period: 1)* ***Row*** *- Use a chisel in the bed without turning the soil; 2)* ***Broadcast*** *- Plow or cultivate above the depth of the treatment zone.* ***Caution****: In both types of treatment, avoid contaminating treated soil with untreated soil. Do not rehill row if there is a danger of contamination with untreated soil. Do not use tools, equipment, and/or residues that are contaminated with soil-borne pathogens. Remember, plant injury will occur if fumigant is still present in the soil at transplanting.*

Precautionary and Restriction Statements

Read and follow all directions, cautions, precautions, restrictions, and special precautions on each product label. This publication must not be used as the only source of precautionary and restriction statements.

Table 3.18 - Diseases of Tobacco Seedlings

Disease	Material	Rate	Remarks
Anthracnose *(Colletotrichum gloeosporoides)* Blue Mold *(Peronospora tabacina)* Target Spot *(Thanatephorus cucumeris)*	Penncozeb 75DF	0.5 lb/100 gal (1 level tsp/gal)	Apply as a fine spray to the point of run-off to ensure thorough coverage. For best results, begin applications before disease has been observed, but not before seedlings are the size of a dime. Use 3 gal of spray mixture/1000 sq ft when plants are about the size of a dime. Use 6 gal/1,000 sq ft. when the canopy has closed and plants are close to ready for transplanting. Repeat applications on a 5-day interval to protect new growth. FRAC Code M3.
Target Spot *(Thanatephorus cucumeris)*	Quadris	0.14 oz (4 cc)/1,000 sq ft	One application to tobacco seedlings in transplant greenhouses is allowed. Use enough water for thorough coverage (3-5 gal/1,000 sq.ft.). Follow-up applications are allowed in the field according to the Quadris field label. FRAC Code 11.
Pythium Root Rot *(Pythium spp.)*	Terramaster 4EC	**Preventative:** 1.0 fl oz/100 gal **Sequential:** 1.0 fl oz/100 gal **Curative:** 1.4 fl oz/100 gal **2nd Curative:** 1.0-1.4 fl oz/100 gal	Can be used before or after symptoms appear, but no earlier than 2 weeks after seeding. If symptoms reappear, a second application can be made no later than 8 weeks after seeding. No more than 2.8 fl oz/100 gal of water may be applied to any crop of transplants, regardless of the number of applications. **Must be evenly distributed**; when mixing, first form dilute slurry, then distribute slurry evenly and thoroughly in float bed water. FRAC Code 14.
Blue mold (*Peronospora tabacina*)	Aliette (for blue mold)	0.5lb/50 gal 8 fl oz/acre	Foliar spray; apply no more than 0.6 lb/1,000 sq ft; **can burn plants if washed into media or float water**; no more than 2 sprays/ greenhouse season. Begin applications prior to disease development and continues on a 7-10 day interval. Make no more than 2 consecutive applications before switching to an effective non-Group 40 fungicide. May be tank-mixed with another blue mold fungicide with a different mode of action. Adding a spreader-penetator, such as a non-ionic surfactant, may increase activity. Thorough coverage is needed for maximum activity. FRAC Code 33.

Table 3.18 - Diseases of Tobacco Seedlings (cont.)

Disease	Material	Rate	Remarks
Tomato Spotted Wilt Virus (TSWV)	Actigard 50WG	1.0-2.0 oz/100,000 plants (~347-288-cell trays)	*Must submit liability waiver to receive a copy of the label, which is required for use.* **One** foliar application in the greenhouse 5-7 days prior to transplanting in sufficient water to ensure good coverage (~6 gal/1,000 sq ft); **use of accurate rate is CRITICAL to avoid crop injury.** A 10% to 15% stand loss due to TSWV should be expected before considering use. Systemic insecticides such as imidacloprid or thiamethoxam as well as Actigard will significantly improve control of TSWV. Tank mixtures are not recommended, but product may be left on foliage or washed off into the root ball. FRAC Code 21.
		0.5 oz/A	Field application as a banded, foliar spray in sufficient water (at least 20 gal/A) to provide thorough coverage. The initial spray should be made within 7 days of transplanting or whenever plants have recovered from transplant shock, whichever comes first. A total of 3 such field applications may be made, 10 to 14 days apart. FRAC code 21.
Angular Leaf Spot or Wildfire *(Pseudomonas)*	Agrimycin 17, etc. Harbour, Fire-Wall 17WP, etc.	100-200 ppm 2-4 tsp/3 gal or 4-8 oz/50 gal	Foliar Spray; preventive use: 100 ppm = 4.0 oz/50 gal or 0.5 lb/100 gal; curative use: 200 ppm = 0.5 lb/50 gal or 1.0 lb/100 gal. FRAC Code 25.

Table 3.19 - Foliar Diseases in the Field

Disease	Material	Rate	Remarks
Blue mold *(Peronospora tabacina);* Frogeye *(Cercospora nicotianae):* Target Spot *(Thanatephorus cucumeris)*	Quadris	6.0-12.0 fl oz	First application should be made prior to disease development or at first indication of disease development in the area; sprays should be applied every 7-14 days, with shorter intervals when weather is conducive for disease, in sufficient water volume for complete coverage and canopy penetration; may enhance weather flecking, but this does not affect yield or quality; up to 4 applications/year allowed; may be applied up to the day of harvest; tank mixing with insecticides formulated as ECs or containing high amounts of solvents may cause some crop injury. FRAC Code 11.
Blue mold *(Peronospora tobacina)*	Revus or Orondis Ultra B	8 fl oz/acre	Begin applications before disease develops and continue spraying on a 7-10 day interval. Spray no more than twice before switching to another effective fungicide that's not in FRAC Group 40. Revus and Orondis Ultra B may be tank-mixed with another effective blue mold fungicide that has a different mode of action (different FRAC Group number). Thorough spray coverage is important in maximizing disease control; adding a spreader-penetrating adjuvant may improve activity. FRAC Group 40.

Table 3.19 - Foliar Diseases in the Field (cont.)

Disease	Material	Rate	Remarks
Blue mold *(Peronospora tobacina)* (cont.)	Orondis Ultra A	2.9-4.8 fl oz/A	Do not use if Orondis Gold 200 has previously been applied to soil. Begin applications before disease development and continue on a 7-to 10-day interval. Use higher rates when disease is present, for longer application intervals, or more susceptible varieties. Make no more than 2 sequential applications before rotating to a fungicide with a different mode of action. See label for additional use restrictions. FRAC Code 49.
	Forum (formerly Acrobat) + Penncozeb 75DF	7.0 fl oz/100 gal 2.0 lb/100 gal	Spray weekly for complete coverage until blue mold no longer threatens. Increase spray volume as the crop grows. Spray volumes should range from 20 gal/A for 1- 3 weeks after transplanting to 40 gal/A for tobacco near layby, to 60 gal/A for waist-high tobacco, to 80-100 gal/A for tobacco near topping or thereafter. If using an air blast sprayer, mix fungicide at 2X concentration, but calibrate sprayer to apply 1/2 the spray volume (gal/acre) used with hydraulic sprayers. Do not spray within 21 days of harvest for flue-cured tobacco or within 30 days of cutting burley tobacco. Forum is FRAC Group 40; mancozeb fungicides are FRAC Group M3.
	Presidio	4 fl oz/A	Two foliar sprays are allowed, the first before or at disease onset. The second spray should be at least 7 days after the first Presidio application. Presidio must be tank-mixed with another blue mold fungicide for resistance management. FRAC Code 43.
	Penncozeb 75DF	2.0 lb/100 gal	Spray weekly for complete coverage until blue mold no longer threatens. Gradually increase spray volume as the crop grows. Spray volumes should range between 80 and 100 gal/A on tobacco ready to be topped. If using an air blast sprayer, mix fungicide at 2X concentration, but calibrate sprayer to apply 1/2 the spray volume (gal/acre) used with hydraulic sprayers. Don't spray within 21 days of harvest for flue-cured tobacco, or within 30 days of cutting burley tobacco. FRAC Code M3.
	Ridomil Gold SL UltraFlourish MetaStar 2E AG	0.5-1.0 pt 1.0-2.0 pt 2.0-4.0 pt	**Flue-Cured –** Apply low rate for early season control. **Burley & dark-fired** — Apply high rate for early season control. **Note:** Apply broadcast & incorporate in top 2-4 inches of soil preplant. Do not use in plant beds or float systems. **Do not apply if mefenoxam or metalaxyl-insensitive pathogen strains have been reported to be present.** FRAC Code 4.
	Ridomil Gold SL UltraFlourish MetaStar 2E AG	0.5 pt 1.0 pt 2.0 pt	Apply to soil beneath plants just before layby cultivation - don't spray leaves. **Do not apply if mefenoxam or metalaxyl-insensitive pathogen strains have been reported to be present.** FRAC Code 4.

Table 3.19 - Foliar Diseases in the Field (cont.)

Disease	Material	Rate	Remarks
Blue mold *(Peronospora tobacina)* (cont.)	Aliette	2.5-4.0 lb/A	Foliar spray; no more than 5 sprays allowed, 3-day preharvest interval; don't tank mix. FRAC Code 33.
	Actigard 50WG	0.5 oz/20 gal/A	Begin applications when blue mold threatens and plants are tall enough (12 inches for flue-cured and dark-fired tobacco, 18 inches for burley). Up to 3 sprays may be applied on a 10-day schedule. FRAC Code P01.

Table 3.20 - Root and Stem Diseases in the Field

Disease	Material	Rate/Acre	Remarks
Black shank (*Phytophthora nicotianae*)	**Transplant Water Use**		Apply Ridomil Gold (FRAC Code 4) and/or Orondis Gold 200 (FRAC Code 49) in at least 100 gal (200 gal for burley and dark tobacco) transplant water/A. Transplant water use carries a risk of plant injury. Use higher rates if disease pressure is expected to be severe. Ultra Flourish and Meta Star are not registered for transplant water application. Season-long disease control usually requires an additional black shank fungicide application at 1st cultivation and/or layby, using a fungicide product with a different FRAC Code. Orondis Gold 200 must not be applied sequentially (back-to-back).
	Ridomil Gold SL	4.0-8.0 fl oz (0.25-0.5 pt)	
	Orondis Gold 200	4.8-19.2 fl oz (0.30-1.2 pt)	
	Pre-Plant Spray		Apply preplant sprays broadcast, then incorporate into the top 2-4 inches of soil. Presidio and Orondis Gold 200 are not labelled for this use. Black shank fungicides should always be used in conjunction with crop rotation and resistant varieties. Failure to control nematodes in treated fields may result in poor black shank control. FRAC Code 4.
	Flue-Cured		
	Ridomil Gold SL	1.0-2.0 pt	
	Ultra Flourish	2.0-4.0 pt	
	MetaStar 2E AG	4.0-8.0 pt	
	Burley and Dark		
	Ridomil Gold SL	2.0-3.0 pt	
	Ultra Flourish	4.0-6.0 pt	
	MetaStar 2E AG	8.0-12.0 pt	
	Post-Plant Spray(s)		Direct banded sprays to soil beneath plants during field cultivation. If significant disease is likely, use after a pre- or at-plant black shank fungicide application. Do not apply Presidio and Orondis sequentially (back-to-back), but alternate each with another black shank fungicide. Later application during cultivation usually extends disease control further through the harvest season. Do not exceed 3.0 pt of Ridomil Gold (FRAC Code 4), 6.0 pt of Ultra Flourish (FRAC Code 4), 12.0 pt of MetaStar (FRAC Code 4), 8.0 fl oz of Presidio (FRAC Code 43), or 38.6 fl oz Orondis Gold 200 (FRAC Code 49) per acre.
	Ridomil Gold SL	1.0-2.0 pt	
	Ultra Flourish	2.0-4.0 pt	
	MetaStar 2E AG	4.0-8.0 pt	
	Presidio	4.0 fl oz	
	Orondis Gold 200	4.8-19.2 fl oz	
	No-Till Sprays		For no-till tobacco, split between 2 sprays, before and 30-35 days after transplanting. See comments in tobacco weed control section for directions in calculating rates for band applications. FRAC Code 4.
	Ridomil Gold SL	0.5-1.0 pt	
	Ultra Flourish	3.0 pt	
	MetaStar 2E AG	6.0 pt	

Table 3.20 - Root and Stem Diseases in the Field (cont.)

Disease	Material	Rate/Acre	Remarks
	Soil Fumigants		Inject 8 inches deep with one shank in center of row when soil temperatures are above 50° F. Wait 2-3 weeks after fumigation before planting. Fumigants should always be used in conjunction with host resistance and crop rotation. A soil fungicide should also always be used in addition to a soil fumigant when the fumigant is applied for black shank control.
	100% Chloropicrin products	3.0 gal	
	Pic+	4.2 gal	
Fusarium Wilt (*Fusarium oxysporum* f. sp. *nicotianae*)	100% Chloropicrin products	3.0 gal	In severe cases, apply a soil fumigant containing chloropicrin, and rotate the field out of tobacco for at least 2-3 years between tobacco crops. Do not rotate with sweet potatoes, since the same fungus attacks both crops.
	Pic+	4.2 gal	
Granville Wilt (*Pseudomonas solanacearum*)	100% Chloropicrin products	3.0 gal	Fumigants should always be used in conjunction with host resistance and crop rotation.
	Pic+	4.2 gal	

Table 3.21 - Nematodes[1,2]

Material	Rate/A	Application Method	Root-Knot And Others	Tobacco Cyst	Remarks
Non-Fumigants					
Nimitz	3.5 -7 pt (56-112 fl oz)/treated acre	Banded PPI	F	F	With spray volume at least 40 gal/A; apply at least 7 days before transplanting. Use higher rates in fields with higher nematode populations and for tobacco cyst.
Fumigants					
100% Chloropicrin products	3.0 gal	Row	E	G	TriPic 100, etc.
42% metam sodium	20.0-25.0 gal	Row	nd	G	Metam CLR, Vapam, Sectagon, etc.
Pic+	4.2 gal	Row	E	G	
Telone II	9.0-10.0 gal	Row	E	G	

[1] Control rating – E = Excellent; G = Good; F = Fair; P = Poor, - = no control or not labeled for disease; nd = no data

[2] **BANDED-PPI** - Research results indicate product performance is best when applied in a 12-24 inch band centered over where the transplanting furrow will be. **Row** – Inject 8 inches deep in row with single shank – 21 day waiting period before planting.

Table 3.22 - No Chemical Available for the Following Diseases

Disease	Comments
Botrytis Blight *(Botrytis cinerea)*	This disease occurs more commonly in “organic” than “conventional” tobacco greenhouses, and only very rarely in the field. A wet rot is often first observed on stems or leaves. A gray, downy material may be present on the surface of diseased areas. Management practices effective for collar rot and target spot also help reduce incidence and severity of Botrytis blight.
Collar Rot *(Sclerotinia sclerotiorum)*	Symptoms of this disease (occurring only in greenhouse systems) resemble damping-off. Small groups of plants have brown, wet lesions near the base of stems. Leaf rot may appear to progress from leaf margins or tips toward the stem. White, cottony mold may be visible. Irregularly shaped, white to black objects (sclerotia) may also be found attached to severely infected plant parts. Infected plants, as well as plants immediately adjacent to diseased areas, should be discarded as soon as possible. Proper clipping procedures, improving ventilation, and reducing excess moisture will help reduce spread of the causal organism.
Frenching (nonpathogenic causal agent)	This disorder has been associated with toxins produced by a nonpathogenic bacterium *(Bacillus cereus)* and other nonpathogenic microorganisms. Frenching is more prevalent on wet, poorly aerated soils. This problem can be more severe on neutral or alkaline soils and is sometimes associated with lack of available nitrogen or other minerals. Proper soil drainage and fertilization can be beneficial. Do not plant in alkaline soils and avoid heavy application of lime.
Weather fleck (ozone)	This disorder appears as small brown to tan leaf spots in the plant bed and field. The major cause of this problem is ozone from thunderstorms and air pollution. Burley and flue-cured tobacco are more susceptible than dark-fired varieties.

Peanuts

Hillary L. Mehl, Extension Plant Pathologist, Virginia Tech, Tidewater AREC

Weather-Based Crop Advisories

The Peanut/Cotton Infonet is designed to electronically collect data from remote weather stations in the peanut and cotton producing areas of Southeastern Virginia. The data are used to provide daily summaries (air and soil temperature, rainfall), peanut leaf spot and Sclerotinia blight advisories, heat unit reports for peanuts, and degree-day reports for cotton. The Peanut Frost Advisory is another weather-based program that is provided during the fall-harvest period. Each program is designed to guide growers in making decisions that maximize yield, quality, and net profit. Because of constant changes in weather and pest populations during the growing season, information must be updated daily and made readily available to growers. The Tidewater Agricultural Research and Extension Center (AREC) in cooperation with Extension agents, growers, and industry make this information available in the following ways:

- **Peanut/Cotton InfoNet:** Information from four weather monitors is available on the Internet at *http://www.ipm.vt.edu/infonet/* Up-to-date leaf spot and Sclerotinia fungicide advisories, heat units, and frost advisories are reported.
- Contact your local Extension agent or call (757) 657-6450 and ask for Dr. Hillary Mehl or Linda Byrd-Masters if you need assistance.

Clinical Services

Diagnostic services for plant diseases are provided by the Tidewater AREC in Suffolk. Plant samples should be submitted with the required forms by unit Extension agents. A period of 3 to 5 days is needed to complete biopsy tests and email reports. Diagnostic tests for nematodes and soil fertility problems during the season are also performed in cooperation with laboratories at Virginia Tech. Diagnostic assays are provided free of charge for agents and growers.

Predictive Nematode Assay

This program provides data on the numbers and kinds of nematodes in soil and recommendations on needs for control. Soil samples must be collected in the fall no later than November 20. Local Extension offices have instructions, sample information sheets, and bags for packaging samples.

Management Inputs

The most effective and economical strategy for disease control combines the benefits of sanitation, crop rotation, resistant varieties, scouting, and judicious use of pesticides. For example, changing from a 2-year to a 3-year rotation of peanut with corn or cotton can reduce disease losses to leaf spot, Sclerotinia blight, and Cylindrocladium black rot by as much as 50 percent in as few as two or three cycles. Inputs for disease control should be determined on the basis of field history, scouting, disease advisory programs, and recommendations by Virginia Cooperative Extension. This approach to disease management will enable the judicious use of chemicals while providing for a maximum return on investments.

Sanitation

The decay of excess crop residues can be enhanced by disking fields after harvest. Plant debris may contain residual inoculum of organisms that cause disease and improve their capability for long-term survival in fields. Wash equipment frequently to avoid transport of inoculum from field to field. Peanut combines should be cleaned to remove loose soil and plant material after harvesting fields with heavy infestations of soil-borne diseases. Attempts at removal and/or destruction of peanut vines after harvest have some value in disease management, but this practice negates a significant part of the soil fertility benefits of peanut hay in the following year.

Crop Rotation

Using a 4-year rotation of peanuts with corn, grain sorghum, fescue, and other grass-type crops is beneficial to control of peanut diseases. Cotton is also a good rotational crop for peanuts in Virginia, but growers should not apply potash (K) in excess of recommended rates of the soil test report. Elevated levels of potash can interfere with calcium uptake and result in pod rot by fungi such a *Rhizoctonia* and *Pythium* species. Soybean and other leguminous crops share many of the common destructive

diseases with peanuts and should be avoided. Where soybean is grown in a peanut rotation, double crop soybean with wheat and follow with either cotton, corn, or another grass-type crop.

Resistant Varieties

No peanut varieties are immune to disease, but there is a wide range in susceptibility. Some important differences are noted below with respect to the most common diseases.

- **Cylindrocladium black rot (CBR):** Currently grown Virginia-type peanuts including Bailey, Sugg, Sullivan, and Wynne are partially resistant to CBR. Disease severity in other varieties can be reduced by good nematode control and delayed planting to May 10 or later. Cool, wet conditions after planting favor epidemics of CBR.
- **Sclerotinia blight:** Sullivan and Bailey are partially resistant to this disease. Early planting at seed rates of 110 lb/A or lower can reduce the susceptibility of varieties in some years. However, this practice will increase the risk of tomato spotted wilt disease.
- **Early leaf spot:** Sullivan, Bailey, and Wynne are moderately susceptible. All other Virginia-type varieties are susceptible.
- **Tomato spotted wilt virus:** Bailey, Wynne, and Sullivan are resistant to TSWV. Sugg and Gregory are moderately less susceptible, but can sustain significant damage in early plantings before May 1 in years of heavy disease pressure.

Scouting

Peanut fields should be scouted once a week for disease after pegging. Scouts should use different entry and exit points as well as travel patterns across fields at each visit. After a canopy of foliage covers the soil, scouts should part the vines and look for signs of soilborne diseases on plant stems at the soil surface.

Chemicals

A wide array of chemicals are registered for disease control in peanuts. Selection of the most effective/economical chemical requires knowledge of the target disease and other diseases in the field. Whenever the cause of disease is uncertain, plant samples should be submitted for diagnostic tests in the plant pathology clinic at the Tidewater AREC. Whenever nematode or soil fertility problems are suspected, a 1 pt sample of soil should be submitted. The Peanut/Cotton InfoNet is an important source of information for timing of fungicide applications to control leaf spot and Sclerotinia blight. The following tables provide listings of some of the approved chemicals for control of specific disease problems. Other products may be available, but these are the most common fungicides for control of peanut diseases in Virginia. **Read the label instructions attached to the pesticide containers before application.**

Though it primarily applies to exports, it should be noted that due to recent pesticide residue restrictions made by the European Union, certain peanut shellers will not accept ANY peanuts that have had the restricted chemicals applied. The new restrictions are NOT based on increased safety concerns, and they may still be labelled for use in the U.S. However, under the current circumstances peanut growers should NOT use them, and many chemical suppliers are voluntarily ceasing sales of these products for use in peanut. The chemicals fall into two major categories:

1) propiconazole-containing products and

2) mono/dipotassium salts or phosphorous acid based products.

Products in category 1 are used for leaf spot management and include Tilt (propiconazole), Tilt Bravo (propiconazole + chlorothalonil), Stratego (propiconazole + trifloxystrobin), and Artisan (propiconazole + flutolanil). There are several generic products with propiconazole as well, so be sure to check labels for propiconazole as an active ingredient. Some good alternatives to propiconazole in leaf spot fungicide programs include Alto (cyproconazole) + Bravo Weather Stik (chlorothalonil), Absolute (tebuconazole + trifoxystrobin), and Priaxor (fluxapyroxad + pyraclostrobin).

Fungicides in the second category are applied for management of Pythium pod rot, and there is not widespread use of these fungicides in Virginia. However, growers still need to be aware and be sure they are not using these. Typically, a different type of fungicide for Pythium control is included in seed treatments such as Dynasty, and these products are still okay to use.

Due to these restrictions, fungicide products containing these active ingredients are no longer recommended and are not included in the fungicide tables below.

Table 3.23 - Seed Treatments

Disease	Product and Formulation	Rate of Formulation/100 lb seed	Method and Timing of Application	Precautions and Remarks[1]
Seed decay and seedling disease	Allegiance-FL (metalaxyl)	0.1-0.375 fl oz	Apply as water-based slurry with commercial seed treatment equipment.	Controls Pythium seed rot and damping-off. Use in combination with a broad spectrum fungicide.
	Apron XL LS (mefenoxam)	0.16-0.64 fl oz	Same as above.	Same as above.
	Protégé (azoxystrobin)	0.153-1.53 fl oz	Same as above.	Controls Aspergillus crown rot and Rhizoctonia damping-off.
	Maxim 4FS (fludioxonil)	0.08-0.16 fl oz	Same as above.	Protects against seed decay, damping-off, and seed transmission of Cylindrocladium black rot.
	Captan 30DD OR Captan 400	6.0 fl oz 3.0-6.0 fl oz	Same as above.	Same as above.
	RTU-PCNB	1.75-2.5 fl oz	Same as above.	Controls damping-off by *Rhizoctonia sp.*
	42-S Thiram	3.0 fl oz	Same as above.	Protects against seed decay, damping-off and seedling blights.
	Vitavax-30C	3.0 fl oz	Same as above.	Controls Sclerotium rot and damping-off. Use in combination with a broad spectrum fungicide.
	Thiram 50WP	4.5 oz	Apply with dust treater.	Controls seed decay, damping-off, and seedling blights.
	Vitavax PC (captan + PCNB + Vitavax)	4.0-5.0 oz	Same as above.	Same as above.
	Trilex Optimum DS (captan, trifloxystrobin, metalaxyl)	4.0 oz	Same as above.	Same as above.
	Trilex Star DS (captan, trifloxystrobin, thiophanate methyl, metalaxyl)	4.0 oz	Same as above.	Same as above, and suppresses seed transmission of CBR.
	Dynasty PD (azoxystrobin + fludioxonil + mefenoxam)	3.0-4.0 oz	Same as above.	Controls seed decay, seedling diseases, and seed transmission of *Cylindrocladium* black rot.
	Rancona V PD (ipconazole + carboxin + metalaxyl)	4.0 oz	Same as above.	Controls seed rot, damping off, and seedling blight.

[1]Do not use treated seed for food, feed, or oil purposes. Bags with treated seed should bear a tag or label cautioning against their use for these purposes as well as the reuse of bags.

Table 3.24 - Fungicide Sprays

Disease(s) controlled	Active ingredient	Product and formulation	Rate per Acre	Method and Timing of Application[1]	Precautions and Remarks[2]
Foliar diseases only (early and late leaf spot, web blotch)	Chlorothalonil	Bravo 720 Bravo Ultrex Echo 720 Various others	1.5 pt 1.4 lb 1.5 pt	Apply according to leaf-spot advisory program or a calendar-based program using 14-21 day intervals.	**Caution:** Sclerotinia blight will be more difficult to control when these products are applied at intervals of less than 21 days.
	Tebuconazole + trifloxystrobin	Absolute 500SC	3.7-7.0 fl oz	Same as above.	Do not apply more than 4 sprays and apply chlorothalonil as the final spray for fungicide resistance management. Also controls limb rot.
	Mancozeb	Koverall	1.0-2.0 lb	Same as above.	Only effective against early leaf spot.
	Cyproconazole	Alto 100SL	5.5 fl oz	Same as above.	Mix or alternate with another fungicide to improve foliar disease control and reduce risk of fungicide resistance.
	Flutriafol	Topguard 1.04 SC	7-14 fl oz	Same as above.	Same as above.
	Tetraconazole	Eminent 125SL	6-13 fl oz	Same as above.	Same as above.
Early and late leaf spot, web blotch, Rhizoctonia limb rot, Southern stem rot	Tetraconazole	Domark 230ME	5.25 to 6.9 fl oz	Same as above.	Do not make more than 2 applications or 13.8 fl oz per acre per year. PHI = 14 days.
	Pydiflumetofen	Miravis	3.4 fl oz	Begin applications prior to disease development. For early and late leaf spot control, apply on a 21 to 28-day interval.	Do not make more than three applications of Miravis or other Group 7 fungicides before alternating with another fungicide mode of action. Also suppresses Sclerotinia blight.

[1]For best results, apply sprays according to leaf spot advisory program in a volume of 12.0 to 15.0 gal/A by ground sprayers or 5.0 gal/A with aircraft.

[2]Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Table 3.24 - Fungicide Sprays (cont.)

Disease(s) controlled	Active ingredient	Product and formulation	Rate per Acre	Method and Timing of Application[1]	Precautions and Remarks[2]
	Tebuconazole + prothioconazole	Provost Opti	7.0 oz	Same as above.	Label also allows up to 2 sprays at 14 oz/A for control of Rhizoctonia limb rot in addition to foliar diseases.
	Metconazole	Quash 50 WDG	2.5-4 oz	Same as above.	Apply up to 4 sprays then use a fungicide with a different mode of action.
Early and late leaf spot, web blotch, Rhizoctonia limb rot, Southern stem rot (con't)	Tebuconazole	Folicur 3.6F Multiple generics	7.2 fl oz	Same as above.	Many populations of leaf spot fungicide are not controlled by tebuconazole alone. Mix with chlorothalonil or another fungicide with a different mode of action.
	Penthiopyrad	Fontelis 1.67SC	12-24 fl oz	Same as above.	Apply up to 3 sprays, then use a fungicide with a different mode of action. Also suppresses Sclerotinia blight.
	Azoxystrobin	Abound 2.08F	9.0-12.3 fl oz	Apply according to leaf spot advisory program, but do not make more than two applications.	Do not apply within 50 days of harvest. Not recommended for the last spray.
	azoxystrobin + tebuconazole	Custodia SC	15.5 fl oz	Apply according to leaf spot advisory.	Make up to 2 to 4 applications in mid-season as part of an advisory program.
	fluoxastrobin	Evito 480SC Aftershock	3.8-5.7 fl oz	Same as above.	Make up to 2 applications per season and rotate or mix with another fungicide with a different mode of action.

[1]For best results, apply sprays according to leaf spot advisory program in a volume of 12.0 to 15.0 gal/A by ground sprayers or 5.0 gal/A with aircraft.

[2]Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Table 3.24 - Fungicide Sprays (cont.)

Disease(s) controlled	Active ingredient	Product and formulation	Rate per Acre	Method and Timing of Application[1]	Precautions and Remarks[2]
	fluoxastrobin + tetraconazole	Evito T	6-11.2 fl oz	Same as above.	Make up to 2 to 4 applications in mid-season as part of an advisory program.
Early and late leaf spot, web blotch, Rhizoctonia limb rot, Southern stem rot (con't)	Pyraclostrobin	Headline 2.09EC, 2.08SC	6-15 fl oz	Same as above.	Make up to 2 applications per season and rotate or mix with another fungicide with a different mode of action.
	Fluxapyroxad + pyraclostrobin	Priaxor	4-8 fl oz	Same as above.	Use 1 to 3 times per season. Use higher rates for limb rot and stem rot control.
	Azoxystrobin + benzovindiflupyr	Elatus	7.3-9.5 fl oz	Same as above.	Make no more than 3 applications before alternating with a fungicide with a different mode of action. May also be applied as an early season banded application for suppression of soilborne diseases. Excellent stem rot control.
Sclerotinia blight	fluazinam	Omega 500F	1.0-1.5 pt	Make first application according to disease scouting and the Sclerotinia advisory program. Up to two additional sprays may be applied depending upon disease pressure.	Provides good control of Sclerotinia blight and suppression of southern stem rot and Rhizoctonia pod rot.

[1]For best results, apply sprays according to leaf spot advisory program in a volume of 12.0 to 15.0 gal/A by ground sprayers or 5.0 gal/A with aircraft.

[2]Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Table 3.24 - Fungicide Sprays (cont.)

Disease(s) controlled	Active ingredient	Product and formulation	Rate per Acre	Method and Timing of Application[1]	Precautions and Remarks[2]
	boscalid	Endura 70 WG	8-10 fl oz	Make first application according to the Sclerotinia advisory program and disease scouting in problem fields. Up to three sprays are allowed, but do not make more than two sequential applications.	Provides partial control of Sclerotinia blight and suppression of stem rot. Also suppresses leaf spot and provides excellent control of web blotch.
Sclerotinia blight (con't)	Penthiopyrad	Fontelis 1.67SC	12-24 fl oz	Apply prior to disease onset and thereafter according to scouting or Sclerotinia blight advisory.	Suppression only. Also controls leaf spot, southern stem rot, and suppresses CBR. Do not apply more than three sequential sprays or 72 fl oz/A per season.
	prothioconazole + fluopyram	Propulse 3.34SC	13.6 fl oz	Apply the first spray when disease is initially detected, and if needed, a second application according to scouting or Sclerotinia blight advisory.	Suppression only. Also suppresses CBR and limb rot. Do not apply more than 34.2 fl oz/A per season. May also be applied to the seed furrow at planting for suppression of soilborne diseases.

[1]For best results, apply sprays according to leaf spot advisory program in a volume of 12.0 to 15.0 gal/A by ground sprayers or 5.0 gal/A with aircraft.

[2]Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Table 3.25 - Soil Treatments

Disease	Product and Formulation	Rate of Formulation /acre	Method and Timing of Application	Precautions and Remarks[1]
Cylindrocladium black rot (CBR) (*Cylindrocladium parasiticum*) and nematodes	Vapam HL 42% Metam 42% Sectagon 42% (metam sodium)	7.5-gal 7.5-gal 7.5-gal	Use with resistant varieties in cases of severe disease pressure; plant other varieties only in cases of light CBR pressure. Apply 8 inches deep at least 14 days preplant with one injector shank in front of a bed shaper to mark rows. Do not mix treated soil with untreated soil by tillage or other cultural practices after application.	Apply after soil temperatures exceed 60° F at 4-inch depth, and temperatures are likely to be above this level for 5 days. Do not apply when rainfall levels are likely to exceed 1 inch in the 72-hour period after treatment.
Cylindrocladium black rot (CBR)	Proline 480SC (prothioconazole)	5.7 fl oz or 0.4 fl oz/1000 ft of row	Apply to the seed furrow at planting in a volume of 5 gal/A with either a spray nozzle or micro-tube	Use for suppression of CBR in conjunction with crop rotations of 3 years or longer. Proline may help to reduce seed transmission of CBR as well as root infection in naturally infested soil.
Nematodes	Telone II (1,3 dichloropropene)	3.0-6.0 gal	Apply 8-12 inches deep in row and bed soil. Wait 7-14 days before planting.	See label for precautions and restrictions.
	Velum Total (fluopyram + imidacloprid)	18 fl oz	Apply in-furrow during planting directed on or below seed. May also be applied by chemigation into the root-zone.	Also controls thrips and suppresses early and late leaf spot.
	Propulse (fluopyram + prothioconazole)	13.6 fl oz	May be applied by chemigation or foliar spray.	For maximum nematode suppression, Propulse should be applied 45 days after planting following an at-plant nematicide (e.g. Velum Total). Also controls early and late leaf spot.
	AgLogic 15G, AgLogic 15GG (aldicarb)	7 lb	In furrow at planting.	See label for precautions and restrictions. Also controls thrips.

[1]Read labels and observe all precautions and restrictions on application, pre-harvest interval, and restrictions on feeding treated hay, vines, or hulls to livestock.

Cotton

Hillary L. Mehl, Extension Plant Pathologist, Virginia Tech, Tidewater AREC

Seed and Seedling Diseases

Rapid emergence and strong early-season growth are recognized as being most important to success in cotton production. Seedling diseases occur more frequently under cool, wet conditions immediately after planting. Soil temperatures at the 4-inch depth should average above 60˚F and the forecast should favor continuation of these conditions over the next 3 days. Daily soil temperatures and cotton degree days are available on the Web at *http://www.ipm.vt.edu/infonet/*. It is also advisable to check the 10-day forecast. Other factors, such as planting too deep, heavy soil crusting, sting and/or reniform nematodes, and misuse of herbicides may increase the problem. Seedling diseases do not usually kill an entire seedling population, but rather cause uneven, slow growing stands with skips in the row.

The first line of defense against seedling disease is to plant high quality seed that is coated with seed protectant fungicides and insecticides. Try to obtain seed with cool germination levels of 80 percent or higher. Avoid seed with cool germination levels below 70 percent. All commercial seed is routinely sold with protectant fungicide coatings which include Captan, Thiram, or Baytan plus PCNB, and metalaxyl. New treatments include Dynasty CST (azoxystrobin, fludioxonil, mefenoxam) and Trilex Advanced (Trilex, Baytan, Allegiance) for seedling diseases and Avicta Complete Pak (Dynasty CST, Cruiser, Avicta) and Aeris (thiodicarb, imidacloprid) for control of thrips and nematodes.

If additional protection is desired, an in-furrow fungicide treatment or hopper-box treatment can be used. Benefits would most likely be seen in fields with a history of seedling disease problems when planting early or when cold, wet weather is expected shortly after planting. Field trials at multiple locations in Virginia since 1990 have not shown an economic benefit from the use of in-furrow or hopper-box fungicide treatments.

Table 3.26 - In-furrow and Hopper-box Fungicides for Cotton

Disease	Fungicide Common Name	FungicideTrade Name	Formulated Rate	Remarks
Seedling disease; damping-off; seed rot.	PCNB + etridiazole	Terraclor Super X 12.5G Terraclor Super X 18.8G (Note: also available in liquid formulation)	8.0-12.0 lb/A 6.0-9.0 lb/A	Apply to seed furrow at planting. Read and follow all label restrictions.
	metalaxyl + PCNB	Ridomil PC (Note: Also available in liquid formulation.)	7.0-10.0 lb/A	Same as above.
	azoxystrobin	Quadris	0.4-0.6 fl oz/1000 row ft	Same as above.
	carboxin + PCNB + metalaxyl	Prevail	8.0-16.0 oz/cwt	Apply to seed in hopper at planting.
	pyraclostrobin	Headline 2.09SC	0.1-0.8 fl oz/1000 row ft	Apply in seed furrow. Do not apply more than 12 fl oz/A. See adjusted rates according to row spacing.

Foliar Diseases and Boll Rots

Common leaf spot diseases of cotton in Virginia are caused by fungi that may include *Stemphylium, Cercospora, Colletotrichum*, and more recently *Corynespora*. Other diseases include fungal boll rots caused by *Fusarium, Colletotrichum, Phoma*, and other fungi and, less frequently, bacterial boll rots. Boll rots are often associated with insect feeding damage. Crop stress caused by drought, excesses of rainfall, and nutrient deficiencies are often associated with leaf and boll diseases and may be predisposing factors in cases with significant loss of yield. Rank growth favors development of Corynespora target spot which starts in the lower canopy and can potential cause premature defoliation. Annual evaluations of foliar fungicides since 2000 in Virginia have provided little or no yield response to fungicide. In severe cases, target spot may cause yield loss and foliar fungicides may be warranted for control of this disease. The table below lists fungicides currently registered for control of foliar and boll pathogens of cotton in Virginia.

Table 3.27 - Foliar Fungicides for Control of Leaf Spots and Boll Rots

Disease	Fungicide Common Name	Fungicide Trade Name	Formulated Rate	Remarks
Alternaria leaf spot Anthracnose Ascochyta leaf spot Cercospora blight Diplodia boll rot Hard lock boll rot *Phoma* boll rot Rust *Stemphylium* leaf spot Target spot	pyraclostobin	Headline 2.09SC	6-12 fl oz/A	Apply 1st spray prior to disease development and continue on 7- to 14-day interval if conditions are conducive for disease. Apply no more than two consecutive sprays of Headline. Do not apply more than 36 fl oz/A per season including in-furrow and foliar applications. PHI= 30 days.
	pyraclostrobin + metconazole	TwinLine 1.75EC	7-8.5 fl oz/A	Same as above. Do not apply more than 26 fl oz/A per season. PHI = 30 days.
	azoxystrobin	Quadris	6.0-9.0 fl oz/A	Same as above. Do not apply more than 27 fl oz/A per year. PHI = 45 days.
	fluxapyroxad + pyraclostrobin	Priaxor	4 to 8 fl oz/A	Same as above. Do not apply more than 24 fl oz/A per season. PHI = 30 days. May also be applied in-furrow (0.1 to 0.6 fl oz/1000 row ft) for control or suppression of seedling diseases.

Nematodes

Nematodes cause significant damage to cotton in some fields in Southeastern Virginia. Sting nematode is recognized as highly destructive to cotton because of the crop's extreme sensitivity to this nematode but is generally only a problem in soils with >80% sand content. Root knot nematodes are generally not a problem when peanut and cotton are rotated in the same field since the two crops are hosts for different root knot nematode species. However, southern root knot nematodes have become an increasing problem where cotton is grown continuously for 5 or more years.

Diagnostic assays for nematodes in soil planted to cotton are conducted by the Nematode Diagnostic Laboratory at Virginia Tech. The Virginia Predictive Nematode Assay Program offers growers an opportunity to locate problem fields prior to planting. The best time to collect soil samples for assay is in the fall following harvest. Assay forms, sample bags, and instructions should be obtained from a local Virginia Cooperative Extension office before collecting samples. Counts of veriform species are all that is needed if cotton is the only crop to be grown. However, if soybean or possibly tobacco might be considered as possible alternative crops, then counts of cyst nematodes would be more important or even critical.

Nematode control is best accomplished by preventing the buildup of harmful numbers of nematodes in soil through crop rotation and good weed control. Some cotton varieties with resistance or tolerance to southern root knot nematode are available. If nematodes pose a threat to cotton production, chemical control can be used to minimize the risk of crop damage.

Table 3.28 - Nematicides for Use in Cotton

Nematode	Active ingredient(s)	Trade Name	Formulated Rate	Remarks[1]
Sting, Reniform, Lesion, Lance, Root knot, Stubby root	1,3 - D	Telone II	3.0 gal/A	Apply 8-12 inches deep in row and bed soil. Wait 7-14 days before planting.
	abamectin	Avicta 500FS	0.10 - 0.15 mg/seed	Must be applied by commercial applicator equipment with rate adjusted for seed size. For early season insect and disease control, Avicta should be combined with Cruiser 5FS (insecticide) and Dynasty CST (fungicide) seed treatments. In high nematode pressure situations, it may be necessary to combine a seed treatment with an in-furrow nematicide.
	fluopyram	COPeO PRIME	0.2 - 0.3 mg ai/seed or 1.127 - 1.69 fl oz/100,000 cotton seeds	Currently available on Stoneville (all seed) and FiberMax (premium seed treatment) varieties. In high nematode pressure situations, it may be necessary to combine a seed treatment with an in-furrow nematicide.
	thiodicarb (nematicide/ insecticide) + imidaclo-prid (insecticide)	Aeris Seed-applied Insecticide/Nematicide	25.6 fl oz/100 cwt seed	Same as above, except lacks a fungicide for additional seedling disease control, and must be applied as an overcoat on fungicide-treated seed.
	Burkholderia rinojenses	BioST Nematicide 100	8 oz/100 lb seed	Can be applied with fungicide and insecticide seed treatments.
	fluopyram (nemati-cide) + imidacloprid (insecticide)	Velum Total	14-18 fl oz/A	Apply in-furrow during planting directed on or below seed. May also be applied by chemigation into the root-zone. Also controls thrips and suppresses *Fusarium* spp.
	aldicarb	AgLogic 15G	3.5 - 7.0 lb/A	This is a restricted use pesticide, so be sure to follow the precautions on the label. Also controls thrips and some other insect pests.

[1]Read product label carefully. Note application hazards, re-entry statements, restrictions on feeding livestock, rotation restrictions, and protective clothing required before treatment. Read and observe all requirements as defined on labels.

Insect Control in Field Crops

Sally Taylor, Assistant Professor, Virginia Tech
Curt Laub, Research Associate, Virginia Tech

Make sure that a definite insect problem exists before applying insecticides to a crop. Use recommended thresholds as a guide when making spray decisions. If you are unable to make this determination, contact your local county Extension office for advice or assistance. Use pesticides only when necessary.

Grain Crops, Soybeans, Forages

Cultural Control Methods

Cultural control methods are powerful tools in managing insect pests. In many instances, growers who follow accepted cultural practices can expect little trouble from insect pests. Some of the most beneficial cultural methods for problem insects include:

Crop rotation

Crop rotation is an inexpensive and effective way of controlling most below ground pests. Rotations that include grass and legume crops (or dissimilar crops), and rotations of at least two years are best. Multiyear rotations are most effective for wireworm because this insect may take up to five years to complete development.

Tillage

Conventional tillage is an effective way to manage multiple pests. Slugs, wireworms, cutworms, white grubs, corn earworm, and other pest populations will be reduced by disking in winter or early spring. Pest suppression using various cover crop systems are being tested throughout the state, but currently there are few data on pest management in these systems. Keep in mind that tillage does not always benefit pest management and may encourage some insect populations.

Planting date

Timely planting will effectively limit pest pressure late-season when insect populations have had time to build over the summer. Rapid germination and early vigor will enable plants to outgrow seedling injury.

Hybrid/variety selection

Uniform stand and healthy plants will minimize economic impact of insect pests. Early maturing varieties will reduce insect damage and avoid some species altogether. Some crop varieties offer increased tolerance to insects as well as microbial pests. Genetically modified Bt corn hybrids protect against a suite of above and below ground insect pests. The Handy Bt Trait Table published by Chris DiFonzo at Michigan State University provides a list of corn trait names and their insect protection benefits - https://lubbock.tamu.edu/files/2018/01/BtTraitTableJan2018.pdf.

Chemical Control

Insecticides are sometimes necessary even when using proper cultural control techniques. Recommendations in this publication deal primarily with chemical control. It is critical to worker safety, efficacy of materials, and the marketability of crops to follow all label instructions. Most insecticides will kill honey bees and pollinating insects if applied to a crop in bloom. To remain compliant with pollinator protection laws, it is recommended that insecticides are sprayed in the afternoon and early evening to lessen the magnitude of bee loss.

Alfalfa Weevil

There are two cultural control tactics that can be utilized to reduce alfalfa weevil damage. In the late fall, remove the alfalfa for hay or by grazing. This removes the overwintering egg-laying sites for the adult weevils, and will help reduce the number of alfalfa weevil larvae attacking the crop the following spring. Early harvest can sometimes be used in the spring instead of insecticide sprays, if the crop has obtained sufficient growth before larval feeding damage becomes severe.

Potato Leafhopper

Spring-planting alfalfa with a companion crop of oats will help prevent soil erosion, and also reduce potato leafhopper infestations in the first summer cutting of alfalfa.

True Armyworm

In no-till corn planted into winter rye cover crop, research at Virginia Tech has shown that rotary mowing of the rye cover crop after it has initiated seed heads will not only kill the cover crop, but also will dramatically reduce the number of armyworm larvae early in the growing season when the corn is susceptible to damage from armyworm feeding. If mowing is to be used to kill the winter cover crop, corn planting should follow as soon as possible after mowing to facilitate coulter penetration of the rye mulch.

Northern and Western Corn Rootworms

Rotating corn with any other crop [except for squash, pumpkin, etc. (Cucurbitaceae)] for one year will control corn rootworms, since the eggs of these pests are laid in corn fields during the summer.

Forages: Alfalfa and Other Legumes

Curt Laub, Research Associate, Virginia Tech
Sally Taylor, Assistant Professor, Virginia Tech

Alfalfa Weevil

Sampling to Determine Whether Control Measures Are Needed

When the alfalfa starts growing in the spring, walk through the field at least once a week and closely inspect alfalfa tips for feeding injury. When damage and weevil larvae are observed, systematic sampling should be conducted (using the procedure described below) at least once weekly (or more frequently if weevil populations are approaching the action threshold) until the fields are sprayed, harvested, or the weevil season is over. If you are required to spray early and you use a short-residual insecticide, wait 2 to 3 weeks after spraying and resume the sampling program. Insecticide spray failures have been reported following periods of cooler temperatures. This may be the result of reduced activity by the insect (i.e., weevils are not eating treated material nor touching treated surfaces) as opposed to insecticide resistance. Please report suspected cases of insecticide resistance to your local County Agent or Extension Specialist.

Equipment needed to sample a field includes a 3- to 5-gallon bucket, a shallow dishpan, a clipboard with pencil and paper, and tape measure or folding rule. Mentally divide the field into 6 equal sections and walk to the approximate center of the first section. Randomly pull 10 entire stems and place them, tip end first, into the bucket. Be careful to hold the bucket under each stem tip as it is pulled to catch any weevil larvae that may fall off. When the ten stems are collected, grasp them firmly by the base and shake them vigorously against the sides of the bucket for 5 to 10 seconds. As you are shaking the stems, hold the clipboard over the top of the bucket to prevent larvae from being thrown out. Pour the contents of the bucket into the shallow dishpan and count the total number of all weevil larvae.

Randomly select two of the stems from your sample and measure their lengths. Record the number of larvae and the two stem lengths on your clipboard. Walk to the approximate center of the other 5 sections of field and repeat the sampling procedure. Note: in a fairly large field (greater than 20 acres) you may wish to take a few extra samples to improve your sampling accuracy. When you have finished the field, total the larvae and stem lengths for all six sample sites. Determine the average number of larvae/stem by dividing the total by 60 (10 stems at 6 sites) and the average stem length by dividing by 12. Then refer to the decision-making chart, Fig. 4.1. Plot your average number of larvae/stem against stem height. If the point falls near or above the economic threshold line, either harvest or treat the field with a short-residual insecticide. If the point falls below the threshold line, no control measures are recommended; sample again in 5 to 7 days. More frequent sampling may be desired if population levels are approaching the threshold and daily temperatures are above 70° F. **Note: these thresholds are intended for alfalfa growing under adequate fertility and soil moisture conditions. Under drought stress conditions, when alfalfa is growing slowly, the threshold should be lowered by about 0.5 weevil per stem.**

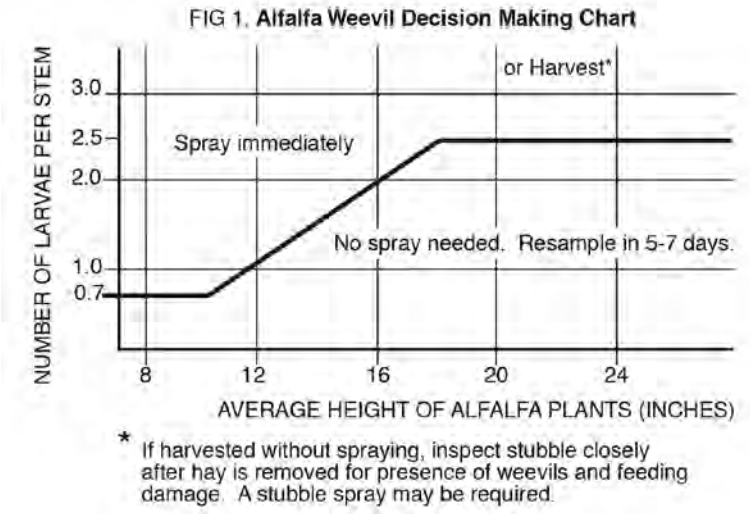


Fig. 4.1. Decision-making chart for determining the need to apply insecticides for alfalfa weevil control.

Spray or Harvest for Weevil Control?

In weevil control zone A, roughly east of the Blue Ridge Parkway, (Fig. 4.2), good survival of overwintering weevil eggs and warm temperatures often result in early larval hatch, causing damage when alfalfa is less than 6 inches tall. Population surveys should be initiated early. If 50 percent of the tips have been damaged and the alfalfa is less than 6 inches tall, spray as soon as possible. In zones B and C, however, the need to control alfalfa weevil varies from year to year, and field sampling should be conducted to determine population levels. Harvesting often can be used as an effective weevil control tactic, if enough growth is present to justify the harvesting process. Yield sacrificed in the first cutting by early harvest will be compensated in 2nd and subsequent cuttings. Cutting alfalfa early assures high quality hay with high protein and TDN, and reduces chance of losing hay to rainy weather later in the season. Early cutting also gives the second growth of alfalfa a head start before the potato leafhopper adults appear in early June. The decision to cut or spray should be based on favorable hay-making weather and time scheduling with other farm operations. If hay is cut before the bud stage in the first cutting, second and subsequent cuttings should be allowed to reach 0.10 bloom before cutting to insure adequate storage of root carbohydrates. Alfalfa may be harvested early only once during the growing season without reducing stand density or longevity.

Determining the Need for Stubble Sprays

If insecticide sprays are used prior to harvest of the first cutting, stubble sprays are seldom necessary. However, if no sprays have been used, or if the field has been cut early because of a heavy weevil infestation, stubble sprays **may** be necessary. Within a week after the hay has been removed from the field, closely inspect the growing shoots of the alfalfa for the presence of larvae or signs of feeding. No formal sampling plan or economic thresholds are available for this crop stage, but, generally, if weevil larvae are easily found, shoot damage is occurring, or regrowth appears delayed, a stubble spray should be applied. Adult weevils can occasionally cause severe damage to regrowth, but because the adult weevils usually hide under the alfalfa crown during the day, they are not easily seen.

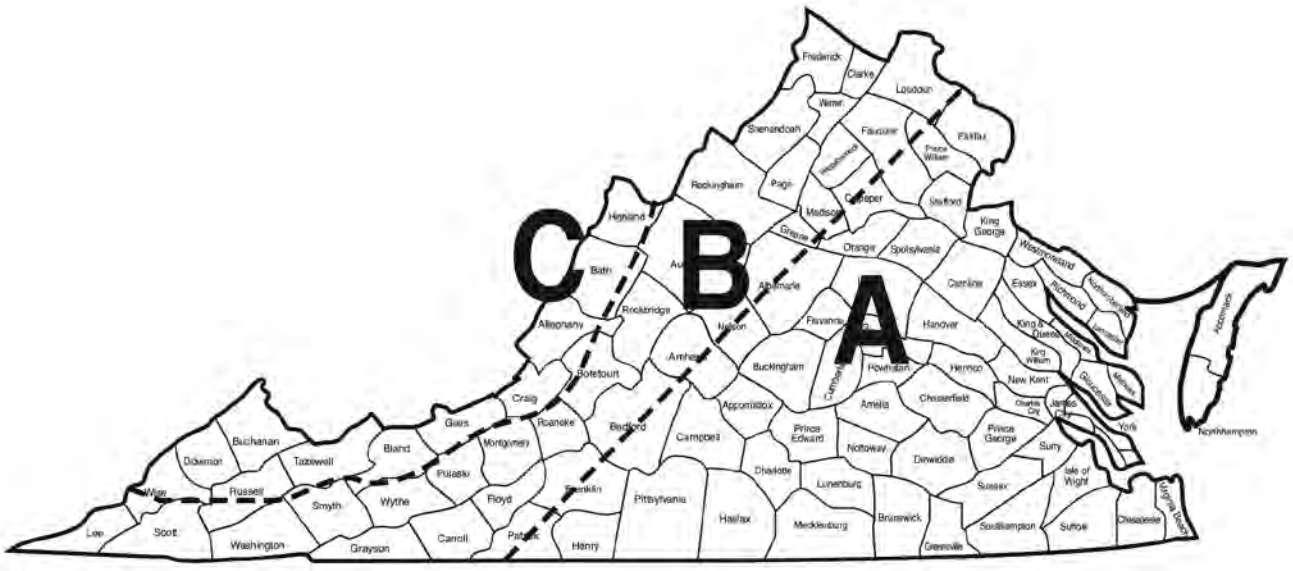


Fig. 4.2. Alfalfa Weevil Control Zones

The dividing line between Zone A and Zone B is roughly the Blue Ridge Parkway.

The line dividing Zone B and Zone C roughly follows the county lines.

Table 4.1 - Recommended Insecticides for Control of Alfalfa Weevil

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.0125-0.022 lb	1.6-2.8 oz	hay harvest: 7 grazing: 7	**RESTRICTED USE.** Maximum product allowed per cutting is 5.6 oz/A. Maximum product allowed per crop season is 22.4 oz/A.
Carbaryl (Sevin 80 Solupak)v	1.5 lb	1.875 lb	7	Highly toxic to bees. Avoid spraying weeds in bloom or alfalfa beyond 10% bloom.
chlorpyrifos (Lorsban 4E)	0.5-1 lb	1.0-2.0 pt	1 pt: 14 > 1 pt: 21	Some temporary yellowing may occur after application, but this will disappear within a week and not cause yield loss. Do not apply if nearby bees are clustered outside of hives and bees are foraging in the area to be treated. Do not apply more than 4 times/year or more than once/cutting.
chlorpyrifos, zeta-cypermethrin (Stallion [3.03 lb AI/ gal prod])	—	9.25-11.75 oz	7 cutting, grazing, or harvesting seed	**RESTRICTED USE.** Do not make applications of Stallion or other products containing chlorpyrifos <10 days apart. Maximum 32.5 oz product/A/season. Product is highly toxic to bees if exposed to direct application to alfalfa.
indoxacarb (Steward EC)	0.065-0.11 lb	6.7-11.3 oz	7	Apply no more than once per cutting. A total of 45 oz/A may be applied/season.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz	forage harvest: 1 hay harvest: 7	**RESTRICTED USE.** Apply as required by scouting. **Ground application**: use 10 to 20 gal water/A. **Aerial application:** use 2 to 10 gal water/A. Apply in sufficient water for full coverage. Do not apply >0.12 pt/A/cutting. Do not apply >0.48 pt/A/ season.
methomyl (Lannate LV 2.4)	0.9 lb	3.0 pt	7	**RESTRICTED USE.** 48 hour re-entry interval. Also labeled for beet armyworm.
zeta-cypermethrin (Mustang Max)	0.014-0.025 lb	2.24-4.0 oz	cutting/grazing: 3 seed harvest: 7	**RESTRICTED USE.** Minimum 7 days between applications. Maximum 0.025 lb AI/cutting. Maximum 0.075 lb AI/season.
Note: to avoid injury to honey bees, do not apply insecticides during bloom.				

Potato Leafhopper

Sampling Methods and Action Thresholds

Although several natural enemies prey upon potato leafhoppers in alfalfa, damaging levels of leafhopper are often reached, requiring insecticide application or harvest management. Leafhopper infestations are highly variable from field to field and from year to year; therefore, monitoring of individual fields is required for effective pest management decision-making. Leafhoppers are most easily sampled using a standard 15-inch diameter sweep net. At each of 6 randomly selected sites in a field, take 10 pendular sweeps with the net (swinging it back and forth in front of you) as you walk. One sweep equals one stroke of the net. After the last sweep, quickly grab the net to prevent insects from escaping. Carefully unfold the net, working your way toward the bottom. Count the number of leafhopper adults and nymphs as they emerge and leafhoppers in the bottom of the net. In fields with high leafhopper infestations, many leafhopper nymphs can be seen on the top and edge of the sweep net before the net is opened to examine the contents. Include these in your count. At each sample site, also measure and record the lengths of two randomly selected stems.

Record the total number of leafhoppers for all 6 sites and divide by 60 to determine the number of leafhoppers per sweep. Divide the total stem length by 12 to estimate average stem length. Then go to the Decision Making Chart shown in Fig. 4.3.

Using the Decision Making Chart

(Fig. 4.3) From the average number of leafhoppers per sweep and the average height of the plants, draw horizontal and vertical lines until they intersect. If the intersection point is above the treatment line, spray or harvest (see below) as soon as possible; if the intersection falls below the line, resample in 5 to 7 days. As can be seen from this chart, the economic threshold is variable, depending on plant height.

For example, if you collected 30 leafhoppers in 60 sweeps for an average of 0.5 leafhoppers per sweep, and your average plant height was 4 inches, spraying would be indicated by the chart. If your average plant height was 12 inches for the same leafhopper count, no spray would be indicated. Keep in mind that this decision-making chart is intended for general use, and individual fields may vary considerably in plant response to the leafhopper feeding depending on soil moisture, fertility, and cultivar.

Spray or Harvest?

Alfalfa should be harvested whenever the crop is in 10 percent or more flower regardless of leafhopper levels. Insecticidal control is most effective if applied early in the crop's growth (assuming leafhopper densities are above the economic threshold), since the spray will protect the alfalfa during the most susceptible stage of growth. As the alfalfa grows in height, the economic return on investment for insecticidal control is reduced but can still be justified if damaging population levels are present. Beyond a crop height of 14 inches, the value of insecticidal control becomes marginal, since considerable clogging of the plant's vascular tissue will have already occurred.

If plants are greater than 14 inches tall and leafhopper numbers are above the treatment threshold (see Decision-Making Chart), two management options are recommended. If the leafhopper count is above the treatment line but less than 2.3 per sweep, and the crop is showing 80 percent or more bud and less than 10 percent flower, harvest as soon as weather conditions are favorable. If the crop is not yet flowering, wait 7 to 10 days, then harvest. If the leafhopper count is greater than 2.3 per sweep, harvest as soon as the alfalfa shows 25 percent bud. Harvest as soon as possible if considerable damage has already occurred.

Harvesting will remove the damaged stems and allow new growth to begin. Newly-planted fields established in the spring are often so severely stunted by potato leafhoppers that harvesting would not produce a significant amount of hay. The crop should still be clipped to remove weeds and the damaged plants.

Determining the Need for Stubble Sprays

Harvesting alfalfa has been shown to kill most potato leafhopper nymphs and many adults. The adults are highly mobile and most adult leafhoppers surviving harvest will leave the field. Even though high numbers of leafhoppers may be present in the field prior to cutting, stubble sprays are not necessarily needed to protect the next cutting. Ideally, the alfalfa should be sampled with a sweep net (as described above) about a week after harvest, or as soon as the alfalfa starts to grow back. If leafhoppers are present at levels greater than 0.4/sweep, spraying is recommended. If sampling the regrowth is not feasible, and high numbers of leafhoppers were present before harvest, a stubble spray on the regrowth may be a good protective measure, especially if green alfalfa was left in the field following harvest. For best results, wait about 5 to 7 days after harvest, or until 4 to 6 inches of new growth has appeared.

Table 4.2 - Recommended Insecticides for Control of Potato Leafhopper

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.0065-0.0125 lb	0.8-1.6 oz	hay harvest: 7 grazing: 7	**RESTRICTED USE.** Maximum product allowed per cutting is 5.6 oz/A. Maximum product allowed per crop season is 22.4 oz/A.
dimethoate (Dimethoate 4EC)	0.25-0.5 lb	0.5-1.0 pt	10	Dimethoate also will control aphids and grasshoppers. Make only one application/ cutting.
carbaryl (Sevin 80 Solpak) (Sevin 4F)	 1.0 lb 1.0 lb	 1.25 lb 2.0 pt	 7 7	Highly toxic to bees; avoid spraying weeds in bloom or alfalfa beyond 10 percent bloom.
chlorpyrifos (Lorsban 4E)	0.25-0.5 lb	0.5-1.0 pt	0.5 pt: 7 1 pt: 14	Some temporary yellowing may occur after application, but this will disappear within a week and not cause yield loss. Do not apply if nearby bees are clustered outside of hives and bees are foraging in the area to be treated. Do not apply more than 4 times/ year or more than once/cutting.
chlorpyrifos, zeta-cypermethrin (Stallion [3.03 lb AI/ gal prod])	—	5.0-11.75 oz	7 cutting, grazing, or harvesting seed	**RESTRICTED USE.** Do not make applications of Stallion or other products containing chlorpyrifos <10 days apart. Maximum 32.5 oz product/A/season. Product is highly toxic to bees if exposed to direct application to alfalfa.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.015-0.025 lb	0.96-1.60 oz	forage harvest: 1 hay harvest: 7	**RESTRICTED USE.** Apply as required by scouting. **Ground application**: use 10 to 20 gal water/A. **Aerial application**: use 2 to 10 gal water/A. Apply in sufficient water for full coverage. Do not apply >0.12 pt/A/cutting. Do not apply >0.48 pt/A/season.
zeta-cypermethrin (Mustang Max)	0.014-0.025 lb	2.24-4.0 oz	cutting/grazing: 3 seed harvest: 7	**RESTRICTED USE.** Minimum 7 days between applications. Maximum 0.025 lb AI/cutting. Maximum 0.075 lb AI/season.

Note: do not wait until yellowing occurs. Materials should be used as a preventative treatment after leafhoppers first appear.

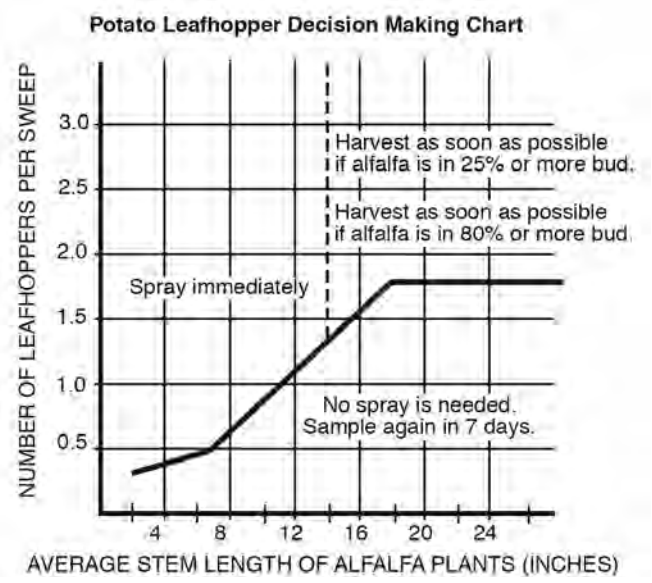


Fig. 4.3. Decision-making chart for determining the need to apply insecticides for potato leafhopper control.

Grasshopper

Table 4.3 - Grasshopper

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.0155-0.022 lb	2.0-2.8 oz	hay harvest: 7 grazing: 7	**RESTRICTED USE.** Maximum product allowed per cutting is 5.6 oz/A. Maximum product allowed per crop season is 22.4 oz/A.
carbaryl (Sevin 80 Slopak) (Sevin 4F)	0.5-1.5 lb 0.5-1.5 lb	0.67-1.875 lb 0.5-1.5 qt	7	Grasshoppers usually cause problems only during drought and in new fall seedlings. Use the lower rate for nymphs on small plants or sparse vegetation. Use the higher rate for adults or applications to dense vegetation.
chlorpyrifos, zeta-cypermethrin (Stallion [3.03 lb AI/ gal prod])	—	9.25-11.75 oz	7 cutting, grazing, or harvesting seed	**RESTRICTED USE.** Do not make applications of Stallion or other products containing chlorpyrifos <10 days apart. Maximum 32.5 oz product/A/season. Product is highly toxic to bees if exposed to direct application to alfalfa.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz	forage harvest: 1 hay harvest: 7	**RESTRICTED USE.** Apply as required by scouting. **Ground application**: use 10 to 20 gal water/A. **Aerial application:** use 2 to 10 gal water/A. Apply in sufficient water for full coverage. Do not apply >0.12 pt/A/cutting. Do not apply >0.48 pt/A/season.
malathion (Malathion 5EC, Malathion 57EC)	1.0-1.5 lb	1.5-2.0 pt	0	Spray may be applied by air or ground equipment. **Dilute application**: use 20 to 60 gal water/A. **Concentrate application**: use ≥5 gal water/A.
zeta-cypermethrin (Mustang Max)	0.017-0.025 lb	2.8-4.0 oz	cutting/grazing: 3 seed harvest: 7	**RESTRICTED USE.** Minimum 7 days between applications. Maximum 0.025 lb AI/cutting. Maximum 0.075 lb AI/season.

Armyworm, Cutworm

Armyworms can be problematic in late summer and early fall. Armyworms are difficult to control with insecticides and options listed below may not effectively reduce large populations.

Table 4.4 - Armyworm (AW), Cutworm (CW)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	AW 0.0125-0.022 lb CW 0.0065-0.0125 lb	1.6-2.8 oz 0.8-1.6 oz	hay harvest: 7 grazing: 7	**RESTRICTED USE.** Maximum product allowed per cutting is 5.6 oz/A. Maximum product allowed per crop season is 22.4 oz/A. Effective against small armyworm larvae up to 2nd instar.
carbaryl (Sevin 80 Solpak) (Sevin 4F)	 1.0-1.5 lb 1.0-1.5 lb	 1.25-1.875 lb 1.0-1.5 qt	 7 7	Apply when insects begin to cause injury. A 5% Sevin bait at 20 lb/A also is effective against cutworms.
chlorpyrifos, zeta-cypermethrin (Stallion [3.03 lb AI/gal prod])	—	AW 9.25-11.75 oz CW 2.5-11.75 oz	7 cutting, grazing, or harvesting seed	**RESTRICTED USE.** Do not make applications of Stallion or other products containing chlorpyrifos <10 days apart. Maximum 32.5 oz product/A/season. Product is highly toxic to bees if exposed to direct application to alfalfa.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC]) armyworm use: cutworm use:	 0.02-0.03 lb 0.015-0.025 lb	 1.28-1.92 oz 0.96-1.60 oz	 forage harvest: 1 hay harvest: 7	**RESTRICTED USE**. Apply as required by scouting. **Ground application**: use 10 to 20 gal water/A. **Aerial application**: use 2 to 10 gal water/A. Apply in sufficient water for full coverage. Do not apply >0.12 pt/A/cutting. Do not apply >0.48 pt/A/season.
methomyl (Lannate LV) (Lannate SP)	0.225 - 0.9 lb	AW 1.5-3.0 pt CW 0.75-3.0 lb AW 0.5-1.0 pt CW 0.25-2.0 pt	7	**RESTRICTED USE.** Do not apply to dormant or semi- dormant alfalfa when minimum daily temp. is ≤50°F. Wait 7 days after application before grazing or feeding livestock.
zeta-cypermethrin (Mustang Max)	0.014-0.025 lb	AW 2.8-4.0 oz CW 2.24-4.0 oz	cutting/grazing: 3 seed harvest: 7	**RESTRICTED USE.** Minimum 7 days between applications. Maximum 0.025 lb AI/cutting. Maximum 0.075 lb AI/season.

Pea Aphid

Sampling/Decision Making

The need to treat for pea aphids is rare (1 year in 10) in Virginia, Maryland, and Delaware because lady bird beetles, wasp parasites, and other beneficial insects usually control this pest. The best sampling technique requires the same 15-inch sweep net used for potato leafhoppers. Ten sweeps at 10 random locations should be used to sample both the aphids and beneficials. If 50 or more aphids per sweep are collected and no beneficials are present, it is recommended that the field be cut early. Avoid spraying first crop because sprays will kill alfalfa weevil parasites.

Table 4.5 - Recommended Insecticides for Controlling Pea Aphids

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.022 lb	2.8 oz	hay harvest: 7 grazing: 7	**RESTRICTED USE.** Maximum product allowed per cutting is 5.6 oz/A. Maximum product allowed per crop season is 22.4 oz/A.
chlorpyrifos, zeta-cypermethrin (Stallion [3.03 lb AI/ gal prod])	—	9.25-11.75 oz	7 cutting, grazing, or harvesting seed	**RESTRICTED USE.** Do not make applications of Stallion or other products containing chlorpyrifos <10 days apart. Maximum 32.5 oz product/A/season. Product is highly toxic to bees if exposed to direct application to alfalfa.
dimethoate (Dimethoate 4EC)	0.25-0.5 lb	0.5-1.0 pt	10	Make only one application/ cutting.
malathion (Malathion 5EC) (Malathion 57EC)	1.0-1.5 lb	1.5-2.0 pt	0	**RESTRICTED USE.** Warm weather favors parasites and predators of aphids; thus control may not be required if the weather forecast predicts a warm trend. Spray may be applied by air or ground equipment. **Dilute application**: use 20 to 60 gal water/A. **Concentrate application**: use ≥5 gal water/A.
lambda-cyhalothrin (KarateZ [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz	forage harvest: 1 hay harvest: 7	**RESTRICTED USE.** Apply as required by scouting. **Ground application**: use 10 to 20 gal water/A. **Aerial application**: use 2 to 10 gal water/A. Apply in sufficient water for full coverage. Do not apply >0.12 pt/A/cutting. Do not apply >0.48 pt/A/season.
methomyl (Lannate LV) (Lannate SP)	0.45 - 0.9 lb	 1.5-3.0 pt 0.5-1.0 pt	7	**RESTRICTED USE.** Do not apply to dormant or semi- dormant alfalfa when minimum daily temp. is ≤50°F. Wait 7 days after application before grazing or feeding livestock.
zeta-cypermethrin (Mustang Max)	0.014-0.025 lb	2.24-4.0 oz	cutting/grazing: 3 seed harvest: 7	**RESTRICTED USE.** Minimum 7 days between applications. Maximum 0.025 lb AI/cutting. Maximum 0.075 lb AI/season.

Orchardgrass, Timothy, and Bermudagrass

Curt Laub, Research Associate, Virginia Tech

The immature stage of white grubs (i.e., Japanese beetle grubs and other related species) and billbug grubs (i.e., bluegrass billbug, hunting billbug, etc.) are the most important root-feeding pests on orchardgrass hay in Virginia. With the exception of Karate Z and Warrior II (billbug supression), none of the insecticides labeled for orchardgrass hay include these insects on their labels. The products listed below target surface feeders and insects found in the thatch layer. Research conducted in Virginia showed that conspicious "paired" feeding-holes on young orchardgrass leaves in April indicate the presence of billbugs moving into fields. More importantly, these paired feeding holes, which are found within the first 15-20 feet of a field's border, begin showing up at about the same time or several days earlier than the first billbug adults are found in pitfall traps. **Armyworms are difficult to control with insecticides and options listed below may not effectively reduce large populations. Be sure your crop is listed on the product label before you spray.**

Table 4.6 - Orchardgrass Hay

Pests	Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
armyworms, cutworms, army cutworm, cereal leaf beetle, green cloverworm, meadow spittlebug	beta-cyfluthrin (Baythroid XL)	0.0125-0.015 lb	1.6-1.9 oz	grass for pasture, rangeland and seed: 0 grazing grass for hay: 0 harvest grass in mixed stands with alfalfa: 7 harvest 7 grazing	**RESTRICTED USE.** For grass grown for hay, pasture, seed, or rangeland, the maximum Baythroid XL allowed per 5-day interval is 0.022 lb AI/A (2.8 oz/A). The maximum Baythroid XL allowed per crop season or cutting is 0.089 lb AI/A (11.3 oz/A) For grass in mixed stands with alfalfa, the maximum Baythroid XL allowed per cutting is 0.022 lb AI/A (2.8 oz/A). The maximum Baythroid XL allowed per crop season is 0.089 lb AI/A (11.3 oz/A). Check label for additional details.
fall armyworm (1st & 2nd instar) yellowstriped armyworm (1st & 2nd instar) Lygus bug, stink bugs, leafhoppers, Japanese beetle (adult), June beetle (adult), grasshoppers, grass thrips, tarnished plant bug (refer to label for additional pests)	beta-cyfluthrin (Baythroid XL)	0.0125-0.022 lb	2.6-2.8 oz		
armyworm, fall armyworm, striped grass looper, chinch bugs, thrips, range caterpillar, range crane fly, essex skipper, ticks	carbaryl (Sevin XLR Plus and Sevin SL)	1.0-1.5 lb	1.0-1.5 qt	14 harvest or grazing	**Caution.** Apply as needed by scouting. Up to 2 applications per year may be made but not more often than once every 14 days. Do not exceed a total of 3 qts/A/year.
	carbaryl (Sevin 80 Solpak)	1.0-1.5 lb	1.25-1.875 lb	14 harvest or grazing	**Caution.** Up to 2 applications per year may be made but not more often than once every 14 days. Do not exceed a total of 3.75 lbs product/A/year.

Table 4.6 - Orchardgrass Hay (cont.)

Pests	Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
army cutworm, cutworms, Essex skipper, range catepillar, striped grasslooper	lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.015-0.025 lb	0.96-1.6 oz	0 grazing 0 cut for forage 7 harvest after last application	**RESTRICTED USE.** Apply as required by scouting. Timing and frequency of applications should be based on locally determined economic thresholds. Use sufficient water for full coverage. Use ≥2 gal by air and ≥7 gal by ground.
	chlorantraniliprole + lambda-cyhalothrin (Beseige)		5.0 to 8.0 oz.	See label for grazing and PHI	Maximum of 9 fl. oz per cutting and 27 fl. oz per year.
billbug species (suppression only), beet armyworm, blue stem midge, cereal leaf beetle, chinch bug, crickets, true armyworm, yellowstriped armyworm, fall armyworm, English grain aphid, bird cherry-oat aphid, Russian wheat aphid, sugarcane aphid, greenbug [aphid] (for aphid species best control is obtained before insects begin to roll leaves), flea beetles, leafhoppers, spittlebugs, stink bugs, thrips, grasshoppers, green June beetle (adult), Japanese beetle (adult), webworms	lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz		Do not apply >0.03 lb AI (1.92 oz product)/A/cutting for pastures, rangeland, and grass grown for seed. A minimum retreatment interval of 30 days is required for pastures and rangeland receiving 0.03 lb AI/A which have not been cut between applications. Do not apply >0.09 lb AI (5.76 oz product)/A/season. Check label for further details.
	chlorantraniliprole + lambda-cyhalothrin (Beseige)		6.0 to 10.0 oz	See label for grazing and PHI	Maximum of 9 fl. oz per cutting and 27 fl. oz per year.
armyworms, aphids, cereal leaf beetle, grasshoppers, leafhoppers	malathion (Malathion 5EC)	15.0-20.0 oz	1.5-2.0 pt	0 harvest or grazing	**Warning.** REI = 12 hours. Maximum 1 application per cutting

Table 4.6 - Orchardgrass Hay (cont.)

Pests	Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
cutworms, flea beetles, meadow spittlebug, potato leafhopper, webworms, blue alfalfa aphid, green peach aphid (Refer to label for additional pests.)	zeta-cypermethrin (Mustang Max)	0.014-0.025 lb	2.24-4.0 oz	0 forage or hay	**RESTRICTED USE.** Apply minimum 2 gal/A by air or 10 gal/A by ground. Use sufficient water to ensure thorough coverage of foliage. Applications ≥7 days apart for hay and forage. Maximum of 0.025 lb AI/A/ cutting. Maximum 0.10 lb AI/A/season.
armyworms, cereal leaf beetle, grasshoppers, plant bugs (including *Lygus* spp. and stinkbugs) (Refer to label for additonal pests.)	zeta-cypermethrin (Mustang Max)	0.0175-0.025 lb	2.8-4.0 oz	0 forage or hay	**RESTRICTED USE.** Apply minimum 2 gal/A by air or 10 gal/A by ground. Use sufficient water to ensure thorough coverage of foliage. Applications ≥7 days apart for hay and forage. Maximum of 0.025 lb AI/A/ cutting and Maximum 0.10 lb AI/A/ season.

Table 4.7 - Timothy Hay[1]

Pests	Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
cereal rust mite[2]	carbaryl (Sevin XLR Plus)	1.0-1.5 lb	1.0-1.5 qt	14 harvest or grazing	**Caution.** Apply with ground equipment only with adequate water for complete coverage (10-50 gal by ground). *Apply at approximately 4 weeks after green-up in the spring.* Treatment is recommended in fields with a previous history of cereal rust mite and/or when 25% of the plant tillers exhibit curled tips of the new leaf blades within several weeks of green-up. In general, one application at 1.0-1.5 qt/A should provide control. If needed, a second application can be made at least 14 days after the first application. A maximum of 2 applications/year may be made. Do not exceed a total of 3.0 qt/A/cutting.

[1] Note: The following recommendation for timothy hay is made as permitted under FIFRA Section 2(ee).

[2] The cereal rust mite, *Abacarus hystrix*, is a very small eriophyid mite (approximate length of an adult mite is 0.008 inch) that infests several grass species, with timothy being a preferred host. The deeply grooved timothy blades seem to be preferred over the smoother leaf blades of orchardgrass and other forage grasses. In Maryland, populations of more than 3,220 cereal rust mites per square inch (i.e., 500 mites per square cm) have been reported. Initial damage symptoms include lengthwise curling-up (or 'piping-up') of the leaf blade followed by the distal ends of the grass blades turning yellow then brown with the lower leaves drying out.

Cultural control option: Maryland research has shown that cereal rust mite may be controlled culturally by removing most of the aboveground growth immediately before or after the first fall frost. This action removes potential egg-laying sites.

Table 4.8 - Bermudagrass Pasture

Pests	Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
fall armyworm, armyworm, striped grass looper	methomyl (Lannate LV)	3.6-14.4 oz	0.75-3.0 pt	7 grazing 3 cutting for hay	**RESTRICTED USE.** **(Danger Poison)** 48 hour restricted entry interval. Refer to label for proper handling and application instructions. Do not apply more than 3 pt product/A/crop. Do not make more than 4 applications/crop.

Corn

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Seedcorn Maggot

Seedcorn Maggot Sampling/Decision Making

Seed treatments are advised on early and no-till plantings before soil is warm enough to promote quick germination. Old sod fields, pasture, heavily manured fields and fields with previous histories of seedcorn maggot damage should be treated regardless of planting time or type of tillage.

Table 4.9 - Recommended Pesticides for Controlling Seedcorn Maggot

Insecticide (Formulation)	Amount active ingredient	Amount product	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.022 lb AI/A (based on 30-inch row spacing)	0.12-0.16 oz/1,000 row ft 2.0-2.8 oz/A	grain or fodder: 21 Green forages after last application: 0	**RESTRICTED USE.** Maximum product per 7-day interval: 2.8 oz/A. Maximum product per crop season: 11.2 oz/A. Row width adjustment: for row spacing <30 inches, adjust rate of product not to exceed 2.8 oz/A. Note: Diminished control may occur when rates are decreased below recommended minimum rates per 1,000 row ft.
bifenthrin (Capture LFR)	0.04-0.16 lb AI/A	3.4-13.6 oz/A 0.2-0.78 oz/1000 row ft	—	Apply 5- to 7-inch band (T-band) over open furrow or in-furrow with the seed. Maximum 0.1 lb/A/season as an at-plant application. Maximum 0.3 lb/A/season of at-plant plus foliar applications of other bifenthrin products.
clothianidin (Poncho 600)	0.25-0.5 mg AI/ kernel	1.13-2.26 oz/80,000 seeds	—	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin and eyes.
thiamethoxam (Cruiser 5FS)	0.25 mg AI/ kernel	1.13 oz/80,000 seeds	—	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin and eyes.

Note: Check labels of the various granular and liquid soil insecticides for information and product efficacy on seedcorn maggot control.

Wireworms

Wireworm Sampling/Decision Making

First-year corn following established sod is frequently attacked by wireworms. Continuous corn is also at high risk. Early sampling before planting should include bait stations. Two paired bait stations per acre are made by placing 0.5 cup of an equal mixture of untreated corn/wheat in the soil 4 inches deep and 9 inches wide. Set bait stations in fields to be planted at least 3 weeks before the planting date. Check by digging in about 2 weeks and record the number of wireworms for each station. Economic thresholds for wireworms have not been established on corn; however, if an average of 1 or more wireworms per bait station are found, a soil insecticide should be applied in the seed furrow to protect the germinated seed and newly-emerged seedlings.

Table 4.10 - Recommended at Planting Pesticides for Controlling Wireworms

Insecticide (Formulation)	Amount active ingredient per 1,000 row ft	Amount product per 1,000 row ft	Time limits: days before harvest	Remarks
bifenthrin (Capture LFR)	0.04-0.16 lb/ AI/A	3.4-13.6 oz/A 0.2-0.78 oz/ 1000 row ft	—	Apply as an in-furrow spray, microsteam, or 5 to 7 inch T-band. Maximum 0.1 lb/A/season as an at-plant application. Max-imum 0.3 lb/A/season of at-plant plus foliar applications of other bifenthrin products.
chlorpyrifos (Lorsban 15G)	2.4 oz	8.0 oz	35 grain, 14 silage, 14 grazing	Apply at planting in a 6- to 7-inch band over the row, in front of the presswheel and incorporate the granules into the top 1 inch of soil. Can also be applied in-furrow.
clothianidin (Poncho 600)	0.25-0.5 mg AI/ kernel	1.13-2.26 oz/80,000 seeds	—	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin and eyes.
phorate (Thimet 20G)	1.2 oz	4.5-6.0 oz	30	**RESTRICTED USE.** Apply at planting in a 7-inch band over the row, in front of or behind the presswheel and lightly incorporate. Granules must be incorporated into the soil. **Do not apply Thimet in-furrow. In-furrow application can reduce stand.**
tefluthrin (Force 3G)	0.12-0.15 oz	4.5-5.0 oz	30	**RESTRICTED USE.** Apply in-furrow at planting for best control. Rotational crops may be planted 30 days after application.
terbufos (Counter)	6 oz	4.5-6.0 oz	30	**RESTRICTED USE.** Apply at planting in 7-inch band over the row, in front of or behind the presswheel and lightly incorporate. Can also be applied in-furrow. **If application is made at planting, do not makepostemergence or cultivation time treatments of Counter.** Use of Accent or Beacon herbicides following Counter applications may result in crop injury.
thiamethoxam (Cruiser 5FS)	0.250-0.80 mg AI/kernel	—	—	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin and eyes.

White Grubs

White Grub Sampling/Decision Making

Spring planting into former soybean fields or old sod fields are often at risk for white grubs and, to a lesser extent, wireworms. In most years, white grub species stop feeding to pupate in mid- to late May in Virginia. Late-planted corn and conventional-tilled corn are at lower risk from white grubs.

Insecticidal seed treatments for seed and root feeders like white grubs are now applied by the manufacturer and must be ordered at the time the seed order is placed; usually from late fall to early winter. A fall soil sampling method for predicting spring-planted cornfields with economic infestations of white grubs is described below.

Compact Method (CM) Soil Sampling Strategy: Fall and spring research-based action thresholds in corn

The CM is a soil sampling strategy for white grubs that provides timely and useful information for pest management decision-making. The CM is based on an 8-inch square by 6-inch deep volume of soil that is hand-sifted for white grubs on a green plastic leaf collection bag placed on the ground next to the sample site. The CM soil sampling strategy was designed for fall sampling as a means to provide producers with a field-specific pest management tool for better managing white grubs on their farms. Using the CM for spring soil sampling of white grubs before planting corn is as useful as fall sampling with the CM. However, keep in mind that sampling in the fall gives you more time to make a decision about white grub management than sampling in the spring.

Definition of Action Threshold (AT): Levels of pest populations at which control should be implemented to avoid significant damage to the crop (determined from research-based relationship of pest levels on yields).

Thresholds: The fall AT is ≥1.6 white grubs per CM soil sample. The spring AT is ≥1.04 white grubs per CM soil sample.

The following represents the minimum number of compact method samples needed per field to be 95 percent confident your sample average is within the specified percentage of the actual field mean:

25% 3 to 4 samples/field (about 10-15 minutes)
20% 5 to 6 samples/field (about 20-25 minutes)
15% 10 samples/field (about 30-40 minutes)
10% 22 samples/field (about ≥1.5 hours)

One point of caution, although soil sampling for white grubs works well in most soils: it is easier to hand sift lighter, sandier soils than heavier soils which do not break apart easily. No data is available for muck soils.

Table 4.11 - Recommended Pesticides for Controlling White Grubs

Insecticide (Formulation)	Amount active ingredient per 1,000 row ft	Amount product per 1,000 row ft	Time limits: days before harvest	Remarks
bifenthrin (Capture LFR)	0.04-0.16 lb AI/A	3.4-13.6 oz/A 0.2-0.78 oz/1000 row ft	—	Apply 5- to 7-inch band (T-band) over open furrow or in-furrow with the seed. Maximum 0.1 lb/A/season as an at-plant application. Maximum 0.3 lb/A/season of at-plant plus foliar applications of other bifenthrin products. Provides control alone without addition of seed treatment.
chlorpyrifos (Lorsban 15G)	2.4 oz	8.0 oz	35 grain, 14 silage, 14 grazing	Apply at planting in a 6- to 7-inch band over the row, in front of the presswheel and incorporate the granules into the top 1 inch of soil. Can also be applied in-furrow.

Table 4.11 - Recommended Pesticides for Controlling White Grubs (cont.)

Insecticide (Formulation)	Amount active ingredient per 1,000 row ft	Amount product per 1,000 row ft	Time limits: days before harvest	Remarks
clothianidin (Poncho 600)	0.25-0.5 mg AI/ kernel	1.13-2.26 oz/80,000 seeds	—	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin and eyes. Note: High rate is recommended based on VA research.
phorate (Thimet 20G)	1.2 oz	4.5-6.0 oz	30	**RESTRICTED USE.** Apply at planting in a 7-inch band over the row, in front of or behind the presswheel and lightly incorporate. Granules must be incorporated into the soil. **Do not apply Thimet in-furrow. In-furrow application can reduce stand.**
tefluthrin (Force 3G)	0.12-0.15 oz	4.0-5.0 oz	—	**RESTRICTED USE.** Available only in SMARTBOX closed handling system. Apply as needed by scouting. Apply in furrow at planting for best control. Rotational crops may be planted 30 days after application.
terbufos (Counter 20G SmartBox®)	0.9-1.2 oz	4.5-6.0 oz	30	**RESTRICTED USE.** Apply at planting in a 7-inch band over the row, in front of or behind the presswheel and lightly incorporate. Can also be applied in-furrow. **If application is made at planting, do not make postemergence or cultivation time treatments of Counter.** Use of Accent or Beacon herbicides following Counter applications may result in crop injury.
thiamethoxam (Cruiser 5FS)	0.25 mg AI/ kernel	1.13 oz/80,000 seeds	—	Note: High rate (0.5-1.25 mg) is recommended based on VA research.

Baited Wire Trap Procedure for Scouting

Seedcorn maggot, wireworms, and white grubs can be scouted before planting

The wire trap itself consists of a 2-ft long by 3-inch wide strip of 0.25-inch hardware cloth (see image below). To strengthen the hardware cloth strip and to facilitate the placement of the corn seed bait, the strip should be bent lengthwise at a 90° angle. Use only corn seeds that have **not been treated** with an insecticidal seed treatment for bait. About 2 weeks before planting, place 20 seeds about 1 inch apart in each wire trap and then bury the baited wire trap 2 inches deep in the soil. Install at least 1 baited wire trap for every acre of corn to be planted. Remove the traps from the soil after 2 weeks and determine the average number of seeds with feeding damage in the wire traps. The following suggested guidelines may help you determine whether your field is at risk to wireworms, seedcorn maggots, or white grubs.

Suggested Treatment Guidelines Using the Baited Wire Trap Method

Conditions for using the baited wire trap method for field corn

1. Unless continuous corn fields have already been scouted for corn rootworms, baited wire traps should only be used in fields in which corn typically is grown in rotation with soybeans, alfalfa, sorghum, or peanuts (see exceptions below for explanation).

2. Refer to the following suggested treatment guidelines for seedcorn maggots, wireworms, and annual white grubs to determine if a granular insecticide may be needed at planting to prevent serious stand loss.

Seedcorn maggot

A granular insecticide may be needed at planting if the average number of seeds damaged by seedcorn maggots in the baited wire traps is **25 percent** or more; otherwise, an insecticidal seed treatment should be sufficient.

Wireworms

A granular insecticide may be needed at planting if the average number of seeds damaged by wireworms in the baited wire traps is **10 percent** or more; otherwise, an insecticidal seed treatment should be sufficient.

Annual white grubs (i.e., grubs with a 1-year life cycle: Japanese beetle, green June beetle, etc.):

A granular insecticide may be needed at planting if the average number of seeds damaged by annual white grubs in the baited wire traps is **5 percent** or more.

Default

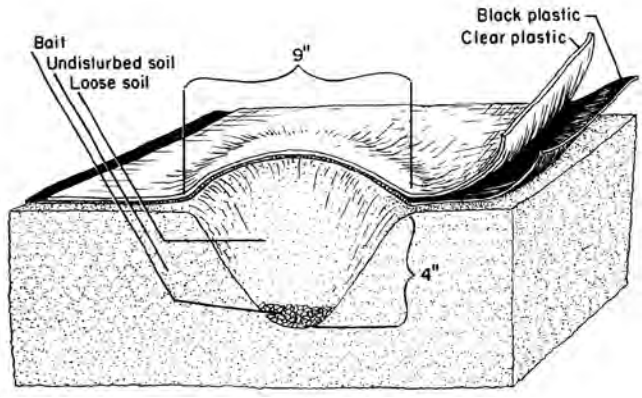
If you are unable to discern which pest is responsible for damaging the corn seeds in the baited wire traps, and if the average number of seeds damaged in the baited wire traps is **5 percent** or more, then a granular insecticide may be needed at planting to prevent serious stand loss.

Exceptions

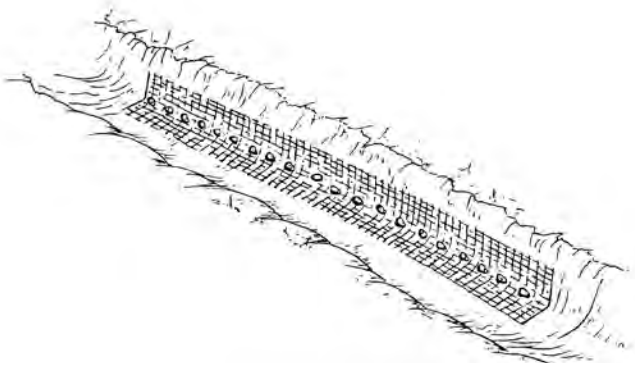
Cropping situations in which the producer is encouraged to make an in-furrow, T-band, or banded over-the-row application of a granular insecticide when planting field corn (**and not just rely on an insecticidal seed treatment**) are the following:

a. when planting corn in old sod or pasture fields, because severe damage from wireworms may occur. Less frequently, damage may occur from true white grubs (i.e., *Phyllophaga* spp. with 2- to 3-year life cycles).

b. when a field is in continuous corn production, because of the potential for corn rootworm damage, and because the low rate of seed treatments do not control corn rootworms.



Bait Station (Cross Section)



Baited Wire Trap

Corn Root Aphid

Corn root aphids are a sporadic pest of field corn in Virginia. Planting field corn no-till in fields with a history of corn root aphid problems can lead to serious root injury if a proper soil insecticide has not been applied at planting. Corn root aphids injure corn by piercing the roots with their stylet-like mouthparts and extracting the sap. The growth of infested corn plants often is stunted and, under severe infestations, may be arrested at a height of only 10 inches.

The ability of this aphid to infest corn roots is highly dependent upon certain species of ants commonly known as corn field ants. Shortly after germination, the ants begin carrying the aphids to the developing corn roots. Aphid numbers increase rapidly once in contact with the roots; females are capable of producing 40 to 50 live nymphs each, and generations can be as short as eight days during warm growing conditions. The ants benefit from this relationship by harvesting the droplets of honeydew produced by the aphids while feeding on the roots.

To determine if a field is at risk to corn root aphids, no-till fields should be scouted for the presence of anthills before planting because, unlike conventionally tilled fields, no-till fields are more likely to have established ant colonies. It should be kept in mind, however, that it is possible for a field to have anthills present without the presence of corn root aphids. Although no specific label reference to corn root aphids has been found among the list of insecticides currently available for use on field corn, application of a granular insecticide at planting to control wireworms or corn rootworms may alleviate a corn root aphid problem. In addition, two cultural practices which can play a role in minimizing corn root aphid infestations are deep tillage every other year to weaken ant colonies, and crop rotation to prevent the buildup of large ant and aphid populations.

Billbug

The southern corn billbug and maize billbug are known to occur throughout the coastal plain of North Carolina and in the Tidewater Region of southeastern Virginia. Unlike other areas of Virginia, the relatively higher organic matter content and poorer drainage characteristics of the soils in southeastern Virginia are two factors considered favorable to billbug infestations. In 2017 and 2018, billbug damage was identified in some northern coastal Virginia no-till fields. Scouting is recommended in all Eastern fields with high organic matter content.

Both adult and immature stages of billbugs damage corn seedlings. Adult billbugs chew into the side of corn seedlings and feed on the inner plant tissue. Eggs are deposited by females within the feeding cavity and hatch in 4 to 15 days. The legless larvae feed in and around the taproot for several weeks. There is only one generation per year. Damaged seedlings which survive infestation typically are stunted, or otherwise deformed, and may exhibit excessive suckering and rows of transverse holes on the leaves.

Rotation is considered the least expensive and most effective method of controlling billbug infestations provided that corn is rotated about 0.25 mile from its previous location. When rotation is not possible, higher rates of neonicotinoid seed treatments are recommended. Remedial control is not effective and, thus, not recommended. Scouting this season will help you make informed decisions in the following year.

Table 4.12 - Preemergence Use of Insecticides to Control Billbugs

Note: Continuous corn, corn planted near last year's corn, corn planted mid-April, and corn near good overwintering habitats are at high risk. These products may not provide adequate control in these situations.

Insecticide (Formulation)	Amount active ingredient per 1,000 row ft	Amount product per 1,000 row ft	Time limits: days before harvest	Remarks
clothianidin (Poncho 600)	1.25 mg AI/ kernel	5.64 oz/80,000 seeds	–	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin.
thiamethoxam (Cruiser 5FS)	1.25 mg AI/ kernel	5.64 oz/80,000 seeds	—	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin.

Cutworm

Cutworm Sampling/Decision Making

Late-planted, minimum-till fields with heavy spring weed growth on poorly drained soils are the most likely to encounter cutworms. Corn fields should be checked twice a week from the spike through the 5th-leaf stage. Leaf feeding is the first sign that cutworms are present. Look for small, irregular holes in leaves and cut plants. Note any leaf feeding that may have resulted from cutworms too small to cut plants and check these areas again in 24 to 48 hours. If cutworms are present, examine at least 10 sets of 20 plants throughout the field and record the percentage of cut or damaged plants. At the same time, look under clods and dig 1 to 2 inches deep around the bases of damaged plants to find cutworms. Record the average size and number of cutworms.

As a general guideline, before the 3rd- to 5th-leaf stage, a rescue treatment should be applied if 10% or more of the young plants show fresh leaf feeding and cutworms are present. At the 3rd- to 5th-leaf stage, treatment should be applied if 5% of the plants are cut and there are 4 or more cutworms per 100 plants.

Transgenic corn varieties (Agrisure Viptera, Herculex, Leptra, PowerCore, Optimum Intrasect, SmartStax) express Bt toxins for cutworm control. Plant refuges as required by label instructions.

Table 4.13 - Recommended Postemergence Insecticides to Control Cutworms

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.017-0.022 lb	1.6-2.8 oz	grain or fodder: 21 Green forages after last application: 0	**RESTRICTED USE.** Maximum product per 7-day interval: 2.8 oz/A. Maximum product per crop season: 11.2 oz/A. Maximum number of applications per season: 4. Minimum application volume (water): 10 gal/A by ground, 2 gal/A by air.
bifenthrin (Brigade, others) 2 EC	0.033-0.10 lb	2.1-6.4 oz	—	**RESTRICTED USE.** Use at least 15 GPA by ground. Use high rates for heavy infestations and aerial applications.
bifenthrin zeta-cypermethrin (Hero 1.24 EC)	0.025-0.06 lb	2.6-6.1 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** Use at least 15 GPA by ground. Use high rates for heavy infestations and aerial applications. Do not apply more than 0.4 lb AI/A/season for foliar applications. Do not graze livestock in treated areas or cut treated crops for feed within 30 days of last application. Do not apply if heavy rainfall is imminent. Use at least 15 GPA by ground. Use high rates for heavy infestations and aerial applications.
chlorpyrifos (Lorsban 4E)	0.5-1.0 lb	1.0-2.0 pt	35 grain 14 silage 14 grazing	Use sufficient water to ensure thorough coverage of treated plants.
esfenvalerate (Asana XL)	0.03-0.05 lb	5.8-9.6 oz	21	**RESTRICTED USE.** Use sufficient water to ensure thorough coverage of treated plants.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.015-0.025 lb	0.96-1.60 oz	21	**RESTRICTED USE.** Apply as required by scouting, usually at intervals of 7 or more days. Apply by ground or air using sufficient water for full coverage. **Aerial application**: use ≥2 gal water/A. Do not apply >0.48 pt/A/season. Do not apply >0.24 pt/A after silk initiation. Do not apply >0.12 pt/A after milk stage.

Table 4.13 - Recommended Postemergence Insecticides to Control Cutworms (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
methoxyfenozide (Intrepid 2F)	0.06-0.12 lb	4 - 8 oz	21	
zeta-cypermethrin (Mustang Max)	0.008-0.0175 lb	1.28-2.8 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** Use minimum 10 gal water/A.

Armyworm

Fall Armyworm

Late planted fields are at risk of economic infestations. Fall armyworm does not overwinter in Virginia. Control is recommended for leaf feeding if larvae are present on >50% of plants. Larvae may infest ears if crop matures late. Some transgenic corn varieties control fall armyworm. Please note that hybrids containing only Cry1F are not recommended for fall armyworm control in Virginia. Plant refuges as required by label instructions. Control of large larvae is difficult with any insecticide.

True Armyworm Sampling/Decision Making

Armyworm is not commonly an economic pest, but economically damaging infestations can occasionally occur in seedling and whorl stage corn. No-till fields planted into a small grain cover crop, pastures, or weedy fields all have at higher risk for armyworm infestation. Survey field edges where margins border small grains or large grassy areas and watch for damaged plants. If armyworm damage is seen, examine 20 plants at each of 5 locations within the field and record the percentage of damaged plants, the average size, and the severity of injury.

Armyworms usually migrate from small grains starting in late May. Controlling grassy weeds will help prevent infestations. Spot treatments may be warranted if infestations are confined to small areas. Control for armyworms is recommended if 35 percent or more of the plants are infested and 50 percent or more defoliation is seen on the damaged plants, provided that larvae average less than 0.75 inch long. Worms greater than 1.25 inches in length usually have completed their feeding. Soil applied insecticides are not effective against this pest. Some transgenic corn varieties control armyworm. Plant refuges as required by label instructions.

Table 4.14 - Recommended Postemergence Insecticides to Control Fall Armyworm

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
chlorantraniliprole (Prevathon 0.43 SC)	0.047-0.067	14-20	14	Use a minimum of 15 GPA for whorl treatment. Less effective against large larvae.

Table 4.15 - Recommended Postemergence Insecticides to Control True Armyworm

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.0125-0.022 lb	1.6-2.8 oz	grain or fodder: 21 Green forages after last application: 0	**RESTRICTED USE.** Effective against 1st and 2nd instars only. Maximum product per 7-day interval: 2.8 oz/A. Maximum product per crop season: 11.2 oz/A. Maximum number of applications per season: 4. Minimum application volume (water): 10 gal/A by ground, 2 gal/A by air.
bifenthrin (Brigade, others)	0.033-0.10 lb	2.1-6.4 oz	—	**RESTRICTED USE.** Insecticide must be preplant incorporated (PPI) and can be tank mixed with PPI herbicides. Product should be applied no deeper than intended planting depth.
bifenthrin zeta-cypermethrin (Hero [1.24 lb AI/gal prod])	0.04-0.1 lb	4.0-10.3 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** For grain, silage, and seed use. Do not apply more than 0.4 lb AI/A/season for foliar applications. Do not graze livestock in treated areas or cut treated crops for feed within 30 days of last application. Do not apply if heavy rainfall is imminent.
chlorantraniliprole (Prevathon 0.43 SC)	0.047-0.067 lb	14-20 oz	—	May not effectively control large larvae.
chlorpyrifos zeta-cypermethrin (Stallion [3.03 lbs AI/gal prod])	—	9.25-11.75 oz	30 grain and fodder (stover), 60 forage	**RESTRICTED USE.** Do not make second application of Stallion or any other product containing chlorpyrifos within 10 days of first application. Do not apply in tank mixes with Steadfast or Lighting herbicides.
esfenvalerate (Asana XL)	0.03-0.05 lb	5.8-9.6 oz	21	**RESTRICTED USE.** Use sufficient water to ensure thorough coverage of treated plants.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz	21	**RESTRICTED USE.** For control of small larvae only. Apply as required by scouting, usually at intervals of 7 or more days. Apply by ground or air using sufficient water for full coverage. **Aerial application**: use ≥2 gal water/ A. Do not apply >0.48 pt/A/season. Do not apply >0.24 pt/A after silk initiation. Do not apply >0.12/A pt after milk stage.
methomyl (Lannate LV) (Lannate SP)	 0.225-0.45 lb 0.225-0.45 lb	 0.75-1.5 pt 0.25-0.5 lb	3 forage 21 ears 21 fodder	**RESTRICTED USE.** Apply when insects first appear. Use sufficient water to ensure thorough coverage of treated plants.
spinosad (Blackhawk 4 SC)	0.038-0.075 lb	1.67-3.3 oz	7 forage and seed, 28 grain	May not effectively control large larvae.
zeta-cypermethrin (Mustang Max)	0.02-0.025 lb	3.2-4.0 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** Use minimum 10 gal water/A.

Slugs and Snails

Slug, Snail Sampling/Decision Making

Slugs can become serious pests in no-till fields during spring periods of cool, wet weather. Fields with heavy layers of manure, crop refuse, or thick weed cover are at higher risk from slugs. Because slugs feed at night and hide during the day in the mulch and surface trash near the seedlings, they often are not suspected of being the cause of the shredded leaves on the young corn seedlings. Yet slugs can be found during the day by turning over clods of dirt and surface trash near the seedlings. It is suggested that samples be taken from the area around 5 plants in 10 locations of the field to determine the average number of slugs associated with each plant. Populations of 5 or more slugs around each plant at the spike through the 3rd-leaf stage may be economic, especially if injury is heavy, plant growth is slow, and cool, wet conditions prevail. During dry, warm weather, 10 or more slugs per plant may be tolerated. Also, corn seedlings that have reached the 3rd-leaf stage of growth generally are able to outgrow feeding damage by slugs.

Cultural practices which may help reduce slug populations include reduction in the use of manure, shift to conventional tillage practices for at least one season, and minimum tillage to reduce the amount of surface trash.

Table 4.16 - Postemergence Use of Insecticides to Control Slugs and Snails

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
metaldehyde (Deadline M-Ps)	0.4-1.6 lb	10.0-40.0 lb	0	For best results, apply product in evening. Especially beneficial if applied following rain or watering. It should be noted that most corn-producing states are suggesting an application rate of 12 to 15 lb/A, if banded over or along side the row after the plants have emerged. Recent Delaware field trials indicate good results against slugs using 10 lb Deadline M-Ps/A broadcast with a cyclone spreader. Spreader must be calibrated to deliver at least 5 pellets/sq ft. Slugs generally stop feeding in 2-3 hours and die within 2-3 days.

Stalk Borer

Stalk Borer Sampling/Decision Making

Good weed control can help eliminate some stalk borer egg-laying sites, but overwintering eggs may be laid on fall-planted small grains such as rye. A postemergence insecticide application is suggested **only** if the larvae **have not bored** into the stalks. Given this restriction, a treatment may be warranted if more than 4, 6, or 10 percent of the plants at the 2nd-, 3rd-, or 4th-leaf stages exhibit signs of stalk borer feeding damage. Refer to sampling procedures for true armyworm.

An alternative strategy for managing stalk borer infestations is to apply a burndown herbicide **at least 10 days before** corn is planted. The slightly earlier burndown herbicide application means that a suitable alternative host (i.e., corn) will not be available to the stalk borer larva as it emerges from its herbicide-treated host. As a consequence of this action, the exposed larvae are subject to a much higher mortality rate from such factors as predation, starvation, and adverse environmental conditions.

Western Corn Rootworm

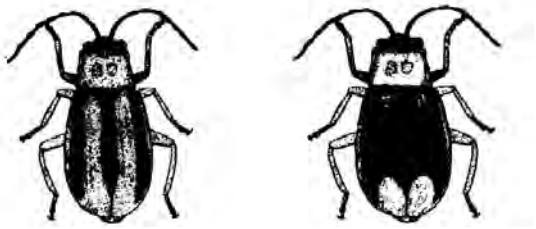


Fig. 4.5 Western Corn Rootworm Adults

Markings range from distinct black and yellow regions (left) to a 'blotchy' black (right).

There is one generation of western corn rootworm (WCR) per year. In late summer, adults lay eggs in soil **in cornfields**. Eggs overwinter in the soil and hatch the following spring. Larvae (grubs) immediately search for corn roots on which to feed, and then pupate in the soil. Adults (beetles) emerge from late June through August and fly to corn plants to feed and mate.

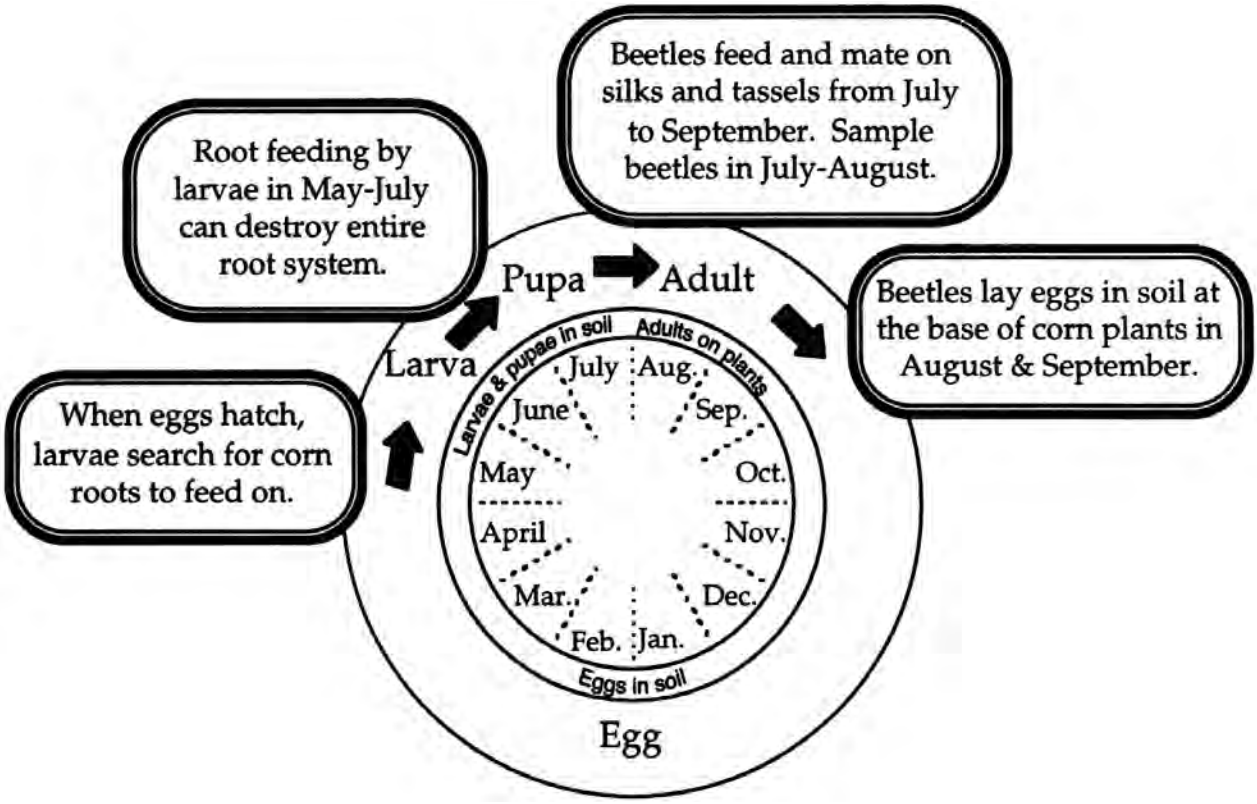


Fig. 4.6 Western corn rootworm life cycle in Virginia

Larvae feed almost exclusively on corn roots, so control is easily accomplished through crop rotation. However, many farmers do not have the option of rotating out of corn, thus the next best control measures are to plant Bt corn hybrids with rootworm specific traits (Agrisure, Herculex XTRA, Genuity VT Triple Pro, SmartStax), or use a seed treatment. Please note that Bt corn hybrids containing only Cry3 toxins (mCry3A, Cry3Bb1, and eCry3.1Ab) have experienced performance issues in 2017 and 2018. No issues have been reported with Bt corn hybrids containing Cry34Ab1/35Ab1. Plant refuges as required by label if transgenic varieties are used. As the life cycle indicates, treatment of first year corn to control WCR is not necessary. Also, rootworm populations in subsequent years of continuous corn may not be large enough to warrant treatment. Economic damage thresholds for rootworm beetles have been developed by correlating beetle populations in a particular field with subsequent larval feeding damage occurring the following year.

Sampling

Western corn rootworm beetles should be sampled in July and August to determine whether a control measure is needed the following year. Two methods for scouting corn rootworm beetles are described here.

1. Yellow sticky card method

Place 4 x 6 inch Olson® (available from Olson Products, P. O. Box 1043, Medina, OH 44258) two-sided yellow sticky cards (traps) in cornfields starting in early July. Use the table below to determine how many traps to install. Place traps about 300 feet apart and at least 100 feet in from all field edges. Place a series of traps along the same corn row. When approaching the field edge, cross over about 30 rows and place another series of traps along a row until the entire field is covered. Use flags to mark the location of each trap. Use continuous flagging (forestry tape) when crossing rows and to mark the start of the trap line. Attach traps to corn plants at a height of about 4 feet. Break off any leaves on the plant and adjacent plants that could possibly stick to a trap. Monitor the traps every 9 to 10 days, recording the number of western corn rootworm beetles on each trap. At each site remove the release paper from the unused side of the trap and re-install the trap on the corn stalk with the fresh side exposed. Install new traps every other visit.

Table 4.17 - Determining the number of traps to place in a field

Field Size (Acres)	Number of Traps per Field
1 to 5	3
6 to 10	6
11 to 15	9
16 to 20	13
21 to 25	16
26 to 30	19
31 to 35	23
36 to 40	26
41 to 45	30
46 to 50	34
51 to 55	37
56 to 60	40

Decision Making

After counting the rootworm beetles on all traps, determine the average number of beetles per trap per week using the following formula:

Average beetles per trap per week = *Total Beetles ÷ No. of usable traps ÷ No. of days since last sampled x 7*

If a field has 20 or more rootworm beetles per trap per week, that field is above threshold and should be rotated out of corn or treated with a granular insecticide at corn planting next year for rootworm control. Once a field exceeds the threshold there is no need to scout it again this year.

If trap catch never reaches 20 beetles per trap per week, the field is below threshold and no treatment is recommended for rootworm control the following year. Scouting can be discontinued if trap counts decline for three consecutive sampling periods.

2. Ear zone count method

Survey fields 4 or 5 times from the second week in July through the third week in August to estimate the number of western corn rootworm beetles in the field. Count the corn rootworm beetles in the ear zone of 50 corn plants throughout each field. The ear zone is the area from the upper surface of the leaf just below the ear to the lower surface of the leaf just above the ear, and includes the ear and ear leaf. Calculate the average number of beetles per ear zone. When scouting fields that have

been in corn more than one year, an average count of 1.0 beetle or more per ear zone indicates that a granular insecticide should be applied if the field is to be planted in corn the following year. When scouting first year corn, control for rootworms the following year if the average count is 0.75 beetles or more per ear zone, because primarily egg-laying females migrate to new cornfields.

Table 4.18 - Western Corn Rootworm

Insecticide (Formulation)	Amount active ingredient per 1,000 row ft	Amount product per 1,000 row ft	Time limits: days before harvest	Remarks
terbufos (Counter 20G SmartBox®)	0.9-1.2 oz	4.5-6.0 oz	30	**RESTRICTED USE.** Apply at planting in a 7-inch band over the row, in front of or behind the press wheel and lightly incorporate. Can also be applied in-furrow. **If application is made at planting, do not make postemergence or cultivation time treatments of Counter.** Use of Accent or Beacon herbicides following Counter applications may result in crop injury.
tefluthrin (Force 3G)	0.12-0.15 oz	4.0-5.0 oz	–	**RESTRICTED USE.** Apply at planting in a 7-inch band over the row, in front of or behind the presswheel and incorporate the granules into the top 1 inch of soil. Can also be applied in-furrow. Rotational crops may be planted 30 days after application.
chlorpyrifos (Lorsban15G)	1.2 oz	8.0 oz	35 grain, 14 silage, 14 grazing	Apply at planting in a 6- to 7-inch band over the row, in front of or behind the presswheel and incorporate the granules into the top 1 inch of soil. Can also be applied in-furrow.
clothianidin (Poncho 600)	1.25 mg AI/ kernel	5.64 oz/80,000 seeds	–	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin.
thiamethoxam (Cruiser 5FS)	1.25 mg AI/ kernel	5.64 oz/80,000 seeds	–	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin.

Table 4.19 - Bt proteins active against western corn rootworm

Protein*	Product	First Marketed
Cry3Bb1	YieldGard	2003
mCry3A	Agrisure	2006
Cry34/35Ab1	Herculex, Optimum	2005
eCry3.1Ab	Duracade	2014

*Resistance by western corn rootworm (WCR) to Bt hybrids expressing either the Cry3 or mCry3A protein has been documented in individual Midwestern cornfields since 2009.

In some locations in Virginia corn rootworm Bt hybrids expressing the Cry3Bb1 proteins have experienced considerable root damage and lodging from WCR feeding.

To preserve the efficacy of Bt traits against western corn rootworm:

Rotate mode of action by planting a hybrid with a different Bt trait or multiple Bt traits for rootworm, or plant a conventional hybrid with a seed treatment.

Rotate out of corn every 3 to 4 years to break the corn rootworm life cycle.

Follow refuge compliance: A refuge (5-20%, depending on hybrid) of non-Bt corn is used to delay the development of resistance to the Bt toxin.

European Corn Borer (ECB)

First Generation

The potential for first-generation damage in field corn during the whorl stage is impossible to predict prior to planting. The best strategy is to scout each field and apply a whorl application of a granular or liquid insecticide if the ECB infestation exceeds the treatment threshold (see Decision Making below). Historically, not all fields need to be treated with insecticides every year. Furthermore, many corn varieties are able to tolerate moderate levels of leaf and stalk injury without economic yield loss. **Also, corn grown for silage rarely needs to be treated for ECB**.

The decision to treat a first generation ECB infestation should be based on the following two criteria: (1) the number of plants exhibiting fresh whorl feeding damage, and (2) the presence of live larvae. ECB mortality typically is very high during the first 3 to 5 days after egg hatch. Plant resistance, natural enemies, and adverse environmental conditions are major causes of ECB larval mortality.

Sampling Begin checking for whorl feeding damage when the plants with extended leaves are 17 inches. Randomly select 5 sets of 20 consecutive plants from throughout the field. Determine the percentage of plants that exhibit fresh whorl feeding. Note: newly hatched larvae feed on the leaves, causing a characteristic "window pane" or "shothole" type of damge that is readily visible as the whorl unrolls. In addition, dissect 2 infested plants from each sample of 20 plants and look for live larvae in the whorl of the stalk. Check weekly or more frequently.

Decision Making. Treatment is suggested if 80 percent or more of the plants exhibit whorl feeding damage and if 80 percent or more of the damaged plants (i.e., 8 out of the 10 dissected plants) have at least 1 live larva per plant.

Second Generation

Although second generation ECB are more likely to attack corn that has been planted late, all corn grown for grain should be scouted when plants with extended leaves are 17 to 24 inches.

Sampling. To assess the potential for economic damage, begin scouting for egg masses when second generation moths emerge and begin egg-laying. The presence of ECB moths in areas bordering a field can be used to indicate a likely infestation. To survey for these moths, walk along the grassy sides of the field and look for large numbers of moths flying when disturbed. However, if no other information is available, it is suggested that scouting for egg masses be initiated the last week of June and continued at 2 to 3 day intervals through the third week of July. Randomly select 5 sets of 20 consecutive plants from throughout the field. Count the number of egg masses found on each plant. ECB moths usually lay their eggs in masses on the undersides of leaves, 2 or 3 leaves below the ear; however, because they can be laid anywhere, it is suggested that every leaf be inspected for egg masses.

Decision Making. To reduce a potential economic loss from second generation ECB in field corn grown for grain, an insecticide treatment is warranted if 35 percent or more of the plants in the pre- to post-tasseling stage of development have at least 1 egg mass per plant.

General Guidelines for Use of Bt Corn in Virginia

The USEPA has identified specific cotton-growing counties in Virginia where corn growers who plant Bt corn hybrids for corn borers or other lepidopterous insects (such as cutworms, armyworms, etc.) and/or corn rootworms also must plant a 50 percent non-Bt corn refuge.

The Virginia counties subject to the 50 percent corn refuge requirement are: Dinwiddie, Franklin City, Greensville, Isle of Wight, Northampton, Southampton, Suffolk City, Surrey, and Sussex.

What Is Bt Corn?

A Bt corn hybrid refers to a corn plant that has been genetically engineered to express a crystalline protein derived from a common soil bacterium, *Bacillus thuringiensis*. Although researchers have identified numerous strains of Bt proteins, only a handful have been incorporated into the current lines of commercial corn hybrids. Bt proteins are highly toxic to European corn borer, meaning that all Bt corn hybrids labeled for caterpillar pests are 100% effective against this pest.

European Corn Borer Life Cycle

European corn borer is a moth that has two main generations per year in Virginia. It overwinters as a fifth instar larva inside pieces of corn stalks, and it has a host range of over 200 plant species. The main damage caused by corn borer larvae results from tunnels bored into the stalk about two weeks before silking. A cornfield that averages one or more tunnels per stalk can expect a yield reduction of about 5%. Despite the fact that it is relatively simple to scout for this pest during the growing season, few growers in Virginia actually do. Their main reasons for not scouting are based on years of observing low levels of stalk breakage and ear drop at harvest.

What Other Corn Pests Are Controlled by Bt Hybrids?

Some Bt traits are effective against multiple caterpillar pests. These traits can be regionally ineffective in areas, including Virginia, where resistance has been documented or is suspected. The Handy Bt Trait Table published by Chris DiFonzo at Michigan State University provides a list of corn trait names and their current insect protection benefits - https://lubbock.tamu.edu/files/2018/01/BtTraitTableJan2018.pdf.

General Guidelines for Planting Bt Corn Borer Hybrids in Virginia

1. Most corn (≥90%) planted timely in Virginia (i.e., from April to early May) will likely not realize an economic benefit from Bt corn because of the lack of European corn borer pressure early in the season.
2. It is strongly recommended that Bt corn be planted anywhere late-planted corn (i.e., corn planted mid- to late May or later) is grown in Virginia because of the increasing risk of corn borer damage.

EPA Refuge Requirements for Planting Bt Corn Hybrids

Refuge requirements vary by hybrid and by region. Use label to determine requirements in your area.

Table 4.20 - European Corn Borer (ECB)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.0125-0.022 lb	1.6-2.8 oz	grain or fodder: 21 Green forages after last application: 0	**RESTRICTED USE.** Application must be made prior to the larva boring into the plant. Maximum product per 7-day interval: 2.8 oz/A. Maximum product per crop season: 11.2 oz/A. Maximum number of applications per season: 4. Minimum application volume (water): 10 gal/A by ground, 2 gal/A by air.
bifenthrin zeta-cypermethrin (Hero [1.24 lb AI/gal prod])	0.04-0.1 lb	4.0-10.3 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** For grain, silage, and seed. Do not apply more than 0.4 lb AI/A/season for foliar applications. Do not graze livestock in treated areas or cut treated crops for feed within 30 days of last application. Do not apply if heavy rainfall is imminent.
chlorantraniliprole (Prevathon 0.43 SC)	0.047-0.067 lb	14-20 oz	14	
chlorpyrifos (Lorsban 15G)	0.9-1.2 oz/1,000 row ft	6.0-8.0 oz/1,000 row ft (band application) 5.0-6.5 lb (broadcast by air)	35 grain, 14 silage, 14 grazing	Uniformly broadcast granules over the plants by air or directly into whorls by ground. Do not exceed 2 applications/season. Do not graze or harvest for silage within 14 days of last treatment.

Table 4.20 - European Corn Borer (ECB) (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
chlorpyrifos (Lorsban 4E)	0.5-1.0 lb	1.0-2.0 pt	35 grain, 14 silage, 14 grazing	**First generation:** Apply when 25 to 50% of plants show pinholefeeding or leaf-feeding scars. Ground applications should be directed into the whorl. **Second generation:** Apply when egg-mass counts reach or exceed the economic threshold. Do not graze or harvest for silage within 14 days of last treatment.
chlorpyrifos zeta-cypermethrin (Stallion [3.03 lbs AI/gal prod])	—	9.25-11.75 oz	30 grain and storage, 60 forage	**RESTRICTED USE.** For grain, silage, seed. Make only one at-plant application in-furrow band or T-band treatment; minimum 4-inch band.
esfenvalerate (Asana XL)	0.04-0.05 lb	7.8-9.6 oz	21	**RESTRICTED USE.** **First generation:** Apply when eggs are in blackhead stage or starting to hatch. Ground application suggested— use 20-30 gal carrier/A and direct spray to both sides of leaves. **Second generation:** Apply when eggs are in blackhead stage or starting to hatch. Good coverage above, below, and in the ear zone is essential.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz	21	**RESTRICTED USE.** Must be applied before larva bores into stalk. Apply as required by scouting, usually at intervals of 7 or more days. Apply by ground or air using sufficient water for full coverage. **Aerial application**: use ≥2 gal water/A. Do not apply >0.48 pt/A/season. Do not apply >0.24 pt/A after silk initiation. Do not apply >0.12 pt/A after milk stage.
methoxyfenozide (Intrepid)	0.06-0.12 lb	4-8 oz	21	Must be applied before borers enter stalk. Use 25 GPA minimum and at most 30 psi.
spinosad (Blackhawk 4 SC)	0.038-0.075	1.67-3.3 oz	28	Must be applied before borers enter stalk. Use 25 GPA minimum and at most 30 psi.
zeta-cypermethrin (Mustang Max)	0.017-0.025 lb	2.72-4.0 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** Use minimum 10 gal water/A. 60 forage

Flea beetle

Flea Beetle Sampling/Decision Making

Flea beetles rarely require control; however, treatment may be necessary if 10 or more flea beetles are present on young corn seedlings at the 1- to 2-leaf stage of growth. No preemergence treatments are recommended for control of flea beetles.

Table 4.21 - Flea Beetle

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.0065-0.0125 lb	0.8-1.6 oz	grain or fodder: 21 Green forages after last application: 0	**RESTRICTED USE.** Maximum product per 7-day interval: 2.8 oz/A. Maximum product per crop season: 11.2 oz/A. Maximum number of applications per season: 4. Minimum application volume (water): 10 gal/A by ground, 2 gal/A by air.
bifenthrin zeta-cypermethrin (Hero [1.24 lb AI/gal prod])	0.025-0.026 lb	2.6-6.1 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** For grain, silage, and seed. Use of Hero on corn is prohibited in all coastal counties. Do not apply more than 0.4 lb AI/A/season for foliar applications. Do not graze livestock in treated areas or cut treated crops for feed within 30 days of last application. Do not apply if heavy rainfall is imminent.
chlorpyrifos (Lorsban 4E)	0.5-1.0 lb	1.0-2.0 pt	35 grain, 14 silage, 14 grazing	Use sufficient water to ensure thorough coverage of treated plants.
chlorpyrifos zeta-cypermethrin (Stallion [3.03 lbs AI/gal prod])	—	9.25-11.75 oz	30 grain and storage, 60 forage	**RESTRICTED USE.** For grain, silage, seed. Make only one at-plant application in-furrow band or T-band treatment; minimum 4-inch band.
clothianidin (Poncho 600)	0.25-0.5 mg AI/kernel	1.13-2.26 oz/80,000 seeds	—	Product is usually applied by manufacturer to seed upon request of grower at the time seed is ordered. Avoid breathing dust and contact with skin and eyes.
esfenvalerate (Asana XL)	0.03-0.05 lb	5.8-9.6 oz	21	**RESTRICTED USE.** Use sufficient water to ensure thorough coverage of treated plants.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz	21	**RESTRICTED USE.** Apply as required by scouting. Apply by ground or air using sufficient water for full coverage. **Aerial application**: use ≥2 gal water/A.
methomyl (Lannate LV) (Lannate SP)	 0.225-0.45 lb 0.225-0.45 lb	 0.75-1.5 pt 0.25-0.5 lb	3 forage, 21 ears, 21 fodder	**RESTRICTED USE.** Use sufficient water to ensure thorough coverage of treated plants.
terbufos (Counter 20G SmartBox®)	0.9-1.2 oz	4.5-6.0 oz	30	**RESTRICTED USE.** Apply at planting in a 7-inch band over the row, in front of or behind the press wheel and lightly incorporate. Can also be applied in-furrow. **If application is made at planting, do not make postemergence or cultivation time treatments of Counter.** Use of Accent or Beacon herbicides following Counter applications may result in crop injury.
zeta-cypermethrin (Mustang Max)	0.017-0.025 lb	2.72-4.0 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** Use minimum 10 gal water/A. 60 forage

Grasshoppers

Grasshopper Sampling/Decision Making

Damage may occur during mid- to late-summer, especially during periods of drought. Examine fields next to pastures and other grassy areas where grasshoppers overwinter and develop. Treatment of these adjacent breeding sites before the young grasshoppers move into the corn field may reduce the area that must be sprayed later. Treatment of non-cropped areas is suggested when young grasshoppers reach 20 per square yard. Treat field margins when young grasshoppers enter the field from roadsides. Treatment of entire field is seldom necessary; however, field sprays may be justified when 5 to 8 grasshoppers per square yard are present during the silking period.

Table 4.22 - Grasshoppers

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.0165-0.022 lb	2.1-2.8 oz	grain or fodder: 21 Green forages after last application: 0	**RESTRICTED USE.** Maximum product per 7-day interval: 2.8 oz/A. Maximum product per crop season: 11.2 oz/A. Maximum number of applications per season: 4. Minimum application volume (water): 10 gal/A by ground, 2 gal/A by air.
bifenthrin zeta-cypermethrin (Hero [1.24 lb AI/gal prod])	0.025-0.026 lb	2.6-6.1 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** For grain, silage, and seed. Use of Hero on corn is prohibited in all coastal counties. Do not apply more than 0.4 lb AI/A/season for foliar applications. Do not graze livestock in treated areas or cut treated crops for feed within 30 days of last application. Do not apply if heavy rainfall is imminent.
chlorpyrifos (Lorsban 4E)	0.25-0.5 lb	0.5-1.0 pt	35 grain, 14 silage, 14 grazing	Use sufficient water to ensure thorough coverage of treated plants.
esfenvalerate (Asana XL)	0.03-0.05 lb	5.8-9.6 oz	21	**RESTRICTED USE.** Apply as necessary to maintain control.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz	21	**RESTRICTED USE.** Apply as required by scouting. Apply by ground or air using sufficient water for full coverage. **Aerial application**: use ≥2 gal water/A.
zeta-cypermethrin (Mustang Max)	0.017-0.025 lb	2.72-4.0 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** Use minimum 10 gal water/A.

Spider Mite

Spider Mite Sampling/Decision Making

Spider mite populations often seem to explode as plants reach the grain-fill period, especially during extended hot, dry weather when the plants are stressed. Sprays applied for other insect pests during mid-summer can devastate the mite predator complex and thus may increase mite populations. If corn has not dented, treatment may be warranted if mite colonies are present along the midribs on the lower surfaces of one-third to one-half of the leaves on 50 percent of the plants. This can also be expressed as 15 to 20 percent of the total leaf area covered with mite colonies, and mites are beginning to colonize significant areas of the field.

Table 4.23 - Spider Mite

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
bifenthrin zeta-cypermethrin (Hero EW [1.24 lb AI/gal prod])	0.1 lb	10.3 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** For grain, silage, and seed. Use of Hero on corn is prohibited in all coastal counties. Do not apply more than 0.4 lb AI/A/season for foliar applications. Do not graze livestock in treated areas or cut treated crops for feed within 30 days of last application. Do not apply if heavy rainfall is imminent.

Corn Leaf Aphid

Corn Leaf Aphid Sampling/Decision Making

Aphids are rarely a problem because infestations either build up too late, or they are controlled by beneficial insects such as lady beetles, lacewings, and parasitic wasps. Economic infestations may occur in mid-summer inside the leaf whorl surrounding the developing tassel. If treatment is considered it should be applied before 50 percent of the tassels emerge to be most effective. Unfold the whorl leaves of 20 plants at each of 5 locations in the field and note the severity of aphid colonies and any natural enemy activity. Treatment may be needed when 25 percent of the plants are heavily infested and natural enemy activity is low.

Table 4.24 - Corn Leaf Aphid

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
bifenthrin zeta-cypermethrin (Hero [1.24 lb AI/gal prod])	0.04-0.1 lb	4.0-10.3 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** For grain, silage, and seed. Use of Hero on corn is prohibited in all coastal counties. Do not apply more than 0.4 lb AI/A/season for foliar applications. Do not graze livestock in treated areas or cut treated crops for feed within 30 days of last application. Do not apply if heavy rainfall is imminent.
chlorpyrifos zeta-cypermethrin (Stallion [3.03 lbs AI/gal prod])	—	9.25-11.75 pt	30 grain and storage, 60 forage	**RESTRICTED USE.** For grain, silage, seed. Make only one at-plant application in-furrow band or T-band treatment; minimum 4-inch band.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz	21	**RESTRICTED USE.** Suppression only. Apply as required by scouting, usually at intervals of 7 or more days. Apply by ground or air using sufficient water for full coverage. **Aerial application:** use ≥2 gal water/A. Do not apply >0.48 pt/A/season. Do not apply >0.24 pt/A after silk initiation. Do not apply >0.12 pt/A after milk stage.
zeta-cypermethrin (Mustang Max)	0.017-0.025 lb	2.72-4.0 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** Use minimum 10 gal water/A.

Japanese Beetle

Japanese Beetle (Adult Feeding) Sampling/Decision Making

Damage is caused when the adult beetles prevent pollination by clipping silks during the early stage of silking. Begin scouting in mid-July before pollination to determine the number of beetles present and the potential for silk clipping damage. Pollination takes place during a period of about 36 hours. If the silks are wilted and/or have turned brown, pollination is complete and further silk feeding will not affect yields. Examine 20 plants in each of 5 locations in the field to determine the stage of pollination, the number of beetles per plant, and the percentage of plants with silks cut back to 0.5 inch or less. An insecticide application may be necessary if 50 percent of the plants have silks cut back to 0.5 inch or less, there is an average of more than 3 Japanese beetles per silk, and the plants are still pollinating.

Table 4.25 - Japanese Beetle

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.0125-0.022 lb	1.6-2.8 oz	grain or fodder: 21 Green forages after last application: 0	**RESTRICTED USE.** Maximum product per 7-day interval: 2.8 oz/A. Maximum product per crop season: 11.2 oz/A. Maximum number of applications per season: 4. Minimum application volume (water): 10 gal/A by ground, 2 gal/A by air.
bifenthrin zeta-cypermethrin (Hero [1.24 lb AI/gal prod])	0.04-0.1 lb	4.0-10.3 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** For grain, silage, and seed. Use of Hero on corn is prohibited in all coastal counties. Do not apply more than 0.4 lb AI/A/season for foliar applications. Do not graze livestock in treated areas or cut treated crops for feed within 30 days of last application. Do not apply if heavy rainfall is imminent.
chlorpyrifos zeta-cypermethrin (Stallion [3.03 lbs AI/gal prod])	—	9.25-11.75 oz	30 grain and storage, 60 forage	**RESTRICTED USE.** For grain, silage, seed. Make only one at-plant application in-furrow band or T-band treatment; minimum 4-inch band.
lambda-cyhalothrin (Karate Z [2.08EC]) (Warrior II [2.08EC])	0.02-0.03 lb	1.28-1.92 oz	21	**RESTRICTED USE.** Apply as required by scouting. Apply by ground or air using sufficient water for full coverage. **Aerial application**: use ≥2 gal water/A.
zeta-cypermethrin (Mustang Max)	0.017-0.025 lb	2.72-4.0 oz	30 grain and stover, 60 forage	**RESTRICTED USE.** Use minimum 10 gal water/A.

Brown Stink Bug

No-till fields are at higher risk for seedling injury. Brown stink bugs migrate from wheat fields just prior to, or following, harvest. Stink bug feeding on larger plants can cause developing ears to deform or abort. There are no established thresholds for stink bugs in corn. Virginia Tech recommends a threshold of one stink bug per four plants when the ear is forming and one stink bug per two plants from pollen shed to blister stage. Treatment past the blister stage is not recommended. Stink bugs will congregate near edges, but infestations of an entire field are possible. Walk at least 15 rows into the field to scout for bugs. Bugs will hide in leaf collars and in the whorl. Apply insecticides to stages just prior to tasseling. Results from aerial applications are variable - sprays can be effective or offer very poor control. Communicate with your applicator that you intend to target stink bugs prior to making an application. There is little to no residual with stink bug sprays and bugs can easily reinvade fields following sprays.

Table 4.26 - Recommended Postemergence Insecticides to Control Stink Bugs

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL 1.0 EC)	0.022 lb	2.8 oz	21	
bifenthrin (Brigade 2 EC, others)	0.10 lb	6.4 oz	30	
bifenthrin + zeta-cypermethrin (Hero 1.24 EC)	0.1 lb	10.3 oz	60 forage 30 grain and stover	
bifenthrin + zeta-cypermethrin (Steed 1.5 EC)	0.055 lb	4.7 oz	60 forage 30 grain and stover	
cyfluthrin (Tombstone 1.0 EC)	0.044 lb	2.8 oz	21	
lamda-cyhalothrin (Karate Z, Warrior II 2.08CS)	0.03 lb	1.92 oz	21	
zeta-cypermethrin (Mustang Maxx 0.8 EC)	0.025 lb	4.0 oz	30	

Brown marmorated stink bug

Brown marmorated stink bugs (BMSB) feed through the husk of corn ears with their piercing mouthparts, causing shriveled kernels. BMSB may rapidly re-infest a treated area. If another application is needed prior to the minimum application interval (see product labels), use a different insecticide.

Table 4.27 - Recommended Postemergence Insecticides to Control Brown Marmorated Stink Bug

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
Azadiractin + Pyrethrins (Azera)	0.05 lb	16 – 56 oz		12 hour re-entry interval.
Bifenthrin (Bifenture EC)	0.1 lb	6.4 oz	30	**RESTRICTED USE.** 12 hour re-entry interval. Toxic to fish and aquatic organisms. .
Chlorpyrifos (Vulcan)	0.94 lb	0.5 – 2.0 pt	21	**RESTRICTED USE.** 24 hour re-entry interval.

Table 4.27 - Recommended Postemergence Insecticides to Control Brown Marmorated Stink Bug (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
Chlorpyrifos + gamma-cypermethrin (Cobalt)		19 – 38 oz	21	**RESTRICTED USE.** 24 hour re-entry interval.
Chlorpyrifos + lambda-cypermethrin (Cobalt Advanced)		16– 38 oz	21	**RESTRICTED USE.** 24 hour re-entry interval.
Methomyl (Lannate SP) (Lannate LV)	 0.45 lb 0.45 lb	 0.5 lb 1.5 pt	3 forage 21 grain and stover	**RESTRICTED USE.** 48 hour re-entry interval. Do not apply more than 2.5 lb Lannate SP or more than 7.5 pt Lannate LV/acre/crop.

Small Grains

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True Armyworm

Sampling

Armyworms are easier to control when they are small. Check fields once each week starting the 2nd week of May. It may be necessary to begin scouting earlier following a warm winter and/or early spring. Examine first the debris and undergrowth on the ground surface along field margins and lodged areas. Small worms usually are found curled in a C-shape around the bases of the plants or under the debris and winter annual weeds. Armyworm frass or droppings also may be found on the soil surface. If small armyworms are present in these areas, obtain 10 to 20 worm counts at 50-pace intervals throughout the field. Note the average size of the worms, and whether any defoliation of the flag leaf and/or head clipping has occurred.

Decision Making

Parasites, diseases, insect predators, and birds usually keep armyworms under control in small grains. Effectiveness of these natural control agents is reduced during cool, wet springs and during growing seasons that follow years of drought.

As a general rule, barley should be treated if the number of armyworms exceeds one per linear foot between rows and most of the worms are greater than 0.75-inch long. In wheat, armyworms tend to nibble on the tips of kernels rather than clip heads; thus, populations of two to three worms per linear foot between rows are required to justify control. In high management wheat fields with 4-inch rows, treatment is recommended when armyworm levels exceed 3 to 5 per square foot of surface area, or per linear foot of row.

Note that wheat fields with mixed infestations of armyworms and sawfly caterpillars may need treatment even if worm counts of each pest do not exceed threshold levels. Also, if the grain crop is close to harvest or the majority of armyworms are longer than 1.5 inches and no head clipping has occurred, control may not be needed.

Table 4.28 - Recommended Insecticides for Armyworm Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.014-0.019 lb	1.8-2.4 oz	30	Do not graze or forage within 7 days.
chlorantraniliprole (Prevathon)	0.047-0.067 lb	14.0-20.0 oz	1	
chlorantraniliprole + lambda-cyhalothrin (Besiege)	0.05-0.078 lb	6.0-8.0 oz	30	**RESTRICTED USE.**
lambda-cyhalothrin				**RESTRICTED USE.**
(Kaiso 24WG)	0.015-0.25 lb	1.0-1.67 oz	30	Do not apply more than 7.68 oz per acre per season.
(Karate Z)	0.02-0.03 lb	1.28-1.92 oz	30	
(Warrior T)	0.02-0.03 lb	2.56-3.84 oz	30	Wheat, wheat hay, and triticale only (Kaiso).
methomyl				**RESTRICTED USE.**
(Lannate LV)	0.225-0.45 lb	0.75-1.5 pt	7	Do not graze or feed treated forage or hay to livestock within 10 days of last treatment.
(Lannate SP)	0.225-0.45 lb	0.25-0.5 lb	7	
spinetoram (Radiant SC)	0.023-0.047 lb	3.0-6.0 oz	21	Do not apply within 21 days of grain or straw harvest or within 3 days of forage, fodder, or hay harvest.

Table 4.28 - Recommended Insecticides for Armyworm Control (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
spinosad (Blackhawk)	0.025-0.068 lb	1.1-3.0 oz	21	Barley, buckwheat, oats, rye, triticale, wheat. Do not apply within 21 days of grain or straw harvest or within 3 days of forage, fodder, or hay harvest.
zeta-cypermethrin (Mustang Max)	0.011-0.025 lb	1.76-4.0 oz	14	**RESTRICTED USE.** Wheat and triticale only.

Aphids

Grain Aphids at Tillering during Fall and Early Spring

Sampling

Grain aphids usually are held in check by their natural enemies, which include predators, parasites, and fungal diseases. When looking for aphids, it is important to recognize these natural enemies. Check grain fields each week starting in the fall or early spring if damage symptoms are evident. Infestations of aphids, particularly the greenbug and corn leaf aphid, occasionally build up in the fall. Symptoms are often first noticed as circular, yellow to brown spots with dead plants in the center. These spots may increase in size if the infestation is allowed to persist. To determine aphid activity on tillering grain, examine 20 sites throughout the field. Each site should consist of at least 5 linear feet of a row. Look at areas in the field that are showing plant stress symptoms. Aphid damage may be confused with moisture stress and/or nitrogen deficiency. Count the number of aphids on small plants and, if aphids are numerous, estimate the numbers per linear foot of a row of larger plants. Make a tally of the proportion of each species, particularly if greenbugs are present.

Decision Making

Treatment during the fall and early spring is not often necessary, but may be needed if infestations are threatening and the weather is unusually mild. Treatment is suggested if aphid counts exceed 150 per linear foot of row throughout the majority of the field and a low degree of beneficial insect activity is present. The greenbug can be the most destructive because of the toxic substances it secretes during feeding, so maintain close surveillance of fields if this aphid is the predominate species. One exception to the treatment threshold applies to wheat under intensive-management practices grown in Virginia, where the transmission of virus diseases by aphids is more prevalent. Treatment of intensive management wheat in Virginia is suggested based on the following threshold table:

Table 4.29 - Aphid Numbers

Time of year	Suggested number needed to treat
Fall	
Plant until spring growth begins	15-25/row-foot and yellowing areas scattered throughout the field.
Spring	
After spring growth resumes until hard-dough stage	100/row-foot, plants 3-6 inches tall 200/row-foot, plants 7-10 inches tall 300/row-foot, plants 11+ inches tall
Heading	20-25/grain head

Grain Aphids During the Grain Head Stage

Sampling

To determine aphid activity after the grain heads form, count the number of aphids on 100 heads throughout the field. Do not bias sampling by checking a few heads along the field margins where infestations usually are higher. Check for natural enemies at the same time that aphids are being counted. Aphids usually are clustered as colonies among bracts of the grain head and may move slightly when disturbed. Anything that actively moves when disturbed is probably a predator. Make a note of the ratio of predators to aphids.

Decision Making

The need for treatment depends primarily on the number of aphids, plant maturity, and the presence of natural enemies. Treatment during the grain head stage is generally considered when aphid numbers exceed more than 25 per head, especially if the crop is late, when cool weather is forecast and the natural enemy complex is lacking. Control is not advised if the crop is approaching the hard dough stage where there is good predator/parasite activity. Ratios of one or more predators to every 50 to 100 aphids are sufficient to achieve biological control.

Table 4.30 - Recommended Insecticides for Aphid Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
Seed Treatments				
imidacloprid (Gaucho XT) (Gaucho 480 FS) (Gaucho 600 FS)	 0.43 oz – –	 3.4 oz/cwt 1-3 oz/cwt 0.8-2.4 oz/cwt	 N/A N/A N/A	For wheat and barley. Do not graze or feed livestock on treated areas for 45 days after planting.
thiamethoxam (Cruiser 5FS)	 –	 0.75-1.33 oz/cwt	 N/A	For wheat and barley. 120-day plantback restriction on certain non-labeled crops.
Foliar Treatments				
beta-cyfluthrin (Baythroid XL)	 0.014-0.019	 1.8-2.4 oz	 30	Do not graze or forage within 7 days.
dimethoate (Dimethoate 4EC) (Dimethoate 2.67EC)	 0.25-0.38 lb 0.25-0.33 lb	 0.5-0.75 pt 0.75-1.0 pt	 35 35	May not give acceptable control below 60°F. Do not apply within 14 days of grazing. Labeled for use on wheat only. Do not make more than 2 applications/season.
lambda-cyhalothrin (Karate Z) (Warrior T)	 0.02-0.03 lb 0.02-0.03 lb	 1.28-1.92 oz 2.56-3.84 oz	 30 30	**RESTRICTED USE.** Do not apply more than 7.68 oz per acre per season.
lambda-cyhalothrin + thiamethoxam (Endigo ZC)	 0.023+0.03 lb - 0.031+0.04 lb	 3.5-4.5 oz	 30	**RESTRICTED USE.** Barley only. Do not allow livestock to graze in treated areas or harvest treated forage as feed for meat or dairy animals within 30 days after treatment.
zeta-cypermethrin (Mustang Max)	 0.02-0.025 lb	 3.2-4.0 oz	 14	**RESTRICTED USE.** Wheat and triticale only. Aids in control.

Cereal Leaf Beetle

Sampling

In many areas of the mid-Atlantic states, cereal leaf beetle eggs are heavily parasitized; thus, the larval stage is the best indicator of the potential yield loss. Cereal leaf beetle development is temperature dependent. Once a week, make field inspections of wheat starting in early May and of spring oats starting by mid-May. It may be necessary to begin scouting earlier following a warm winter and/or early spring. Scouting reports from 2017 and 2018 indicated that sampling is necessary beginning in mid-April. Examine the flag leaf of wheat or the entire tiller of oats on 5 plants at each of 10 locations in the field. Count the number of larvae per flag leaf or tiller and note any defoliation.

Decision Making

A number of introduced parasites have been instrumental in keeping cereal leaf beetle populations below economic damage levels. Also, favorable planting dates may help suppress populations. Wheat planted early in the fall immediately after the Hessian fly-free date will be more advanced in growth the next spring than late-planted small grains. These early plantings will be less attractive to and more tolerant of the beetles when they peak in the spring. Cereal leaf beetle infestations on spring-planted oats cannot be avoided by means of planting date. Generally, barley is more advanced in maturity and thus less attractive when beetles are active.

Adults move into small grain in late February and early March and deposit eggs which hatch into larvae. Larvae feed on grain stripping leaves of valuable photosynthetic tissue. Research indicated that damage to both flag and stem leaves reduces yield. Best control is achieved if treatments are applied when larvae are small. Treatment should be considered if 25, total, eggs and small larvae are found on 100 stems. Of that 25, at least 1/2 should be larvae. Once wheat reaches the hard dough stage, beetle damage has little effect on yield and controls are not needed.

Table 4.31 - Recommended Insecticides for Cereal Leaf Beetle Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin (Baythroid XL)	0.008-0.014 lb	1.0-1.8 oz	30	Do not graze or forage within 7 days.
carbaryl				Apply to wheat only. No time limits on use as pasture or forage.
(Sevin XLR PLUS)	1.0 lb	2.0 pt	21	
(Sevin 80S)	1.25 lb	1.0 lb	21	
(Sevin 4F)	1.0 lb	2.0 pt	21	
lambda-cyhalothrin + thiamethoxam (Endigo ZC)	0.023+0.03 lb - 0.031+0.04 lb	3.5-4.5 oz	30	**RESTRICTED USE.** Barley only. Do not allow livestock to graze in treated areas or harvest treated forage as feed for meat or dairy animals within 30 days after treatment.
lambda-cyhalothrin				**RESTRICTED USE.**
(Karate Z)	0.02-0.03 lb	1.28-1.92 oz	30	Do not apply more than 7.68 oz per acre per season.
(Warrior T)	0.02-0.03 lb	2.56-3.84 oz	30	
methomyl				**RESTRICTED USE.**
(Lannate LV)	0.225-0.45 lb	0.75-1.5 pt	7	Do not graze or feed treated forage or hay to livestock within 10 days of last treatment.
(Lannate SP)	0.225-0.45 lb	0.25-0.5 lb	7	
spinetoram (Radiant SC)	0.016-0.047 lb	2.0-6.0 oz	21	Do not apply within 21 days of grain or straw harvest or within 3 days of forage, fodder, or hay harvest.
zeta-cypermethrin (Mustang Max)	0.011-0.025 lb	1.76-4.0 oz	14	**RESTRICTED USE.** Wheat and triticale only.

Hessian Fly

The Hessian fly is not a major pest in the mid-Atlantic states because small grains normally are planted after the adult flies occur ("fly-safe" date). There are no insecticidal control measures that can be applied once the field becomes infested. Control is based entirely upon prevention. The important components of preventative fly management include: planting wheat only after the fly-safe planting date; destroying volunteer wheat plants by tillage methods; and planting resistant varieties, especially when planting very early. Check the following tables for the fly-safe dates in your area and contact your local Extension agent for information on resistant varieties. In Virginia, it is generally thought that the fly-safe date is around Oct. 20. However, flies can infest fields planted after that date by moving from volunteer grain plants in or from nearby fields.

Table 4.32 - Safe Planting Dates

Maryland counties					
Anne Arundel	Oct. 7	Dorchester	Oct. 9	Queen Anne's	Oct. 7
Allegany	Sept. 27	Frederick	Oct. 2	St. Mary's	Oct. 9
Baltimore	Oct. 2	Garrett	Sept. 20	Somerset	Oct. 10
Calvert	Oct. 8	Harford	Oct. 1	Talbot	Oct. 8
Caroline	Oct. 7	Howard	Oct. 2	Washington	Oct. 1
Carroll	Sept. 28	Kent	Oct. 6	Wicomico	Oct. 10
Cecil	Oct. 3	Montgomery	Oct. 4	Worcester	Oct. 11
Charles	Oct. 8	Prince George's	Oct. 7		
Delaware counties					
New Castle	Oct. 3	Kent	Oct. 8	Sussex	Oct. 10

Brown Stink Bug

Large populations of brown stink bug may develop in small grains during May and June. There is no evidence that their feeding is capable of reducing yields. Migration into surrounding corn may be problematic following harvest. Sprays targeting stink bug in small grains to prevent movement into corn are ineffective and, thus, not recommended.

Sorghum

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Seedling Pests

Insect pests, if not managed properly, can cause significant losses to grain sorghum grown in the mid-Atlantic. Sorghum should not be considered a low input crop in terms of insect control and regular scouting, especially of late-planted fields, is strongly recommended. In addition to spraying for sugarcane aphid, budget one insecticide application for headworms.

It is difficult to predict and sample for soil insects, and remedial treatments are not possible. Wireworms, billbugs and sugarcane beetles have the potential to infest Virginia sorghum. There are several factors that may predispose your crop to infestation including reduced tillage, organic soils, lack of rotation from corn/sorghum, presence of nutsedge or other grassy weeds, and planting in late April-early May. Practices that may help to prevent infestations include a high-vigor crop, tillage, rotation and weed management.

Note: Seed treatments are generally not recommended for Virginia Sorghum due to the lack of early-season pests and short window of product activity. There is evidence that seed treatments can delay infestations by sugarcane aphid on susceptible varieties. Seed treatments offer less benefit to aphid resistant varieties. Consider using a seed treatment if you are planting late or plant a susceptible variety.

Table 4.33 - Insecticide Seed Treatments for Sorghum

Insecticide	Active ingredient	Application rate	Target Species
Poncho Votivo	clothianidin + Bacillus firmus	6.13 fl oz/100 lb seed (0.08 mg ai/seed) based on 13,500 seed/pound	aphid (including yellow sugarcane aphid and corn leaf aphid),wireworm
NipsIT INSIDE	clothianidin	5.1 to 6.4 fl oz/100 lb seed	aphid (including yellow sugarcane aphid and corn leaf aphid),wireworm
Cruiser 5FS	thiamethoxam	5.1 to 7.6 fl oz per 100 pounds of seed (0.062-0.093 mg ai/seed) based on 14,500 seed/pound	aphid (including yellow sugarcane aphid and corn leaf aphid),wireworm

Aphids

A mixture of aphids may be found in Virginia sorghum including white sugarcane aphid (Melanaphis sacchari), a species that was first detected in Virginia in 2015. Infestations can stunt or kill sorghum plants that are in the pre-head stage, and after heading the honeydew can interfere with mechanical harvest by plugging up combines. Resistant varieties may provide some protection against this pest. A list of available varieties can be found here - http://www.sorghumcheckoff.com/news-and-media/newsroom/2017/02/27/2017-sugarcane-aphid-tolerant-hybrids/.

Yellow sugarcane aphid (Sipha flava) and corn leaf aphid (Rhopalosiphum maidis) can infest sorghum alone or in combination with white sugarcane aphid. These aphids are rarely worth concern–they provide food for beneficial natural enemies!

Sampling/Decision Making

All sorghum grown in Virginia is at high risk for sugarcane aphid. Sugarcane aphid typically infests in July and August. It is important to scout sorghum at least weekly for this pest. Scout at least twice a week once this species is found since treatment should be applied quickly once threshold is reached. Start with field edges, especially checking the underside of lower leaves. Initially, scout for aphids at field borders. Aphids will infest borders first. Aphids are seldom evenly distributed across a field, so examine plants from all parts of the field. Leaves that are shiny with honeydew indicate that aphids are present on that plant. Aphids are found on the underside of leaves. A general threshold is 25% of plants infested. Thresholds by growth stage are

provided in Table 1 based on North Carolina Cooperative Extension recommendations. When white sugarcane and other aphid species are present, control decisions should be based on white sugarcane aphid numbers and product recommendations (i.e., Sivanto and Transform). Good coverage is essential, a minimum spray volume of 10 g/A is recommended and repeat applications (if needed) should rotate chemistries. As of 2018, insecticides labeled for sugarcane aphid in grain sorghum are not labeled for sweet sorghum varieties in Virginia.

Note: Pyrethroids are not effective against white sugarcane aphid and are harmful to natural enemy populations, thus should be avoided for this species.

Table 4.34 - Economic Thresholds for Treatment of Sugarcane Aphid in Sorghum.

Growth stage	Threshold
Pre-boot and Boot	20% infested plants with localized area of honeydew and established aphid colonies
Flowering milk, Soft dough, and Dough	30% infested plants with localized area of honeydew and established aphid colonies
Black layer	Heavy honeydew and established aphid colonies in head (treat to avoid problems at harvest). **Note:** Check product label for pre-harvest interval.

Thresholds in this table are from Sugarcane Aphid Now Present in NC-2016 https://entomology.ces.ncsu.edu/2016/07/sugarcane-aphid-now-present-in-nc-2016/ by Dr. Dominic Reisig, Associate Professor and Extension Specialist, NCSU.

Table 4.35 - Insecticides Recommended for the Control of White Sugarcane Aphid in Sorghum.

Insecticide	Active ingredient	Application rate (oz/A)	Max annual application rate (oz/A/year)	Pre-harvest interval (days)
Sivanto Prime[1]	flupyradifurone	4-7	28	7 (forage) and 21 (grain)
Transform WG[2]	Sulfoxaflor	0.75-1.5	3.0	7 (forage) and 14 (grain)

[1]Section 2(ee) use recommendation
[2]Section 18 emergency exemption

For more information on the sugarcane aphid, please contact your local extension agent. Contact information can be found at http://www.ext.vt.edu/offices/index.html.

Headworms (corn earworm, fall armyworm, and sorghum webworm)

Sampling/Decision Making

Control of caterpillar pests in pre-headed sorghum is rarely necessary, even with 40-60% leaf injury. Treat only when 75-100% of plants are infested. Headworms (e.g., armyworm, corn earworm, sorghum webworm) routinely infest grain heads. Begin to sample for worms soon after flowering by beating heads of 10 consecutive plants into a 5-gallon bucket or net. Check multiple locations in a field. Recommended thresholds are two corn earworm or fall armyworm per head or five sorghum webworm. Open headed sorghum accumulates less damage than closed-headed types. Coverage can be an issue when spraying sorghum. Pyrethroids offer poor to moderate control of corn earworm and fall armyworm in Virginia. If you decide to spray a pyrethroid, use the highest labeled rate and do not expect good control of heavy infestations or large worms.

Sorghum Midge

Damaging infestations of sorghum midge are rare. However, Virginia is in the known range of this pest and heavy infestations of this pest can be damaging to sorghum in the bloom period. Adult midges are flies that are orange or reddish in color and 1.3-1.6 mm in length. Larvae are spindle-shaped and range in color from colorless (small larvae) to pink to red-orange (full-grown).

Sampling/Decision Making

Adult midges do not damage sorghum, but midge larvae feed on and destroy developing seeds. To determine the presence of sorghum midge, fields should be inspected during midmorning until shortly after noon when midges are most active. During the sorghum bloom period, inspect fields daily or every other day to detect sorghum midges. Scout for midges by clapping the head between your hands and inspecting palms for dead flies (i.e., orange spots). Thresholds are one fly per head. Midge resistant sorghum hybrids are available commercially and, within limits, provide an additional management tool. At similar infestation levels of ovipositing midge females, resistant hybrids generally suffer one-third the damage that susceptible sorghum hybrids suffer. The antibiosis resistance increases the economic threshold level to five adults per head during flowering compared with one midge per head for susceptible hybrids.

Stink Bugs

Several species of stink bug may infest Virginia sorghum including green, brown and potentially the invasive brown marmorated. Stink bugs usually move into sorghum soon after flowering. Stink bugs have sucking mouthparts and feed on developing seed within the panicle. Their feeding will shrivel seed thereby reducing seed size and quality. They also may feed on stems and other plant parts but the main damage is from kernel (seed) feeding. Sorghum is most susceptible during the milk and soft dough stage. Injury normally is not damaging from hard dough to maturity.

Sampling/Decision Making

Sample for stink bugs along with headworms (method described above). Treat if combined numbers of all stink bugs (large nymphs and adults) exceeds 2-4 bugs per head during milk stage or 4-8 bugs per head during soft dough stage.

Note: Some insecticides recommended for stink bug control may control headworms. In general, pyrethroids will offer poor to moderate control of headworms. Not all insecticides recommended for headworms such as spinosad (Tracer™) are not effective against stink bug.

Table 4.36 - Foliar Insecticides for Sorghum

Insecticide	Active ingredient	Application rate	Pre-harvest interval	Target species
Baythroid XL 1EC	Beta-cyfluthrin	1.0-1.3 fl oz/A 0.008—0.01 lb ai/A	14	Sorghum midge
		1.3-2.8 fl oz/A 0.010-0.022 lb ai/A		Headworms (armyworm 1st and 2nd instar only), stink bugs
Asana XL	Esfenvalerate	2.9-5.8 fl oz/A 0.015-0.03 lb ai/A	21	Sorghum midge
		5.8-9.6 fl oz/A 0.03-0.05 lb ai/A **Note:** Do not apply >0.15 lb ai/A/season.		Corn earworm
Tombstone	Cyfluthrin	1.0-1.3 fl oz/A 0.016-0.020 lb ai/A	14	Sorghum midge
		1.3-2.8 fl oz/A 0.020-0.044 lb ai/A **Note:** Do not apply >0.044 lb ai/10 day interval. Do not apply >0.131 lb ai/A/season.		Headworms (armyworm 1st and 2nd instar only), stink bugs
Karate 2.08EC, Warrior II 2.08EC	Lambda-cyhalothrin	1.28-1.92 fl oz/A	30	Headworms (armyworm 1st and 2nd instar only), stink bugs

Table 4.36 - Foliar Insecticides for Sorghum (cont.)

Insecticide	Active ingredient	Application rate	Pre-harvest interval	Target species
Mustang Max	Zeta-cypermethrin	1.76-4.0 fl oz/A	14 grain and fodder, 21 forage and silage	Headworms, stink bugs
Beseige	Lambda-cyhalothrin + chlorantraniliprole	6.0 – 10.0 fl oz/A	30	Headworms, stink bugs
		5.0-6.0 fl oz/A		Sorghum midge
Prevathon	Chlorantraniliprole	14-20 fl oz/A	1	Headworms
Tracer, Blackhawk	Spinosad	Tracer: 1.5-3 fl oz/A	7 grain, 14 forage	Headworms
		Blackhawk: 1.7-3.3 oz/A	21 grain, 3 forage	
Sevin XLR Plus, Sevin 4F, Sevin 80s	Carbaryl	2.0-4.0 pt/A 1.25-2.5 lb/A (80s) **Note:** Direct spray into forming heads.	21 grain, 14 grazing or silage	Headworms
Lannate LV, Lannate 90SP, Nudrin	Methomyl	0.75-1.5 pt/A (LV) 0.25-0.5 lb/A (SP) **Note:** 48 hour restricted entry interval.	14	Headworms
Lorsban, Eraser, Stallion	Chlorpyrifos	2 pt/A	30 (rate 1 pt/A), 60 (rate >1 pt/A)	Armyworm, corn earworm
		1 pt/A		Webworm
		0.5 pt/A		Sorghum midge
		0.5-1 pt/A		

Soybeans

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Essentials of a Good Soybean Insect Pest Management Program

Know Soybean Insect Pests

It is very important that you know how to identify common soybean insect pests, and when they are most likely to occur. Different pest species have different economic thresholds and can require different insecticides for effective control. Various Virginia Cooperative Extension publications are available that can be useful in identifying insect pests. Also, consult your local Extension agent.

Know Pest Economic Thresholds

An economic threshold is the number of a particular insect pest that must be controlled to prevent economic loss to the crop. Thresholds have been established through many scientific studies. Thresholds provide a starting place when making control decisions. Consider health of crop, development stage, profit potential, and insecticide costs before applying insecticides. A treatment before a pest has reached its economic threshold usually will not pay and may cause an increase in other pests, requiring a second insecticide treatment.

Know What Crop Growth Stages Are Most Susceptible to Insect Attack

Leaf feeding insects can attack soybeans at almost any time during the season. Full-season and double-crop planting systems react differently to this leaf damage. Yield is highly related to total leaf area, as measured by LAI (leaf area index). To achieve maximum yield potential, soybeans must develop an LAI of 3.5 to 4.0 or above. An easy way to visualize LAI is to think of a field with an LAI of 4 having 4 acres of leaf area for every acre of ground. Any leaf canopy above that can be removed (i.e., by insect leaf feeders) without reducing the yield potential. Most full-season plantings achieve larger leaf canopies and LAIs, regardless of the climatic conditions (temperature, cloud cover, or rainfall) and are tolerant of leaf feeding. Double-crop plantings do not always achieve as large a leaf canopy and can be more sensitive to defoliation. Leaf percent defoliation thresholds (30% prior to bloom, 15% from flowering to pod fill, 35% after pod fill) should only be applied to full-season plantings, or double-crop plantings with large canopies. Be more conservative with double-crop plantings without large canopies due to very late planting, dry conditions, poor soil, or other factors. With these plantings, use the following thresholds: 20% prior to bloom, 10% from flowering to pod fill, 15% after pod fill.

Know What Conditions Predispose Soybeans to Insect Injury

Corn earworm damage is typically most severe in fields with open leaf canopies, ones having flowers or young pods, or fields under some degree of drought or nematode stress. Double crop soybeans or soybeans planted in fields affected by drought or nematodes should be watched more closely. In dry seasons, all fields should be watched more closely.

Stay Informed of Current Pest Status

A corn earworm advisory is issued weekly to Virginia Cooperative Extension agents from August through September. These advisories summarize current moth activity as monitored by a system of blacklight and pheromone traps. Earworm infestations, if they occur, will most likely follow peak moth activity periods by 8 to 10 days. Stay informed about the moth situation in your area and intensify your scouting efforts during critical periods.

Scout Field Regularly

Scouting (described below) is an essential part of successful economic management of insect pests. You must know what kind and how many insects are in your fields before making treatment decisions. **Do not apply insecticides unless you have confirmed that a real problem exists in your fields.**

Mexican Bean Beetle, Green Cloverworm, Bean Leaf Beetle

Sampling

Check for overwintered Mexican bean beetles as soon as the plants emerge, and first examine the field margins next to overwintering areas. Feeding injury usually is not evenly distributed during the early season. Count the number of beetles over a 3-foot section of row in at least five locations in the infested area. Estimate the level of stand reduction if seedlings are killed, or estimate the percentage of defoliation on older plants. Bean leaf beetles also may cause damage to young soybean plants. These insects prefer tender plant tissue and leave rounded holes on leaves. This type of leaf injury is distinguishable from the lacelike injury caused by Mexican bean beetles.

Mexican bean beetle and green cloverworm infestations usually do not reach economic levels before August. Early-planted, full-season soybeans usually attract more colonizing beetles than do later fields. However, double-crop fields may become infested with adults that are moving out of maturing fields late in the season in search of more succulent foliage. Start scouting for both insect pests at least weekly during late July through September. Examine the entire field because larval populations may be localized. Check the undersides of leaves on plants and keep a tally of the number of egg masses, young larvae, older larvae, pupae, and adults. When possible, use a drop cloth to determine numbers in fields with wide rows. Estimate defoliation to the nearest 10 percent on 20 to 30 plants selected throughout the field. Each plant should be pulled up to examine the total leaf area; not just the upper canopy leaves.

When sampling, remember to check for diseased or parasitized larvae because the natural enemies play an important role in controlling these pests. Clover worms are killed by a fungal disease which causes larvae to become hard, mummified, and covered with powdery white to light green spores. The presence of diseased worms usually signals the decline of the pest population.

Decision Making

Spray only when Mexican bean beetles and/or leaf-feeding caterpillars are actively feeding. At seedling, spray when defoliation reaches 40 percent with 2 to 3 beetles per plant throughout the field. At prebloom, spray when defoliation exceeds 30 percent, with 20 or more adults and/or larvae per 3-foot row. At bloom and podset, spray when defoliation exceeds 15 percent, with 16 or more adults and/or larvae per 3-foot of row. Consider the relative size and age composition of the population. If eggs and pupae of the Mexican bean beetle are the predominant stages it is advisable to wait until egg hatch or adult emergence before treating. Also consider the presence of natural controls, such as cloverworms infected with fungal disease or parasitized Mexican bean beetle larvae (mummies).

Table 4.37 - Recommended Insecticides for Mexican Bean Beetle, Green Cloverworm, and Bean Leaf Beetle Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
acephate (Orthene 97)	0.73-0.97 lb	0.75-1.0 lb	14	
beta-cyfluthrin (Baythroid XL) (Mexican bean and bean leaf beetle)	0.0125-0.022 lb	1.6-2.8 oz	45	**RESTRICTED USE.** Green forage may be fed 15 days after last application.
(green cloverworm)	0.0065-0.0125 lb	0.8-1.6 oz		
beta-cyfluthrin + imidacloprid (Leverage 360)	0.02-0.04 lb	2.8 oz	45	**RESTRICTED USE.**
bifenthrin (Brigade 2EC)	0.033-0.1 lb	2.1-6.4 oz	18	**RESTRICTED USE.**
chlorantraniliprole (Prevathon)	0.047-0.066 lb	14.0-20.0 oz	21	

Table 4.37 - Recommended Insecticides for Mexican Bean Beetle, Green Cloverworm, and Bean Leaf Beetle Control (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
chlorpyrifos (Lorsban 4E) (bean leaf beetle) (green cloverworm) (Mexican bean beetle)	 0.5-1.0 lb 0.25-0.5 lb 0.5-0.75 lb	 1.0-2.0 pt 0.5-1.0 pt 1.0-1.5 pt	28	Do not feed or graze livestock on treated plants.
chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced) (green cloverworm) (Mexican bean beetle and bean leaf beetle)	 0.12 + 0.006 – 0.25 + 0.013 lb 0.31 + 0.016 – 0.74 + 0.038 lb	 6.0-13.0 oz 16.0-38.0 oz	30	**RESTRICTED USE.**
esfenvalerate (Asana XL) (bean leaf beetle)	 0.015-0.03 lb 0.03-0.05 lb	 2.9-5.8 oz 5.8-9.6 oz	21	**RESTRICTED USE.** Do not feed or graze livestock on treated plants. Do not exceed 0.2 lb ai per acre per season. Extremely toxic to fish.
indoxacarb (Steward EC) (green cloverworm)	 0.045-0.11 lb	 4.6-11.3 oz	21	
lambda-cyhalothrin + chlorantraniliprole (Besiege)	 0.016 +0.033lb-0.026 + 0.052 lb	 5.0-8.0 oz	30	**RESTRICTED USE**
lambda-cyhalothrin (Karate Z)	 0.015-0.025 lb	 0.96-1.6 oz	45	**RESTRICTED USE**. Do not apply more than 7.68 oz per acre per season. Do not graze or harvest treated soybean forage, straw or hay for livestock feed.
methomyl (Lannate LV) (green cloverworm and Mexican bean beetle) (Lannate SP) (green cloverworm and Mexican bean beetle) (Lannate LV) (bean leaf beetle) (Lannate SP) (bean leaf beetle)	 0.12-0.225 lb 0.11-0.225 lb 0.225-0.3 lb 0.225-0.34 lb	 0.4-0.75 pt 0.125-0.25 lb 0.75-1.0 pt 0.25-0.375 lb	 14 14 14 14	**RESTRICTED USE.** Wait 3 days to feed or graze as forage or 7 days for hay. Up to 2 applications may be used.
methoxyfenozide (Intrepid 2F) (green cloverworm)	 0.06-0.12 lb	 4.0-8.0 oz	7 (hay/forage) 14 (seed)	
spinetoram (Radiant SC)	 0.15-0.31 lb	 2.0-4.0 oz	28	

Table 4.37 - Recommended Insecticides for Mexican Bean Beetle, Green Cloverworm, and Bean Leaf Beetle Control (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
spinosyn (Blackhawk) (green cloverworm)	0.025-0.05 lb	1.1-2.2 lb	28	Do not feed treated forage or hay to meat or dairy animals.
thiamethoxam + lambda-cyhalothrin (Endigo ZC) (bean leaf beetle)	0.064-0.072 lb	4.0-4.5 oz	30	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw, or hay for livestock feed.
zeta-cypermethrin (Mustang Max)	0.0175-0.025 lb	2.8-4.0 oz	21	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw, or hay for livestock feed.

Thrips

Sampling/Decision Making

Thrips rarely require treatment; however, early season injury to drought-stressed plants may occasionally reduce yields. Both nymphs and adults feed on the undersides of the leaves, causing small, silvery streaks and whitish or yellowish discoloration. Treatment may be required when injury appears on drought-stressed plants and more than eight thrips per leaflet are found. Treatment is not recommended in non-stressed fields because soybeans can tolerate thrips injury.

Table 4.38 - Recommended Insecticides for Thrips Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
acephate (Orthene 97)	0.24-0.49 lb	0.25-0.5 lb	14	
beta-cyfluthrin (Baythroid XL)	0.0065-0.0125 lb	0.8-1.6 oz	45	**RESTRICTED USE.** Green forage may be fed 15 days after last application.
bifenthrin (Brigade 2EC)	0.033-0.1 lb	2.1-6.4 oz	18	**RESTRICTED USE.**
chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)	0.31 + 0.016 – 0.74 + 0.038 lb	16.0-38.0 oz	30	**RESTRICTED USE.**
clothianidin + ipconazole + metalaxyl (Inovate - Nipsit Inside + Rancona Xxtra)	—	4.78 oz/cwt		Seed treatment. Do not graze or feed soybean forage and hay to livestock.
imidacloprid (Gaucho 600)	1.0 oz/cwt	1.6 oz/cwt	N/A	Seed treatment.

Table 4.38 - Recommended Insecticides for Thrips Control (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
methomyl (Lannate LV) (Lannate SP)	 0.225-0.3 lb 0.225-0.34 lb	 0.75-1.0 pt 0.25-0.375 lb	 14 14	**RESTRICTED USE.** Wait 3 days to feed or graze as forage or 7 days for hay. Up to two applications may be used per season.
thiamethoxam (Cruiser 5FS)	 0.8 oz/cwt	 1.28 oz/cwt	 N/A	Seed treatment.
zeta-cypermethrin (Mustang Max)	 0.02-0.025 lb	 3.2-4.0 oz	 21	**RESTRICTED USE.** Aids in control. Do not graze or harvest treated soybean forage, straw, or hay for livestock feed.

Potato Leafhopper

Sampling/Decision Making

Leafhoppers attack soybeans during late June through July but rarely reach population levels that affect yields. Using a standard 15-in sweep net, take five sweeps in each of five locations in the field. Count the number of leafhoppers and empty the net before proceeding to the next location. A single sweep consists of a swath of the net along the row in the top one-third of the plant in one direction only.

The symptoms of leafhopper injury include localized stippling, curling, and yellowing of leaf margins. Treatment is suggested when injury appears and infestations exceed four leafhoppers per sweep in stressed beans or eight leafhoppers per sweep in normal growing fields. Dense pubescent varieties are less susceptible.

Table 4.39 - Recommended Insecticides for Potato Leafhopper Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
acephate (Orthene 97)	 0.49-0.97 lb	 0.5-1.0 lb	 14	
beta-cyfluthrin (Baythroid XL)	 0.0065-0.0125 lb	 0.8-1.6 oz	 45	**RESTRICTED USE.** Green forage may be fed 15 days after last application.
bifenthrin (Brigade 2EC)	 0.033-0.1 lb	 2.1-6.4 oz	 18	**RESTRICTED USE.**
chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)	 0.31 + 0.016 – 0.74 + 0.038 lb	 16.0-38.0 oz	 30	**RESTRICTED USE.**
esfenvalerate (Asana XL)	 0.015-0.03 lb	 2.9-5.8 oz	 21	**RESTRICTED USE.** Do not feed or graze livestock on treated plants. Do not exceed 0.2 lb ai per acre per season. Extremely toxic to fish.
lambda-cyhalothrin + chlorantraniliprole (Besiege)	 0.016 + 0.033 lb – 0.026 + 0.052 lb	 5.0-8.0 oz	 30	**RESTRICTED USE.**

Table 4.39 - Recommended Insecticides for Potato Leafhopper Control (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
lambda-cyhalothrin (Karate Z)	0.015-0.025 lb	0.96-1.6 oz	45	**RESTRICTED USE**. Do not apply more than 7.68 oz per acre per season. Do not graze or harvest treated soybean forage, straw or hay for livestock feed.
thiamethozam + lambda-cyhalothrin (Endigo ZC)	0.056-0.064 lb	3.5-4.0 oz	30	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw or hay for livestock feed.
zeta-cypermethrin (Mustang Max)	0.0175-0.025 lb	2.8-4.0 oz	21	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw, or hay for livestock feed.

Spider Mites

Sampling/Decision Making

Mite outbreaks usually are associated with hot, dry weather, which accelerates reproduction and development. During periods of high humidity and field moisture, a fungal disease can reduce populations but high temperatures can nullify these effects. Outbreaks also are associated with the application of certain insecticides that kill natural enemies and/or seem to make the soybean plant more nutritionally suitable for mites.

Check weekly for mites, starting in early July through August, especially during a hot, dry season. Concentrate on the field borders and look for the early signs of white stippling at the bases of the leaves. Do not confuse mite damage with dry weather injury, mineral deficiencies, and herbicide injury. If feeding injury is evident, press the undersides of a few damaged leaves on white paper to reveal any crushed mites. Determine the extent of the infestation and assess the level of injury by examining 20 to 30 plants in the infested area. Field infestations often show defoliated or injured plants at some localized point, with injury becoming less evident and extending in a widening arc into the field.

If isolated spots of mite activity are confined to the perimeter of the field, spot-treatment using ground equipment is recommended to prevent further spread of mites into the field. If the infestation is distributed throughout the interior of the field, treatment of the entire field is suggested if live mites are numerous (20 to 30 per leaflet) and more than 50 percent of the plants show stippling, yellowing, or defoliation over more than one-third of the leaves. If rains come, mite development and survival will decrease but may not drop to economic levels if heavy populations are developing under high temperatures.

Table 4.40 - Recommended Insecticides for Spider Mite Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
bifenthrin (Brigade 2EC)	0.08-0.1 lb	5.12-6.4 oz	18	**RESTRICTED USE.**
chlorpyrifos (Lorsban 4E)	0.25-0.5 lb	0.5-1.0 pt	28	**RESTRICTED USE**. May need second spray 4 to 5 days after initial treatment to control newly hatched mites. Do not graze or feed forage within 14 days after application. Use of vegetable oil as an adjuvant may improve control during hot weather.
dimethoate (Dimethoate 2.67EC) (Dimethoate 4EC)	 0.5 lb 0.5 lb	 1.5 pt 1.0 pt	 21 21	Do not feed or graze within 5 days of the last application. Do not store above 90° F or below 32° F.

Table 4.40 - Recommended Insecticides for Spider Mite Control (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
etoxazole (Zeal SC)	0.045-0.135 lb	2.0-6.0 oz	*	*Do not apply after R5 stage. Do not graze or feed forage or hay to livestock after application.

Corn Earworm

Sampling

Outbreaks often follow a midsummer drought, which causes the corn to ripen earlier and become less attractive to the moths. Female moths prefer to lay eggs in open-canopied, late-blooming soybean fields. Drought conditions also delay soybean maturity and prevent normal canopy growth, so peak moth activity is more coincidental with blooming of open-canopied fields.

Sampling for corn earworm should be done on a weekly basis from mid-August through September. If row spacing is 30 inches or greater any of the techniques described below can be used to sample for insects. Narrow-row beans, 21 inches or less, are best sampled with either the sweep net or rigid beat cloth. Concentrate on high-risk fields, such as ones that have open canopies, are late flowering, or were previously treated with insecticides.

Standard Beat or Ground Cloth

For each sample, place a standard 3-foot ground cloth on the ground between rows and shake the plants bordering both sides vigorously. The number of insects shaken onto the cloth will be the number per 6 feet of row, so divide by 6 to get the number per row-foot. About ten samples should be taken in each 40 acre area. Thresholds are based on number or earworms per row-foot.

Rigid Beat Cloth

The RBC works on the same principle as a standard beat cloth but the RBC is not flexible. Samples are taken by placing the sampler on its side between two rows of plants (plants cannot be seriously lodged) and beating or vigorously shaking adjacent plants into the sampler while it is leaned away from those plants at about a 45° angle. Two 7-inch rows are beaten and one 14-inch or 21-inch row is beaten per sample. Thresholds are based on the number of earworms ***per sample***.

Sweep Net

Each sample should consist of 15 net sweeps with a 15-inch diameter sweep net done continuously one after the other. Each sweep consists of swinging the net in one direction through the foliage so that the top of the net passes 2 or 3 inches below the tops of plants. Fifteen consecutive sweeps are done from one side to the other while walking down a middle row. Swing the net with enough force to dislodge insects into the net. If some leaves are not broken off and in the net after the sample, the sampler is not using enough force. Each swing should pass through the tops of 5, 3, or 2 rows in 7-inch, 14-inch, or 21-inch row-space plantings, respectively. After each sample, stop and count how many earworms are in the net. Thresholds are based on the number of earworms **per sample**.

Decision Making

Treatment is suggested if sample counts exceed economic thresholds. Thresholds are presented at the end of this chapter. Visit the website *http://soybeans.ces.ncsu.edu/thresholds/* for access to the new threshold calculator.

Table 4.41 - Recommended Insecticides for Corn Earworm Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
Bacillus thuringiensis (DiPel ES)	8.0-16.0 BCLUs	1.2 pts	0	For pyrethroid resistant corn earworms when tank-mixed with a pyrethroid at a labeled rate.
beta-cyfluthrin (Baythroid XL)	0.0125-0.022 lb	1.6-2.8 oz	45	**RESTRICTED USE.** Green forage may be fed 15 days after last application.
beta-cyfluthrin + imidacloprid (Leverage 360)	0.02 + 0.04 lb	2.8 oz	45	**RESTRICTED USE.**
bifenthrin (Brigade 2EC)	0.033-1.0 lb	2.1-6.4 oz	18	**RESTRICTED USE.**
chlorantraniliprole (Prevathon)	0.047-0.066 lb	14.0-20.0 oz	21	
chlorpyrifos (Lorsban 4E)	0.5-1.0 lb	1.0-2.0 pt	28	**RESTRICTED USE.** Do not feed or graze livestock on treated plants.
chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)	0.31 + 0.016 – 0.74 + 0.038 lb	16.0-38.0 oz	30	**RESTRICTED USE.**
esfenvalerate (Asana XL)	0.02-0.03 lb	5.8-9.6 oz	21	**RESTRICTED USE.** Do not feed or graze livestock on treated plants. Do not exceed 0.2 lb per acre per season. Extremely toxic to fish.
indoxacarb (Steward EC)	0.045-0.11 lb	4.6-11.3 oz	21	
lambda-cyhalothrin + chlorantraniliprole (Besiege)	0.016 + 0.033 lb –0.026 + 0.052lb	5.0-8.0 oz	30	**RESTRICTED USE.**
lambda-cyhalothrin (Karate Z, Warrior II)	0.015-0.025 lb	0.96-1.92 oz	45	**RESTRICTED USE**. Do not apply more than 7.68 oz per acre per season Do not graze or harvest treated soybean forage, straw or hay for livestock feed.
methomyl (Lannate LV) (Lannate SP)	0.12-0.225 lb 0.11-0.225 lb	0.4-0.75 pt 0.125-0.25 lb	14 14	**RESTRICTED USE.** Wait 3 days to feed or graze as forage or 7 days for hay. Up to two applications may be used/season.
Methoxyfenozide + spinetoram				
spinetoram (Radiant SC)	0.15-0.31 lb	2.0-4.0 oz	28	
spinosyn (Blackhawk)	0.038-0.05 lb	1.7-2.2 oz	0	Do not feed treated forage or hay to meat or dairy animals.

Table 4.41 - Recommended Insecticides for Corn Earworm Control (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
thiamethoxam + lambda-cyhalothrin (Endigo ZC)		3.5-4.0 oz	30	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw or hay for livestock feed. Note: thiamethoxam does not add increased activity against corn earworm over lamda-cyhalothrin alone.
zeta-cypermethrin (Mustang Max)	0.0175-0.025 lb	2.1-6.4 oz	18	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw, or hay for livestock feed.

Grasshopper

Table 4.42 - Recommended Insecticides for Grasshopper Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
acephate (Orthene 97)	0.24-0.49 lb	0.25-0.5 lb	14	
chlorpyrifos (Lorsban 4E)	0.25-0.5 lb	0.5-1.0 pt	28	**RESTRICTED USE**. Do not feed or graze livestock on treated plants.
dimethoate (Dimethoate 2.67EC) (Dimethoate 4EC)	0.5 lb 0.5 lb	1.5 pt 1.0 pt	21 21	**RESTRICTED USE**. Do not feed or graze within 5 days of the last application. Do not store above 90°F or below 32°F.

Armyworms

Table 4.43 - Recommended Insecticides for Fall, Yellowstriped, and Beet Armyworm

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
acephate (Orthene 97) (except beet)	0.73-0.97 lb	0.75-1.0 lb	14	
beta-cyfluthrin (Baythroid XL) (fall armyworm and beet armyworm - 1st and 2nd instars only)	0.0125-0.022 lb	1.6-2.8 oz	45	**RESTRICTED USE.** Green forage may be fed 15 days after last application.
bifenthrin (Brigade 2EC)	0.033-0.10 lb	2.1-6.4 oz	18	**RESTRICTED USE.**
chlorantraniliprole (Prevathon)	0.047-0.066 lb	14.0-20.0 oz	21	

Table 4.43 - Recommended Insecticides for Fall, Yellowstriped, and Beet Armyworm (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)				**RESTRICTED USE.**
(beet)	0.43 + 0.022 lb – 0.74 + 0.038 lb	22.0-38.0 oz		
(yellowstriped)	0.215 + 0.01 – 0.51 + 0.026 lb	11.0-26.0 oz		
indoxacarb (Steward 1.25SC)	0.045-0.11 lb	4.6-11.3 oz	21	
lambda-cyhalothrin + chlorantraniliprole (Besiege)	0.026 + 0.052 lb 0.033 + 0.065 lb	8.0-10.0 oz	30	**RESTRICTED USE.**
methomyl (Lannate LV) (Lannate SP)	0.225-0.3 lb 0.225-0.34 lb	0.75-1.0 pt 0.25-0.375 lb	14 14	**RESTRICTED USE.** Wait 3 days to feed or graze as forage or 7 days for hay. Up to two applications may be used per season.
methoxyfenozide (Intrepid 2F)	0.06-0.12 lb	4.0-8.0 oz	7 (hay/forage) 14 (seed)	
methoxyfenozide + spinetoram (Intrepid Edge)	0.078 + 0.015 0.125 + 0.025	4-6.4 oz.	28 (seed)	
spinetoram (Radiant SC)	0.15-0.31 lb	2.0-4.0 oz	28	
spinosyn (Blackhawk)	0.038-0.05 lb	1.7-2.2 oz	28	Do not feed treated forage or hay to meat or dairy animals.
thiamethozam + lambda-cyhalothrin (Endigo ZC) (bean leaf beetle)	0.064-0.072 lb	4.0-4.5 oz	30	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw or hay for livestock feed.
zeta-cypermethrin (Mustang Max) (beet and fall) (yellowstriped)	 0.02-0.025 lb 0.0175-0.025 lb	 3.2-4.0 oz 2.8-4.0 oz	21	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw, or hay for livestock feed.

Stinkbugs

Table 4.44 - Recommended Insecticides for Stinkbug Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
acephate (Orthene 97)	0.49-0.97 lb	0.5-1.0 lb	14	
beta-cyfluthrin (Baythroid XL)	0.0125-0.022 lb	1.6-2.8 oz	45	**RESTRICTED USE.** Green forage may be fed 15 days after last application.

Table 4.44 - Recommended Insecticides for Stinkbug Control (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
beta-cyfluthrin + imidacloprid (Leverage 360)	0.02 + 0.04 lb	2.8 oz	45	**RESTRICTED USE.**
bifenthrin (Brigade 2EC)	0.033-0.1 lb	2.1-6.4 oz	18	**RESTRICTED USE.**
chlorpyrifos (Lorsban 4E)	1.0 lb	2.0 pt	28	**RESTRICTED USE.** Do not feed or graze livestock on treated plants.
chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)	0.31 + 0.016 – 0.74 + 0.038 lb	16.0-38.0 oz	30	**RESTRICTED USE.**
clothianidin (Belay)	0.05-0.067 lb	3.0-4.0 oz	21	Do not graze or feed soybean forage and hay to livestock.
esfenvalerate (Asana XL)	0.03-0.05 lb	5.8-9.6 oz	21	**RESTRICTED USE.** Do not feed or graze livestock on treated plants. Do not exceed 0.2 lb ai/A/season. Extremely toxic to fish.
lambda-cyhalothrin + chlorantraniliprole (Besiege)	0.026 + 0.052 lb – 0.033 + 0.065 lb	8.0-10.0 oz	30	**RESTRICTED USE.**
lambda-cyhalothrin (Karate Z, Warrior II)	0.025-0.03 lb	1.6-1.92 oz	45	**RESTRICTED USE**. Do not apply more than 7.68 oz/A per season. Do not graze or harvest treated soybean forage, straw or hay for livestock feed.
thiamethozam + lambda-cyhalothrin (Endigo ZC)	0.064.0.072 lb	4.0-4.5 oz	30	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw or hay for livestock feed.
zeta-cypermethrin (Mustang Max)	0.02-0.025 lb	3.2-4.0 oz	21	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw, or hay for livestock feed.

Soybean Looper

Soybean loopers can completely defoliate a field in a short period of time, in as few as 5-7 days if numbers are extremely high (i.e., 1 or more larvae per sweep). Large populations of soybean looper may develop in mid-August through September. Adult moths migrate from the southern US and can be pushed ahead of weather fronts or arrive earlier following higher than normal temperatures. We do not have a threshold specific to loopers in Virginia, but lump them into a general leaf defoliators 'guild' which can include many leaf eaters (Japanese beetles, green cloverworms, grasshoppers, bean leaf beetles and others). Base a treatment decision on the total leaf area destroyed by the guild. We recommend not treating fields with fully developed seed unless 35-40% of the leaf area is eaten and bugs are still present.

Do not use a pyrethroid to treat for soybean loopers. These products will only worsen infestations. Spray trial results and resistance screening assays indicate that products containing chlorantraniliprole are becoming less effective. As of 2018, products containing indoxacarb and methoxyfenozide provide the most consistent control.

Table 4.45 - Recommended Insecticides for Soybean Looper Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
chlorantraniliprole (Prevathon)	0.047-0.066 lb	14.0-20.0 oz	21	
indoxacarb (Steward 1.25SC)	0.055-0.11 lb	5.6-11.3 oz	21	
lambda-cyhalothrin + chlorantraniliprole (Besiege)	0.033 + 0.065 lb	10.0 oz	30	
methoxyfenozide (Intrepid 2F)	0.06-0.12 lb	4.0-8.0 oz	7 (hay/forage) 14(seed)	
methoxyfenozide + spinetoram (Intrepid Edge)	0.078 + 0.015 0.125 + 0.025	4-6.4 oz.	28 (seed)	
spinetoram (Radiant SC)	0.15-0.31 lb	2.0-4.0 oz	28	
spinosyn (Blackhawk)	0.025-0.05 lb	1.1-2.2 oz	28	Do not feed treated forage or hay to meat or dairy animals.

Soybean Aphid

Table 4.46 - Recommended Insecticides for Soybean Aphid Control

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
acephate (Orthene 90S) (Orthene 97)	 0.5 -1.0 lb 0.73-0.97 lb	 0.56-1.1 lb 0.75-1.0 lb	 14 14	Do not graze or cut vines for hay or forage.
bifenthrin (Brigade 2EC)	0.033-0.1 lb	2.1-6.4 oz	18	**RESTRICTED USE.**
chlorpyrifos (Lorsban 4E)	0.5-1.0 lb	1.0-2.0 pt	28	**RESTRICTED USE.** Do not feed or graze livestock on treated plants.
chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)	0.21 + 0.01 – 0.51 + 0.026 lb	11.0-26.0 oz		**RESTRICTED USE.**
clothianidin (Belay)	0.05-0.067 lb	3.0-4.0 oz	21	Do not graze or feed soybean forage and hay to livestock.
cyfluthrin (Baythroid XL)	0.044 lb	2.0-2.8 oz	45	**RESTRICTED USE.** Green forage may be fed 15 days after last application.
esfenvalerate (Asana XL)	0.03-0.05 lb	5.8-9.6 oz	21	**RESTRICTED USE.** Do not feed or graze livestock on treated plants. Do not exceed 0.2 lb per acre per season. Extremely toxic to fish.
flupyradifurone (Sivanto)	0.09-0.137 lb	7.0-10.5 oz	21	

Table 4.46 - Recommended Insecticides for Soybean Aphid Control (cont.)

Insecticide (Formulation)	Amount active ingredient per acre	Amount product per acre	Time limits: days before harvest	Remarks
imidacloprid (Gaucho 600)	1.0 oz/cwt	1.6 oz/cwt	N/A	Seed treatment.
lambda-cyhalothrin + chlorantraniliprole (Besiege)	0.016 + 0.033 lb – 0.026 + 0.052 lb	5.0-8.0 oz	30	**RESTRICTED USE.**
lambda-cyhalothrin (Karate Z) (Warrior T)	0.015-0.025 lb 0.015-0.025 lb	0.96-1.6 oz 1.92-3.2 oz	45 45	**RESTRICTED USE.** Do not apply more than 7.68 oz per acre per season. Do not graze or harvest treated soybean forage, straw, or hay for livestock feed.
thiamethoxam (Cruiser 5FS)	0.8 oz/cwt	1.28 oz/cwt	N/A	Seed treatment.
thiamethozam + lambda-cyhalothrin (Endigo ZC)	0.056-0.064 lb	3.5-4.0 oz	30	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw or hay for livestock feed.
zeta-cypermethrin (Mustang Max)	0.0175-0.025 lb	2.8-4.0 oz	21	**RESTRICTED USE.** Do not graze or harvest treated soybean forage, straw, or hay for livestock feed.

Pest Thresholds

Table 4.47 - Corn Earworm Thresholds in Soybeans[1]

Sampling Tool	Row Width	Rows Sampled	Threshold
Sweep Net[2]	7"	5	2.5
	14"	3	2.4
	21"	2	3.1
	36"	1	3.1
	7"	2	0.9
Rigid Beat Cloth[3]	14"	1	0.7
	21"	1	1.2
Beat Cloth	30"	1 or 2	1.0
Standard or Rigid[4]	36"	1 or 2	1.2

[1] Only count worms 3/8 inch or longer.
[2] Based on a 15-sweep sample.
[3] Number per sample.
[4] Number per row foot rather than number per sample.

The timing strategy is to wait until most of the larvae are three-eights of an inch or more in length and then treat when pod damage is first evident. This allows for most egg laying and hatching to occur before treatment and thus reduces the chances of a second spray being needed later. Some defoliation may occur before it is time to treat and this injury should be evaluated just like that of any defoliator. If other defoliating pests are present when pod damage is first evident, then adjustments should be made in the treatment thresholds for earworms. For example, if green cloverworms are actively feeding and have already caused 15 percent defoliation, then insecticide treatment would be justified at lower earworm infestations, about one-half the normal threshold. Finally, treatment may not be necessary if the majority of worms are infected with the fungus disease. This white to greenish white fungus can have a significant impact on earworm populations. Access the web (*www.ipm.vt.edu/cew*) to calculate thresholds based on your estimated cost of control (product cost plus application cost) and today's bushel value.

Table 4.48 - Other Soybean Insect Pest Thresholds

	# per row-foot row-spacing		# per 15 sweeps row-spacing		
Pest species	**7"-21"**	**above 21"**	**7"-21"**	**above 21"**	**Other comments**
Full-season plantings					
Mexican bean beetle	4	6	24	36	40% defoliation - pre-bloom, 15% defoliation - pod-fill, 35+% defoliation - fully developed seeds.
Spider mite	Damage occurring and live mites present				Live mites on 50% of leaves and 50% leaves showing white spotting or premature leaf drop.
Other defoliators[1]					40% defoliation - pre-bloom, 15% defoliation - pod-fill, 35+% defoliation - fully developed seeds.
Double-crop plantings with poor growth					
Mexican bean beetle	2	4	12	24	20% defoliation - pre-bloom, 15% defoliation - fully developed seeds.
Spider mite	Damage occurring and live mites present				Live mites on 50% of leaves and 50% leaves showing white spotting or premature leaf drop.
Other defoliators[1]					20% defoliation - pre-bloom, 10% defoliation - pod-fill, 15% defoliation - fully developed seeds.

[1]Other defoliators include any combinations of green cloverworm, bean leaf beetle, blister beetle, Japanese beetle, soybean looper, yellowstriped armyworm, grasshoppers, or fall armyworm.

Table 4.49 - Revised Stink Bug Thresholds for Soybean (all stink bug species combined)

	# per row foot		# per 15 sweeps	
Row spacing	7-21" rows	Above 21"	7-21" rows	Above 21"
New (Grain)	1-2	1-2	5	5
New (Seed)	0.5	0.5	2.5	2.5

Apply from R3-4 to R7, double after R7

Soybean aphid

The current economic threshold for aphids is an average of 250 aphids per plant, on two consecutive field visits spaced about 5-7 days apart. This is because aphid populations can "crash" quickly due to heavy pressure by natural enemies like lady beetles, parasitic wasps, and fungal diseases. When scouting, choose a "Z" or "W" shaped pattern to cover the entire field and sample at least 20 to 30 plants per field by examining the entire plant, including stems and upper and lower leaf surfaces. Use the aphid/plant average for determining the need for treatment. The threshold applies to soybeans through the R5 growth stage (3 mm long seed in the pod at one of the four uppermost nodes on the main stem), after which time plants can tolerate 1,000+ aphids with no threat to yield.

Peanuts

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Thrips

Seedling peanut plants are usually attacked by thrips within the first 6-8 weeks after planting. These tiny, spindle-shaped insects feed primarily within the developing, unfolded leaflets causing crinkling of the leaflets and stunting of the plants. Blackening of the small leaflets occurs with severe infestations and can be mistaken for chemical injury. Under favorable conditions, plants normally outgrow this injury with no reduction in yield or grade. However, the delay in vine growth from early season thrips injury may delay maturity. This in combination with other injury, such as herbicide burn, can reduce yield.

Thrips can be controlled with either systemic or with foliar-applied insecticides. Systemics can be incorporated in the furrow with the seed at planting. Foliar treatments can be applied as needed after crop emergence. During dry seasons or seasons with excessive rains, insecticides may not give adequate thrips control due to poor uptake by the plants or leaching of chemicals from the soil. Foliar treatments may be warranted if systemics are ineffective, or if injury appears excessive. Foliar treatment is recommended when 25 percent of the leaves show thrips damage and pest populations are still active.

Table 4.50 - Recommended Insecticides for Thrips Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	acephate (Orthene 97) band rate broadcast rate	 3.0-6.0 oz 6.0-12.0 oz	14	Do not feed treated forage or hay to livestock or allow animals to graze treated areas.
	beta-cyfluthrin (Baythroid XL)	2.8 oz	14	**RESTRICTED USE.**
On-seed	acephate (Acephate 90SP)	3.5 oz/100 lbs seed	–	Mix in the planter to obtain good coverage of ALL seed by layering seed and product. Fill the planter box 1/3 full of seed with 1/3 of the product,add the next 1/3 of the seed and product, then add the last 1/3 of the seed and product. Gently stir each layer before adding the next. **Caution:** Do not use with seed inoculants. Not recommended for air planters. Do not use treated seed for food or feed purposes, or process for oil.
	thiamethoxam (CruiserMaxx Peanut)	3.0-4.0 oz/100 lbs seed	0	
In-furrow	aldicarb (AgLogic 15G, AgLogic 15GG)	7 lb	90	Do not hog-off treated fields or allow livestock to graze in treated areas before harvest. Do not feed hay or vines to livestock. Immediately deep-disk any spills at row ends or elsewhere to ensure the granules are covered with a layer of soil.
	imidacloprid (Admire Pro)	7.0-10.5 oz	14	Apply as an in-furrow spray during planting directed on or below seed.
	imidacloprid + fluopyram (Velum Total)	18 oz	14	Apply as an in-furrow spray during planting directed on or below seed
	phorate (Thimet 20G)	5.0 lb	90	**RESTRICTED USE.** Distribute granules evenly in the furrow. Do not graze or feed treated hay or forage to livestock.

Potato Leafhopper

The potato leafhopper is a common pest of peanuts in Virginia. This small, wedge-shaped, light green to yellow insect damages the peanut plant by feeding on the undersides of leaves in a piercing-sucking manner. Injured leaf tips turn yellow first then brown and tend to curve downward. Toxins are also passed into plants at feeding sites. If enough damage is done, toxins can stop vine growth resulting in reductions in yield and grade. Injury may occur at any time from early June until the middle of August or later in some years. It is important to note that although late-season damage appears worse in some years, damage done early in the season probably affects plant vigor and yield more. Systemic insecticides applied at planting time will usually control potato leafhoppers that occur early, but if no pegging-time insecticide is applied, it may be necessary to make foliar applications in July or early August. Pegging time applications of rootworm insecticides will usually control leafhoppers until harvest.

Foliar treatments should be made only if needed. When 25% of the leaves show tip yellowing typical of leafhopper damage, and active adult and immature leafhoppers are seen, treat with an effective chemical. When foliar treatments are required, the first application usually is made about the middle of July, and the second about the first of August (if needed). If scheduled treatments are being made for control of leafspot, insecticides may be tank mixed. Do not include insecticides with all leafspot treatments. Too many insecticide applications, or applications later in the season, could cause spider mite populations to increase, especially in dry years after adjacent corn and weedy areas have been cut. Make leafhopper applications only when problems have been identified.

Table 4.51 - Recommended Insecticides for Potato Leafhopper Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	acephate (Orthene 97)	6.0-12.0 oz	14	Do not feed treated forage or hay to livestock or allow animals to graze treated areas.
	beta-cyfluthrin (Baythroid XL)	1.0-1.8 oz	14	**RESTRICTED USE.**
	beta-cyfluthrin + imidacloprid (Leverage 360)	2.8 oz	14	**RESTRICTED USE.**
	bifenthrin (Brigade 2EC)	2.1-6.4 oz	14	**RESTRICTED USE.** Do not feed immature plants and peanut hay to livestock.
	esfenvalerate (Asana XL)	2.9-5.8 oz	21	**RESTRICTED USE.** Do not feed or graze livestock on treated vines. Do not exceed 29 oz/ season.
Foliar (cont.)	fenpropathrin (Danitol 2.4EC)	6.0-10.6 oz	14	**RESTRICTED USE.** Do not graze or feed treated peanut vine forage or dried hay within 14 days of the last application. Do not exceed 2.6 pints total application/A/season.
	lambda-cyhalothrin (Karate EC) (Karate Z, Warrior II)	 1.92-3.2 oz 0.96-1.6 oz	 14 14	**RESTRICTED USE.** Do not apply more than 15.36 oz/ A/season. Do not graze livestock in treated areas, or use treated vines or hay for animal feed.
	methomyl (Lannate LV) (Lannate SP)	 0.75- 3.0 pt 0.25- 1.0 lb	 21 21	**RESTRICTED USE.** Do not feed treated vines.

[1]**General -** Apply pegging treatments in 10- to 18-inch bands on row during the first 2 weeks in July after pegging begins and before vines close in middles. Effectiveness of treatments is increased if insecticides are covered by shallow cultivation to avoid exposure to sunlight and lateral movement with heavy rains.

Table 4.51 - Recommended Insecticides for Potato Leafhopper Control (cont.)

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
	zeta-cypermethrin (Mustang Max)	1.28-4.0 oz	7	**RESTRICTED USE.** Do not graze livestock in treated areas. Do not use treated vines or hay for animal feed.
Pegging[1]	chlorpyrifos (Lorsban 15G)	—	—	Lorsban 15G is not labeled for use against leafhopper but will provide suppression if applied for soil insects.

[1]**General -** Apply pegging treatments in 10- to 18-inch bands on row during the first 2 weeks in July after pegging begins and before vines close in middles. Effectiveness of treatments is increased if insecticides are covered by shallow cultivation to avoid exposure to sunlight and lateral movement with heavy rains.

Southern Corn Rootworm

The southern corn rootworm, which is the immature stage of the spotted cucumber beetle, can cause extensive injury to the Virginia peanut crop. Rootworm larvae develop in the soil and feed directly on pegs and pods. Finding rootworms in the soil is very difficult and injury is often not detected until after peanuts are dug, when it is too late for control measures. A preventive treatment is the best strategy. After an infestation is established, control is difficult and often ineffective. Determining the need to treat for southern corn rootworm should be done on a field-by-field basis. Decisions can be based on both adult populations and past history of peanut fields. Adult beetles can be readily detected in peanut fields. Their presence in moderate to high numbers from mid-July to early August should be a warning that a problem could develop. Adults will lay eggs that could develop into the damaging larval stage. Early detection of adults can thus allow for timely treatment and prevention of injury.

Knowledge of the past history of rootworm injury can also be useful in determining the need for treatment. If injury has ever occurred in a field, it will likely occur in other years. Keep field records on the extent of pod and peg injury noticed at harvest time. Pay particular attention to fields with higher levels of organic matter and clay. Rootworms have a higher survival rate in those soils due to higher moisture holding capacity, and injury will typically be more severe than in "light" soils. Use the "Southern Corn Rootworm Risk Index" to aid you in deciding which fields need insecticide treatment.

If rootworm treatments are necessary, they should be applied as 10-18 inch bands on the row during early pegging. Usually, this period occurs during the first 2 weeks of July. Treatment effectiveness is increased if materials are lightly incorporated using shallow cultivation. If vine growth and pegging are in an advanced stage, do not cultivate, as vine "dirting," which leads to disease development and injury to pegs, may offset the gain from insect control. Carefully calibrate equipment to deliver recommended insecticide rates. Using more than is recommended will not increase effectiveness and using less could result in a complete insecticide failure.

Table 4.52 - Recommended Insecticides for Southern Corn Rootworm Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Pegging[1]	chlorpyrifos (Lorsban 15G)	13.0 lb	21	Do not apply more than 13.3 lb/ season. Do not feed peanut forage or hay to meat or dairy animals.

[1]**General -** Apply pegging treatments in 10-18 inch bands on row during the first 2 weeks in July after pegging begins and before vines close in middles. Effectiveness of treatments is increased if insecticides are covered by shallow cultivation to avoid exposure to sunlight and lateral movement with heavy rains.
[2]Labels stipulate light incorporation.

Corn Earworm

Annual infestations of the corn earworm and fall armyworm occur in most Virginia peanut fields. Usually there is a single generation of each species per season. Worms feed on leaf tissue causing peanuts to look ragged; however, research has shown that one-third of peanut foliage can be lost at the normal time of corn earworm infestations (mid-August to early September) without loss of yield or grade. Scouting fields is the only way to determine if treatment is needed. Scout by reaching halfway across 2 row-feet of plants and shaking foliage vigorously towards the row middle. Repeat on the opposite row. Count the worms on the ground and repeat the sample in several spots in the field. Treatment is recommended if an average of 8 or more worms are found per sample, or 4 per row-foot.

If treatment is necessary, apply sprays using systems that provide good canopy penetration and coverage. If spider mites are already present in the field, use of some insecticides may allow for rapid build-up. Scout fields for treatment effectiveness and for possible increases in spider mite activity soon after applications. Pyrethroids offer poor to moderate control of corn earworm in Virginia and poor control of fall armyworm. If you decide to spray a pyrethroid, use the highest labeled rate and do not expect good control of heavy infestations or large worms.

Table 4.53 - Recommended Insecticides for Corn Earworm Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remark
Foliar[1]	acephate (Orthene 97)	12.0-16.0 oz	14	Do not feed treated forage or hay to livestock or allow animals to graze treated areas.
	Bacillius thuringiensis (DiPel ES)	1.0-2.0 pt	0	For pyrethroid resistant corn earworm when tank mixed with a pyrethroid at a labeled use rate.
	beta-cyfluthrin (Baythroid XL)	1.8-2.4 oz	14	**RESTRICTED USE.**
	beta-cyfluthrin + imidacloprid (Leverage 360)	2.8 oz	14	**RESTRICTED USE.**
	bifenthrin (Brigade 2EC)	2.1-6.4 oz	14	**RESTRICTED USE.** Do not feed immature plants and peanut hay to livestock.
	chlorantraniliprole (Prevathon)	14.0-20.0 oz	1	
	chlorantraniliprole + lambda-cyhalothrin (Besiege)	6.0-10 oz	14	**RESTRICTED USE.**
	esfenvalerate (Asana XL)	2.9-5.8 oz	21	**RESTRICTED USE.** Do not feed or graze livestock on treated vines. Do not exceed 29.0 oz/season.
	fenpropathrin (Danitol 2.4EC)	10.6-16.0 oz	14	**RESTRICTED USE.** Do not graze or feed treated peanut vine forage or dried hay within 14 days of the last application. Do not exceed 2.6 pints total application/A/season.
	indoxacarb (Steward EC)	6.7-11.3 oz	14	Do not feed or graze livestock on treated fields.

[1]**General** - Treat only if foliage loss is heavy (1/3 or more). Earworms are easier to control when they are less than 1/2 inch long.

Table 4.53 - Recommended Insecticides for Corn Earworm Control (cont.)

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remark
Foliar[1] (cont.)	lambda-cyhalothrin (Karate EC) (Karate Z, Warrior II)	2.56-3.84 oz 1.28-1.92 oz	14 14	**RESTRICTED USE.** Do not apply more than 15.36 oz/A/ season. Do not graze livestock in treated areas, or use treated vines or hay for animal feed.
	methomyl (Lannate LV) (Lannate SP)	0.75-3.0 pt 0.25-1.0 lb	21 21	**RESTRICTED USE.** Do not feed treated vines.
	methoxyfen-ozide + spinetoram (Intrepid Edge)	4.0-8.0 OZ	7	Do not exceed 3 applications/season.
	spinetoram (Radiant SC)	3.0-8.0 oz	3	Do not allow grazing of peanut hay.
	spinosyn (Blackhawk)	1.7-3.3 oz	3	Do not allow grazing of crop residue or harvest of crop residue for hay until 14 days after the last application.
	zeta-cypermethrin (Mustang Max)	3.2-4.0 oz	7	**RESTRICTED USE.** Do not graze livestock in treated areas. Do not use treated vines or hay for animal feed.

[1]**General** - Treat only if foliage loss is heavy (1/3 or more). Earworms are easier to control when they are less than 1/2 inch long.

Table 4.54 - Recommended Insecticides for Fall Armyworm Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remark
Foliar[1]	acephate (Orthene 97)	12.0-16.0 oz	14	Do not feed treated forage or hay to livestock or allow animals to graze treated areas.
	Bacillius thuringiensis (DiPel ES)	1.0-2.0 pt	0	For pyrethroid resistant corn earworm when tank mixed with a pyrethroid at a labeled use rate.
	beta-cyfluthrin (Baythroid XL)	2.4-2.8 oz	14	**RESTRICTED USE.**
	beta-cyfluthrin + imidacloprid (Leverage 360)	2.8 oz	14	**RESTRICTED USE.**
	bifenthrin (Brigade 2EC)	2.1-6.4 oz	14	**RESTRICTED USE.** Do not feed immature plants and peanut hay to livestock.
	chlorantraniliprole (Prevathon)	14.0-20.0 oz	1	
	chlorantraniliprole + lambda-cyhalothrin (Besiege)	6.0-10.0 oz	14	**RESTRICTED USE.**

[1]**General** - Treat only if foliage loss is heavy (1/3 or more). Earworms are easier to control when they are less than 1/2 inch long.

Table 4.54 - Recommended Insecticides for Fall Armyworm Control (cont.)

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remark
Foliar[1] (cont.)	esfenvalerate (Asana XL)	9.6 oz	21	**RESTRICTED USE.** Suppression only. Do not feed or graze livestock on treated vines. Do not exceed 29.0 oz/season.
	fenpropathrin (Danitol 2.4EC)	10.6-16.0 oz	14	**RESTRICTED USE.** Do not graze or feed treated peanut vine forage or dried hay within 14 days of the last application. Do not exceed 2.6 pints total application/A/season.
	indoxacarb (Steward EC)	9.2-11.3 oz	14	
	lambda-cyhalothrin (Kaiso 24WG)	2.0 oz	14	**RESTRICTED USE.**
	methomyl (Lannate LV) (Lannate SP)	0.75-1.5 pt 0.25-0.5 lb	21 21	**RESTRICTED USE.** Do not feed treated vines. 2 pints may be required for good control.
	methoxyfen-ozide + spinetoram (Intrepid Edge)	4.0-8.0 oz		Do not exceed 3 applications/season.
	methoxyfenozide (Intrepid 2F) (beet armyworm only)	6.0-10.0 oz	7	
	spinetoram (Radiant SC)	3.0-8.0 oz	3	Do not allow grazing of peanut hay.
	spinosyn (Blackhawk)	1.7-3.3 oz	3	Do not allow grazing of crop residue or harvest of crop residue for hay until 14 days after the last application.
	zeta-cypermethrin (Mustang Max)	3.2-4.0 oz	7	**RESTRICTED USE.** Do not graze livestock in treated areas. Do not use treated vines or hay for animal feed.

[1]**General** - Treat only if foliage loss is heavy (1/3 or more). Earworms are easier to control when they are less than 1/2 inch long.

Spider Mite

Mites, which have become more numerous during the past several years, are especially injurious during hot, dry weather. While insecticides are very valuable in controlling leafhoppers, thrips, and worms, they may be responsible for destroying some of the natural enemies of spider mites and thus promoting the build-up of mite populations. Insecticides should be used **only when needed** for insect control. Tank mixes that include both fungicides and insecticides are more likely to allow spider mite build-up than when either material is used separately.

Spider mites feed mainly on the undersides of the leaves. They suck the juice from the foliage and cause the leaves to turn brown and eventually drop off. Heavy infestations usually occur first around the borders of peanut fields; then they spread inward throughout the fields. Avoid harvesting spider mite infested cornfields or mowing weedy areas next to peanut fields until peanuts are harvested. Spider mites will readily move into peanuts when corn dries down or is harvested. Be prepared to treat peanuts if adjacent corn is infested.

Important: If you are going to treat, calibrate your equipment to deliver the right amount of pesticide per acre. Arrange and adjust the nozzles or spouts in a manner that will direct the chemical into the desired area to be treated. Adequate sprayer pres-

sure (40 to 60 psi) will aid in getting chemicals in contact with the undersides of leaves and within denser foliage. Penetration of foliage with 20 to 30 gallons of water per acre is very important for the control of spider mites.

Table 4.55 - Recommended Insecticides for Spider Mite Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	bifenthrin (Brigade 2EC)	5.12-6.4 oz	14	**RESTRICTED USE.** Do not feed immature plants and peanut hay to livestock.
	fenpropathrin (Danitol 2.4EC)	10.6-16.0 oz	14	**RESTRICTED USE.** Do not graze or feed treated peanut vine forage or dried hay within 14 days of the last application. Do not exceed 2.6 pints total application/A/season.
	propargite (Comite 6.5EC) (Omite 30W)	2.0 pt 3.0-5.0 lb	14 14	Use a minimum of 20 gallons/A with ground equipment or 5 gallons by air. Make no more than 2 applications/year (either Comite OR Omite). Do not plant rotational crops within 6 months of last application. Do not feed hay to livestock.

Lesser Cornstalk Borer

Lesser cornstalk borer is typically not a problem in Virginia peanut fields. However, it does thrive under hot dry conditions and can become a problem when those conditions continue for 3-4 weeks. Infestations will be most severe where soils are sandy and in high, well drained areas within fields. Larvae are 0.5 to 0.75 inch long and are banded with alternating brown and blue stripes. They wiggle vigorously when disturbed. Larvae feed by burrowing into main stems, lateral limbs, plant crowns, and pods and can do extensive damage, even kill plants. Larvae produce silk-and-sand web tubes, which are attached to pods or stems at the point of feeding. Evidence of web tubes is a sure sign of borer activity.

If weather conditions become favorable for borers, survey fields for damaged plants and larvae. If damage is obvious and active larvae are still present in 10% or more of the plants, treatment is recommended.

Table 4.56 - Recommended Insecticides for Lesser Cornstalk Borer Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Granular	chlorpyrifos (Lorsban 15G)	6.7-13.3 lb	21	Apply in 10-18 inch band on row at first sign of borer. Do not feed peanut forage or hay to meat or dairy animals. Do not apply more than 13.3 lb/season. 10.0-13.0 lb may be broadcast by air as a rescue treatment.

Grasshopper

Table 4.57 - Recommended Insecticides for Grasshopper Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	acephate (Orthene 97)	4.0-8.0 oz	14	Do not feed treated forage or hay to livestock or allow animals to graze treated areas.
	beta-cyfluthrin (Baythroid XL)	1.8-2.4 oz	14	**RESTRICTED USE.**
	bifenthrin (Brigade 2EC)	2.1-6.4 oz	14	**RESTRICTED USE.** Do not feed immature plants and peanut hay to livestock.
	esfenvalerate (Asana XL)	5.8-9.6 oz	21	**RESTRICTED USE.** Do not feed or graze livestock on treated vines. Do not exceed 29.0 oz/season.
	zeta-cypermethrin (Mustang Max)	3.2-4.0 oz	7	**RESTRICTED USE.** Do not graze livestock in treated areas. Do not use treated vines or hay for animal feed.

Pesticide Usage Charts

Many pesticides control more than one pest. The three tables below summarize the effectiveness of some popular pesticides used at time of planting, at time of pegging, or as foliar treatments for the control of major insect pests which attack peanuts.

Table 4.58 - Insecticide Activity of Products Applied at Time of Planting

	Pests			
Chemical	**Thrips**	**Leafhopper**	**Rootworm**	**Spider Mite**
Orthene	E	Early	No	No
Thimet	G	Early	No	No

P=poor control, F=fair control, G=good control, E=excellent control, No=not labeled or no activity expected.

Table 4.59 - Insecticide Activity of Granules Applied at Time of Pegging

	Pests			
Chemical	**Rootworm**	**Leafhopper**	**Spider Mite**	**Corn Earworm**
Lorsban[1]	E	G	No	No

P=poor control, F=fair control, G=good control, E=excellent control, No=not labeled or no activity expected.
[1] **NOT SYSTEMIC.** Do not apply in the furrow.

Table 4.60 - Insecticide Activity of Foliar Treatments Applied when Pests Are Present

		Pest Species Controlled						
Insecticide	**Formulation**[1]	**Thrips**	**Leaf-hopper**	**Root-worm**	**Corn earworm**	**Fall army-worm**	**Lesser corn stalk borer**	**Spider mite**
Asana	XI	No	E	No	F/P	G	No	No[2]
Comite, Omite	6.5EC, 30W	No	No	No	No	No	No	E
Danitol	2.4EC	No	E	No	E	G	No	E
Karate	Z	E	E	No	F/P	G	No	F
Lannate	L	P	G	No	E	G	No	No[2]
Orthene	97	E	E	No	G	F	No	No[2]
Sevin	4F, 80s, XLR Plus	P	E	No	F	F	No	No[2]
Steward	1.25SC	No	No	No	E	E	No	No
Blackhawk		No	No	No	E	E	No	No

P=poor control, F=fair control, G=good control, E=excellent control, No=not labeled or no activity expected.
[1]There are other insecticides and other formulations which have federal registration for use on peanuts.
[2]Use of these insecticides may allow rapid build-up of spider mites. Use with caution during extended periods of dry weather.

Cotton

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Thrips

Insect pests such as aphids, spider mites, cutworms, plant bugs and thrips affect cotton in the early stages of development. At present, only thrips must be controlled annually. These tiny, spindle-shaped insects complete several generations per season under favorable conditions and feed primarily by puncturing and rasping the outer cells of the young leaves and buds. Damage results in ragged looking plants with crinkled or "possum-eared" leaves. The damage associated with thrips feeding can stunt growth resulting in fruiting at higher positions and delayed maturity. Damage is most severe if young cotton is subjected to adverse growing conditions such as cool or dry weather or when alternate thrips hosts such as small grains dry down prematurely forcing large numbers of thrips to seek other hosts. Adverse growing conditions during the early stages of cotton development may reduce the uptake of systemic insecticides, therefore early inspection of the crop is important due to the length of the growing season in most of Virginia.

Orthene 97 in furrow - Orthene 97 can be dribbled or sprayed in furrow during the planting operation. Orthene provides good thrips control for up to five weeks if applied at 12-16 oz of product per acre. Applications are usually made at 5 to 10 gallons per acre and are compatible with several liquid fungicides.

Gaucho and Cruiser seed treatment - Gaucho- and Cruiser-treated seed provide good thrips control. May need foliar treatment to provide season-long control.

There is no formal threshold for thrips based on insect numbers or plant injury. Treatment is thought to be justified if the following conditions are met: 1) thrips injury is common, 2) 10% or more plants show extensive bud damage, 3) immature thrips can be easily found, and 4) plant growth is poor.

Table 4.61 - Recommended Insecticides for Thrips Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
In-furrow or seed	acephate (Orthene 97)	12.0-16.0 oz	21	Apply as a liquid into the seed furrow in 5-10 gal of water/A with a system that insures good seed coverage. Do not feed treated forage or hay to livestock or allow animals to graze treated areas.
	aldicarb (AgLogic 15G, AgLogic 15GG)	3.5-5.0 lb	90	Do not feed cotton forage to livestock or allow livestock to graze in treated area. Immediately deep-disk any spills at row ends or elsewhere to ensure the granules are covered with a layer of soil. Application rate may be reduced by 1/2 if seeds and granules are hill dropped.
	imidacloprid (Admire Pro)	7.4-9.2 oz	—	Apply as an in-furrow spray during planting directed on or below seed. Do not graze treated fields after any application of Admire Pro.
	imidacloprid (Gaucho Grande, Aeris)	0.375 mg ai/ seed	—	—
	imidacloprid + fluopyram (Velum Total)	14-18 oz	30	Apply as an in-furrow spray during planting directed on or below seed

Table 4.61 - Recommended Insecticides for Thrips Control (cont.)

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
In-furrow or seed (cont.)	phorate (Thimet 20G)	6.0-9.0 oz/1,000 row ft	—	**RESTRICTED USE.** Do not graze or feed treated hay or forage to livestock.
	thiamethoxam (Cruiser 5FS, Avicta CP)	0.30-0.375 mg ai/seed	—	—
Foliar	acephate (Orthene 97)	2.5-3.0 oz	21	May be tank mixed with Roundup Ultra or Roundup Ultra Max (for use on Roundup ready cotton), Buctril (for use on BXN cotton), or Staple.
	spinetoram (Radiant SC))	4.25-8.0 oz	28	1.5-3.0 oz for early season suppression.

Plant Bugs

Prebloom: Prior to bloom, tarnished plant bugs, or Lygus bugs, damage cotton by feeding on tender terminals and small squares causing squares to turn black and abort. Excessive square loss can reduce yields and slow plant maturity. Cotton acreage treated for Lygus has increased in recent years. Plant bugs are found across Virginia's entire cotton growing region throughout the pre-bloom and bloom period (late May-August). Fields adjacent to Irish potatoes, weed fields, and other sources of plant bugs in eastern counties may be at higher risk of plant bug injury. Frequent scouting during prebloom and flowering is advised. Lygus adults can rapidly infest fields and re-infest following treatment. Multiple applications may be required. Rotation between modes of action is recommended. The best way to determine the need for pre-bloom plant bug control is to assess square retention rates (percent missing squares) in addition to scouting for insects. Treatment should be considered if square retention drops below 80% (see threshold table below) and plant bugs are active.

After blooming: Once blooming begins, plant bugs continue feeding on smaller squares and blooms, both of which can cause 'dirty blooms' (white blooms with brown pollen anthers or brown-streaked petals). The presence of dirty blooms indicates that plant bugs are, or have very recently been, active. Levels at or above 15% dirty bloom indicate a large and active plant bug population and the need for sampling of bolls for damage (see threshold table below). Do not spray insecticides based on dirty blooms alone. Neonicotinoid insecticides (i.e., products containing imidacloprid, thiamethoxam, or clothianidin) are less effective during bloom. Read and follow label instructions with all pesticide applications. All insecticides labeled for plant bug control are toxic to bees and beneficial predators. Only spray insecticides when necessary.

Boll damage: Once bolls are formed, plant bugs prefer feeding on small bolls up to 3 weeks old. Damage to bolls can range from warts or calluses on the insides of boll walls, to small areas of stain lint, to deformed and rotting fruit that is due to direct feeding on seed. This damage is identical to damage caused by stink bugs. Virginia studies indicate that treatments are justified if boll damage by plant bugs (and/or stink bugs) exceeds 15% of a random sample of quarter-sized bolls and plant bugs are active in the field (see threshold table below).

Table 4.62 - Sampling for Plant Bugs and Thresholds in Cotton

Prebloom	below 80% square retention and plant bugs active
After blooming	15% dirty blooms indicates the presence of an active population 8 plant bugs per 100 sweeps indicates a large, active population
Boll damage	15% or more damaged quarter-sized bolls and plant bugs active

Table 4.63 - Recommended Insecticides for Plant Bug Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	acephate (Orthene 97)	4.0-16.0 oz	21	
	acetamiprid (Assail 70WP)	1.1-2.3 oz	28	
	beta-cyfluthrin (Baythroid XL)	1.6-2.6 oz	0	**RESTRICTED USE.**
	bifenthrin (Brigade 2EC)	2.6-6.4 oz	14	**RESTRICTED USE.**
	chlorpyrifos (Lorsban 4EC)	6.1 oz	14	
	chlorpyrifos+ lambda-cyhalothrin (Cobalt Advanced)	16.0-38.0 oz	21	**RESTRICTED USE.** Do not allow meat or dairy animals to graze in treated areas. Do not feed gin trash or treated forage to meat or dairy animals.
	clothianidin (Belay)	3.0-4.0 oz	21	
	dicrotophos (Bidrin XP)	4.0-6.0 oz	30	**RESTRICTED USE.**
	dicrotophos + bifenthrin (Bidrin XPII)	8.0-10.5, 12.8* oz	30	**RESTRICTED USE.** Do no graze livestock, cut treated crops for feed, or feed gin trash. Do not apply as a ULV application. *Use higher rate with heavy infestations.
	dinotefuran (Venom 20SG)	0.44-0.67 lb	14	
	esfenvalerate (Asana XL 0.66EC)	5.8-9.6 oz	21	**RESTRICTED USE.**
	imidacloprid (Admire Pro)	0.9-1.7 oz	14	
	lambda-cyhalothrin (Karate EC) (Karate Z, Warrior II)	2.56-3.84 oz 1.28-1.92 oz	21 21	**RESTRICTED USE.**
	lambda-cyhalothrin + thiamethoxam (Endigo ZC)	3.5-5.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	chlorantraniliprole + lambda-cyhalothrin (Besiege)	6.5-12.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	methomyl (Lannate 2.4 LV) (Lannate 90SP)	0.75 pt 0.5 lb	15 15	**RESTRICTED USE.**
	oxamyl (Vydate C-LV)	12.7-17.0 oz	14	**RESTRICTED USE.**
	thiamethoxam (Centric 40WG)	1.25-2.0 oz	21	

Table 4.63 - Recommended Insecticides for Plant Bug Control (cont.)

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
	zeta-cypermethrin (Mustang Max)	2.64-3.6 oz	14	**RESTRICTED USE.**

Tobacco Budworm/Cotton Bollworm

Bollworms (AKA corn earworms) occur primarily on field corn during their first two generations. Third generation moths usually emerge in large numbers from mid-July to early August when corn is drying and fly to more attractive blooming cotton.

Regular weekly scouting for the bollworm should begin in early to mid-June. Weekly scouting is adequate until egg laying or light-trap catches increase. Fields should then be scouted twice a week, with the emphasis placed upon finding eggs, until insecticide treatments begin. After that, a 4- to 7-day scouting schedule will usually suffice. Once the egg threshold has been met and treatments made, the primary focus of scouting shifts toward finding small bollworms feeding on squares and bolls, including those under bloom tags. Pyrethroids offer poor to moderate control of corn earworm in Virginia and poor to no control of tobacco budworm. If you decide to spray a pyrethroid, use the highest labeled rate and do not expect good control of heavy infestations or large worms.

Tobacco budworm adults are not readily attracted to blacklight traps and sometimes begin laying eggs on cotton prior to the time at which the bollworm egg threshold has been met; occasional fields may reach a 3 percent larval threshold prior to bollworm treatment initiation. Under these circumstances, tobacco budworm pheromone trap deployment and correct sight identification of adult tobacco budworms can assist in recognition of this situation. Unlike bollworm, tobacco budworm are 100% controlled by currently available Bt cotton varieties. It is not possible to visually distinguish budworm and bollworm eggs. Conservatively, base treatment decisions on the assumption that all eggs found in cotton are bollworm.

After the upper bolls that will be harvested have become difficult to cut with a pocket knife (approximately three weeks after bloom), they are normally safe from bollworm attack. Bollworm scouting can normally be stopped at that time—usually in late August to early September. Spot scouting for fall armyworms and European corn borers should continue through early September, especially in fields of late maturing cotton or in green areas.

Table 4.64 - Bollworm and Tobacco Budworm Thresholds in Cotton

Cotton Type	Threshold	Remarks
Conventional Cotton		
Prebloom	8 bollworms/100 terminals or 6 bollworms/100 squares	Limiting this treatment to one well-timed pyrethroid application is strongly recommended.
Egg	10+ eggs/100 terminals or 2 eggs/100 fruiting forms	After the onset of the major (third generation) bollworm moth flight.
Post-bloom larval	3 live worms/100 terminals, or 3 percent fresh damage to squares, blooms,or bolls	Usually after the egg threshold has been employed; also used after blooming begins and before major bollworm flight, particularly if tobacco budworms are present.
Two-gene cotton (Widestrike, Bollgard II, and TwinLink varieties)		
Egg	25 eggs/100 terminals or leaves	Sample both terminals and leaves. Check leaves at multiple levels throughout the canopy. If applying product at egg threshold, use Prevathon.

Table 4.64 - Bollworm and Tobacco Budworm Thresholds in Cotton (cont.)

Cotton Type	Threshold	Remarks
Larval	3 second-stage (1/8 inch or larger) bollworms/100 squares or bolls or 2 second-stage bollworms on 2 consecutive scouting trips or 1 second-stage bollworm on 3 consecutive scouting trips	Use against the major bollworm generation. Pay particular attention to bollworms in or under yellow, pink, or dried blooms, but only sample in proportion to their occurrence. No product will provide good control of larvae in bloom tags or bolls.
Damage	3 to 6 percent significantly damaged squares (would cause squares to abort) or bolls	
Three-gene cotton (Widestrike 3, Bollgard III, and TwinLink Plus varieties)		
Larval	3 second-stage (1/8 inch or larger) bollworms/100 squares or bolls or 2 second-stage bollworms on 2 consecutive scouting trips or 1 second-stage bollworm on 3 consecutive scouting trips	Use against the major bollworm generation. Pay particular attention to bollworms in or under yellow, pink, or dried blooms, but only sample in proportion to their occurrence. No product will provide good control of larvae in bloom tags or bolls.

Table 4.65 - Recommended Insecticides for Bollworm Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar (pyrethroids)	beta-cyfluthrin (Baythroid XL)	1.6[1]-2.6[2] oz	0	**RESTRICTED USE.**
	bifenthrin (Brigade 2EC)	3.2[1]-6.4[2] oz	14	**RESTRICTED USE.**
	esfenvalerate (Asana XL 0.66EC)	5.8[1]-9.7[2] oz	21	**RESTRICTED USE.**
	fenpropathrin (Danitol 2.4EC)	10.6[1]-16.0[2] oz	21	**RESTRICTED USE.**
	lambda-cyhalothrin (Karate EC) (Karate Z, Warrior II))	3.2[1]-5.1[2]oz 1.6[1]-2.56[2] oz	21 21	**RESTRICTED USE.**
	lambda-cyhalothrin + thiamethoxam (Endigo ZC)	3.5-5.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	chlorantraniliprole + lambda-cyhalothrin (Besiege)	6.5-12.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	dicrotophos + bifenthrin (Bidrin XPII)	8.0-10.5, 12.8* oz	30	**RESTRICTED USE.** Do no graze livestock, cut treated crops for feed, or feed gin trash. Do not apply as a ULV application. *Use higher rate with heavy infestations.
	zeta-cypermethrin (Mustang Max)	2.64[1]-3.6[2] oz	14	**RESTRICTED USE.**

[1]Standard rate
[2]High rate

Table 4.65 - Recommended Insecticides for Bollworm Control (cont.)

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar (others)	*Bacillus thuringiensis* (DiPel ES)	1.0-2.0 pt	0	For pyrethroid resistant corn earworms (bollworms) when tank mixed with a pyrethroid at a labeled use rate.
	chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)	16.0-38.0 oz	21	**RESTRICTED USE.** Do not allow meat or dairy animals to graze in treated areas. Do not feed gin trash or treated forage to meat or dairy animals.
	indoxacarb (Steward EC)	11.3 oz	14	
	methomyl (Lannate 2.4LV) (Lannate 90SP)	1.5 pt 0.5 lb	15 15	**RESTRICTED USE.**
	methoxyfenozide + spinetoram (Intrepid Edge)	4.0-8.0 oz	28	
	rynaxypyr (Coragen)	3.5-7.0 oz	21	
	spinetoram (Radiant SC) (prebloom) (postbloom)	2.8-8.0 oz 4.25-8.0 oz	28	
	spinosyn (Blackhawk)	1.6-3.2 oz	28	For second-generation tobacco budworms, 1.6 oz is adequate; for post-bloom bollworms, use the 3.2 oz rate.
	chlorantraniliprole (Prevathon)	14.0-27.0 oz	21	

[1]Standard rate
[2]High rate

European Corn Borer

European Corn Borer (ECB) larvae damage cotton by feeding on large bolls from early August through mid-September. In rank or late-maturing cotton, this damage can be significant. An earlier tunneling type of damage may occur within stems and leaf petioles, usually in mid-July through late August. Although this damage looks serious, with wilting and eventual death of the tissue above the feeding site, it causes no known economic loss. The major moth flight for the ECB often occurs a few days to three weeks later than the major bollworm flight. The female moths lay egg masses that contain 15-75 eggs each. These small, flat, scale-like masses are deposited on the underside of cotton leaves deep within the canopy. At first, early instars feed within the leaf petioles and stems, but they begin to enter and feed upon large bolls, sometimes within 48 hours, particularly after mid-August. Although the caterpillars of this species generally do not feed as extensively within the bolls as do bollworms, most bolls are destroyed. European corn borer is controlled by currently available Bt cotton varieties.

Controlling ECB damage in conventional cotton presents an unusual problem. The flat egg masses are almost impossible to find, even by the trained scouts searching heavily infested fields. By the time the larvae are found feeding on or within bolls, insecticide treatments are usually ineffective. Thus scouting for this pest benefits the producer little during the present year. However, scouting to detect the caterpillars is advised. If small larvae are present (3 percent or more), treatment may be prescribed if an active flight is confirmed. This situation may indicate a late, rank cotton crop that should be avoided in the future.

No control threshold has been developed since finding the egg masses is virtually impossible, and live caterpillars are spotted too late to achieve effective control. Growers must depend on another observation as a trigger for directing insecticide against the pest. Fortunately, because egg laying of the corn earworm usually occurs somewhat earlier than the ECB flight, employing

the egg threshold for bollworm control usually works well for ECB if treatments are extended into the ECB infestation period. An insecticide should be selected that is effective against both insects. If the major part of the ECB flight occurs after the bollworm flight has subsided and spraying has been completed, fields can be particularly susceptible. Under this condition, 3-6 total applications may be required for adequate suppression. This approach is recommended only where late rank growth points toward a high probability of ECB damage. Finding moths of this species in local light or pheromone traps, or flushing the adults from around or within cotton fields can help confirm the need for this extended treatment.

Table 4.66 - Recommended Insecticides for European Corn Borer Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	beta-cyfluthrin (Baythroid XL)	1.6-2.6 oz	0	**RESTRICTED USE.**
	bifenthrin (Brigade 2EC)	1.3-6.4 oz	14	**RESTRICTED USE.**
	chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)	16.0-38.0 oz	21	**RESTRICTED USE.** Do not allow meat or dairy animals to graze in treated areas. Do not feed gin trash or treated forage to meat or dairy animals.
	dicrotophos + bifenthrin (Bidrin XPII)	8.0-10.5, 12.8* oz	30	**RESTRICTED USE.** Do no graze livestock, cut treated crops for feed, or feed gin trash. Do not apply as a ULV application. *Use higher rate with heavy infestations.
	lambda-cyhalothrin (Karate EC) (Karate Z, Warrior II)	3.2 oz 1.6 oz	21 21	**RESTRICTED USE.**
	lambda-cyhalothrin + thiamethoxam (Endigo ZC)	3.5-5.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	chlorantraniliprole + lambda-cyhalothrin (Besiege)	6.5-12.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	rynaxypyr (Coragen)	3.5-7.0 oz	21	
	spinetoram (Radiant SC)	2.8-8.0 oz	28	
	zeta-cypermethrin (Mustang Max)	2.64-3.6 oz	14	**RESTRICTED USE.**

Stink Bugs

Stink bugs typically begin invading cotton fields in mid-July and build to damaging levels in August. Insecticide applications for the bollworm usually keep stink bug numbers below damaging levels if sprays include a pyrethroid or stink bug specific product. Problems with stink bugs usually only develop where the bollworm applications are limited or not applied at all. Stink bugs damage cotton by puncturing the carpal walls of bolls and feeding on the soft developing seeds. If bolls are small when feeding occurs, the boll will dry up, turn brown and either remain on the plant or be shed. Bollrot pathogens are sometimes introduced when feeding is concentrated on medium and larger bolls, resulting in portions of the boll being destroyed, hard-lock, and lower grades. External feeding damage appears as small round purplish depressions about the size of a pencil point. The feeding sites are slightly larger but closely resemble the spots that naturally appear on maturing bolls. Stink bug feeding sites can be confirmed by slicing the bolls open under the depressions. The damaged bolls will have a brown stain (bollrot organisms) in the seed area under these spots.

Stink bugs often occur in a clumped distribution within a cotton field; therefore, at least 10 samples should be taken throughout a field to determine if a problem exists. Both sweep nets and shake cloths can be used to sample for stink bugs, but our research showed that of the two, shake cloths tend to do a better job. A sweep net sample should consist of 25 hard sweeps using a pendulum-like motion with enough speed and force to end up with some leaves and small bolls in the net. An average of one stink bug per 25 sweeps could indicate a problem. A shake cloth sample should consist of placing a 3-foot long cloth on the ground between the rows, bending the bordering plants on either side (first one side, then the other) and vigorously shaking those plants to dislodge any insects. An average of one plant bug per 6 row feet (one 3-foot long shake cloth sample, both sides of the cloth) could indicate a problem.

Research in the southeast has resulted in a dynamic threshold based on percent of bolls injured by stink bug feeding, that changes with week after first bloom (see below).

Table 4.67 - Sampling for Stink Bugs and Thresholds in Cotton

Indicates presence	an average of 1 per 6 row feet using a 3-foot shake cloth
	an average of 1 per 25 sweeps using a 15-inch diameter sweep net
Boll damage	Week of bloom 1 = 50% internal boll damage; week 2 = 30%; weeks 3, 4 and 5 = 10%; week 6 = 20%; week 7 =30%; week 8 = 50%.

Table 4.68 - Recommended Insecticides for Stink Bug Control

Treatment	Insecticide (Formulation)	Amount per acre product	Time limits: days before harvest	Remarks
Foliar	acephate (Orthene 97)	8.0-12.0 oz	21	Do not feed treated forage or hay to livestock or allow animals to graze treated areas. For brown and green stink bugs.
	chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)	22.0-38.0 oz	21	**RESTRICTED USE.** Do not allow meat or dairy animals to graze in treated areas. Do not feed gin trash or treated forage to meat or dairy animals.
	clothianidin (Belay)	3.0-4.0 oz	21	Suppression only
	dicrotophos (Bidrin XP)	4.0-6.0 oz	30	**RESTRICTED USE.** For brown and green stink bugs.
	dicrotophos + bifenthrin (Bidrin XPII)	8.0-10.5, 12.8* oz	30	**RESTRICTED USE.** Do no graze livestock, cut treated crops for feed, or feed gin trash. Do not apply as a ULV application. *Use higher rate with heavy infestations.
	imidacloprid (Admire Pro)	0.9-1.8 oz	14	Suppression only
	imidacloprid + beta-cyfluthrin (Leverage 360)	3.2 oz	14	**RESTRICTED USE.** Do not graze treated fields after application.
	lambda-cyhalothrin + thiamethoxam (Endigo ZC) (brown stink bug) (green stink bug)	 5.5 oz 3.5-5.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	chlorantraniliprole + lambda-cyhalothrin (Besiege)	6.5-12.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.

Table 4.68 - Recommended Insecticides for Stink Bug Control (cont.)

Treatment	Insecticide (Formulation)	Amount per acre product	Time limits: days before harvest	Remarks
	pyrethroids (see product labels)			**RESTRICTED USE.** Pyrethroids, when applied two or more times against bollworms, usually provide adequate suppression of green stink bugs.
	thiamethoxam (Centric 40WG)	2.0 oz	21	

Aphids

A number of beneficial insects and fungal diseases can hold aphid numbers below economic threshold levels. By limiting early season insecticide applications, the grower is allowing beneficial insect populations to build, decreasing the chances of developing resistant aphid populations (observed in North Carolina and Virginia), and possibly reducing or eliminating the need for insecticide applications later in the season. An aphid rating level of four or more just before boll opening, plus the presence of honeydew, is probably a good indicator of the need to treat. Aphid control with insecticides should be attempted only as a last resort, particularly in early season (before major bollworm moth flight).

Table 4.69 - Aphid Rating Scale

0	No aphids
1	Occasional plants with low numbers of aphids
2	Plants with low numbers common; heavily infested plants rare; honeydew visible occasionally
3	Most plants with some aphids; occasional plants heavily infested; honeydew easily visible in most areas of the field
4	Heavily infested plants common; aphids clumped on upper leaves
5	Many heavily infested plants

Table 4.70 - Recommended Insecticides for Aphid Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	acetamiprid (Assail 70WP)	0.6-1.1 oz	28	
	bifenthrin (Brigade 2EC)	2.6-6.4 oz	14	**RESTRICTED USE.**
	clothianidin (Belay)	3.0-4.0 oz	21	
	dicrotophos (Bidrin 8)	4.0 oz	30	**RESTRICTED USE.**
	flupyradifurone (Sivanto)	7.0-10.5 oz	14	
	imidacloprid (Admire Pro)	0.9-1.7 oz	14	
	thiamethoxam (Centric 40WG)	1.25-2.0 oz	21	

Table 4.71 - Recommended Insecticides for Aphid/Bollworm Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	cyfluthrin + imidacloprid (Leverage 2.7)	3.0-3.75 oz	21	**RESTRICTED USE.**
	dicrotophos + bifenthrin (Bidrin XPII)	8.0-10.5, 12.8* oz	30	**RESTRICTED USE.** Do no graze livestock, cut treated crops for feed, or feed gin trash. Do not apply as a ULV application. *Use higher rate with heavy infestations.
	lambda-cyhalothrin + thiamethoxam (Endigo ZC)	3.5-5.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.

Spider Mites

Spider mites can occur during any time of the season, but are favored by dry weather and/or the removal of alternative hosts (e.g., corn). Mite damage first appears as a slight yellowing of the leaves, which later changes to a purplish or bronze color and is usually associated with webbing. Damage occurs especially in spots or on field edges but widespread defoliation is not uncommon if favorable conditions persist.

Spider mites can be checked while scouting for other insect pests. Active mite populations should be confirmed before applications are made. Delaying treatment should also be considered if rainy, humid conditions are predicted in the near future. Rainy, humid conditions favor a fungus that preys upon mites and may greatly reduce mite numbers.

Table 4.72 - Recommended Insecticides for Spider Mite Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	bifenthrin (Brigade 2EC)	3.8-6.4 oz	14	**RESTRICTED USE.**
	dicofol (Kelthane MF 4E)	1.5-3.0 pt	30	Do not make more than 2 applications/season. Do not feed cotton stalks or trash to meat or dairy animals.
	dicrotophos + bifenthrin (Bidrin XPII)	8.0-10.5, 12.8* oz	30	**RESTRICTED USE.** Do no graze livestock, cut treated crops for feed, or feed gin trash. Do not apply as a ULV application. *Use higher rate with heavy infestations.
	etoxazole (Zeal)	0.66-1.0 oz	28	Zeal is predominantly an ovicide (egg activity) and larvicide and should be applied early in the life cycle of mites.
	fenpropathrin (Danitol 2.4EC)	10.6-16.0 oz	21	**RESTRICTED USE.**
	propargite (Comite 6.55EC[1])	1.0-2.0 pt	14	
	spiromesifen (Oberon 4SC)	3.0 oz (early season) 4.0-8.0 oz (mid-late season)	30	

[1]not after bolls begin to open

Loopers

Cabbage and soybean loopers rarely damage cotton because they prefer foliage, are prone to virus attack and occur sporadically. Scouting for this pest, which normally appears late season, is done by observing foliage during scouting for other pests. As a general rule, if defoliation exceeds 30% in cotton with a significant portion (25% or more) of the bolls still immature and filling out, treatment may be needed. Soybean loopers are difficult to control with insecticides. Because foliage feeding typically begins at the bottom of the cotton plant and proceeds upward and outward, foliage feeding may be beneficial in preharvest cotton that has begun to open. The brownish larval frass (droppings) can be plentiful and temporarily stain opening cotton; however, this is not thought to be an economic problem. Since loopers are usually controlled by naturally occurring diseases and chemical controls are sometimes not effective due to resistance, recommendations will be available on a year to year basis through your local extension office.

Fall Armyworms

The presence of fall armyworms (FAW) and their damage is recorded as part of bollworm scouting. Additional samples are unnecessary. FAW migrate into Virginia from the south so numbers are generally highest in the southern part of the state. FAW prefer blooms and bolls of all sizes. These caterpillars can be extremely damaging if present in moderate numbers and can become established late in the season. They can feed on mature bolls normally resistant to bollworm penetration. Because FAW are not always controlled effectively by the same insecticides as bollworms, it is very important that they be identified correctly. Also, because fall armyworms are difficult to control with insecticides, treatments are best applied at an early boll bract feeding stage.

Table 4.73 - Recommended Insecticides for Fall Armyworm Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	chlorpyrifos (Lorsban 4E)	1.0-2.0 pt	14	Various rates and combinations may be recommended for armyworm control, depending upon the phenology and the age distribution and population levels of larvae. Pyrethriods will provide some control of fall armyworms hatching from egg masses. Fall armyworms may have more difficulty becoming established following Karate or Capture treatments used for bollworm control.
	chlorpyrifos + lambda-cyhalothrin (Cobalt Advanced)	16.0-38.0 oz	21	**RESTRICTED USE.** Do not allow meat or dairy animals to graze in treated areas. Do not feed gin trash or treated forage to meat or dairy animals.
	chlorantraniliprole + lambda-cyhalothrin (Besiege)	6.5-12.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	dicrotophos + bifenthrin (Bidrin XPII)	dicrotophos + bifenthrin (Bidrin XPII)	30	**RESTRICTED USE.** Do no graze livestock, cut treated crops for feed, or feed gin trash. Do not apply as a ULV application. *Use higher rate with heavy infestations.
	indoxacarb (Steward EC)	9.2-11.3 oz	14	Various rates and combinations may be recommended for armyworm control, depending upon the phenology and the age distribution and population levels of larvae. Pyrethriods will provide some control of fall armyworms hatching from egg masses. Fall armyworms may have more difficulty becoming established following Karate or Capture treatments used for bollworm control.

Table 4.73 - Recommended Insecticides for Fall Armyworm Control (cont.)

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
	lambda-cyhalothrin + thiamethoxam (Endigo ZC)	3.5-5.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	methomyl (Lannate 2.4LV) (Lannate 90SP)	1.5 pt 0.5 lb	15 15	Various rates and combinations may be recommended for armyworm control, depending upon the phenology and the age distribution and population levels of larvae. Pyrethriods will provide some control of fall armyworms hatching from egg masses. Fall armyworms may have more difficulty becoming established following Karate or Capture treatments used for bollworm control.
	methoxyfenozide (Intrepid 2F)	4.0-10.0 oz	14	
	methoxyfenozide + spinetoram (Intrepide Edge)	6.0-8.0 oz	28	
	rynaxypyr (Coragen)	3.5-7.0 oz	21	
	spinetoram (Radiant SC)	4.25-8.0 oz	28	
	spinosyn (Blackhawk)	2.4-3.2 oz	28	Various rates and combinations may be recommended for armyworm control, depending upon the phenology and the age distribution and population levels of larvae. Pyrethriods will provide some control of fall armyworms hatching from egg masses. Fall armyworms may have more difficulty becoming established following Karate or Capture treatments used for bollworm control.
	chlorantraniliprole (Prevathon)	14.0-27.0 oz	21	

Table 4.74 - Recommended Insecticides for Beet Armyworm Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
	dicrotophos + bifenthrin (Bidrin XPII)	8.0-10.5, 12.8* oz	30	**RESTRICTED USE.** Do no graze livestock, cut treated crops for feed, or feed gin trash. Do not apply as a ULV application. *Use higher rate with heavy infestations.
	indoxacarb (Steward EC)	9.2-11.3 oz	14	
	methoxyfenozide (Intrepid 2F)	4.0-10.0 oz	14	
	methoxyfenozide + spinetoram (Intrepide Edge)	4.0-8.0 oz	28	
	rynaxypyr (Coragen)	3.5-7.0 oz	21	

Table 4.74 - Recommended Insecticides for Beet Armyworm Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
	spinetoram (Radiant SC)	4.25-8.0 oz	28	
	chlorantraniliprole + lambda-cyhalothrin (Besiege)	6.5-12.5 oz	21	**RESTRICTED USE.** Do not graze livestock in treated areas.
	spinosyn (Blackhawk)	2.4-3.2 oz	28	
	chlorantraniliprole (Prevathon)	14.0-27.0 oz	21	

Table 4.75 - Recommended Insecticides for Cutworm Control

Treatment	Insecticide (Formulation)	Amount product per acre	Time limits: days before harvest	Remarks
Foliar	acephate (Orthene 97)	12.0 oz	21	Control is most effective when ground application is made in the evenings and sprays are directed toward the base and lower portion of plants.
	beta-cyfluthrin (Baythroid XL)	0.8-1.6 oz	14	**RESTRICTED USE.**
	bifenthrin (Brigade 2EC)	2.6-6.4 oz	14	**RESTRICTED USE.**
	dicrotophos + bifenthrin (Bidrin XPII)	8.0-10.5, 12.8* oz	30	**RESTRICTED USE.** Do no graze livestock, cut treated crops for feed, or feed gin trash. Do not apply as a ULV application. *Use higher rate with heavy infestations.
	esfenvalerate (Asana XL 0.66EC)	5.8 oz	21	**RESTRICTED USE**.
	fenpropathrin (Danitol 2.4EC)	8.0 oz	21	**RESTRICTED USE.**
	lambda-cyhalothrin (Karate EC) (Karate Z) (Warrior T)	 1.92 oz 0.96 oz 1.92 oz	 21 21 21	**RESTRICTED USE.**
	zeta-cypermethrin (Mustang Max)	1.28-1.92 oz	14	**RESTRICTED USE.**

Beneficial Insects

About a dozen beneficial insects are common in Virginia cotton. Ambush bugs, big-eyed bugs, minute pirate bugs, green lacewings, two species of ladybird beetles, and several types of spiders are examples. They are of two types: 1) predators that prey upon an insect pest, or 2) parasites that live within the host insect. These insects, particularly the predators, reduce the number of eggs and larvae of bollworms, caterpillars and aphids. Because these allies lessen the impact of pest insects, common sense dictates that producers use them as a management tool. Their presence often means that growers can delay and, on occasion, eliminate some insecticide applications.

Many complex factors are involved in determining just how many of each beneficial insect species are needed to influence a given level of pests. Therefore, it is usually not possible to asses the value of these insects except in a very general way. If relatively high numbers of beneficial insects are eating a large portion of aphids or bollworm eggs and larvae, the treatment threshold will be reached later than would otherwise be the case, reducing the number of insecticide applications needed. However, the rapid increase in pest populations, the third generation of bollworms, will often overwhelm the beneficial population and applications become necessary. The careful observation of sound economic thresholds offers the producer the best odds of balancing beneficial insect numbers against damaging insects.

Introduction to Weeds and Weed Management

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Weeds and Their Impacts

There are numerous definitions of a weed. The following are some common definitions:

- A plant that is out of place and not intentionally sown
- A plant that grows where it is not wanted or welcomed
- A plant whose virtues have not yet been discovered
- A plant that is competitive, persistent, pernicious, and interferes negatively with human activity

No matter which definition is used, weeds are plants whose undesirable qualities outweigh their good points, at least according to humans. Human activities create weed problems, since no plant is a weed in nature. Though we may try to manipulate nature for our own good, nature is persistent. Through manipulation, we control certain weeds while other, more serious weeds may thrive due to favorable growing conditions. Weeds are naturally strong competitors, and those weeds that can best compete always tend to dominate.

Both humans and nature are involved in plant-breeding programs. The main difference between the two programs is that humans breed plants for yield and/or aesthetic qualities, while nature breeds plants for survival.

Characteristics of Weeds

There are approximately 250,000 species of plants worldwide; of those, about 3 percent, or 8,000 species, behave as weeds. Of those 8,000, only 200 to 250 are major problems in worldwide cropping systems. A plant is considered a weed if it has certain characteristics that set it apart from other plant species. Weeds possess one or more of the following characteristics that allow them to survive and increase in nature:

- Abundant seed production
- Rapid population establishment
- Seed dormancy
- Long-term survival of buried seed
- Adaptation for spread
- Presence of vegetative reproductive structures
- Ability to occupy sites disturbed by humans

Abundant Seed Production

Weeds can produce tens or hundreds of thousands of seeds per plant, while most crop plants only produce several hundred seeds per plant. Below are some examples of approximate numbers of seeds produced per weed:

- Giant foxtail—10,000
- Common ragweed—15,000

- Purslane—52,000
- Lambsquarters—72,000
- Pigweed—117,000

Since most weeds deposit their seed back to the soil, seed numbers in the soil increase rapidly from year to year if the weeds are not managed. Despite the fact that many weed seeds are either not viable, eaten by animals or insects, or decompose within several months after they are deposited, hundreds of millions of viable weed seeds per acre can still be present and waiting to germinate.

Rapid Population Establishment

Most weeds can germinate and become established relatively quickly. They also produce viable seed even under environmental and soil conditions that are not favorable for most crop plants. Under ideal conditions, dense weed populations can thrive and easily outcompete a crop if left unchecked. Under poor conditions, certain weeds can adapt and produce some viable seed in a relatively short time period (6 to 8 weeks).

Seed Dormancy

Dormancy is basically a resting stage or a temporary state in which the weed seed does not germinate because of certain factors. Seed dormancy allows the weed to disperse itself in time. Dormancy is a survival mechanism that prevents germination when conditions for survival are poor. For example, seeds of summer annual weeds will generally not germinate in the fall, preventing them from being killed by cold, winter conditions. The various factors that affect dormancy are temperature, moisture, oxygen, light, the presence of chemical inhibitors, tough seed coat, and immature embryos.

Long-Term Survival of Buried Seed

Most crop, turf, and ornamental plant seeds lose their viability after a few years and will usually rot if they don't germinate soon after planting. Weed seeds tend to resist decay for longer periods and remain dormant. If conditions are adequate, buried weed seeds have the potential to remain viable for 40 years or more. Broadleaf weed seeds tend to last longer in the soil than grassy weed seeds since they usually have tougher seed coats. In most cases, the majority of seeds only exist in the soil for a few years due to germination, decomposition, predator feeding, or other factors. However, with the large number of seeds produced, a small percentage may remain viable for long-term survival.

Adaptation for Spread

Weeds have certain mechanisms for easy dispersal of seeds. Most seeds or seed pods have special structures allowing them to cling, fly, or float. Common cocklebur and burdock seed pods have hooks that attach to animal fur or feathers; curly dock seeds have bladderlike structures that allow them to float; and milkweed, dandelion, and thistle seeds have a feathery pappus that allows them to be carried by the wind. Other weeds, such as jewelweed or snapweed, have pods that "explode" when the seeds are mature, projecting them several feet from the parent plant. Weeds also can be spread when animals or birds eat their fruit and deposit the seeds with their droppings. Weed seed can be widely spread through crop seeds, grains feed, hay, straw, manure, and mulch, to name a few. These and other human activities probably account for the long-distance spreading of weeds—for example, interstate and worldwide freight transport and travel.

Vegetative Reproductive Structures

Many weeds have two means of reproduction: by seed and vegetatively. Most perennial weeds possess special vegetative structures that allow them to reproduce asexually and survive. These structures contain carbohydrates (food reserves, sugars) and have numerous buds in which new plants can arise. Most of these underground parts grow rapidly (many feet per year) and can penetrate and emerge from deep (2 to 5 feet or more) in the soil. Such perennial structures include the following:

- Stolons—aboveground, horizontal stems that root at the nodes (e.g., crabgrass, bermudagrass, ground ivy)
- Rhizomes—belowground, thickened stems that grow horizontally in the upper soil layers (e.g., quackgrass, Johnsongrass, wirestem muhly, Canada thistle)
- Tubers—enlarged rhizomes with compressed internodes located at the ends of rhizomes (e.g., yellow nutsedge, Jerusalem artichoke, potato)

- Bulbs—modified leaf tissues for carbohydrate storage that are located at the base of the stem or below the soil line (e.g., wild garlic, onion, Star-of-Bethlehem)
- Budding roots—modified roots that can store carbohydrates and grow both vertically and horizontally (e.g., hemp dogbane, Canada thistle).

Despite these vegetative reproductive structures, many perennials also reproduce by seed. Some depend heavily on reproduction by seed (e.g., dandelion), while for others it is less important (e.g., yellow nutsedge).

Ability to Occupy Disturbed Sites

Weeds are very opportunistic and capable of growing under adverse conditions. When conditions are adequate, weed seeds germinate and colonize if left unchecked. When a site is disturbed, weeds are usually the first to emerge. If a weed becomes established first, it has the competitive advantage over crop plants or desirable vegetation.

Problems with Weeds

Weeds are troublesome in many ways. Primarily, they reduce crop yield by competing for:

- Water
- Light
- Soil nutrients
- Space
- CO_2

Other problems associated with weeds include:

- Reducing crop quality by contaminating the commodity
- Interfering with harvest
- Serving as hosts for crop diseases or providing shelter for insects to overwinter
- Limiting the choice of crop rotation sequences and cultural practices
- Producing chemical substances that cause allergies or toxins to humans, animals, or crop plants (allelopathy)
- Producing thorns and woody stems that cause irritations and abrasions to skin, mouths, or hooves of livestock
- Being unsightly, dominant, or aggressive
- Obstructing visibility along roadways, interfering with delivery of public utilities (power lines, telephone wires), obstructing the flow of water in waterways, and creating fire hazards
- Accelerating deterioration of recreational areas, parking lots, buildings, and equipment
- Invading exotic weed species that can displace native species in stabilized natural areas

Cost of Weeds

Weeds are common on all 485 million acres of U.S. cropland and almost one billion acres of range and pasture. Weeds are one of the most significant threats to crop production in North America with losses in crop yield and quality along with the costs of control having a significant economic impact for many farmers. In 1992, it was estimated that weeds caused a 1 to 15% loss in corn yield and a 2 to 20% loss in soybean yield even with the use of herbicides and nonchemical control tactics. In 2003 it was estimated that without herbicides and the substitution of alternatives (e.g., cultivation, hand-weeding) would result in a loss of $13.3 billion in food and fiber production. The total impact of herbicide nonuse would be an income loss of $21 billion, which includes $7.7 billion in increased costs for weed control and $13.3 billion in yield losses. The most recent survey conducted by scientist members of the Weed Science Society of America considered corn and soybean yield performance in the US from 2007 to 2013 in the absence of herbicides. Without effective herbicides, they estimated that weeds would cause a 52% corn and 49 soybean yield loss. This was based on corn and soybean performance in university weed control trials.

Weed control and other input costs (e.g., seed, fertilizer, other pesticides, fuel, etc.) vary with the crop. In Pennsylvania in 2015, herbicide costs for corn grain production were estimated to be about $42 per acre for reduced till and $45 for no-till with total variable costs of about $440 per acre. For full season soybean, cost of herbicide averaged $13 per acre without a burndown application with a total variable cost of about $200 per acre. For winter wheat, herbicide costs averaged about $6 per acre with a total variable cost of about $260. The cost of herbicides for weed control remains 10% or less the total variable cost for all agronomic crops grown in Pennsylvania. Several factors help determine the relative costs of weed control from one crop to another, including the competitive ability of the crop, the weeds present, the contribution of nonchemical control practices, the tillage method, management decisions, the type of crop seed used (i.e., normal versus resistant GMO variety) and the value of the crop. Weeds not only cause losses in crops but also can affect livestock production if poisonous weeds are present or weeds invade and reduce the carrying capacity or render the pasture useless.

Benefits of Weeds

Despite the negative impacts of weeds, some plants usually thought of as weeds may actually provide some benefits such as:

- Stabilizing and adding organic matter to soils
- Providing habitat and feed for wildlife
- Providing nectar for bees and other pollinator species
- Offering aesthetic qualities
- Serving as a genetic reservoir for improved crops
- Providing products for human consumption and medicinal use
- Creating employment opportunities

Weeds have a controversial nature. But to the agriculturist, they are plants that need to be managed, in an economical and practical way, in order to produce food, feed, fiber, and ornamental and vegetative cover for humans and animals. In this context, the negative impacts of weeds indirectly affect all living beings.

Weed Ecology and Biology

Origins of Weeds

Weeds are found throughout the world. However, all are not common in every region. Since weeds can be easily spread, more and more are being disseminated to places where they were not originally found. Only about 40 percent of the weeds found in the United States are native, while the remaining 60 percent are considered exotic or imported. Below are some examples of weeds and their origins:

- United States—common and giant ragweed, common milkweed, hemp dogbane, fall panicum, common cocklebur, poison ivy, marestail (horseweed), nightshade, wild or common sunflower, wild onion, Joepyeweed, ironweed, smooth sumac, spotted waterhemlock, goldenrod, hedge bindweed, burcucumber, dodder, wild four-o'clock, devil's claw, common pokeweed, reed canarygrass, jimsonweed, groundcherry, eastern black nightshade, horsenettle, common cattail, stinging nettle
- South America—pigweed species, prickly sida, giant salvinia, and parrot feather watermilfoil
- Europe—quackgrass, chickweed, dandelion, Canada thistle, common lambsquarters, common purslane, wild garlic, yellow foxtail, common burdock, garlic mustard, purple loosestrife, poison hemlock, wild carrot, chicory, bull thistle, St. Johnswort, yellow nutsedge, ground ivy, downy brome, smooth and large crabgrass, annual bluegrass, Johnsongrass
- Asia or Africa—Johnsongrass, wild carrot, giant foxtail, velvetleaf, shattercane, kudzu, Japanese knotweed, spotted knapweed, multiflora rose, tree-of-heaven, mile-a-minute, Japanese stiltgrass, witchweed, hydrilla, Eurasian watermilfoil, autumn olive, bush honeysuckles, Bradford pear

Weeds not native to an area tend to become invasive and spread rapidly. In some cases, these alien species have displaced natural populations of native vegetation. Alien species distribute so rapidly not only because their natural enemies were not brought with them but also because they may easily adapt to areas disturbed by people.

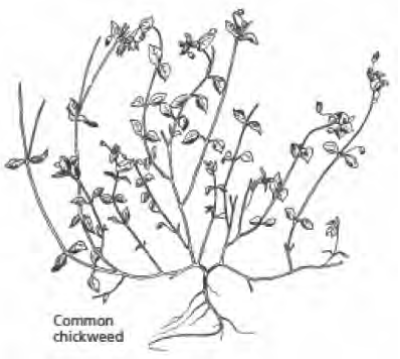
Classification of Weeds

Almost all plants are categorized by some sort of plant classification system and given a scientific name to identify them anywhere in the world. Keep in mind the scientific name (i.e., genus and species) is universal, but the common name of a weed may differ from region to region. For example, velvetleaf is also known as buttonweed and butter print; common lambsquarters can be referred to as pigweed, goosefoot, fat-hen, or bacon-weed; and wild carrot is known as Queen Anne's lace. Weeds are also classified by other means. In general, they can be classified by their structure and appearance (for example, dicots [broadleaves] and monocots [grasses and sedges]), habitat, or physiology. A common categorization system groups them according to their life cycle (how long they live). The three major life cycle groups are annuals, biennials, and perennials.

Annuals

Annuals are generally divided further into summer annual and winter annual weeds. Summer annuals germinate in the spring, mature, produce seed, and die in one growing season. Large crabgrass, giant foxtail, smooth pigweed, common lambsquarters, common ragweed, velvetleaf, hairy galinsoga, and common purslane are examples of troublesome summer annuals.

Winter annual weeds germinate in late summer or fall, mature, produce seed, and then die the following spring or summer. Examples of winter annuals include common chickweed, henbit, shepherdspurse, downy brome, and annual bluegrass. (Some annual bluegrass subspecies can occasionally function as a perennial.)

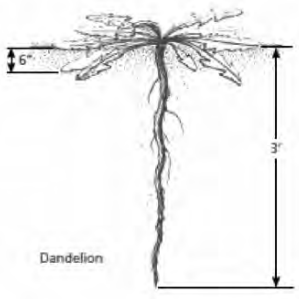


Biennials

Biennial weeds grow from seed any time during the growing season. They normally produce a rosette of leaves close to the soil surface the first year, then flower, mature, and die during the second year. A true biennial never produces flowers or seeds the first year. There are relatively few biennial weeds. Some examples include wild carrot, common burdock, bull and musk thistle, and poison hemlock.

Perennials

Perennial weeds live for more than two years and can be divided into two groups: simple and creeping. Simple perennials form a deep taproot and spread primarily by seed dispersal. Some examples of simple perennials include dandelion, broadleaf plantain, curly/broadleaf dock, autumn olive, and common pokeweed. Creeping perennials may be either herbaceous or woody, and can spread by both vegetative structures as well as by seed. Some common herbaceous perennials include Canada thistle, common milkweed, hemp dogbane, creeping buttercup, slender speedwell, ground ivy, quackgrass, and yellow nutsedge. Some examples of woody perennials include poison ivy, multiflora rose, Japanese knotweed/bamboo, brambles, wild grape, and Virginia creeper. Creeping perennials become established by seed or by vegetative parts. Since perennial weeds live indefinitely, their persistence and spread is not as dependent on seed as the other two weed groups.



Weed Management Techniques

Over the past decade or so there have been a number of rapid changes in weed management techniques and ideologies. New directions in weed management include shifting crop management practices, continuously changing weed control technologies, increasing concern for the environment, and using computer software and electronic information technology for decision making, record keeping, and data managing. Environmental concerns have resulted in more no-till, cover crop, and organic crop production systems. Advancements in technology have allowed the development of lower-use-rate herbicides with less soil persistence, biotechnology that produces genetically modified crops, and computers that allow us to develop predictive models for weed and crop development, while weed mapping and GPS units enhance more precise herbicide application on specific weed patches and at various herbicide rates. However, despite all these advances, mechanical and chemical tactics still provide the majority of weed control in many settings. Regardless of the weed control tactic or setting, knowledgeable and experienced field consultants and technicians will be necessary to diagnose problems, interpret information and results, and provide practical advice about weed management.

Since weeds are so prevalent in many areas of the landscape, management techniques are necessary to maintain order. Weed management is most successful when it involves an integrated approach using a variety of methods. The common methods used to manage weeds include prevention and cultural, mechanical, biological, and chemical means. Relying on any single tactic can lead to severe problems such as high costs and crop failure. In planning a weed management strategy, keep in mind the available equipment and time, land characteristics, weed spectrum, and yield objective. Management inputs such as herbicides sometimes can be reduced, but alternative approaches must be substituted if the production level is to be maintained.

Integrated Weed Management

Corn and soybean fields that are weed-free for the first 4 to 6 weeks after planting will often yield the same as fields that are weed-free for the entire growing season. This approach relies on a residual soil-applied herbicide program. Weeds that germinate with the crop but are controlled in a timely (3 to 4 weeks after planting) fashion will not impact final yields. This approach relies upon effective and timely postemergence weed control. In addition, if weeds are kept out of the field for 4 to 6 weeks after crop emergence, any weeds that later invade will not reduce yield significantly, although they may produce seeds, cause harvesting problems, or reduce crop quality. Also, it is not necessary to control all weeds in a field to achieve maximum yield. Weed populations of 10 to 20 weeds per 10 square yards are sufficient to cause severe yield loss. However, weed populations at 1 plant per 10 square yards will have no impact on final yield. The impact of weed populations between 1 and 10 per yard is difficult to predict. The decision to treat the field depends on the weed species present, crop vigor, weather conditions, and herbicide cost.

Prevention

Preventative methods are used to stop the spread of weeds. It is usually easier to prevent the introduction of weeds than it is to control them after establishment. Preventative practices include cleaning tillage and harvesting or mowing equipment of weed seeds and vegetative structures; planting certified, weed-free crop seed or sod; and controlling weeds in barnyards, around structures, and along fencerows, roadways, and ditch banks. Scouting areas to assess weed populations and controlling them before they spread further is another means for preventing additional weed problems.

Early Season Weed Scouting

The first key to weed management is proper weed identification. The best method for timely identification is through field scouting. The first reports on weed conditions in a field are needed within two weeks after crop emergence to evaluate herbicide performance and to determine if there is a need for rotary hoeing, cultivation, or postemergence herbicides. Earlier scouting will be needed in no-till fields where a knockdown or early preplant herbicide may be applied. Identify and record all weed species found. Determine the severity of the infestation by counting the number of weeds found per 10 feet of row for large infestations or per 100 feet of row for smaller infestations in all areas sampled. Sample areas should represent no more than 5 acres, so sample enough areas to get an accurate count of the different weeds present in the field or on the farm. The approximate height and growth stage of both weeds and crop should be recorded. Along with weed reports, early soil moisture observations are important. They serve as indicators of herbicide effectiveness. Adequate moisture is necessary for effective weed control with all soil-applied herbicides. Too little rainfall can mean there is not enough moisture to allow adequate mobilization of the herbicide; too much rain can cause more soluble herbicides to move downward below the zone where they are most effective. Postemergence herbicides usually are most effective when weeds are young and actively growing. The degree of control with

these herbicides will vary due to differences in weed species, growth stages, weather conditions, and herbicide application method. To select the best possible herbicide and apply it at the optimum time to maximize control, the manager needs to be able to identify weed seedlings when they are small.

Cultural

Cultural and crop management techniques provide a healthy crop to best compete with weeds. Competition from crop, turf, or desirable vegetative cover can be an inexpensive and effective aid to weed management if used to its fullest advantage. Examples of cultural techniques include following soil test recommendations for fertilizer and lime; selecting the best varieties for the environmental conditions; planting dense populations at the proper timing; proper mowing practices; scouting fields or areas regularly for weeds, insects, and diseases, and controlling them when necessary; and including crop rotations in the system including cover crops. Composting, ensiling, or feeding weeds or weed-infested crops to livestock can destroy the viability of weed seeds. The heat and/or digestive acids break down the majority of weed seeds. However, some seeds pass through livestock or the composting process unharmed and can germinate if spread back onto the land.

Managing Cover Crops to Help Suppress Weeds

Cover crops provide important benefits to the Mid-Atlantic Region including soil and water conservation and nutrient retention. Some growers are also finding that cover crops can help reduce weed problems and especially winter annuals like horseweed. The following management factors should be considered to enhance weed suppression with your cover crops.

Species selection. Choose cover crops based on your objectives. If weed suppression is an objective, select an aggressive species that will cover the ground quickly. If you desire a cover crop that will protect the soil through the fall and winter and suppress winter annual weeds, plant a winter cereal in late summer or early fall.

Establishment date. Establishing a hardy winter cover, such as cereal rye, as early in the fall as possible will result in greater cover crop biomass over the winter and rapid growth during the spring. Other establishment dates may be preferable for different cover crops depending on the species and your objectives.

Seeding rate, row spacing, and planting arrangement. The seeding rate and arrangement of the cover crop can influence weed suppression. Planting at higher-than-normal seeding rates and in narrow rows can influence the amount of soil cover, particularly in the first several weeks after seeding. Thick, dense cover crop stands can help reduce the establishment of weeds.

Soil fertility. It is important to provide adequate soil fertility to cover crops to ensure they are competitive and successful. This is particularly true for small grains like cereal rye and wheat and forage radish, which require adequate nitrogen. Lime may be necessary to maintain or raise the soil pH for legumes like hairy vetch and red clover. Regular soil tests will help you determine how best to manage your cover crops so as to maximize their beneficial effects on weed suppression and soil quality.

Termination timing. Allowing a cover crop to grow as long as possible before controlling it reduces weed populations through competition for light, nutrients, and moisture. In no-till, letting the cover crop achieve maximum dry matter production (often at flowering or beyond) will increase weed suppression. This may mean delaying termination and cash crop planting until the cover crop has achieved sufficient growth to suppress weeds (weed suppression may require dry matter production of at least 4,000 pounds per acre). Keep in mind, however, that high-biomass cover crops can be more challenging to manage, may need shorter-season cash crops to allow for adequate cover crop growth, and may require specialized planting equipment or may increase the potential for some insect pest problems.

Cover crops can be terminated mechanically or with herbicides. Each method has advantages and disadvantages. Mowing can be effective for some annual cover crops, but the mulch may degrade quite rapidly because it has be chopped. Plowing can be an effective physical control for cover crops, but the benefit of the weed-suppressive mulch in the subsequent cash crop is lost. The roller-crimper offers effective physical control of some annual cover crops, but without an accompanying herbicides, control is delayed until the winter annual cover crops are flowering and control can be inconsistent. Rolling creates a longer-lived mulch layer than mowing. Herbicides can effectively control most cover crops, but product selection and application timing are important.

Mechanical

Mechanical or physical techniques either destroy weeds or make the environment less favorable for seed germination and weed survival. These techniques include hand-pulling, hoeing, mowing, plowing, disking, cultivating, and digging. If adequate weed

control is obtained from other methods such as herbicides, tillage or cultivation may not be necessary, which in turn may avoid soil crusting and soil erosion that can occur when soils are routinely tilled. Mowing removes the seed heads of most weeds and reduces the amount of spread of seed in an area. Mowing is used primarily for weed control in lawns, meadows, pastures, waste areas, and along roadsides. Digging or pulling is an effective method of controlling a limited number of weeds. Smaller weeds can be easily hand-pulled or hoed in small garden areas or flower beds; however, the use of heavy machinery may be necessary to remove large woody weeds such as multiflora rose, tree of heaven, and autumn olive. Mulching (straw, wood chips, compost, gravel, plastic, landscape fabric, etc.) can also be considered a mechanical control means since it uses a physical barrier to block light and impede weed growth. In landscaping and vegetable production, it usually helps to reduce the need for other weed management tactics.

Biological

Biological weed control involves the use of other living organisms, such as insects, diseases, or livestock, for the management of certain weeds. In theory, biological control is well suited for an integrated weed management program. However, the limitations of biological control are that it is a long-term undertaking, its effects are neither immediate nor always adequate, only certain weeds are potential candidates, and the rate of failure for past biological control efforts has been fairly high. There have been a few success stories of weed species (e.g., St. Johnswort, prickly pear, multiflora rose, purple loosestrife, thistles) being managed or affected by insect or disease biocontrol agents. Herbivores such as sheep and goats can provide successful control of some common pasture weeds. Finally, conservation biological control may improve our ability to manage weeds and use less herbicide. This involves enhancing populations of natural enemies by manipulating field habitats to create more favorable environments for predator insects and rodents. Ground beetles, crickets, ants, and mice are some of the more common weed seed predators. In general, providing cover in the form of living or dead crops, less soil disturbance, and avoiding the use of toxic pesticides can encourage these biocontrol agents. Research continues in this area of weed management.

Chemical

Chemicals used for the control of weeds are called herbicides. Herbicides can be defined as crop- (or desirable plant) protecting chemicals used to kill weedy plants or interrupt normal plant growth. Herbicides provide a convenient, economical, and effective way to help manage weeds. They allow fields to be planted with less tillage, allow earlier planting dates, and provide additional time to perform the other tasks that farm or personal life require. Due to reduced tillage, soil erosion has been reduced from about 3.5 billion tons in 1938 to one billion tons in 1997, thus reducing soil from entering waterways and decreasing the quality of the nation's surface water. Without herbicide use, no-till agriculture becomes impossible. However, herbicide use also carries risks that include environmental, ecological, and human health effects. It is important to understand both the benefits and disadvantages associated with chemical weed control before selecting the appropriate control.

Herbicides may not be a necessity on some farms or landscape settings, but without the use of chemical weed control, mechanical and cultural control methods become that much more important. There are many kinds of herbicides from which to choose. Many factors determine when, where, and how a particular herbicide can be used most effectively. Understanding some of these factors enables you to use herbicides to their maximum advantage.

No-till Weed Management

Successful production of no-till crops requires control of existing vegetation at planting (cover crops and weeds) and broadleaf and grass weeds that emerge after planting. A diversity of herbicides and cover crop and residue situations makes it impossible to utilize a single program to efficiently control weeds and grasses in all situations. Herbicide selection based on weed identification histories of each field is necessary to achieve maximum yield potential. Fields with heavy crop residues may require the maximum labeled rate of residual herbicides for acceptable performance. Encapsulated formulations, when available, may be less readily absorbed by heavy crop residues and may perform more consistently.

Cultivation and mechanical weed control are very difficult or impossible and are generally not considered an option in most no-till production systems. However, high residue cultivators are manufactured by some companies and are designed for use in no-till/reduced-till systems. We have had a number of trials examining their effectiveness and generally two passes will provide about a 50% reduction in weed dry matter. Combining these tools with herbicides can provide a more integrated approach to weed management.

Existing vegetation is traditionally controlled by the nonselective herbicides, which are often tank mixed with residual herbi-

cides. Burndown herbicide options include paraquat or glyphosate and perhaps a growth regulator herbicide. No-till crop production tends to favor perennial weed populations, because their root systems are not disrupted by tillage. No-till also favors small-seeded broadleaf weeds and grasses (small seeded broadleaves include lambsquarters and pigweed) rather than large-seeded weeds such as velvetleaf.

Escalating herbicide costs and interest in keeping herbicide use to a minimum encourages many people to consider use of postemergence herbicide programs. Experience leads us to suggest that existing vegetation should always be controlled prior to planting. In the mid-Atlantic region, soil moisture is often the factor most limiting yield. The decision to apply postemergence herbicides early preplant, at planting, or as a delayed preemergence (spike) treatment to control existing emerged vegetation should always be made with consideration to the impact of the existing vegetation on the availability of soil moisture. Preemergence or postemergence herbicides that can provide residual weed control can then be selected that will control weeds that emerge after planting. Reducing or eliminating all or some of the residual preemergence herbicides can reduce costs in fields that historically have required postemergence herbicide applications.

Herbicides

Herbicides can be classified several ways, including by weed control spectrum, labeled crop usage, chemical families, mode of action, application timing/method, and others. For this publication, herbicides will be grouped according to mode and site of action, which are also important in understanding herbicide resistance in weeds.

Some Considerations When Using Herbicides

The perfect herbicide does not exist. No single herbicide is capable controlling all weeds that can develop in a crop or planting. Since every herbicide has advantages and disadvantages, selecting the correct herbicide(s) is crucial. Consider these points before you choose or apply a herbicide:

- Is it registered for use on the crop or area you want to treat? If it is, the directions for use and rate of application will appear on the label. Recommended rates for soil-applied herbicides may vary according to the soil texture and the amount of organic matter in the soil. Labels usually give a range of rates because soil types differ in the amount of herbicide that binds to soil particles. The application for postemergence treatments varies with weed size and climatic conditions. Weeds that are growing under dry conditions or during prolonged cool weather will not actively translocate a systemic herbicide. A higher herbicide rate may be needed than the rate used on weeds that are actively growing.
- Will it control the weeds that are causing the biggest problem? And does it take into account methods for managing herbicide resistance? Many weed control measures fail because the chosen herbicide will not control the weeds that are present.
- Can it be used effectively at the current stage of crop or weed growth? Very few herbicides can be applied at any stage during the growth cycle of a plant. Pendimethalin and metolachlor are good examples of how growth stage affects herbicide performance. They are excellent herbicides for annual grasses when applied before the grass weeds emerge. However, they are useless if applied after the weeds have emerged.
- Can the herbicide be used effectively and safely under the current conditions? Soil-applied herbicides must move into the soil to be taken up by roots and shoots of weed seedlings and perennial plant parts. Rainfall is usually adequate to provide soil incorporation of soil-applied herbicides, but in the absence of rainfall, weed control may be poor. The effectiveness of soil-applied herbicides can be reduced if the chemical is intercepted by debris from a previous crop, a prior application of livestock manure, thatch, or other barrier. Reduced-tillage cropping systems may require higher application rates of soil-applied herbicides than are required by conventional systems, depending on the amount of crop residue. Vegetation remaining on the soil surface binds some of the herbicide and prevents even distribution of the herbicide. Herbicides can also be lost to runoff, leaching, or volatilization. These and other processes that move and break down pesticides are discussed in a later chapter.
- Will the herbicide(s) interact negatively with other pesticides, fertilizers, or other inputs being used on the crop or area? Because of such interactions, injury or death to desirable plants may occur.
- Is the herbicide being applied to a “normal” or genetically modified crop? Since genetically modified crops look similar to normal crops once growing, misapplication can occur and the crop can be unintentionally killed or severely injured. Make sure to record the type of crop that was planted in each field.
- Will carryover of the herbicide result in a residue that might affect the crop or cover crop you want to plant next in rotation? Herbicide carryover is a problem with chemicals that persist in sufficient quantity to injure succeeding plantings. Some

examples of herbicides prone to carryover include the triazines (atrazine and simazine), dinitroanilines (Treflan, Curbit, Barricade, Prowl), ALS inhibitors (Classic, Cimarron, Steadfast, Outrider, Spirit, Pursuit, Python), and pigment inhibitors (Command, Balance, Callisto, Impact). These herbicides can provide season-long control of certain weeds. However, if an excessive rate was applied, the soil pH was above 7.0, or the weather during the growing season was cool and dry, natural breakdown of the chemicals may not occur and carryover may result. Read labels carefully for warnings about carryover and rotation.

- What is the appropriate method of application (i.e., broadcast, band, directed, spot)? Is it convenient to use such as ready-to-use (RTU) products or does it require special equipment or need to be mixed with water before application? Are there other characteristics, such as compatibility with other herbicides when tank-mixing or staining, that make it difficult to use?
- Does the herbicide label recommend that a surfactant, crop oil, or other additive be used to improve leaf coverage or herbicide performance? Many postemergence herbicides require the use of an adjuvant in the mixture (see later section for more details).
- Can this product be used safely on the intended planting? What is required to handle, mix, and apply it safely during and after use? Is it a restricted-use pesticide (RUP)?
- Can the herbicide injure nontarget plants in adjacent areas? Exercise caution to avoid drift, runoff, leaching to groundwater, and cross-contamination of other materials. Be especially alert to the potential for residues left in sprayers when spraying a different crop. This is discussed in more detail in a later chapter.

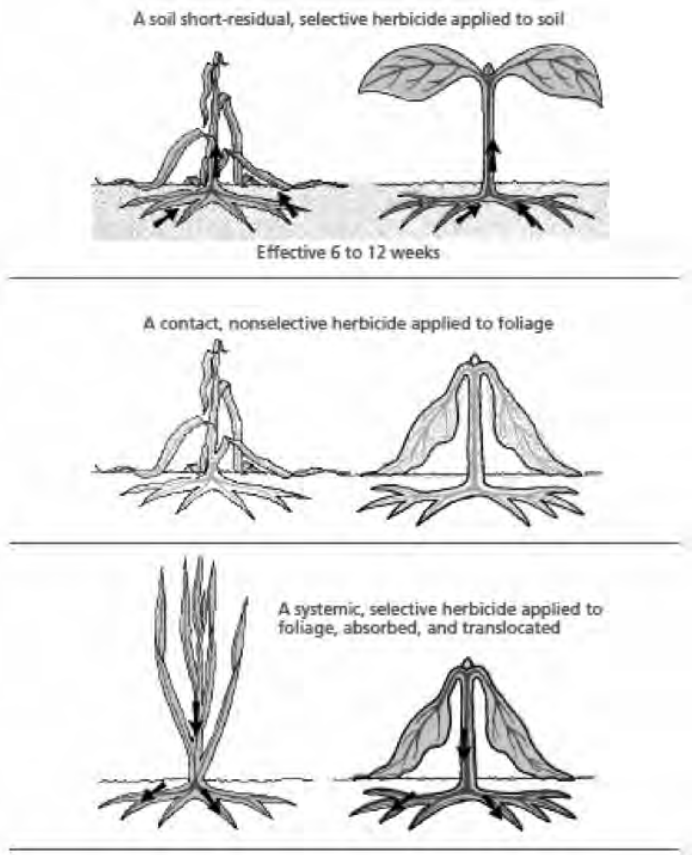
Classification of Chemical Weed Control

Timing of Application: Preemergence or Postemergence

Preemergence or soil-applied herbicides control weeds at the seed germination stage, or as they are emerging from the soil. Postemergence or foliar herbicides control existing weeds. Combinations of preemergence and postemergence herbicides may be necessary to control the various types of weeds in an area.

Contact or Translocated

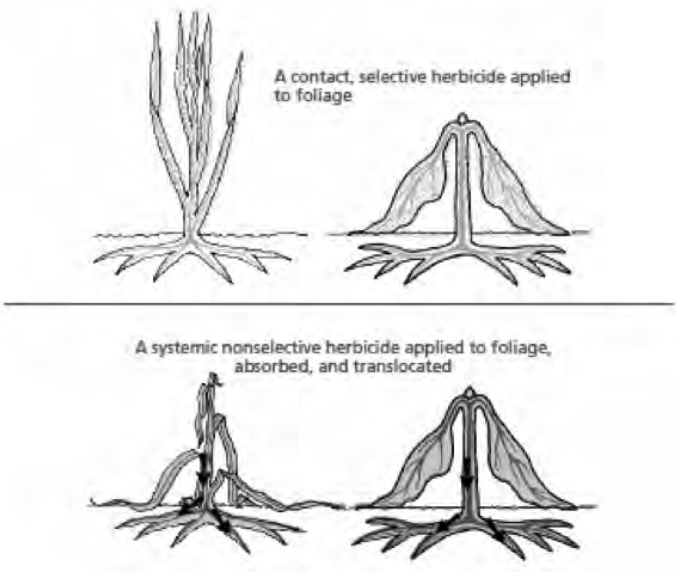
Contact herbicides kill or injure only the part of the plant with which the spray droplets come in contact, so adequate spray coverage is very important. Annual weeds may be killed, but regrowth of perennial weeds from belowground parts usually occurs following application of a contact herbicide. (On a side note, sometimes the term "contact" is used to describe an herbicide that is applied postemergence or is sprayed directly on the weed and thus "contacts" the foliage of the plant. When used in this context, it may have a different meaning and the herbicide could have systemic activity throughout the plant depending on the product.) Translocated (or systemic) herbicides are absorbed by the leaves or roots of the plants and move within the plant. They are needed to kill underground parts of perennial weeds.



Selective or Nonselective

Nonselective herbicides kill or injure almost all plants, while selective herbicides kill some plants but do little or no damage to others. Were it not for the fact that most herbicides can be applied just before crop planting or emergence, and even over the top after crop emergence, without excessive injury, herbicides would be of little value. Most of the herbicides labeled for use today will selectively remove most of the weeds without injuring the crop

or planting. Selectivity is accomplished primarily by two methods: selectivity by placement and true selectivity. Selectivity accomplished by avoiding or minimizing contact between the herbicide and the desired crop is called selectivity by placement. An example is wiping or directing an herbicide, such as glyphosate, on a weed without exposing the desired plant. Selectivity by this means is as good as any, as long as the excess herbicide is not washed off the weeds and leached into the root zone where it might be absorbed by the root. Selectivity by placement also is accomplished when an herbicide that does not readily leach is applied to the soil surface for control of shallow-rooted weeds but does not leach into the root zone of a more deeply rooted crop such as fruit trees or established alfalfa. Selectivity that is true tolerance as a result of some morphological, physiological, or biochemical means is referred to as true selectivity. The herbicide can be applied to the foliage of the crop or to the soil in which the crop is growing without danger of injury. Although true tolerance may be the best type of selectivity, it is not perfect. Such things as crop growth stage, cuticle thickness, hairiness of the leaf surface, location of the growing point, air temperature and humidity, spray droplet size, and the surface tension of spray droplets all can influence herbicide activity. When conditions are ideal for herbicide activity, even true selectivity may not adequately prevent some crop injury.



Fumigants

Fumigants may kill all living things in the soil, including weeds, weed seeds, insects, and disease organisms.

Herbicide Mode and Site of Action

To be effective, herbicides must (1) adequately contact plants, (2) be absorbed by plants, (3) move within the plants to the site of action without being deactivated, and (4) reach toxic levels at the site of action. The term "mode of action" refers to the sequence of events from absorption into plants to plant death, or, in other words, how an herbicide works to injure or kill the plant. The specific site the herbicide affects is referred to as the site or mechanism of action. Understanding herbicide mode of action is helpful in knowing what groups of weeds are killed, specifying application techniques, diagnosing herbicide injury problems, and preventing herbicide-resistant weeds.

A common method of grouping herbicides is by their mode of action. Although a large number of herbicides are available in the marketplace, several have similar chemical properties and herbicidal activity. Herbicides with a common chemistry are grouped into families. Also, two or more families may have the same mode of action and can thus be grouped into classes. Table 5.1 lists several groups of herbicides and information related to their mode of action.

Table 5.1 - Important Herbicide Groups for Corn, Soybean, Small Grain, Commercial Vegetable, and Forage

Herbicide Class / MOA					
WSSA group[1]	**Site of action**	**No. resistant in U.S.**	**Family**	**Common Name**	**Trade name**
Lipid Synthesis Inhibitors					
1	ACCase Inhibitors	15	Aryloxyphenoxy-	diclofop	Hoelon
	(acetyl CoA carboxylase)		propionate (fops)	fenoxaprop	Puma, Tecoma
				fluazifop	Fusilade
				quizalofop	Assure II, Targa
			Cyclohexanedione (dims)	clethodim	Select Max
				sethoxydim	Poast,
			Phenylpyrazolin	pinoxaden	Axial XL
Amino Acid Synthesis Inhibitors					
2	ALS Inhibitors	52	Imidazolinone	imaxamox	Beyond, Raptor
	(acetolactate synthase)			imazapic	Plateau
				imazapyr	Arsenal
				imazethapyr	Pursuit
				pyrithiobac	Staple
			Pyrimidinylthio-benzoic acid	flucarbazone	Everest, Pre-Pare
			Sulfonylaminocarb-onyltriazolinone	propoxycarb-azone	Olympus
				thiencarbazone	*component of Capreno, Corvus*
			Sulfonylurea	chlorimuron	Classic
				chlorsulfuron	Glean
				foramsulfuron	Option
				halosulfuron	Permit, Sandea
				imazosulfuron	League
				iodosulfuron	Autumn
				mesosulfuron	Osprey
				metsulfuron	Cimmaron, others
				nicosulfuron	Accent Q
				primisulfuron	Beacon
				prosulfuron	Peak
				rimsulfuron	Matrix, Resolve
				sulfosulfuron	Maverick

Table 5.1 - Important Herbicide Groups For Corn, Soybean, Small Grain, Commercial Vegetable, and Forage (cont.)

Herbicide Class / MOA					
WSSA group[1]	**Site of action**	**No. resistant in U.S.**	**Family**	**Common Name**	**Trade name**
				thifensulfuron	Harmony
				tribenuron	Express
				triflusulfuron	UpBeet
			Triazolopyrimidine	cloransulam	FirstRate
				flumetsulam	Python
				pyroxsulam	PowerFlex
9	EPSP Synthase inhibitor (5-enolpyruvyl-shikimate-3-phosphate)	15	Organophosphorus	glyphosate	Roundup, Touchdown, *others*
Growth Regulators					
4	T1R1 Auxin receptors	8	Arylpicolinate	Halauxifen-methyl	Elevore
	(synthetic auxins)		Benzoic acid	dicamba	Banvel, Clarity
			Carboxylic acid	aminopyralid	Milestone
				clopyralid	Stinger
				fluroxypyr	Starane, Vista
				picloram	Tordon
				quinclorac	Facet
				triclopyr	Garlon, Remedy
			Phenoxy	2-4-D	*various*
				2,4-DB	Butyrac, *various*
				MCPA	*various*
19	Auxin Transport Inhibitor	0	Semicarbazone	diflufenzopyr	*component of Status*
Photosynthesis Inhibitors					
5	Photosystem II	26	Phenylcarbamate	phenmedipham	Spin-Aid
	Inhibitors		Triazine	atrazine	Atrazine
	(mobile) *different*			prometon	Pramitol
	binding than 6 & 7			simazine	Princep
			Triazinone	hexazinone	Velpar
				metribuzin	Glory, Metribuzin, TriCor
			Uracil	terbacil	Sinbar
6	Photosystem II Inhibitors	1	Benzothiadiazole	bentazon	Basagran
	(non-mobile) *different binding than 5 & 7*		Nitrile	bromoxynil	Buctril/Maestro

Table 5.1 - Important Herbicide Groups For Corn, Soybean, Small Grain, Commercial Vegetable, and Forage (cont.)

Herbicide Class / MOA					
WSSA group[1]	**Site of action**	**No. resistant in U.S.**	**Family**	**Common Name**	**Trade name**
7	Photosystem II Inhibitors (mobile) *different binding than 5 & 6*	11	Urea	diuron linuron tebuthiuron	Direx, Karmex Linex, Lorox Spike
Nitrogen Metabolism Inhibitor					
10	Glutamine Synthetase Inhibitor	1	Amino acid derivative	glufosinate	Finale, Liberty, Rely
Pigment Inhibitors					
12	Phytoene Desaturase Biosynthesis Inhibitor	1	Pyridazinone	norflurazon	Solicam
13	DOXP Synthase Inhibitor (1-deoxy-D-xyulose 5-phosphate)	1	Isoxazolidinone	clomazone	Command
27	HPPD Inhibitors (4-hydroxy-phenyl-pyruvate-dioxygenase)	2	Isoxazole	isoxaflutole mesotrione	Balance Flexx Callisto
			Pyrazole	pyrasulfotole	*component of Huskie*
			Pyrazolone	topramezone	Armezon, Impact
			Triketone	tembotrione	Laudis
Cell Membrane Disrupters					
14	PPO Inhibitors (protoporphyrinogen oxidase)	2	Aryl triazolinone	carfentrazone fluthiacet sulfentrazone	Aim Cadet Authority, Spartan
			Diphenyl ether	acifluorfen fomesafen lactofen oxyfluorfen	Ultra Blazer Reflex Cobra, Phoenix Goal
			N-phenylphthalimide	flumiclorac flumioxazin	Resource Château, Valor
			Oxadiazole	oxadiazon	Ronstar
			Pyrimidinedione	saflufenacil	Kixor, Sharpen
22	Photosystem I Electron Diverter	6	Bipyridylium	diquat paraquat	Reglone Gramoxone

Table 5.1 - Important Herbicide Groups For Corn, Soybean, Small Grain, Commercial Vegetable, and Forage (cont.)

Herbicide Class / MOA					
WSSA group[1]	**Site of action**	**No. resistant in U.S.**	**Family**	**Common Name**	**Trade name**
Seedling Root Growth Inhibitors					
3	Microtubule Inhibitors	6	Benzamide	pronamide	Kerb
			Dinitroaniline	ethalfluralin	Curbit, Sonalan
				oryzalin	Surflan
				pendimethalin	Pendulum, Prowl, *others*
				prodiamine	Barricade
				trifluralin	Treflan, *others*
			Phthalic acid	DCPA	Dacthal
			Pyridazine	dithiopyr	Dimension
Seedling Shoot Growth Inhibitors					
8	Lipid Synthesis Inhibitors (not ACCase)	5	Phosphorodithioate	bensulide	Prefar
			Thiocarbamate	butylate	Sutan+
				cycloate	Ro-Neet
				EPTC	Eptam, Eradicane
15	Long-chain Fatty Acid Inhibitors	1	Acetamide	napropamide	Devrinol
			Chloroacetamide	acetochlor	Breakfree, Degree, Harness Topnotch, Warrant, *others*
				alachlor	Intrro, Micro-Tech
				dimethenamid	Outlook
				metolachlor	Dual, Cinch, *others*
			Oxyacetamide	flufenacet	Define
			Pyrazole	pyroxasulfone	Zidua
16	Specific Site Unknown	0	Benzofurane	ethofumesate	Nortron

Table 5.1 - Important Herbicide Groups For Corn, Soybean, Small Grain, Commercial Vegetable, and Forage (cont.)

Herbicide Class / MOA					
WSSA group[1]	**Site of action**	**No. resistant in U.S.**	**Family**	**Common Name**	**Trade name**
Cell Wall Synthesis Inhibitors					
20	Cellulose Inhibitor (Site A)	0	Nitrile	dichlobenil	Casoron, Norosac, *others*
21	Cellulose Inhibitor (Site B)	0	Benzamide	isoxaben	Gallery
29	Cellulose Inhibitor (unspecified site)	0	Alkylazaine	indaziflam	Alion

[1] WSSA group is a system of classifying herbicides developed by the Weed Science Society of America, based on site of action. The following section provides a brief overview of herbicide functions in the plant and associated injury symptoms for each of the herbicide classes found in Table 5.1.

Plant Growth Regulators (PGRs) – Groups 4 and 19

These herbicides are effective on annual and perennial broadleaf plants and usually have no activity on grasses or sedges, except at high application rates. They produce responses similar to those of natural growth-regulating substances called auxins. Application of artificial auxins, such as 2,4-D, upsets normal growth as follows:

- Cells of leaf veins rapidly divide and elongate, while cells between veins cease to divide. This results in long, narrow, strap-like young leaves.
- Water content increases, making treated plants brittle and easily broken.
- Cell division and respiration rates increase, and photosynthesis decreases. Food supply of treated plants is nearly exhausted at their death.
- Roots of treated plants lose their ability to take up soil nutrients, and stem tissues fail to move food effectively through the plant.

The killing action of growth-regulating chemicals is not caused by any single factor but results from the effects of multiple disturbances in the treated plant.

Injury Symptoms

Broadleaf plant leaves become crinkled, puckered, strap shaped, stunted, and malformed; leaf veins appear parallel rather than netted; and stems become crooked, twisted, and brittle, with shortened internodes. If injury occurs in grasses (e.g., corn), new leaves do not unfurl but remain tightly rolled in onionlike fashion, and stems become brittle, curved, or crooked, with short internodes. A lesser effect in corn is the fusion of brace roots, noticed later in the season.

Amino Acid Biosynthesis Inhibitors – Groups 2 and 9

These herbicides are effective mostly on annual broadleaves, while a few in this large group have activity on grasses, nutsedge, and/or perennial plants. (Glyphosate [Roundup], for example, is a broad-spectrum herbicide and has activity on all types of plants.) These herbicides work by interfering with one or more key enzymes that catalyze the production of specific amino acids in the plant. When a key amino acid is not produced, the plant's metabolic processes begin to shut down. The effect is like that of an assembly line worker not doing his or her job. Different herbicides affect different enzymes that catalyze the production of various amino acids, but the result is generally the same—the shutdown of metabolic activity with eventual death of the plant.

Injury Symptoms

Plants that are sensitive to these herbicides stop growth almost immediately after foliar treatment; seedlings die in two to four days, established perennials in two to four weeks. Plants become straw colored several days or weeks after treatment, gradually turn brown, and die.

Table 5.2 - Selected Glyphosate (Group 9) Products and Premixes for Agronomic Use

Currently, numerous products contain glyphosate. Most of them are labeled for "burndown"/preemergence and/or spot applications. The majority, but not necessarily all, of the products below are labeled for over-the-top application in Roundup Ready crops (namely, RR corn and RR soybean). Refer to the product label for additional information on crop use, formulation, application rates, and other use restrictions. Other glyphosate-containing products may be available in your area. Contact your local dealer for more details.

		Product Rate (fl oz) Equivalent to:				Formulation	
Product and Amount of Glyphosate/Gallon[1]	**Company**	**0.375 lb ae**	**0.56 lb ae**	**0.75 lb ae**	**1.13 lb ae**	**Salt[2]**	**Adjuvant Load[3]**
5 lb ae/5.5 lb ai							
Touchdown HiTech	Syngenta	10	14	19	29	Potassium	minimal
4.5 lb ae/5.5 lb ai							
Abundit Edge	DuPont	11	16	22	32	Potassium	fully loaded
Credit Xtreme	Nufarm	11	16	22	32	IPA + Potassium	fully loaded
Gly Star K-Plus	Albaugh/AgriStar	11	16	22	32	Potassium	fully loaded
Honcho K6	Monsanto	11	16	22	32	Potassium	fully loaded
Roundup WeatherMax	Monsanto	11	16	22	32	Potassium	fully loaded
Roundup PowerMax	Monsanto	11	16	22	32	Potassium	fully loaded
4 lb ae/5 lb ai							
Cinco (5.4 ai)	Loveland	12	18	24	36	IPA	partial
Cornerstone 5 Plus	WinField Solutions	12	18	24	36	IPA	fully loaded
Durango DMA/Duramax (5.4 ai)	Dow AgroSciences	12	18	24	36	DMA	fully loaded
Extra Credit 5	Nufarm	12	18	24	36	IPA	fully loaded
Gly Star 5 Extra	Albaugh/AgriStar	12	18	24	36	IPA	fully loaded
Touchdown Total (4.17 ae)	Syngenta	12	18	24	36	Potassium	fully loaded
Traxion (4.17 ae)	Syngenta	12	18	24	36	Potassium	fully loaded
3 lb ae/4 lb ai							
Abundit Extra	DuPont	16	24	32	48	IPA	fully loaded
Buccaneer	Tenkoz	16	24	32	48	IPA	partial
Buccaneer Plus	Tenkoz	16	24	32	48	IPA	fully loaded
Cornerstone Plus	WinField Solutions	16	24	32	48	IPA	fully loaded
Credit 41	Nufarm	16	24	32	48	IPA	partial
Credit 41 Extra	Nufarm	16	24	32	48	IPA	fully loaded
Envy	Innvictis	16	24	32	48	IPA	partial
Glyfine Plus	Aceto	16	24	32	48	IPA	fully loaded
Glyfos Xtra	Cheminova	16	24	32	48	IPA	fully loaded
Gly Star Original	Albaugh/AgriStar	16	24	32	48	IPA	partial

Table 5.2 - Selected Glyphosate (Group 9) Products and Premixes for Agronomic Use (cont.)

		Product Rate (fl oz) Equivalent to:				Formulation	
Product and Amount of Glyphosate/Gallon1	**Company**	**0.375 lb ae**	**0.56 lb ae**	**0.75 lb ae**	**1.13 lb ae**	**Salt[2]**	**Adjuvant Load[3]**
Gly Star Plus	Albaugh/AgriStar	16	24	32	48	IPA	fully loaded
Glyphogan Plus	Adama	16	24	32	48	IPA	fully loaded
Helosate Plus Advanced	Helm Agro	16	24	32	48	IPA	fully loaded
Honcho	Monsanto	16	24	32	48	IPA	minimal
Honcho Plus	Monsanto	16	24	32	48	IPA	fully loaded
Hoss Ultra	Helena	16	24	32	48	IPA	fully loaded
Mad Dog	Loveland	16	24	32	48	IPA	partial
Mad Dog Plus	Loveland	16	24	32	48	IPA	fully loaded
Makaze	Loveland	16	24	32	48	IPA	fully loaded
Mirage	Loveland	16	24	32	48	IPA	partial
Mirage Plus	Loveland	16	24	32	48	IPA	fully loaded
Rascal	WinField Solutions	16	24	32	48	IPA	partial
Rascal Plus	WinField Solutions	16	24	32	48	IPA	fully loaded
Showdown	Helena	16	24	32	48	IPA + monoammonium	fully loaded

[1] Glyphosate products can be formulated to have different concentrations of glyphosate acid per gallon of product. To improve handling, performance, and concentration, the glyphosate acid is formulated as a salt compound. Acid equivalent (ae) is only the weight of the glyphosate acid, which is herbicidally active. Active ingredient (ai) is the weight of the glyphosate acid plus the salt. It is best to refer to ae when comparing glyphosate products and rates.

[2] Glyphosate can be formulated as different salts: isopropylamine (IPA), monoammonium, diammonium, or potassium.

[3] Some glyphosate products contain all the necessary adjuvants (i.e., fully loaded). Others contain only a limited amount and additional surfactants must be added to the tank before application. All brands of glyphosate recommend adding ammonium sulfate (AMS), if using hard water as a carrier or under other challenging conditions. If using AMS, always add it to the spray solution before glyphosate. Refer to product label for more information.

Fatty Acid (Lipid) Biosynthesis Inhibitors – Group 1

These herbicides are rapidly absorbed by grasses and are translocated to the growing points, where they inhibit meristematic activity, stopping growth almost immediately. They have no activity on broadleaf plants and are most effective on warm-season grasses such as Johnsongrass, shattercane, corn, fall panicum, giant foxtail, and crabgrass. Cool-season grasses like quackgrass, annual and perennial ryegrass, orchardgrass, timothy, and small grains are not as sensitive as warm-season grasses. Some of these herbicides are weaker on perennial species than other products. They are frequently referred to as "postgrass" herbicides.

Injury Symptoms

Growing points are killed first, resulting in the death of the leaves' inner whorl. Older, outer leaves of seedlings appear healthy for a few days, and those of perennials for a couple of weeks, but eventually they also wither and die. After several weeks, the growing points begin to rot, allowing the inner leaves to be pulled out of the whorl. Sensitive grasses commonly turn a purplish color before dying.

Seedling Growth Inhibitors (Root and Shoot) – Groups 3,and 8

Herbicides in this group prevent cell division primarily in developing root tips and are effective only on germinating small-seeded annual grasses and some broadleaves.

Injury Symptoms

Seeds of treated broadleaved plants germinate, but they either fail to emerge or emerge as severely stunted seedlings that have thickened, shortened lower stems, small leaves, and short, club-shaped roots. Seedlings of taprooted plants, such as soybeans

and alfalfa, usually are not affected, nor are established plants with roots more than a couple inches deep.

Grass seeds germinate but generally fail to emerge. Injured seedlings have short, club-shaped roots and thickened, brittle stem tissue. Seedlings die from lack of moisture and nutrients because of the restricted root system.

Seedling Growth Inhibitors (Shoot) – Group 15

Herbicides in this class are most effective on annual grasses and yellow nutsedge. Depending on the product, some will control small-seeded annual broadleaves. These herbicides cause abnormal cell development or prevent cell division in germinating seedlings. They stop the plant from growing by inhibiting cell division in the shoot and root tips while permitting other cell duplication processes to continue. Then follows a slow decline in plant vigor.

Injury Symptoms

Germinating grasses normally do not emerge. If they do, young leaves fail to unfold, resulting in leaf looping and an onionlike appearance. The tip of the terminal leaf becomes rigid, not free flapping (flaglike). The leaves of broadleaved plants turn dark green, become wrinkled, and fail to unfold from the bud. The roots become shortened, thickened, brittle, and clublike.

Photosynthesis Inhibitors (Mobile) – Groups 5 and 7

These herbicides are effective primarily on annual broadleaves, while some provide control of grasses as well. Photosynthesis-inhibiting herbicides block the photosynthetic process so captured light cannot be used to produce sugars. In the presence of light, green plants produce sugar from carbon dioxide and water. Energy is needed for carbon, hydrogen, and oxygen atoms to rearrange and form sugar. To supply this necessary energy, electrons are borrowed from chlorophyll (the green material in leaves) and replaced by electrons split from water. If chlorophyll electrons are not replaced, the chlorophyll is destroyed and the plant's food-manufacturing system breaks down. The plant slowly starves to death due to lack of energy.

As soil-applied treatments, these herbicides permit normal seed germination and seedling emergence but cause seedlings to lose their green color soon afterward. With the seeds' food supply gone, the seedlings die. These herbicides are more effective on seedling weeds than on established perennial weeds. Herbicides such as prometon (Primitol) and tebuthiuron (Spike) are considered soil sterilants. Soil sterilants are nonselective chemicals that can kill existing vegetation and keep the soil free from vegetation for one or more years.

Injury Symptoms

In broadleaved plants, early seedling growth appears normal, but shortly after emergence (when energy reserves in cotyledons are depleted), leaves become mottled, turn yellow to brown, and die. In most cases, the oldest leaves turn yellow on the leaf margins first, the veins remain green, and eventually the plant turns brown and dies. Herbaceous and woody perennials starve very slowly because they have large energy reserves in roots or rhizomes to live on while photosynthesis is inhibited. The herbicide may have to effectively inhibit photosynthesis for a full growing season to kill trees or brush. This kind of death may be slow, but it is certain.

Photosynthesis Inhibitors (Nonmobile, "Rapid-Acting") – Group 6

Herbicides in this group have activity primarily on annual and some perennial broadleaves and are applied to the plant foliage. The mode of action is the same as the mobile photosynthesis inhibitors.

Injury Symptoms

Their activity within the plant is similar to that of the mobile photosynthesis inhibitors, except the injury occurs at the site of contact, causing "leaf burning" and eventual death of the plant.

Cell Membrane Disrupters – Groups 14 and 22

These herbicides control mostly broadleaves. Certain products have some activity on grasses, and paraquat (Gramoxone) provides broad-spectrum control of many different species.

These herbicides are referred to as contact herbicides and they kill weeds by destroying cell membranes. They appear to burn plant tissues within hours or days of application. Good coverage of the plant tissue and bright sunlight are necessary for maximum activity. The activity of these herbicides is delayed in the absence of light.

Injury Symptoms

All contact herbicides cause cellular breakdown by destroying cell membranes, allowing cell sap to leak out. Effected plants initially have a "water-soaked" appearance, followed by rapid wilting and "burning" or leaf speckling and browning. Plant death occurs within a few days.

Pigment Inhibitors – Groups 12, 13, and 27

These herbicides provide control of many annual broadleaves and some grasses. These products are referred to as "bleachers" because they inhibit carotenoid biosynthesis or the HPPD enzyme by interfering with normal chlorophyll formation.

Injury Symptoms

Symptoms are very evident and easy to identify. Effected plants either do not emerge, or emerge white or bleached and eventually die. Older leaf tissue is affected first.

Phosphorylated Amino Acid (Nitrogen Metabolism) Disrupters – Group 10

This herbicide provides broad-spectrum control of most annual grasses and broadleaves and some perennials. It affects growth by disrupting nitrogen metabolism, thus interfering with other plant processes. It is a contact herbicide with slight translocation throughout the plant. Good spray coverage and sunlight are important for maximum efficacy.

Injury Symptoms

Injury is similar to that of the cell-membrane-disrupter herbicides. Sensitive plants show "leaf burning," yellowing and browning, and eventual death after a week or so. Perennials generally take longer for symptoms and death to occur.

Unknown Herbicides

This category contains miscellaneous products for which the mode of action and family are unknown. Dazomet (Basamid) and metam (Vapam) are considered soil fumigants. These products are applied to the soil and covered with a gas-tight tarp, where they are converted to gases and penetrate the soil to kill weeds, diseases, and nematodes. Endothall (Aquathol) is used for aquatic weed control. Fosamine (Krenite) is used in noncrop areas to control perennial weeds and brush. Other compounds such as pelargonic acid (Scythe), fatty-acid herbicides, and clove oil and vinegar are contact, nonselective, broad-spectrum, foliar-applied products that are sometimes used for weed control in organic crop production settings. However, because they basically "burn" only the plant tissue they contact, there is potential for plant regrowth.

Trade Name, Formulation Notations, and Premixes

In certain publications, many herbicides are listed by trade name (or product name) and formulation—for example, Roundup 4S or Permit 75WDG. Roundup is the trade name and 4S stands for 4 pounds of active ingredient (glyphosate) per gallon of product in a soluble (S) formulation. Permit is formulated as a water-dispersible granule with each granule (or certain unit) containing 75 percent active ingredient (halosulfuron). The remaining parts of the formulation contain inert ingredients, which have no effect on weed control. Additional information about formulation and ingredients can be found in another part of this publication and on the product's label and MSDS sheet.

Premixes contain two or more herbicide active ingredients mixed into one product by the manufacturer. The actual premix formulation can vary but commonly contains two or more herbicides that are already used together. The primary reason for using premixes is convenience. Many herbicide products are now marketed as premixes.

Herbicide Safeners

Herbicide safeners also called antidotes or protectants are chemicals that help prevent injury to crops without reducing weed control. Early discovery of compounds capable of safening herbicides started in the late 1940's with the phenoxy herbicides, but commercialization really started with seed treatments and soil-active safteners in the 1970's and early 1980's. In general, herbicide safeners allow crops with fair tolerance to an herbicide, to metabolize or detoxify the herbicide more quickly thus providing increased crop safety. To date, safeners have only been developed for grass crops such as corn and wheat with few advances in dicot or broadleaf crops. Some of the more notable of these safeners includes dichlormid (Eradicane, Sutan and

some acetochlor formulations), benoxacor (Dual II), and the seed treatment Concept (fluxofenim) that allows chloroacetamide herbicide use in sorghum. More recently, a number of Group 2 (ALS) and other herbicides use isoxadifen (Accent Q, Resolve Q, Status, Steadfast Q, etc.) which provides increased safety from foliar applications. The most recently launched safener is cyprosulfamide that provides preemergence and foliar safening with several herbicides. Cyprosulfamide is used in a number of Bayer CropScience products including Balance Flexx, Corvus, Capreno, and Diflexx.

Table 5.3 - Common Herbicide Safeners Used as Commercial Products

Safener	Approximate date of introduction	Herbicide(s)	Crop	Other
1,8-naphthalic anhydride (NA)	1971	EPTC and butylate	Corn	Seed treatment
Benoxacor	1985	metolachlor	Corn	Premixed with herbicide
Cloquintocet-methyl	2006	pinoxaden	Wheat, cereals	Premixed with herbicide
Cyposulfamide	2009	numerous (Groups 4 and 27)	Corn	Premixed with herbicide
Dichlormid	1972	EPTC, butylate, acetochlor	Corn	Premixed with herbicide
Fenchlorazole-ethyl	1992	fenoxaprop	Wheat, cereals	Premixed with herbicide
Fluxofenim	1986	alachlor, metolachlor	Sorghum	Seed treatment
Furilazole	1991	acetochlor	Corn	Premixed with herbicide
Isoxadifen	2001	Numerous (Groups 2 and 4)	Corn	Premixed with herbicide
Mefenpyr-diethyl	1989	pyrosulfotole	Wheat	Premixed with herbicide

Generic or Post Patent Products

The pace of novel herbicide active ingredient commercialization has greatly slowed over the last 15 years and many herbicides are going off-patent. Also, several new manufacturers have entered the herbicide market and are reintroducing older active ingredients. Most original brands still dominate, but the post-patent product market is growing. It can be challenging finding all post-patent herbicides sold in our region, but we have tried to summarize some of the more common ones in the following table. Other generic herbicide products may be available in your area. Be cautious and consider all factors when looking at generic herbicide alternatives, especially guarantees for resprays on product failures. Contact your local dealer for details.

Table 5.4 - Selected Generic (or Post-Patent) Alternative Herbicides for Agronomic Uses

Active ingredient(s)	Trade name	Manufacturer	Labeled crops*	Alternative to:
Acetochlor + atrazine	Bridger ATZ	Altitude Crop Innov.	C	Harness Xtra, Degree Xtra, Keystone (NXT)
	Cadence ATZ (NXT)	Loveland		
	Confidence Xtra	WinField Solutions		
	Overtime ATZ (NXT)	Helena		
	Tremor ATZ	WinField		
	Volley ATZ (NXT)	Tenkoz		
Acetochlor + flumetsulam + clopyralid	Smackdown	Loveland	C	SureStart, SureStart II
	Staunch (II)	Tenkoz		
	Trisidual	Winfield		

Table 5.4 - Selected Generic (or Post-Patent) Alternative Herbicides for Agronomic Uses (cont.)

Active ingredient(s)	Trade name	Manufacturer	Labeled crops*	Alternative to:
Acifluorfen	Acifin	SummitAgro	Sb	Ultra Blazer
	Avalanche Ultra	Winfield		
	Levity	Innvictis		
Chlorimuron	Curio	NuFarm	Sb	Classic
Chlorimuron + metribuzin	Cedock	AgSurf	Sb	Canopy DF
	Cloak DF	NuFarm		
	Metrixx Plus	Sharda		
	Resist	Tenkoz		
Chlorimuron + tribenuron	Cloak EX	NuFarm	Sb	Canopy EX
	FallOut	AgSurf		
Clethodim	Arrow	ADAMA	Sb, A	Select, (Select Max), Prism
	Atlas	Altitude Crop Innov.		
	Avatar	Innvictis		
	Clethodim 2EC	Albaugh/Agri-Star		
	Dakota	Rotam North Amer.		
	Intensity	Loveland		
	(Intensity One)	Loveland		
	Section	WinField Solutions		
	Shadow	Arysta LifeScience		
	TapOut	Helena		
	Volunteer	Tenkoz		
Cloransulam	Traject SC	SummitAgro	Sb	FirstRate
Clopyralid	Clean Slate	Nufarm	C, P, SG	Stinger
	Spur	Albaugh/Agri-Star		
Dimethenamid-P + atrazine	Establish ATZ	Tenkoz	C, Sr	Guardsman Max
	Slider ATZ	Loveland		
	Sortie ATZ	Helena		
Flumioxazin	Outflank	ADAMA	Sb (or A depending on label)	Valor SX, Chateau
	Panther/Tuscany	NuFarm		
	Varsity WDG	Innvictis		
Fluroxypyr	Comet	NuFarm	SG	Starane

Table 5.4 - Selected Generic (or Post-Patent) Alternative Herbicides for Agronomic Uses (cont.)

Active ingredient(s)	Trade name	Manufacturer	Labeled crops*	Alternative to:
Fomesafen	Andros 1.88/2.0	Rotam North Amer.	Sb	Reflex, Flexstar
	Battle Star	Albaugh/Agri-Star		
	Foma 1.88/2SL	Drexel		
	Rumble	ADAMA		
	Shafen	Sharda		
	Sinister	Helena		
	TopGun	Loveland		
	Vamos	Innvistis		
Fomesafen + imazethapyr	Camo	Albaugh/Agri-Star	SB	—
	Torment	ADAMA		
Fomesafen + metolachlor	Vise	ADAMA	Sb	Prefix
	UP-Front	Drexel		
Glufosinate	Cheetah	NuFarm	LibertyLink C & Sb, other	Liberty 280
	Forfeit 280	Loveland		
	Interline	UPI		
	Refer	SummitAgro		
	Surmise	Albaugh/Agri Star		
	Total	WinField		
Halosulfuron	Halomax 75	Aceto	C	Permit, Sandea
	Herbivore	WinField		
	Profine 75	Aceto		
Imazethapyr	Praxis	Sharda	Sb, A	Pursuit
	Thunder	Albaugh/Agri-Star		
Imazethapyr + glyphosate	Praxis Plus	Sharda	Sb	Extreme
	ThunderMaster	Albaugh/Agri-Star		
Mesotrione	Bridle/Incinerate	WinField	C, Sr	Callisto
	Intrusion	Altitude Crop Innov.		
	MesoStar	Sharda		
	Motif	UPI		
	MesoTryOne	Drexel		
	Undercover	Innvictis		
Metolachlor	Me-Too-Lachlor	Drexel	C, Sb, Sr	Dual, Dual II
	Me-Too-Lachlor II	Drexel		
	Parallel	ADAMA		
	Stalwart	Sipcam		

Table 5.4 - Selected Generic (or Post-Patent) Alternative Herbicides for Agronomic Uses (cont.)

Active ingredient(s)	Trade name	Manufacturer	Labeled crops*	Alternative to:
Metolachlor + atrazine	Parallel Plus	ADAMA	C, Sr	Bicep II
	Stalwart Xtra	Sipcam		
	Triangle	Tenkoz		
	Trizmet II	Drexel		
	Visor ATZ	Innvictis		
Metolachlor + imazethapyr	Pummel	ADAMA	Sb	—
Metolachlor + metribuzin	Galvan	Innvictis	Sb	Boundary
	Ledger	Tenkoz		
	PREsidual	Winfield Solutions		
	Tailwind	ADAMA		
Metribuzin	Derive 75DF	Innvictis	Sb, C, A	formerly Sencor
	Dimetric 75DF	Winfield Solutions		
	Glory	ADAMA		
	Metribuzin 75	Loveland		
	Metribuzin 75DF	ADAMA		
	Metrixx	Sharda		
	TriCor 75DF/4F	UPI		
Metsulfuron-methyl	Accurate	FMC	P	Cimarron 60DF
	Ciramet	AgSurf		(DuPont no longer sells the single ai product for pastures)
	Metsulfuron 60EG AG	Arysta LifeScience		
	Plotter	Rotam North Amer.		
	PureStand	NuFarm		
	Rometsol	Rotam North Amer.		
Nicosulfuron	Primero 75DF & 40SC	Rotam North Amer.	C	Accent (not Accent Q)
Paraquat	Blanco	Altitude Crop Innov.	All	Gramoxone
	Devour	Innvictis		
	Helmquat	Helm		
	Para-SHOT 3.0	Sharda		
	Parazone	ADAMA		
	Quik-Quat 300	Drexel		
Pendimethalin	Acumen	Tenkoz	C, Sb	Prowl 3.3EC, (Prowl H_2O)
	Framework	Windfield Solutions		
	Pavilion	Innvictis		
	Pin-dee 3.3	Drexel		
	(Satellite HydroCap)	UPI		
	Stealth	Loveland		
Quinclorac	Quinstar 4L or GT	Albaugh/Agri-Star	P	Paramount/Facet

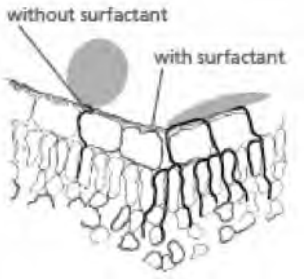
Table 5.4 - Selected Generic (or Post-Patent) Alternative Herbicides for Agronomic Uses (cont.)

Active ingredient(s)	Trade name	Manufacturer	Labeled crops*	Alternative to:
Rimsulfuron	Pruvin	ADAMA	C	Resolve, Matrix
	Solida	FMC (Cheminova)		
S-metolachlor	Brawl	Tenkoz	C, Sb, Sr	Dual Magnum
	Brawl II	Tenkoz		Dual II Magnum
	Moccasin	UPI		
S-metolachlor + atrazine	Brawl II ATZ	Tenkoz	C, Sr	Bicep II Magnum
	Charger MAX ATZ	WinField Solutions		
	Visor S-MOC II	Innvictis		
Sulfentrazone	Blanket	Tenkoz	Sb	Authority 75DF, Spartan
	Petra	Altitude Crop Innov.		
	Shutdown	UPI		
	Sulfin	SummitAgro		
	Vandal	Innvictis		
Thifensulfuron	Treaty	NuFarm	C, Sb, SG	Harmony GT 75DF
	Volta	Rotam North Amer.		(not Harmony SG 50WDG)
Thifensulfuron + tribenuron	Edition	FMC	C, Sb, SG	Harmony Extra 75DF (not Harmony Extra SG 50WDG)
	Nimble	FMC		
	Rapport	NuFarm		
	Treaty Extra	NuFarm		
	T-Square	AgSurf		
	Volta Extra	Rotam North Amer.		
Triclopyr	Triclopyr 4E	Albaugh/Agri-Star	P	Remedy Ultra
	Trycera	Helena		
Triclopyr + 2,4-D	Candor	NuFarm	P	Crossbow
	Crossbow L	Loveland		
	Crossroad	Albaugh/Agri-Star		

*A = alfalfa, C = corn, P = pasture, Sb = soybean, Sr = sorghum, SG = small grain

Herbicide Spray Additives (Adjuvants)

Additives, or adjuvants, are substances in herbicide formulations or that are added to the spray mixture to improve herbicidal activity or application characteristics. Over 70 percent of all herbicides recommend the use of one or more adjuvants in the spray mixture. In general, there are two types of adjuvants: formulation and spray. Formulation adiuvants are "alreadv in the container" from the manufacturing process. These help with mixing, handling, effectiveness, and providing consistent performance.



Spray adjuvants can be divided into special-purpose adjuvants and activator adjuvants. Special-purpose adjuvants include compatibility agents, buffering agents, antifoam agents, drift retardants, and others that widen the range of conditions for herbicide use. Activator adjuvants are commonly used to enhance postemergence herbicide performance by increasing herbicide activity, absorption, and rainfastness and decreasing photodegradation. These include surfactants (i.e., "surface active agents"), crop oil concentrates, vegetable oil concentrates, wetting agents, stickers-spreaders, N-fertilizers, penetrants, and others. Commonly used surfactants are nonionic surfactants and organosilicones and are typically used at a rate of 1 quart per 100 gallons (0.25 percent v/v) of spray mixture. Crop oil concentrates are 80 to 85 percent petroleum based plus 15 to 20 percent surfactant, while vegetable oil concentrates contain vegetable or seed oil in place of petroleum oil. Oil concentrates are typically included at a rate of 1 gallon per 100 gallons (1 percent v/v) of spray mixture. In general, oil concentrates are "hotter" than surfactants, so they provide better herbicide penetration into weeds under hot/dry conditions, but they are more likely to cause greater crop injury under normal growing conditions. Nitrogen fertilizers, such as UAN (a mixture of ammonium nitrate, urea, and water) or AMS (ammonium sulfate), are used in combination with surfactants or oil concentrates to increase herbicide activity and reduce problems with hard water. Many blended adjuvants are available that include various combinations of special purpose adjuvants or activator adjuvants.

Be sure to include the proper adjuvant(s) for the herbicide being used. Most herbicide labels specify the type and amount of additive to use. Failure to follow the recommendations can result in poor weed control or excessive crop injury.

Managing Herbicides

Environmental Hazard Warnings.

Some herbicide labels carry *Environmental Hazard Warnings* on the label. The environmental hazard may specify a "water-quality advisory," which requires special precautions for coarse-textured soils (sandy), soils with a shallow water table, and soils with other potential water-contamination risks. Herbicides with water-quality advisories have been detected in small amounts in water supplies after normal agricultural use. Additional environmental dangers include toxicity to fish and wildlife and hazards to endangered species. Check the label or specific hazard warning information before using a product.

Herbicide Use Rate

The recommended use rates of soil-applied herbicides often vary with soil texture, organic matter content, and tillage systems. The use of soil-applied herbicide rates that are incorrect for the soil texture, pH, and organic matter may result in poor weed control or crop injury. Consult the herbicide label for the proper herbicide rate for your soils.

Most of the herbicides recommended in this publication are selective. At the recommended rate of application, they will selectively control or injure weeds but will not seriously damage the crop in which these weeds are growing. In using selective herbicides, you should carefully follow the recommended application rate and follow instructions related to the use of surfactants and other additives. Using higher herbicide rates or additives that are not recommended may result in severe crop injury. You must accept the responsibility if you use a herbicide in a manner other than that directed on the herbicide label.

Herbicide Persistence and Rotational Crop Intervals

Herbicides are applied to the soil to manage weeds. It is desirable for the chemicals to control weeds during the season of application, but they should not persist and affect subsequent crop growth. The length of time that a herbicide remains active in the soil is called "soil persistence" or "soil residual life". With some herbicides, there may be a fine line between controlling the weeds for the entire growing season and then planting a sensitive rotation crop. Anything that affects the disappearance or breakdown of herbicides will affect persistence. Herbicides vary in their potential to persist in the soil. Some herbicide families

that have persistent members include the triazines, uracils, phenylureas, sulfonylureas, dinitroanilines, isoxazolidinones, imidazolinones, and certain plant growth regulators belonging to the pyridine family. Several factors determine the length of time herbicides persists. These factors fall into three categories: *soil factors*, *climatic conditions*, and *herbicidal properties*. The factors within each of these categories can strongly interact with one another.

Soil Factors. The soil factors affecting herbicide persistence include soil composition, soil chemistry, and microbial activity. Soil composition is a physical factor that is determined by relative amounts of sand, silt, and clay (the soil texture) and the organic-matter content. An important chemical property of the soil that can influence herbicide persistence is pH. The microbial aspects of the soil environment include the type and abundance of soil microorganisms present. Soils containing more clay and organic matter (heavier) tend to bind herbicides more strongly and they will persist longer. Also, higher soil pH (>7) can be more problematic for some herbicides.

***Climatic Factors*.** The climatic variables involved in herbicide breakdown are *moisture, temperature*, and *sunlight.* Herbicide degradation rates generally increase as temperature and soil moisture increase, because both chemical and microbial decomposition rates increase with higher temperatures and moisture levels. Cool, dry conditions slow down herbicide degradation. Carryover problems are always greater the year following a drought. If winter and spring conditions are wet and mild following a previously dry summer, the lower the likelihood of herbicide carryover.

***Herbicide Properties*.** An herbicide's chemical properties affects its persistence. Properties include water solubility, vapor pressure, and susceptibility of the molecule to chemical or microbial alteration or degradation. Much of this boils down the herbicide half-life or the time it takes for 50% of the active ingredient to dissipate. Several factors influence the rate of dissipation such as rainfall, soil texture and soil pH, etc. The basic manufactures along with universities and some other research organizations have evaluated the persistence of herbicides in soil for local conditions and it can vary widely.

Avoiding Herbicide Persistence in Subsequent Crops. There are several ways to avoid herbicide carryover problems. First, check the recrop statement on the herbicide label and do not plant a sensitive crop prior to the specified time. Second, always apply the correct rate of any pesticide for your specific soil type and weed problem. This means applying the lowest rate of the chemical consistent with obtaining the desired effect. Higher rates of more persistent products certainly carry more risk of follow crop injury. Accurate acreage determination, chemical measurement, proper sprayer calibration, and uniform application are essential for avoiding misapplication problems. ***Always read the label before applying any herbicide.***

In summary, the first step in avoiding herbicide persistence problems is choosing less persistent products. Check the herbicide label for recrop statements before selecting any material. With all pesticides, use the appropriate rates and the application timings. The use of selective tillage, herbicide combinations, and tolerant crops and varieties will also help reduce the risk of carryover crop injury. Wise herbicide use will ensure the continued availability of these important weed management tools for the future. The following table provides the cash crop rotation restrictions for common herbicides that are used in multiple crops. These restrictions are the label guidelines and may be due to the concern for herbicide residues accumulating in forage or feed or carryover injury.

Table 5.5 - Herbicide Rotational Restrictions for Cash Crops

The information listed in this rotation restriction table is our interpretation of label statements. Consult the label if two or more of these materials are applied during the same season. Herbicide labels are constantly changing; therefore, this list is not a substitute for the most recent herbicide label.

	Rotational Crops (months after application)[1]																									
Trade Name	**Alfalfa**	**Cabbage**	**Clover**	**Cotton**	**Cucumber**	**Field Corn**	**Grain Sorghum**	**Lima Bean**	**Muskmelon**	**Onion**	**Peanut**	**Peas**	**Pepper**	**Pumpkin**	**Snap Bean**	**Soybean**	**Spring Oat**	**Squash**	**Sweet Corn**	**Tobacco**	**Tomato**	**Watermelon**	**White Potato**	**Winter Barley**	**Winter Rye**	**Winter Wheat**
2,4-D[1]	3	3	3	1	3	1	1	3	3	3	1	3	3	3	3	0.25–1[1]	1	3	1	3	3	3	1	1	1	1
Accent/Accent Q	10[1]	10[2]	10	10	10[2]	NR	10-18[1]	10-18[1]	10[2]	10[2]	10[2]	10	10[2]	10[2]	10	0.5	8	10[2]	10	10[2]	10[2]	10[2]	10[1]	4	4	4
Acuron	18	18	18	10	18	NR	10	18	18	18	10	18	18	18	18	10	4	18	NR	18	18	18	10	4	4	4
Acuron Flexi [23]	10	18	18	10	18	NR	10	18	18	18	10	18	18	18	18	10	4	18	NR	18	18	18	10	4	4	4
Afforia (2.5 oz)	4[24]	4[24]	4[24]	1	4[24]	0.5[24]	1	4[24]	4[24]	4[24]	1.5	3	4[24]	4[25]	3	NR[24]	4[24]	4[24]	3	1.5	4[24]	4[24]	4[24]	3	3	1[24]
Aim	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	12	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Anthem	10	18	18	4	18	NR	6	11	18	18	4	11	18	18	11	NR	11	18	NR	18	18	18	4	11	11	4
Anthem ATZ	SY	SY	SY	NY	SY	NR	SY	SY	SY	SY	NY	SY	SY	SY	SY	NY	SY	SY	NR	SY	SY	SY	SY	18	18	18
Anthem Maxx (4.87 oz)	10	18	18	4	18	NR	11[25]	11	18	18	4	11	18	18	11	NR	11[25]	18	NR	18	18	18	4	11[25]	11[25]	4[25]
Armezon/ Impact (0.75 oz)	9	18	18	9	18	NR	9	9	18	18	9	9	18	18	9	9	3	18	NR	18	18	18	9	3	3	3
Armezon PRO (16-20 fl oz/A)	9	18	18	9	18	NR	9	9[3]	18	18	9	9[3]	18	18	9[3]	9	4	18	NR	18	18	18	9	4	4	4
Assure II	4	4	4	NR	4	4	4	4	4	4	4	NR	4	4	NR	NR	4	4	4	4	4	4	4	4	4	4
Atrazine	SY	SY	SY	NY	SY	NR	NR	SY	SY	SY	NY	SY	SY	SY	SY	NY	SY	SY	NR	SY	SY	SY	SY	NY	NY	NY
Authority Elite/ Broadaxe XC	12	2[9]	12B	18[4]	12B	10	10	12B	12B	12B	4	12B	12B	12B	12B	NR	12	12B	18	10	4	12B	4	4.5	4.5	4.5
Authority First/ Sonic	12	30B	30B	12-18[1]	30B	10-18[1]	12	12	30B	30B	12	9	30B	30B	12	NR	12	30B	10-18[1]	30[1]	30B	30B	18	12	12	4
Authority MTZ	12	18	18	18[4]	18	10	12	18	18	18	12	18	18	18	18	NR	18	18	18	12	NR[9]	18	12	4		4
Authority XL	12-18[1]	18	18	18	18	10-18[1]	10-18[1]	36	36	36	12	36	36	18	36	NR	12-18[1]	36	18	10-18[1]	12-18[1,9]	10[1]	36	4	4	4
Authority Supreme	12	18[9]	18	12-18[1]	18	4	10[1]	9	18	18	4	9	18	18	9	NR[1]	12[1]	18	10	18	18	18	4	11[1]	11[1]	4[1]
Autumn Super[1]	18B	18B	18B	10	18	1	18B	18B	18B	18B	18B	18B	18B	18B	18B	2	18B	18B	9	18B	18B	18B	18B	9	18B	3

Table 5.5 - Herbicide Rotational Restrictions for Cash Crops (cont.)

The information listed in this rotation restriction table is our interpretation of label statements. Consult the label if two or more of these materials are applied during the same season. Herbicide labels are constantly changing; therefore, this list is not a substitute for the most recent herbicide label.

	Rotational Crops (months after application)[1]																										
Trade Name	**Alfalfa**	**Cabbage**	**Clover**	**Cotton**	**Cucumber**	**Field Corn**	**Grain Sorghum**	**Lima Bean**	**Muskmelon**	**Onion**	**Peanut**	**Peas**	**Pepper**	**Pumpkin**	**Snap Bean**	**Soybean**	**Spring Oat**	**Squash**	**Sweet Corn**	**Tobacco**	**Tomato**	**Watermelon**	**White Potato**	**Winter Barley**	**Winter Rye**	**Winter Wheat**
Axial XL	3	1	3	3	3	3	3	3	3	1	3	3	3	3	3	3	3	3	3	3	3	3	1	NR	3	NR
Axiom	12	12B	12	8	12B	NR	12	12B	12B	18	12B	12B	12B	12B	12B	NR	12	12B	12B	12B	12B	12B	1	12	12	0.23-4
Balance Flexx/ Pro	10[1]	18	18	10[1]	18	NR	6	18	18	18	11	18	18	18	18	6	18	18	6	12	18	18	6	6	4	4
Balance Pro[1]	10	18	18	10[1]	18	NR	6	18	18	18	11	18	18	18	18	6	6	18	6	18	18	18	6	6	4	4
Banvel	AH	AH	AH	0.75-1.5[5]	AH	NR	NR	AH	AH	AH	AH	AH	AH	AH	AH	1[5]	1[5]	AH	AH	AH	AH	AH	AH	1[5]	1[5]	1[5]
Basagran	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Basis	10	18	10	1[6]	10	NR	10[6]	18	18	18	18	10	18	18	10	10[6]	9	18	10	18	1	18	NR	3	3	3
Basis Blend[6]	10[6]	18	10[6]	1[6]	10	NR	10[6]	18	18	18	1.5	10	18	18	10	10[6]	9	18	10	1.5	1	18	1	3	3	3
Beacon	8	18	18	8	18	0.5[8]	8	18	18	18	8	8	18	18	18[6]	8	8	18	8	8	18	18	18[7]	3	3	3
Beyond	3	9	18	9	9	8.5[8]	9	NR	9	9	9	NR	9	9	NR	NR	9	9	8.5	9	9	9	9	9	4	3[8]
Bicep products/ Cinch ATZ	SY	SY	SY	NY	SY	NR	NR[10]	SY	SY	SY	NY	SY	SY	SY	SY	NY	SY	SY	NY	SY	SY	SY	SY	NY	NY	NY
Boundary	4.5	12	12	12	12	4	12	12	12	18	12	8	12	12	12	NR	12	12	4	12	12	12	NR	4.5	12	4.5
Breakfree	NY	NI	NY	NI	NI	NR	NY	NI	NI	NI	NI	NI	NI	NI	NI	NY	NY	NI	NR	NY	NI	NI	NY	NY	NY	4
Buctril/ Maestro	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cadet	AH	AH	AH	AH	AH	NR	AH	AH	AH	AH	AH	AH	AH	AH	AH	NR	AH	AH	AH	NR	AH	AH	AH	AH	AH	AH
Callisto	10	18	18	10	18	NR	NR	18	18	18	10	10[1]	18	18	10[1]	10	NR	18	NR	10	18	18	10	4	4	4
Callisto Xtra	NY	18	18	NY	18	NR	NR	18	18	18	NY	18	18	18	18	NY	18	18	NR	NY	18	18	NY	NY	18	NY
Canopy[1]	10	18	12	10	18	10	12	30	30	30	18	12	30	18	12	NR	30	30	18	10[10]	10[10]	18	30	4	4	4
Canopy Blend	10	18	18	18	18	10[26]	18	30	30	30	18	12	30	18	18	NR	4	30	18	18[9]	10[9]	18	30	4	30	4
Canopy EX	10	18	12	10	18	10[1]	10[1]	30	30	18[1]	8	12	30	18	12	0.25[1]	4	30	18	10[9]	10[9]	18	18[1]	4	4	4
Caparol	12	5	12	5	12	5	12	12	12	8	12	5	12	12	12	12	12	12	5	12	12	12	12	12	12	12
Capreno[1]	10-18	18	18	10	18	NR	10	18	18	18	11	18	18	18	18	10	10	18	10	12	18	18	18	10	18	4
Chaparral	SYB	SYB	SYB	SYB	SYB	NY	NY	SYB	SYB	SYB	SYB	SYB	SYB	SYB	SYB	SYB	NY	SYB	SYB	SYB	SYB	SYB	SYB	NY	NY	NY

Table 5.5 - Herbicide Rotational Restrictions for Cash Crops (cont.)

The information listed in this rotation restriction table is our interpretation of label statements. Consult the label if two or more of these materials are applied during the same season. Herbicide labels are constantly changing; therefore, this list is not a substitute for the most recent herbicide label.

	Rotational Crops (months after application)[1]																									
Trade Name	**Alfalfa**	**Cabbage**	**Clover**	**Cotton**	**Cucumber**	**Field Corn**	**Grain Sorghum**	**Lima Bean**	**Muskmelon**	**Onion**	**Peanut**	**Peas**	**Pepper**	**Pumpkin**	**Snap Bean**	**Soybean**	**Spring Oat**	**Squash**	**Sweet Corn**	**Tobacco**	**Tomato**	**Watermelon**	**White Potato**	**Winter Barley**	**Winter Rye**	**Winter Wheat**
Chateau (up to 3 oz)[11]	5[11]	12B	5[11]	2[11]	12B	0.5-1	1[1]	12B	12B	12B	NR	4	12B	12B	4	NR	5[11]	12B	4	2	12B	12B	5[11]	4	4	2
Cimarron Max/ metsulfuron[1]	12[1]	NYB	12[1]	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	NYB	10	NYB	NYB	NYB	NYB	NYB	NYB	10	NYB	1
Cimarron Plus	4	B	4-12[1]	B	B	12[1]	B	B	B	B	B	B	B	B	B	12[1]	10	B	B	B	B	B	B	10	NY	1
Clarity	4	4	4	0.75-1.5[5]	4	NR	NR	4	4	4	4	4	4	4	4	0.5–1[5]	0.5-1.5[5]	4	4	4	4	4	4	0.5-1.5[5]	0.5-1.5[5]	0.5-1.5[5]
Classic[1]	12	18	12	9	18	9	9	30	30	30	15	9	30	18	9	NR	3	30	18	10[9]	10[9]	18	30	3	3	3
Cobra	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Command	12	9	12	NR[12]	9	9	9	12	9	12	9	NR[1]	NR	NR[1]	9	NR	12	NR[1]	9	NR	9[9]	9	9	12	12	12
Corvus	17	17B	17B	10	17B	NR	17B[1]	17B	17B	17B	11[1]	17B	17B	17B	17	9	17	17B	9	12[1]	17B	17B	17	9	4	4
Crossbow[30]	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
Curbit	AH	AH	AH	AH	NR	AH	AH	AH	NR	AH	NR	AH	AH	NR	AH	NR	AH	NR	AH	AH	AH	NR	AH	AH	AH	AH
Curtail	10.5-18[1]	10.5-18[1]	10.5B	10.5B	10.5B	1	10.5-18[1]	10.5B	10.5 B	10.5-18[1]	10.5B	18	10.5B	10.5 B	10.5B	10.5-18[1]	1	10.5 B	10.5-18[1]	10.5B	10.5B	10.5B	18	1	10.5B	1
Dacthal	8	NR	8	8	8	8	8	8	8	NR	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Degree Xtra	SY	SY	SY	NY	SY	NR	NR[10]	SY	SY	SY	SY	SY	SY	SY	SY	NY	SY	SY	NR	NY	SY	SY	SY	SY	SY	AH
Devrinol	12	NR	12	12	12	12	12	12	12	12	12	12	NR	12	12	12	6	12	12	NR	NR	12	12	6	6	6
DiFlexx	4	4	4	2	4	NR	2	4	4	4	4	4	4	4	4	2[1]	2	4	4	4	4	4	4	2	4	2
DiFlexx Duo	10	18B	18B	10	18	NR	10	18B	18	18[27]	11	10	18B	18	10	8	4	18B	4	12	10	18	10	4	4	4
Distinct[1]	1	4	4	1	4	0.25	1	4	4	4	4	4	4	4	4	1	1	4	4	4	4	4	4	1	1	1
Dual products/ Cinch	4	2[1]	9	NR	12	NR	NR[10]	NR	12	2[1]	NR	NR	2	2[1]	NR	NR	4.5	12	NR	NY	2[1]	12	NR	4.5	4.5	4.5
Elevore	9	9	9	1	15B	0.5	0.5	15B	15B	15B	9	9	15B	15B	15B	0.5	0.5	15B	15B	15B	15B	15B	15B	0.5	0.5	0.5
Enlist Duo	NI	NI	NI	1[32]	NI	0.23-0.53[32]	NI	NI	NI	NI	NI	NI	NI	NI	NI	1[32]	NI	NI	0.2-0.5	NI	NI	NI	NI	NI	NI	NI
Envive	10	18	12	10	18	10	12	30	30	30	8	12	30	18	12	NR	10	30	18	10[9]	12[9]	18	30	4	4	4

Table 5.5 - Herbicide Rotational Restrictions for Cash Crops (cont.)

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Rotational Crops (months after application)[1]

Trade Name	Alfalfa	Cabbage	Clover	Cotton	Cucumber	Field Corn	Grain Sorghum	Lima Bean	Muskmelon	Onion	Peanut	Peas	Pepper	Pumpkin	Snap Bean	Soybean	Spring Oat	Squash	Sweet Corn	Tobacco	Tomato	Watermelon	White Potato	Winter Barley	Winter Rye	Winter Wheat
Eptam	NR	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	NR	AH	AH	AH	AH	AH	AH	AH	NR	AH	AH	AH
Evik	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	3	11	11	11	11	11	10	3	3	3
Expert	SY	SY	SY	NY	SY	NR	NR[10]	SY	SY	SY	NY	SY	SY	SY	SY	NY	SY	SY	NY	SY	SY	SY	SY	NY	NY	NY
Extreme	4	40B	4	18	40B	8.5[8]	18	NR	40B	40B	NR	NR	40B	40B	2	NR	18	40B	18	9.5	40B	40B	26	4	4	3
Facet L	24B	10	24B	10	10	10	NR	10	10	10	10	24B	10	10	10	10	10	10	10	24B	24B	10	24B	10	10	NR
Fierce	10	18	18	1.5-2[1]	18	0.25-1[1]	18	11	18	18	4	11	18	18	11	NR	11-12[1]	18	18	12	18	18	4	11-12[1]	11-12[1]	1-2[1]
Fierce XLT[1]	18	18-30	18	18-30	18	10	18	18-30	18-30	18-30	18-30	18-30	18-30	18-30	18-30	NR	18-30	18-30	18-30	18[9]	18[9]	18-30	18-30	18	18	4
Finesse Cereal & Fallow (0.4 oz)	B	B	B	18	B	18	4-18[1]	B	B	B	B	B	B	B	B	18[14]	10	B	B	B	B	B	10	10-16[1]	0-4[1]	0-4[1]
FirstRate	9	18	18	9	18	9	9	9	18	18	9	9	18	18	9	NR	9	18	18	18[15]	18	18	18	12	18	4
Flexstar/ Flexstar GT	18	18	18	NR	12	10	18	4	12	18	4	4	10[9]	10	NR	NR	18	12	10	18	10[9]	10	NR	4	4	4
Fultime/ Keystone/ Breakfree ATZ	15	SY	SY	NY	SY	NR	NY	SY	SY	SY	NY	15	SY	SY	SY	NY	15	SY	NR	15	SY	SY	15	15	SY	15
Fusilade/ Fusion	NR	NR	NR	NR	NR	2	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	2	NR	2	NR	NR	NR	NR	2	2	2
Galigan	2	NR[9]	2	0.25	2	10	10	2	2	4[1]	2	2	1[9]	2	2	0.25	10	3-4[1]	10	2	1[9]	2	2	10	10	10
Glyphosate	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Goal/ GoalTender	2	NR[9]	2	0.25	1-2[1]	10	10	2	2-3[1]	4[1]	2	2	1[9]	2	2	0.25	10	3	10	2	1[9]	1-2[1]	2	10	10	10
Gramoxone/ paraquat	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
GrazonNext HL	24B	24B	24B	24B	24B	12	24B	24B	24B	24B	24B	24B	24B	24B	24B	24B	12	24B	12	24B	24B	24B	24B	12	12	12
Grazon P+D	B	B	B	B	B	B	8	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	2	2	2
Guardsman Max	SY	SY	SY	NY	SY	NR	NR[10]	SY	SY	SY	NY	SY	SY	SY	SY	NY	SY	SY	NY	SY	SY	SY	SY	SY	SY	SY

Table 5.5 - Herbicide Rotational Restrictions for Cash Crops (cont.)

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	Rotational Crops (months after application)[1]																										
Trade Name	**Alfalfa**	**Cabbage**	**Clover**	**Cotton**	**Cucumber**	**Field Corn**	**Grain Sorghum**	**Lima Bean**	**Muskmelon**	**Onion**	**Peanut**	**Peas**	**Pepper**	**Pumpkin**	**Snap Bean**	**Soybean**	**Spring Oat**	**Squash**	**Sweet Corn**	**Tobacco**	**Tomato**	**Watermelon**	**White Potato**	**Winter Barley**	**Winter Rye**	**Winter Wheat**
Halex GT	10	18	18	10	18	NR	NR[10]	18	18	18	10	10[1]	18	18	10[1]	10	4.5	18	NR	10	18	18	10	4.5	4.5	4.5
Harmony Extra SG	1.5	1.5	1.5	0.75	1.5	0.75	0.75	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	NR	1.5	NR
Harmony SG	1.5	1.5	1.5	0.25	1.5	NR	NR	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	NR	NR	1.5	1.5	1.5	1.5	1.5	1.5	NR	1.5	NR
Harness	9	SY	SY	NY	SY	NR	NR[10]	SY	SY	SY	NY	NY	SY	SY	SY	NY	NY	SY	NR	NY	SY	SY	NY	NY	NY	4
Harness Xtra	SY	SY	SY	NY	SY	NR	NY	SY	SY	SY	NY	SY	SY	SY	SY	NY	SY	SY	NR	SY	SY	SY	SY	SY	SY	NY
Hornet/Stanza	10.5[1]	26B	26B	18	26B	NR	12	10.5[1]	26B	26B	18	18[16]	26B	26B	18[16]	10.5	4	26B	18[16]	18	26B	26B	18	4	4	4
Huskie	4[1]	1B	1B	1B	1B	4	0.25	1B	1B	9[1]	1B	9	1B	1B	9	4	1	1B	1B	1B	1B	1B	9	0.25	1	0.25
Instigate	10	18	18	10	18	NR	10	18	18	18	10	10[1]	18	18	10[1]	10	9	18	10	10	18	18	10	4	4	4
Karmex	24	24	24	NR	24	NY	NY	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Kerb[1]	NR	3-6	NR	3-5	3-6	12	12	3	3-6	3-6	12	3-4	3-6	3-6	3-4	3-4	12	3-6	12	12	3-6	3-6	3	12	12	12
Keystone NXT	SY	18	SY	NY	18	NR	NY	SY	18	18	SY	SY	18	18	18	NY	SY	18	NR	SY	18	18	SY	15	15	15
Laudis	10	18	18	10	18	NR	10	18	18	8[1]	11	10	18	18	10	8	4	18	NR	12	10	18	10	4	4	4
Leadoff (1.5 oz)	10	18	10[1]	1	10	NR	10	18	18	18	1.5	10	18	18	10	1[1]	9	18	10	1.5	1	18	1	3	3	3
Lexar/Lexar EZ	18	18	18	NY	18	NR	NR[10]	18	18	18	NY	18	18	18	18	NY	NY	18	NR	18	18	6	18	NY	NY	NY
Liberty/ Interline/Rely 280	6	2.3	6	NR	6	NR	6	6	6	2.3	6	6	6	6	6	NR	2.3	6	NR	6	6	18	2.3	2.3	2.3	2.3
Lightning	9.5	40B	40B	9.5[1]	40B	8.5[8]	18	9.5	40B	40B	9.5	9.5	40B	40B	9.5	9	18	40B	18	9.5	40B	40B	26	9.5	4	4
Lorox/Linex	4	4	4	4	4	NR[1]	NR[1]	4	4	4	4	4	4	4	4	NR[1]	4	4	4	4	4	4	NR	12	4	4
Lumax/Lumax EZ	18	18	18	NY	18	NR	NR[10]	18	18	18	NY	18	18	18	18	NY	NY	18	NR	18	18	18	18	4.5	4.5	4.5
Marksman	SY	SY	SY	NY	SY	NR	NR	SY	SY	SY	NY	SY	SY	SY	SY	NY	10	SY	NR	SY	SY	SY	SY	10	10	10
Marvel	18	18	18	NR	18	10	18	18	18	18	10	10	4[9]	18	NR	NR	4	18	18	18	4[9]	18	NR	4	4	4
Matrix	4	12	18	10	10	NR	18	10	18	10	18	8	12	12	10	4	9	18	10	18	NR	12	NR	12	12	4
Maverick	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	NR
Metribuzin	4	18	12	12	12	4	12	18	18	18	12	8	12	12	12	NR	12	18	4	12	4	18	12	4[1]	12	4[1]
Milestone	24B	12B	24B	24B	24B	12	24B	24B	24B	24B	24B	24B	24B	24B	24B	24B	12	24B	24B	24B	24B	24B	24B	12	12	12

Table 5.5 - Herbicide Rotational Restrictions for Cash Crops (cont.)

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	Rotational Crops (months after application)[1]																									
Trade Name	**Alfalfa**	**Cabbage**	**Clover**	**Cotton**	**Cucumber**	**Field Corn**	**Grain Sorghum**	**Lima Bean**	**Muskmelon**	**Onion**	**Peanut**	**Peas**	**Pepper**	**Pumpkin**	**Snap Bean**	**Soybean**	**Spring Oat**	**Squash**	**Sweet Corn**	**Tobacco**	**Tomato**	**Watermelon**	**White Potato**	**Winter Barley**	**Winter Rye**	**Winter Wheat**
Northstar	8	18	18	8	18	0.5[8]	8	18	18	18	8	8	18	18	8	8	8	18	8	8	18	18	8	3	3	3
Optill[1]	4	40B	4	18	18	8.5[8]	18	4	40B	40B	4	4	18	40B	4	0-1	18	40B	18	9.5	18	40B	26	9.5	4-18	4[8]
Option	2	2	2	2	2	0.25	2	2	2	2	2	2	2	2	2	0.5	2	2	2	2	2	2	2	2	2	2
Osprey	10	10	10	3	10	3	3	10	10	10	3	3	10	10	10	3	10	10	10	10	10	10	10	1	10	0.25
Outlook[1]	4-6	6-9	6-9	4	6-9	NR	NR[10]	6-9	6-9	6-9	NR	4	6-9	6-9	6-9	NR	4	6-9	NR	6-9	6-9	6-9	6-9	4	4	4
Outrider	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	3B	NR
Overdrive	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
PastureGard	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	4	NI	NI	NI	NI	NI	NI	4	NI	4
Peak (0.25 oz)[1]	22	22	22	10	22	1[8]	1	22	22	22	10	10	22	22	10	10	NR	22	10	10	22	22	22	NR	NR	NR
Permit	9	15	9	4	2	1[8]	2	NI	9	18	6	9	10	9	2	9[1]	2	9	3	36	2	9	9	2	2	2
Permit Plus	9	15	9	4	2	1	2	NI	9	18	6	9	10	9	2	9[1,14]	2	9	3	36	2[9]	9	9	2	2	2
Poast	NR	NR	NR	NR	NR	30	AH	NR	NR	NR	NR	NR	NR	NR	NR	NR	30	NR	30	NR	NR	NR	NR	30	30	30
Powerflex HL	9	12	12	3[1]	12	9	9	12	12	12	9	9	12	12	12	3[1]	9	12	9	12	12	12	9	9	12	1
Prefar[1]	4	NR	4	4	NR	4	4	4	NR	NR	4	4	NR	NR	4	4	4	NR	4	4	NR	NR	4	4	4	4
Prefix	18	18	18	1	12	10	18	4	12	18	4	4	10[9]	10	NR	NR	4.5	12	10	18	10[9]	10	1	4.5	4.5	4.5
Prequel[1]	10	18	18	10	18	NR	10	18	18	18	11	18	18	18	10	10[14]	9	18	10	12	18	18	6	4	4	4
Princep	SY	SY	SY	NY	SY	NR	NY	SY	SY	SY	NY	SY	SY	SY	SY	NY[17]	SY	SY	NY	SY	SY	SY	SY	NY	NY	NY
Prowl H_2O	6[1]	NY	NY	NR	NY	NR[18]	NY	NR	NR	NY	NR	NR	NR[1]	NY	NR	NR	NY	NR	NR[18]	NR[1]	NR[1]	NR	NR	4[1]	NY	4[1]
Pursuit[1]	4	18	4	18[19]	18	8.5[8]	18	NR	18	18	NR	NR	18[9]	40B	2	NR	18	40B	18	9.5	18[9]	18	18[1]	4[1]	4	4
Python/ Accolade	4	18	26B	18	26B	NR	12	4	26B	26B	4	4	26B	26B	4[1]	NR	4	26B	18[1]	9	26B	26B	12	4	4	4
Raptor	3	9	18	9	9	8.5[8]	9	NR	9	9	9	NR	9	9	NR	NR	9	9	8.5	9	9	9	9[1]	9[1]	4	3
Realm Q	10	18	18[1]	10	18	NR	10	18	18	18	10	10[1]	18	18	10[1]	10	9	18	10	10	18	18	10	4	4	4
Reflex	18	18	18	NR	12	10	18	4	12	18	4	4	10[9]	10	NR	NR	18	12	10	18	10[9]	10	NR	4	4	4
Remedy Ultra[20]	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
Resicore	10.5[28]	18	18	12	18	NR[28]	10.5[28]	18	18	18	18	18	18	18	18	10.5[28]	10.5[28]	18	10.5	18	18	18	18	10.5[28]	10.5[28]	4
Resolve (1 oz)	10	18	10[1]	10	10	NR	10	18	18	18	18	10	18	18	10	10[14]	9	18	10	18	1	18	NR	18	18	3
Resolve Q (1.25 oz)	10	18	10[1]	1	10	NR	10	18	18	18	1.5	10	18	18	10	2[1]	9	18	10	1.5	1	18	NR	3	3	3
Resource	1	1	1	1	1	NR	1	1	1	1	1	1	1	1	1	NR	1	1	1	1	1	1	1	1	1	1

Table 5.5 - Herbicide Rotational Restrictions for Cash Crops (cont.)

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	Rotational Crops (months after application)[1]																									
Trade Name	**Alfalfa**	**Cabbage**	**Clover**	**Cotton**	**Cucumber**	**Field Corn**	**Grain Sorghum**	**Lima Bean**	**Muskmelon**	**Onion**	**Peanut**	**Peas**	**Pepper**	**Pumpkin**	**Snap Bean**	**Soybean**	**Spring Oat**	**Squash**	**Sweet Corn**	**Tobacco**	**Tomato**	**Watermelon**	**White Potato**	**Winter Barley**	**Winter Rye**	**Winter Wheat**
Revulin Q	10[1]	18	18	10	18	NR	10[1]	18	18	18	18	18	18	18	18	10	8	18	10[20]	18	18	18	10[1]	4	4	4
Ro-Neet	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH
Sandea	9	15	9	4	2	1[8]	2	36	9	18	6	9	10	9	2	9[1]	2	9	3	36	2	9	9	2	2	2
Scepter[1]	18	18	18	18	18	9.5[13]	11	11	18	18	11	18	18	18	11	NR	11	18	18	9.5	18	18	18	11	18	3
Select/Select Max	NR	NR	NR	NR	NR	0.2	1	NR	NR	NR	NR	NR	NR	NR	NR	NR	1	NR	1	1	NR	NR	NR	1	1	1
Sentrallas	4	4	4	4	4	NR	NR	4	4	4	4	4	4	4	4	4[1]	NR	4	4	4	4	4	4	NR	4	NR
Sharpen (1 oz)[1]	4	4	4	1.5	4	NR	NR	4	4	4	4	NR	4	4	4	0–1	NR	4	0.5	4	4	4	4	NR	NR	NR
Sierra[1]	24	24	24	24	24	11	24	24	24	24	24	24	24	24	24	9[14]	24	24	24	24	24	24	9	9	24	NR
Sinbar	12	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	NR[1]	24	24	24	24
Solicam	16	24B	24B	1-16[1]	24B	24B	24B	24B	24B	24B	1-16[1]	24B	24B	24B	24B	1.5-16[1]	24B	24B	24B	24B	24B	24B	24B	24B	24B	24B
Solstice[1]	10	18	18	10	18	NR	AH	18	18	18	10	18	18	18	18	10	AH	18	NR	10	18	18	10	4	4	4
Sonalan	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	NR	AH	AH	AH	AH	NR	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH
Spartan	12	NR	12B	18	12B	10	10[1]	NR	12B	12B	12B	12B	12B	12B	12B	NR	12	12B	18	NR	NR[9]	12B	12B	4	4	4
Spartan Charge	12	NR[9]	12B	12-18[1]	12B	4	10[1]	12B[1]	12B	12B	NR	12B	12B	12B	12B	NR	12	12B	12	NR	NR[9]	12B	4	4	4	4
Spin-aid	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	AH	4	AH	AH	AH	AH	AH	AH	4	4	4
Spirit	18	10	18	10	18	1[8]	10	18	18	18	18	10	18	18	10	10	3	18	8	10	10	18	10	3	3	3
Spur	10.5	NR	10.5B	10.5B	10.5	NR	10.5	10.5 B	10.5 B	10.5	10.5B	18	10.5B	10.5 B	10.5B	10.5-18	NR	10.5 B	NR	10.5B	10.5B	10.5B	18	NR	10.5	NR
Starane Ultra	4	4	4	4	4	NR	NR	4	4	4	4	4	4	4	4	4[31]	NR	4	NR	4	4	4	4	NR	NR	NR
Status	1[5]	4	4	1[5]	4	0.25	1[5]	4	4	4	4	4	4	4	4	1[5]	1[5]	4	4	4	4	4	4	1[5]	1[5]	1[5]
Steadfast Q	10[1]	18	10[1]	10	10-18	NR	10-18	10-18	10-18	10-18	10-18	10	10-18	10-18	10	0.5	8	10-18	10[20]	10-18	10-18	10-18	10[1]	4	4	4
Stinger	10.5	NR	18	B	18B	NR	10.5	18B	18B	10.5	18B	18B	18B	18B	18B	10.5[1]	NR	18B	10.5	18B	18B	18B	18B	NR	18B	NR
Storm	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	NR	3.3	3.3	3.3	3.3	NR	1.5	3.3	3.3	3.3	3.3	3.3	3.3	1.5	1.5	1.5
Stout	10[1]	18	10[1]	10	18	NR	10	18	18	18	18	10	18	18	10	0.5	8	18	10[20]	18	18	18	10[1]	4	4	4
SureStart / TripleFLEX	NY[1]	26B	NY[1]	26B	26B	NR	12	26B	26B	26B	26B	NY	26B	26B	26B	NY[1]	NY	26B	18[1]	18	26B	26B	18	NY	NY	4
Surpass NXT	9	NI	9	NY	NI	NR	NR[10]	NY	NI	NI	NY	NY	NI	NI	NY	NY	NY	NI	NR	NY	NY	NI	NY	NY	NY	4

Table 5.5 - Herbicide Rotational Restrictions for Cash Crops (cont.)

The information listed in this rotation restriction table is our interpretation of label statements. Consult the label if two or more of these materials are applied during the same season. Herbicide labels are constantly changing; therefore, this list is not a substitute for the most recent herbicide label.

Rotational Crops (months after application)[1]

Trade Name	Alfalfa	Cabbage	Clover	Cotton	Cucumber	Field Corn	Grain Sorghum	Lima Bean	Muskmelon	Onion	Peanut	Peas	Pepper	Pumpkin	Snap Bean	Soybean	Spring Oat	Squash	Sweet Corn	Tobacco	Tomato	Watermelon	White Potato	Winter Barley	Winter Rye	Winter Wheat
Surveil	10	30B	30B	9	30B	9	9	9	30B	30B	9	9	30B	30B	9	NR	9	30B	18	10[21]	30B	30B	18	30B	30B	3
Synchrony XP[1]	12	18	12	9	18	9	9	30	30	30	15	9	30	18	9	NR	3	30	18	9[9]	9[9]	18	30	3	3	3
Targa	4	4	4	NR	4	4	4	4	4	4	4	NR	4	4	NR	NR	4	4	4	4	4	4	4	NR	4	NR
Treflan	NR	NR	5	NR	5	NR	NR	NR	5	NR	NR	NR	NR[9]	5	NR	NR	5	5	5	5	NR	5	NR	NR	NR	NR
Trivence	10	18	18	18	18	10[1]	18	30	30	30	18	12	30	18	30	NR	18	30	18	18[9]	12[9]	18	30	4	30	4
Ultra Blazer	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	NR	3.3	3.3	3.3	3.3	NR	1.5	3.3	3.3	3.3	3.3	3.3	3.3	1.5	1.5	1.5
Valor/Rowel (up to 3 oz)	5[11]	6-12B	5[11]	2[11]	6-12B	0.5-1[1]	1	6-12B	6-12B	6-12B	NR	4	6-12B	6-12B	4	NR	5[11]	12	4	2[11]	6-12B	6-12B	5[11]	4	4	2[11]
Valor XLT/ Rowel FX	12-18	18-30[1]	12[22]	10	18-30[1]	10[22]	10-18[1]	18[22]	18[22]	18[22]	18-30[1]	12	18-30[1]	18-30[1]	12-30[1]	NR	18-30[1]	18[22]	18-30[1]	10[9]	12-18[1,9]	18-30[1]	18[22]	4	4	4
Varisto	3	9	18	9	9	8.5[29]	9	NR	9	9	9	NR	9	9	NR	NR	9	9	8.5	9	9	9	9[29]	9[29]	4	3[29]
Verdict	7	7	7	6	7	NR	NR	7	7	7	7	4	7	7	7	NR	4	7	NR	7	7	7	7	4	4	4
Vida	1	1 day	1	NR	1 day	NR	1 day	1 day	1 day	1 day	1	1 day	1 day	1 day	1 day	NR	1 day	1 day	1	1	1 day	1 day	NR	1 day	1 day	NR
Warrant	9	NI	9	NR	NI	NR	NR[10]	NY	NI	NI	NR	NY	SY	SY	NY	NR	NY	NI	NY	NY	NI	NI	NY	NY	NY	4
Warrant Ultra	18	NI	18	1	NI	10	18	NY	NI	NI	10	10	NI	NI	NY	NR	4	NI	10	NI	NI	NI	NI	4	4	4
Xtendimax[1]	4	4	4	1[1]	4	NR	0.5[1]	4	4	4	4	4	4	4	4	1	1	4	4	4	4	4	4	1	1	1
Yukon	9	15	9	4	9	1[8]	2	NI	9	18	6	9	10	9	2	9[1]	2	9	3	NI	2[9]	9	9	2	2	2
Zemax	18	18	18	NY	18	NR	NR[10]	18	18	18	NY	18	18	18	18	NY	4.5	18	NR	18	18	18	NY	4.5	4.5	4.5
Zeus XC	12	NR[9]	12B	18	12B	10	10[1]	12B	12B	12B	4	12B	12B	12B	12B	NR	12	12B	18	NR	NR[9]	12B	12B	4	4	4
Zidua (3 oz or 5 fl oz)[1]	10	18	18	4	18	NR	10	11	18	18	4	11	18	18	11	NR	11	18	NR	18	18	18	4	11	11	4

Abbreviations: **AH** = after harvest; **B** = Bioassay of soil recommended before planting **NY** = next year; **SY** = second year following application, **NR** = no restrictions.

[1] Read the label for additional restrictions due to application rate, timing, geographical region, rainfall, soil, pH, tillage, variety, or supplemental labeling.

[2] 18 months with a soil pH > 6.5. At rates greater than 2.1 oz/A, a rotational interval of 30 months and a successful field bioassay are required.

[3] Rotation interval for lima bean is 18 months if Armezon PRO is applied at greater than 20 fl oz/A. Rotation interval for pea and snap bean is extended to 18 months if Armezon PRO is applied at greater than 25 fl oz/A.

[4] Cotton may be planted after 12 months where Authority Elite/Broadaxe was applied at rates less than 36 oz/A, Authority MTZ DF at rates less than 17 oz/A, or Authority First/Sonic at rates less than 5 oz/A and the following conditions are met: Medium and fine soils, pH < 7.2, and rainfall or irrigation must exceed 15" after herbicide application and prior to planting cotton.

[5] Following application of Banvel/Clarity and a minimum of 1" of rainfall or overhead irrigation, a waiting interval of 21 days is required per 8 fluid ounces per acre applied prior to planting cotton, 30 days per pint restriction for soybean, 20 day per pint restriction for small grains. If less than 1" or rainfall or irrigation is received after application and Status is applied at greater than 5 oz/A the rotational interval is 4 months.

[6] If Basis rate is 0.33 to 0.5 oz/A or Basis Blend rate is 1.25 oz/A, alfalfa, sorghum, pea = 18 months; soybean, snap bean = 10 months; STS soybean = 1 month; spring oat = 9 months; if Basis rate is greater than 0.5 oz/A or Basis Blend rate is 2.5 oz/A, cotton = 10 months and 18 months if greater than and less than 15 inches of rainfall or irrigation occur after application and prior to planting, respectively; STS soybean = 4 months; if Basis rate is 0.33 oz/A or Basis Blend rate is 0.825, soybean = 0.5 month.

[7] 8 months if 0.38 oz/A Beacon is applied.

[8] NR for IMI (IR/IT) or Clearfield (CL) varieties.

[9] Transplanted.

[10] Use safener with seed.

[11] Cotton may be planted no-till or strip-till after 14 or 21 days when applied at 1 oz/A or 1.5 to 2 oz/A, respectively. For winter wheat, at rates up to 2 oz/A, the rotation interval is 7 days for no-till or minimum-till wheat and 30 days for conventional-till wheat. At least 1 inch of rainfall/irrigation must occur between application and cotton, field corn, grain sorghum, tobacco, or wheat planting, or crop injury may occur. For alfalfa, clover, potato, and spring oats the rotation interval is 5 months if the soil is tilled prior to planting or 10 months if no tillage is preformed prior to planting. At lower rates of Valor/Rowel/Chateau, rotation interval for many crops are reduced. Chateau may be applied to potato following hilling at a rate of 1.5 oz/A. Consult labels for more specific information.

[12] Command may be applied preemergence to cotton only if Di-Syston or Thimet insecticides are applied in furrow with the seed at planting.

[13] Corn hybrids that are classified as IMI-corn or as tolerant (IT) or resistant (IR) may be planted in the spring of the year following regardless of rainfall or time interval from chemical treatment to corn planting.

[14] Rotational interval is shorter for STS soybean.

[15] Transplanted tobacco = 10 months if ≤ 0.3 oz/A.

[16] If Hornet WDG rate is < 4 oz/A, snap beans, peas, and some varieties of sweet corn = 10.5 months.

[17] If no more than 2 lb ai applied the previous year.

[18] Regardless of tillage, be sure to plant corn at least 1.5 inches deep and completely cover with soil.

[19] Cotton may be planted 9.5 months following Pursuit if all of the following criteria are met: Pursuit is applied to peanuts only; soil texture is sandy loam or loamy sand only; and greater than 16 inches of rainfall/irrigation is received following application of Pursuit through October of the application year.

[20] The rotational interval for the sweet corn varieties 'Merit', 'Carnival', and 'Sweet Success' is 15 months.

[21] Transplanted tobacco may be planted 10 months after application of 2.1 oz/A of Surveil. Tobacco in seeded nurseries may be planted 18 months after application of 2.1 oz/A of Surveil and following a successful field bioassay. At rates greater than 2.1 oz/A, a rotational interval of 30 months and a successful field bioassay are required.

[22] Rotational intervals based on soil pH less than 7.0. In Pennsylvania, rotational interval for clover, lima bean, muskmelon, onion, pepper, spring oat, squash, and white potato is 18, 30, 30, 30, 30, 30, 30, and 30 months, respectively. Consult seed corn agronomist regarding inbred sensitivity to Valor XLT/Rowel FX prior to planting inbred seed corn lines.

[23] If applied after June 1, rotating to crops othern than corn (all types) may result in crop injury.

[24] For Bolt or Non-Bolt soybean and minimum- or no-till field corn, if Afforia is used on coarse textured soils, such as sands and loamy sands, or on high pH soils (>7.9), extend time to planting by 7 additional days. For minimum- or no-till wheat in the states of DE, MD, NJ, or VA, Afforia may be applied at a minimum 7 days before planting. Do not us on Durum wheat and do not irrigate between emergence and spike. Wheat must be planted at least 1 inch deep. Do no graze until wheat has reached 5 inches in height. For conventional-till field corn, grain sorghum, cotton, and wheat, at least one inch of rainfall/irrigation must occur between application and planting or crop injury may occur. For alfalfa, cabbage, clover, cucumber, lima bean, muskmelon, onion, pepper, pumpkin, spring oat, squash, sweet corn, tobacco, tomato, watermelon, and white potato, the rotational interval is 4 months if the soil is tilled prior to planting. If no tillage is performed prior to planting these crops the rotational interval is extended to 8 months.

[25] Rotation interval for spring oat or winter barley at 5.7 oz/A or greater rates, the rotation interval is extended to 18 months. For winter wheat, at 5.7 oz/A or greater rates, the rotation interval is extended to 6 months.

[26] Seed corn inbred lines vary in sensitivity to herbicides, therefore, users should seek advice from seed corn agronomist regarding inbred sensitivity to Canopy Blend prior to planting inbred seed corn.

[27] For onion, the rotational interval for irrigated and non-irrigated is 8 and 18 months, respectively.

[28] For corn, if the original corn crop is lost do not make a second application. Injury may occur to soybean planted the year following application on soils having a calcareous subsurface layer, if products containing atrazine were used at rates greater than 0.75 lb/ai atrazine per acre in tank mixtures and/or sequentially with Resicore. If Resicore is applied after June 1, rotating to crops other than corn or grain sorghum the next spring may result in crop injury.

[29] NR for Clearfield corn (field and seed). For wheat, planting non-Clearfield cultivars in areas receiving less than 10 inches of precipitation from time of application up until wheat planting may result in wheat injury. Injury potential increases if less than normal precipitation occurs in the 2 months just after Varisto application. For barley, the rotation interval at pH > 6.2 and > 18 inches of rainfall/irrigation, pH < 6.2 and < 18 inches of rainfall/irrigation and with moldboard plowing, and pH < 6.2 and < 18 inches rainfall/irrigation and without moldboard plowing is 9, 9, and 18 months, respectively. For potato, the rotation interval at pH > 6.2 and > 18 inches of rainfall/irrigation and pH < 6.2 and < 18 inches of rainfall/irrigation is 9 and 18 months, respectively.

[30] Rotation information is unknown for this product. Please contact manufacturer for recommendations.

[31] In Delaware and Virginia, a Special Local Needs Label 24(c), has approved a 3 month plant back restriction for soybeans after an application to winter wheat.

[32] NR for Enlist varieties.

Herbicides Persistence and Rotation to Cover Crops

The question about whether corn or soybean herbicide programs will pose a problem for establishing fall cover crops has become a common question, particularly in areas of severe drought where corn is harvested earlier than normal and the desire to plant a cover/forage crop is strong. If you look at the rotation crop restrictions for corn and soybean herbicides in Table 5.4, you will see that many products limit rotation to alfalfa and/or the clovers as well as some of the small grains. This is a good place to start when thinking about rotation to fall cover crops. However, these tables are inadequate because these cash crop rotation restrictions may be due to the concern for herbicide residues accumulating in forage or feed rather than carryover injury. If the crop is not going to be harvested and consumed by livestock or humans, then the primary concern is carryover injury and achieving an acceptable stand that provides the benefits of a fall or winter cover. Cover crops that are not harvested can be planted after any herbicide program, but the grower assumes the risk of crop failure.

Two factors become important when trying to predict the potential for carryover injury to rotational crops. **1.**) How long does the herbicide last or persist in the soil assuming that it has soil activity, and **2.**) How sensitive is the rotational crop to potential herbicide residues? Herbicides with shorter half-lives (the time it takes for 50% of the active ingredient to dissipate) are always less of a concern. Of course several factors influence the rate of dissipation such as rainfall, soil texture and soil pH, etc., however, most guidelines generally are for "normal" conditions (e.g. not severe drought). In general, products with a 4 month or less rotation restriction for the species of interest, close relative, or sensitive species (i.e. clovers) should pose little problem. These products typically have half-lives of less than 30 days. Species sensitivity can play a role if only a small amount of residue is necessary to cause injury and the herbicide persists. Quite often, small seeded legumes and grasses like the clovers and ryegrass and mustard species like canola are very sensitive to some herbicides.

The following table provides some persistence and carryover information for some commonly used corn and soybean herbicides. Some of this information is our best guess and only pertains to the eastern US, not heavy Midwest soils or the western US where soils have high soil pH and rainfall is lower.

Table 5.6 - Corn Herbicide Half-Lives and Their Potential to Injure Fall Cover Crops

This table does not directly address preharvest establishment of cover crops such as interseeding or aerial seeding, which may be more restrictive.

Trade Name	Common Name	Normal Rate/acre	Half life (days) [1]	Fall-established Cover Crops		Other
				OK to plant	Concern for	
2,4-D 4S	2,4-D	1-2 pt	7	All grasses	Wait 30 days before planting sensitive broadleaves	Amine formulations more water soluble and can leach into seed zone
Accent 75DF/ Steadfast75DF	nicosulfuron/ nicosulfuron+ rimsulfuron	0.66 oz/ 0.75 oz	21	Fall cereal grains, ryegrass	Small seeded legumes, mustards, sorghum	More persistent in high pH soils (> 7)
Armezon/Impact 2.8SC	topramezone	0.75 fl. oz	14	Wheat, barley, oats, and rye are allowed after 3 mo. Ryegrass should also be OK	Although many broadleaves are restricted, Impact does not have much soil activity	We have not seen this herbicide carryover in the Mid-Atlantic region.

Table 5.6 - Corn Herbicide Half-Lives and Their Potential to Injure Fall Cover Crops (cont.)

This table does not directly address preharvest establishment of cover crops such as interseeding or aerial seeding, which may be more restrictive.

Trade Name	Common Name	Normal Rate/acre	Half life (days) [1]	Fall cover crops		Other
				OK to plant	Concern for	
Atrazine 4L	atrazine	1-2 qt	15-90	Sorghum species	Cereals, ryegrass, legumes, and mustards	More persistent in high pH soils (> 7). Rates < 1 lb/acre can allow more flexibility. Half-life in Mid-Atlantic probably closer to 30
Balance Pro 4L Balance Flexx 2L (Prequel also contains isoxaflutole)	isoxaflutole	3 fl. oz 6 fl. oz	50-120	Fall cereals grains	Ryegrass, legumes, and mustards	15 inches of cumulative precipitation required from application to planting rotation crops except soybean, barely, wheat, sorghum, and sunflower
Callisto 4L (includes Acuron, Acuron Flexi, Halex GT, Harness Max, Instigate, Lexar, Lumax, Resicore, Revulin, Solstice, Zemax, etc.)	mesotrione	3-6 fl. oz	10-50	All grasses	Small seeded legumes, mustards	Sequential applications (PRE fb POST) increase the potential for injury
Clarity/Banvel 4S (DiFlexx, Distinct, Engenia, Status, Xtendimax/ Fexapan)	dicamba	16 to 24 fl. oz	5-14	All	Only at high rates or less than 120 days after application	Anything can be planted after 120 days with 24 fl. oz/acre or less
Corvus 2.63SC	isoxaflutole+ thiencarbazone	5.6 fl. oz	50-120	Wheat, triticale, rye	Small seeded legumes, mustards, sorghum	15 to 30 inches of cumulative precipitation from application to planting for sensitive crops
Dual II Mag 7.62E/ Cinch	metolachlor	1.67 pt	15-50	Cereal grains, legumes	Annual ryegrass or other small seeded grasses	Higher rates and later applications more of a potential problem

Table 5.6 - Corn Herbicide Half-Lives and Their Potential to Injure Fall Cover Crops (cont.)

This table does not directly address preharvest establishment of cover crops such as interseeding or aerial seeding, which may be more restrictive.

Trade Name	Common Name	Normal Rate/acre	Half life (days) [1]	Fall cover crops		Other
				OK to plant	Concern for	
Glyphosate 4L	glyphosate	0.75 to 1.25 lb ae	47[3]	All	None	Glyphosate does not have soil activity at normal use rates
Gramoxone 2S	paraquat	2 pt	1000[3]	All	None	Paraquat does not have soil activity at normal use rates
Harmony 50WDG	thifensulfuron	1/8 oz	12	No restrictions for wheat, barley, and oats	None with 45 day waiting interval	Harmony Extra also contains tribenuron
Harness 7E (Degree, Surpass, Warrant)	acetochlor	2 pt	10-20	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	Nonfood/feed winter cover crops are allowed after corn harvest
Laudis 3.5SC (Diflexx Duo)	tembotrione	3 fl. oz	14	Cereal grains after 4 mo.	Unknown - Small seeded legumes, mustards could be a problem	Other crops may be seeded after a successful field bioassay.
Liberty 2.34L	glufosinate	22 - 36 fl. oz	7[3]	All	Food or feed residues rather than crop injury may be a concern	Glufosinate does not have soil activity at normal use rates
Metribuzin 75DF (Sencor)	metribuzin	0.33 lb ai	14-60	Cereal grains and ryegrass	Slight risk for small seeded legumes and mustards	Nonfood/feed winter cover crops allowed
Outlook 6E (Armezon Pro)	dimethenamid	16 fl. oz	20	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	Nonfood/feed winter cover crops should be OK after corn harvest
Peak 57WG (& Spirit)	prosulfuron	1 oz	9-152	Cereal grains and sorghum are labeled, other grasses	Small seeded legumes, mustards	More persistent in high pH soils (> 7)
Permit/Sandea 75DF	halosulfuron	2/3 oz	9-27	Cereal grains and sorghum after 2 mo. and other grasses	Small seeded legumes, mustards	Halosulfuron also an ingredient in Yukon

Table 5.6 - Corn Herbicide Half-Lives and Their Potential to Injure Fall Cover Crops (cont.)

This table does not directly address preharvest establishment of cover crops such as interseeding or aerial seeding, which may be more restrictive.

Trade Name	Common Name	Normal Rate/acre	Half life (days) [1]	Fall cover crops		Other
				OK to plant	Concern for	
Prowl H_2O 3.8CS	pendimethalin	3 pt	44	Cereal grains	Small seeded legumes and annual ryegrass	We have not seen this herbicide carryover in Mid-Atlantic; nonfood/ feed winter cover crops should be OK
Python 80WDG (Hornet and Surestart)	flumetsulam	1 oz	14-120	Cereal grains	Small seeded legumes, mustards, and annual ryegrass	Cover crops and forage grasses are restricted for 9 mo.
Resolve 25DF (Resolve Q)	rimsulfuron	2 oz	2-4	Based on the short half-life, most fall cover crops should be OK in Mid-Atlantic	None	More persistent in drought conditions
Sharpen 2.85SC (Verdict)	saflufenacil	3 fl. oz	7-35	All	None	This product has been reported more persistent in western Canada
Simazine 4L (Princep)	simazine	1-2 qt	60	Sorghum species	Cereals, Ryegrass, legumes, and mustards	Soil pH > 7
Stinger 3S (Hornet, Resicore, and Surestart)	clopyralid	5 oz	40	All grasses	Small seeded legumes	
Zidua (Anthem)	pyroxasulfone	2.5 oz	20	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	Nonfood/feed winter cover crops should be OK after corn harvest

[1] The herbicide half-life is defined the time it takes for 50% of the herbicide active ingredient to dissipate. See the Managing Herbicides Section for additional information. The herbicide half-life estimates are derived for the WSSA Herbicide Handbook and other scientific literature.

[2] Common small-seeded legumes include alfalfa, clovers,and hairy vetch.

[3] This herbicide does not have soil residual activity at normal application rates.

Table 5.7 - Soybean Herbicide Half-Lives and Their Potential to Injure Fall Cover Crops

This table does not directly address preharvest establishment of cover crops such as interseeding or aerial seeding, which may be more restrictive.

Herbicide	Active ingredient	Normal Rate/acre	Half life (days)[1]	Fall cover crops OK to plant	Concern for Fall cover crops	Other
2,4-D 4S	2,4-D	1-2 pt	7	All grasses	Wait 30 days before planting sensitive broadleaves	Amine formulations more water soluble and can leach into seed zone
Assure II/Targa 0.88E	quizalofop	8 oz	60	Most broadleaves	All grasses if less than 120 days or at high rates	Plant anything after 120 days
Authority 75DF (Authority First, BroadAxe, Sonic, Spartan)	sulfentrazone	4 oz	32-302	Cereals and ryegrass	Small seeded legumes, mustards, sorghum[2]	Labeled on tobacco, sunflowers, transplanted tomato
Classic 25DF (Authority XL, Canopy, Envive, Fierce, Fierce XLT, Synchrony, Trivence, Valor XLT, etc.)	chlorimuron	0.5-2 oz	40	Cereals and ryegrass	Small seeded legumes, mustards, sorghum	More persistent in high pH soils (> 7) and with higher soil applied rates
Dual II Mag 7.62E/ Cinch	metolachlor	1.67 pt	15-50	Cereal grains, legumes	Annual ryegrass or other small seeded grasses	Higher rates and later applications more of a potential problem
FirstRate 84WDG (Authority First, Sonic)	cloransulam	0.3 to 0.6 oz	8-33	Wheat, triticale, rye	Small seeded legumes, mustards, sorghum	The restriction for transplanted tobacco is 10 mo. for 0.3 oz/acre. Sugarbeet and sunflower have a 30 month restriction.
Glyphosate 4L	glyphosate	0.75 to 1.25 lb ae	47[3]	All	None	Glyphosate does not have soil activity at normal use rates
Gramoxone 2S	paraquat	2 pt	1000[3]	All	None	Paraquat does not have soil activity at normal use rates

Table 5.7 - Soybean Herbicide Half-Lives and Their Potential to Injure Fall Cover Crops (cont.)

This table does not directly address preharvest establishment of cover crops such as interseeding or aerial seeding, which may be more restrictive.

Herbicide	Active ingredient	Normal Rate/acre	Half life (days) [1]	Fall cover crops OK to plant	Concern for Fall cover crops	Other
Harmony 50WDG	thifensulfuron	1/8 oz	12	No restrictions for wheat, barley, and oats	None with 45 day waiting interval	Harmony Extra also contains tribenuron
Liberty 2.34L	glufosinate	22 - 36 fl. oz	7[3]	All	Food or feed residues rather than crop injury may be a concern	Glufosinate does not have soil activity at normal use rates
Metribuzin 75DF (Sencor)	metribuzin	0.33 lb ai	14-60	Cereal grains and ryegrass	Slight risk for small seeded legumes and mustards	Nonfood/feed winter cover crops allowed
Outlook 6E (Verdict)	dimethenamid	16 fl. oz	20	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	Nonfood/feed winter cover crops should be OK after corn harvest
Prowl H_2O 3.8CS	pendimethalin	3 pt	44	Cereal grains	Small seeded legumes and annual ryegrass	We have not seen this herbicide carryover in Mid-Atlantic; nonfood/feed winter cover crops should be OK
Pursuit 2S (Authority Assist, Optill, Zidua Pro)	imazethapyr	4 fl. oz	60-90	Wheat, triticale, rye, alfalfa, clover	Oats, sorghum, mustards	Any crop can be planted 40 months after Pursuit application
Python 80WDG	flumetsulam	1 oz	14-120	Cereal grains	Small seeded legumes, mustards, and annual ryegrass	Cover crops and forage grasses are restricted for 9 mo.
Raptor 1E	imazamox	5 fl. oz	20-30	Wheat, triticale, rye, alfalfa, clovers	Slight risk for mustards	Most cash crops allowed 9 mo. following application
Reflex 2E/ Flexstar 1.88E (Warrant Ultra)	fomesafen	1.5 pt	100	Cereal grains	Small seeded legumes, mustards, sorghum	Since fomesafen is often applied postemergence, soil activity can surprise users

Table 5.7 - Soybean Herbicide Half-Lives and Their Potential to Injure Fall Cover Crops (cont.)

This table does not directly address preharvest establishment of cover crops such as interseeding or aerial seeding, which may be more restrictive.

Herbicide	Active ingredient	Normal Rate/acre	Half life (days) [1]	Fall cover crops OK to plant	Concern for Fall cover crops	Other
Scepter 1.5AS	imazaquin	0.66 pt	60-90	Cereal grains	Small seeded legumes, mustards	Carryover much more of a risk with drought
Select 2E	clethodim	10 oz	3 d	All broadleaves	None assuming at least 30 days.	Plant anything after 30 days
Sharpen 2.85SC (Optill, Verdict, Zidua Pro)	saflufenacil	3 fl. oz	7-35	All	None	This product has been reported more persistent in western Canada
Valor 51WDG (Afforia, Envive, Fierce, Surveil, Trivence, Valor XLT, etc.)	flumioxazin	2.5 oz	12-20	All grasses	Small seeded legumes and mustards	Based on the half-life, all nonfood/feed winter cover crops should be OK
Warrant	acetochlor	2 pt	10-20	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	Nonfood/feed winter cover crops are allowed after corn harvest
Zidua (Fierce, Anthem etc.)	pyroxasulfone	2.5 oz	20	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	Nonfood/feed winter cover crops should be OK after corn harvest

[1] The herbicide half-life is defined the time it takes for 50% of the herbicide active ingredient to dissipate. See the Managing Herbicides Section for additional information. The herbicide half-life estimates are derived for the *WSSA Herbicide Handbook* and other scientific literature.

[2] Common small-seeded legumes include alfalfa, clovers,and hairy vetch.

[3] This herbicide does not have soil residual activity at normal application rates.

Herbicide-Resistant Crops

Herbicide-resistant crops are available for use in crop production systems. Corn, soybean, sorghum, alfalfa, and canola varieties are currently the key agronomic crops with herbicide resistance that can be grown in the northeast. Herbicide resistance in crops results from two different procedures: tolerance selection and genetic engineering techniques. Tolerance selection involves selecting naturally occurring herbicide-tolerant cells from a particular crop cultivar or cell culture and incorporating them into crop varieties and hybrids using traditional breeding techniques. Genetically engineering herbicide-resistant plants involves transferring a gene with a certain trait from one organism to another (e.g., from bacteria to plant) using complex technology (also called a GMO). The transferred genetic trait(s) is then incorporated into crop varieties using breeding techniques. (The same genetic engineering technology is used to create crop protection to insect pests—e.g., Bt corn.) Several crop protection chemical companies and seed companies are involved in developing and marketing these crops. Following is a brief summary of the herbicide-resistant corn and soybean varieties currently available or soon to be released. See the corn and soybeans sections of this guide for detailed information on herbicide use for these crops.

Clearfield (CL) corn is non GMO and was developed by tolerance selection to be resistant/tolerant to imidazolinone herbi-

cides (e.g., Pursuit, Scepter). Although these hybrids initially were introduced to help manage herbicide carryover, Pursuit and Pursuit-containing products such as Lightning can be applied directly to the CL corn hybrids as part of the weed-management program.

Enlist corn and soybean are genetically engineered (GMOs) to resist 2,4-D. In addition to 2,4-D resistance, Enlist corn is resistant to the aryoxyphenoxy-propionate herbicides (fops) such as Fusilade and Assure. Enlist corn and soybean are also stacked with Roundup Ready and Liberty Link traits. A new low volatility 2,4-D formulation (2,4-D choline or Colex-D) has been developed for use with this technology. Enlist corn should be available for the first time in 2018 with Enlist soybean sometime thereafter.

Inzen Z Herbicide Tolerant sorghum is a non-GMO trait that provides tolerance to certain Group 2 or ALS-inhibitor herbicides. Nicosulfuron (Zest) from Dupont is the product that will be co-marketed with Inzen Z sorghum.

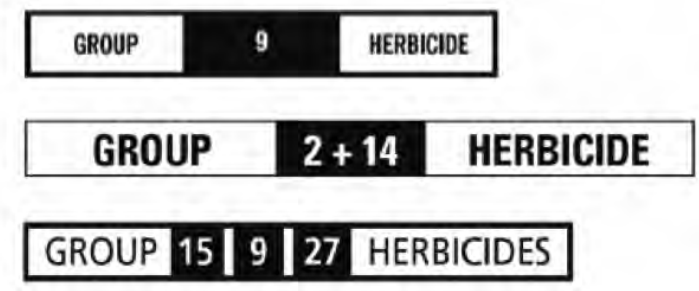
LibertyLink/GR corn and soybean is genetically engineered (GMO) to allow over-the-top applications of Liberty (glufosinate) herbicide. This program should provide broad-spectrum control of annual broadleafs and grasses of low to moderate pressure. Sequential applications or tank mixtures may be required for new weed flushes and perennials.

Roundup Ready alfalfa, corn, canola, and soybean were developed using genetic engineering techniques (GMO). They have an altered target site not sensitive to glyphosate and allow postemergence applications of glyphosate directly to alfalfa, corn, canola, and soybean. Glyphosate resistant weeds are becoming an increasing issue in Roundup Ready crops.

Xtend soybean were introduced for the first time in 2017. These soybean are genetically engineered (GMOs) to allow preemergence and over-the-top application of dicamba. Xtend soybean are also Roundup Ready. Three different dicamba products (Engenia, Xtendimax/Fexapan) specially formulated for reduced drift are labeled for Xtend soybean. All other dicamba products are not allowed. In addition, a number of stewardship guidelines are required including using low drift nozzles, at least 10 GPA carrier, and making applications only when certain environmental conditions exist to reduce the potential for off-site movement. In the Mid-Atlantic region, this technology is best suited for burndown application in no-till for control of winter annual weeds including horseweed/marestail. Over-the-top application and use in double-crop soybean is not encouraged due to greater concern for off-target movement.

The STS and BOLT soybean/herbicide system enhance crop safety from certain sulfonylurea herbicides such as thifensulfuron and chlorimuron. STS is a non-GMO, but Bolt also includes the GMO glyphosate-resistant trait. Although these varieties were developed to be used in combination with STS-labeled herbicides, they also provide greater safety from many of the ALS-type herbicides. The BOLT Herbicide-Tolerant trait provides enhanced tolerance to additional herbicides such as rimsuluron (Basis Blend).

Herbicide Resistant Weeds



Examples of herbicide group numbers on product labels

A number of weed species that once were susceptible to and easily managed by certain herbicides have developed resistance. These weeds are no longer controlled by applications of previously effective herbicides. As a result of repeated use of a certain type of herbicide on the same land, many different species of weeds have developed resistance to these chemicals. Globally, resistance has developed in all herbicide modes of action in about 250 weed species and the number of species continues to increase each year. (More information about herbicide-resistant weeds and herbicide modes of action can be found at www.weedscience.org.) It is believed that within any population of weeds, a few plants have sufficient tolerance to survive any herbicide that is used. Since only the survivors can produce seed, it is only a matter of time until the population of resistant weeds (or biotypes) outnumbers the susceptible type. Depending on the herbicide family and weed species, resistance can occur within five to twenty years. Reasons or mechanisms for resistance vary depending on the herbicide family. Resistant biotypes may have slight structural or biochemical differences at the cellular level from their susceptible counterparts that make them less sensitive to certain herbicides and therefore are not killed. Regardless of the mechanism for resistance, becoming familiar with the herbicide mode of action can help when

designing programs that prevent the introduction and spread of herbicide-resistant weeds. Growers, consultants, and those working with herbicides to manage weeds should know which herbicides are best suited to combat specific resistant weeds. The Weed Science Society of America (WSSA) developed a grouping system to help with this process. Herbicides that are classified as the same WSSA group number kill weeds using the same mode of action. Therefore, choose a combination of different herbicide modes of action that each contributes to the control of the target weeds. In other words, make sure to have at least two unique modes of action that are effective against the same weed during the season whether in tank-mixtures or sequential applications. Try to avoid using the same products and herbicide mode of action every year. This is especially important on weeds that are typically prone to resistance such as pigweed species, common lambsquarters and ragweed, horseweed, and foxtail species. WSSA group numbers can be found on many herbicide product labels (see graphic below) and can be used as a tool to choose herbicides in different mode of action groups so mixtures or rotations of active ingredients can be planned to better manage weeds and resistant species. Keep in mind that many products contain similar active ingredients even though the products may have different trade or brand names. Using a different product or brand does not guarantee you are selecting a different herbicide mode of action. Refer to Table 5.1 for herbicide—or WSSA—mode of action group numbers and corresponding herbicides. Other resources, such as university pest guides or recommendations, can provide effectiveness ratings of numerous herbicides on many different weed species to help with this process of developing appropriate weed management programs.

Dependence on a single strategy or herbicide family for managing weeds will increase the likelihood of additional herbicide resistance problems in the future. Management programs to combat herbicide resistance should emphasize an integrated approach. Some management guidelines for an integrated approach include using herbicide tank mixtures containing more than one herbicide mode of action that are active on similar weeds, shorter residual herbicides, crop rotations that allow for application of different herbicide classes, judicious and noncontinuous use of herbicide-resistant crops in a rotation, nonchemcial control measures, and combinations of weed management techniques such as avoiding spreading resistant weed seed with machinery or in manure and ensiling to help destroy weed-seed-infested forage.

Reducing the risk for developing herbicide-resistant weed populations requires incorporating a number of guidelines in managing your fields. These guidelines include: (from VanGessel)

- Spray only when necessary
- Use alternative methods of control whenever possible such as mechanical cultivation or delayed planting (row crops), mowing (forage crops), and using weed-free crop seeds
- Rotate crops and their accompanying herbicides' site of action
- Limit number of applications of herbicide(s) with same site of action in a given growing season
- Use mixtures or sequential herbicide treatments having different sites of action that will control the weeds of concern
- Scout fields after herbicide application to detect weed escapes or shifts
- Clean equipment before leaving fields infested with or suspected to have resistant weeds

Table 5.8 - Weed species prone to resistance and of concern in the Mid-Atlantic Region

	WSSA Site of Action Numbering											
Broadleaf species	**1**	**2**	**3**	**4**	**5**	**7**	**9**	**10**	**14**	**15**	**22**	**27**
Chickweed, Common		■										
Horseweed/Marestail		■			■		■				■	
Lambsquarters, Common		■			■							
Pigweed (Amaranth), Palmer		■		■	■		■		■			■
Pigweed, Redroot/Smooth		■			■		■					
Pigweed, Waterhemp		■		■	■		■					■
Ragweed, Common		■			■		■		■			
Ragweed, Giant		■					■					
Grass Species												
Barnyardgrass	■	■		■	■	■						
Foxtail, Giant	■	■			■							
Goosegrass			■		■		■					
Johnsongrass	■	■	■				■					
Ryegrass, annual/Italian	■	■					■	■		■		
Shattercane		■	■		■		■					

Banded Herbicide Application

Herbicide use can be reduced by fifty to seventy-five percent by applying the herbicide in a narrow strip or band over the row. Preemergence and postemergence herbicides can be applied as banded sprays to reduce cost and the amount of herbicide used in conventional and certain minimum tillage systems. Band spraying consists of applying an herbicide in an 8- to 15-inch band over the crop row, leaving the row middles unsprayed. Weeds that emerge between the rows must be controlled by mechanical cultivation which may be done more economically than treating them with herbicides. Banding is not practical with herbicides that must be preplant incorporated, in no-till planting systems, or when rows are planted at a close spacing.

Drift

Drift is the movement of any pesticide through the air to areas not intended for treatment. During application, droplet or particle drift occurs as spray droplets or dust particles are carried by air movement from the application area to other places. Vapor drift takes place after application as herbicides evaporate (volatilize) and yield fumes (gases) that are carried on wind currents and deposited on soils or plants in untreated areas.

Herbicide drift may injure sensitive crops, ornamentals, gardens, livestock, wildlife, or people, and may contaminate streams, lakes, or buildings. It may contaminate crops and cause illegal or intolerable residues. Excessive drift may mean poor performance in the desired spray area because the application rate is lower than expected.

Drift control should be considered with each pesticide application. Here are some ways to prevent severe drift problems:

- Use sprayer nozzles especially designed for drift reduction
- Use low-volatile or nonvolatile formulations
- Use low spray-delivery pressures (15–30 psi) and nozzles with a larger orifice
- Use drift-inhibiting adjuvants in the spray mixture when spraying under less-than-ideal conditions
- Use nozzles that allow for lowered boom height

- Avoid application of volatile chemicals at high temperatures
- Spray when wind speed is low (less than 10 mph) or when the wind is blowing away from areas that should not be contaminated
- Use higher spray volumes during applications (e.g., 20 to 30 gallons per acre versus 5 to 10 gallons per acre)
- Spray during the early morning or evening hours when there is usually less wind
- Leave border areas unsprayed if they are near sensitive crops

General Herbicide Mixing Procedures

Specific mixing or tank-mixing procedures may vary among product labels. When using a product alone, adhere to the mixing instructions on the product label. When tank-mixing two or more products, adhere to the most restrictive label's instructions. If it is difficult to determine which instructions to follow or when the instructions on the labels contradict each other, use the general instructions outlined below.

1. Make sure the spray equipment is properly cleaned according to the labels of the products that were last applied with the sprayer.
2. Make sure the sprayer is properly calibrated, has good agitation, and is equipped with the appropriate screens (no finer than 50 mesh; 100 mesh is finer than 50 mesh) and spray tips.
3. If tank-mixing two or more products, make sure there are no label restrictions prohibiting those products from being tank-mixed.
4. If tank-mixing two or more herbicides that are not specifically allowed on the labels, or if the labels require it, perform a compatibility test (such as a jar test) to assure that the products mix properly.
5. If a suspension or liquid fertilizer is being used as the carrier, perform a compatibility test (such as a jar test) to assure that the products dissolve properly and remain stable.
6. Fill the spray tank ½ to ¾ full with clean water or suspension or liquid fertilizer (if being used as the carrier) and begin agitation. If possible, maintain agitation until all applications are completed.
7. If ammonium sulfate (AMS) is being added as a water conditioner, add the AMS first. This is particularly important if glyphosate (Roundup, Touchdown, etc.) or paraquat (Gramoxone) products are being used. Make sure the AMS is completely dissolved before continuing.
8. If compatibility agents are required, follow the herbicide label first, followed by the directions with the compatibility agent. Compatibility agents are generally either mixed or slurried with the products and/or added to the carrier solution prior to adding any products.
9. Add water soluble packets and thoroughly mix. Make sure the packets are completely dissolved.
10. Add wettable powders (WP) and thoroughly mix.
11. Add dispersible granules (DG) and dry flowables (DF) that are not in water soluble packets and thoroughly mix.
12. Add liquid flowable (FL) formulations and thoroughly mix.
13. The products in steps 9-12 can be slurried in water to assure that the products are completely dissolved before adding them to the spray tank. Some labels require that the product be slurried, particularly when using a suspension or liquid fertilizer as the carrier. Make sure to use enough water to allow the products to be completely dissolved.
14. Add water soluble concentrates (SC) and other aqueous solution products and thoroughly mix.
15. Add emulsifiable concentrate (EC) formulations and thoroughly mix.
16. Add spray adjuvants (nonionic surfactants, crop oil concentrates, methylated seed oil, etc.).
17. Add nitrogen fertilizer solutions such as urea ammonium nitrate (UAN) or ammonium sulfate (AMS) that is not being added as a water conditioner.

18. Add other tank products such as defoamers, drift control agents, dyes, etc., unless labels require their addition earlier in the mixing process.

19. Finish filling the spray tank.

General Jar Test Procedures

A "jar test" is a type of compatibility test used to determine if two or more herbicides will mix properly, or if an herbicide(s) will mix properly with a carrier solution such as a suspension or liquid fertilizer. Incompatibility of tank mixtures is more common with suspensions of liquid fertilizers and pesticides. The idea of the jar test is to create a miniature of the actual spray tank mixture with all of the components in the proper ratios. Many herbicide labels have specific jar test procedures. If possible, follow the procedures outlined on the product label(s). If it is difficult to determine which label instructions to follow or when the instructions on the labels contradict each other, use the general instructions outlined below.

1. Use only water or carrier solution from the intended source and at the source temperature.

2. One jar will usually be adequate if only herbicide compatibility in water is being tested. Two or three jars may be needed if compatibility agents and/or adjuvants will be compared to the tank mixture alone. Use quart-size jars with re-sealable lids.

3. Add the appropriate amount of water or carrier solution to each quart jar using this formula: **[spray volume (gal/A) x 0.04 = carrier to add in pint/jar]**. For example, for a spray volume of 20 gal/A, add 20 x 0.04 = 0.8 pint (378 ml) of carrier to each jar.

4. If a compatibility agent will be used, add the appropriate amount of the compatibility agent to one labeled jar based on this formula: **[compatibility agent rate (pint/100 gal) x spray volume (gal/A) x 0.005 = compatibility agent to add in teaspoons/jar]**. For example, if the label rate for the compatibility agent is 3 pints/100 gal and the spray volume is 20 gal/A, then 3 x 20 x 0.005 = 0.3 teaspoon (1.5 ml) of compatibility agent to one jar.

5. Add the appropriate amount of pesticides in the proper order (wettable powders, dispersible granules, dry flowables, liquid flowables, soluble concentrates and other aqueous solutions, and emulsifiable concentrates) to all jars according to one of the methods below. After each addition shake, invert several times, or stir gently to thoroughly mix.

    a. Use the formula **[product rate/A x 0.005]**, and convert to an appropriate measurement using the conversion factors below. Or,

    b. For dry products add 1 teaspoon per pound of product per acre, and for liquid products add ½ teaspoon per pint of product per acre.

        i. **Dry product conversion factors:**

            1. 1 pound = 16 ounces = 454 grams

            2. 1 ounce = 28.3 grams

        ii. **Liquid product conversion factors:**

            1. 1 gallon = 4 quarts = 8 pints = 128 fluid ounces

            2. 1 pint = 2 cups = 16 fluid ounces = 473 milliliters

            3. 1 fluid ounce = 29.57 milliliters = 2 tablespoons = 6 teaspoons

            4. 1 teaspoon = 4.93 milliliters = 60 drops

6. If adjuvants are being tested for compatibility, these should be added last to one labeled jar. Use one of these formulas based on how the adjuvant rate is expressed: **[adjuvant rate (pint/100 gal) x spray volume (gal/A) x 0.005 = adjuvant to add in teaspoons/jar]**, or **[adjuvant rate (pint/A) x 0.48 = adjuvant to add in teaspoons/jar]**.

7. When all components have been added to the jar(s), invert each jar ten times to mix and let stand for 15 to 30 minutes. If the spray solution balls up or forms flakes, sludges, jels, oily films or layers, or other precipitates it is not compatible. If a compatibility agent has not already been tested, repeat the test with a suitable compatibility agent. The tank mixture should not be used if any signs of incompatibility are evident. If the mixture separates but can be remixed readily, the mixture can be sprayed as long as good agitation is used.

8. Compatibility may be improved by using the following methods when testing and mixing.

a. Slurry the dry pesticides in water before addition to the mixture.

Oily films are usually caused by incompatibility of emulsifiable concentrates (EC). Add ½ of the compatibility agent to the carrier and ½ to emulsifiable concentrates and/or flowable pesticides before adding them to the mixture.

Sprayer Cleanout *(Modified from article Iowa State University of Science and Technology, Ames, Iowa. File code: Pest Management; PAT-30, Nov. 1997.)*

Crop injury due to contaminated sprayers is a continuing problem for both vegetables and field crops. Herbicide residues can be dissolved with time and some herbicide formulations are very effective at removing residues. This problem can be avoided by ensuring that sprayers are properly cleaned between tank loads. Sprayer cleaning is particularly important before you begin spraying a different crop. When determining the correct clean-out procedure, it is important to consider the product's mode of action, carrier, and additives. They all have an impact on what cleaning solutions to use and potential damage to sensitive crops.

Rinsate disposal. Clean the sprayer in an area that will not contaminate water supplies, streams, or crops and in an area inaccessible to children, pets, and livestock. Pay particular attention to sensitive vegetation that is in the runoff area. The best method for rinsate disposal is in the field in a manner consistent with the product's label. The easiest way to do this is to have rinse water available in the field, either on the sprayer or support vehicle.

Tank-cleaning agents. A tank-cleaning agent's function is to penetrate, loosen, and dissolve herbicide residues and then to remove them through dilution. In some cases, the agent will provide deactivation or decomposition of the herbicide.

- Commercial tank cleaners are recommended on many product labels and help remove water and oil-soluble herbicides.
- Household ammonia, a commonly recommended cleaning agent, is effective at penetrating and loosening deposits and residues in the spraying system. Although ammonia does not decompose herbicides, it increases the solubility of some herbicides by raising the pH.
- Chlorine bleach can decompose residues of most sulfonylurea and other herbicides into inactive compounds. However, some tank-mix partners may inhibit the decomposition. Care must be used with chlorine bleach. Chlorine bleach can combine with fertilizers containing ammonia to produce dangerous chlorine gas, which is irritating to the eyes, nose, throat, and lungs. Also, rinsate containing chlorine bleach is not labeled for application to cropland.
- Kerosene or fuel oil should be used to remove oil-based herbicide formulations such as 2,4-D esters. Following the oil rinse, the system should be cleaned with detergent or ammo

Removing precipitated pesticides. Tank-mixing more than one pesticide can sometimes result in the chemicals forming a "gunky mess" in the bottom of the tank. The result is that the pesticides are not compatible with one another and the pesticides will settle out (form gunk). If your tank does end up with incompatible pesticides gunking up the bottom use a compatibility agent (usually at a pint/100 gallons, follow directions).

Surfactants and fertilizer additives. When switching from a growth regulator herbicide (2,4-D, Banvel, or Stinger) to a postemergence application in soybeans, special care should be taken if the application involves surfactants or fertilizer additives. Such materials are particularly adept at removing these herbicides from poly tanks, hoses, and strainers. It is recommended that a small amount of fertilizer or crop oil be flushed through the system before the application.

General cleaning guidelines. To avoid drying and hardening of pesticide residues, and potential corrosion and damage to equipment, clean the sprayer immediately following an application. If you are continuing with the same pesticide the next day, flushing with water is sufficient. However, if you are switching products or crops, a more thorough cleaning is required.

Be sure to clean the entire sprayer system, not just the tank. Operate the pump and flush the cleaning solution through all hoses, strainers, screens, nozzles, and the boom. Small amounts of residue left in these areas can be sufficient to cause serious damage to a sensitive crop.

Most injury occurs when switching between crops. The following procedure is recommended when there are no specific cleaning requirements given on the label.

1. Drain the sprayer tank and lines and rinse tank, boom, and lines with water for a minimum of 5 minutes.

2. Fill the tank with clean water and one of the following cleaning solutions per 100 gallons of water:

- 1 gallon household ammonia, **or**
- 8 lbs trisodium phosphate cleaner detergent, **or**
- commercial tank cleaner (follow instructions).

Flush the solutions through the entire sprayer system. For growth regulator herbicides (2,4-D, Banvel, Clarity, Distinct, Stinger, etc.), let the solution stand overnight. Add more water to fill tank and agitate solution for at least 15 minutes and flush through the nozzles. Drain the tank.

3. Remove the nozzles, screens, and strainers and clean them separately in a bucket of cleaning agent and water.

4. Rinse the entire system with clean water.

Sprayer Calibration

Proper sprayer calibration is one of the most important steps in any integrated pest management program. There are many reasons why you should calibrate your sprayers at least once a year. One of the most important reasons is to ensure you are not over-applying or under-applying a pesticide. Applying too much pesticide hurts your bottom line, may harm non-target plants or insects and is illegal. Too little can lead to poor pest control. Sprayer calibration is a step many producers skip because they think it is too complicated or time consuming.

A simple method for sprayer calibration has been developed which requires very few calculations. This method is based on spraying 1/128th of an acre per nozzle and simply collecting the spray released during the time it takes to travel over that area. Since there are 128 fluid ounces in 1 gallon, the number of ounces collected equals the application rate in gallons per acre. This method works well for broadcast applications, banded applications and directed applications.

To calibrate your sprayer, you will need a measuring tape, a stopwatch and a graduated liquid measuring cup. Follow these steps to determine the sprayer output:

Step 1. Determine the nozzle spacing, band width or row spacing based on type of application. Example: 18 inch band application (see Table 1).

Step 2. Determine the calibration distance for the appropriate spacing using the information in Table 1. Example: 18 inch band = 226.9 feet calibration distance.

Step 3. Mark off the appropriate calibration distance you determined in step 2. To obtain the most accurate results, conduct this step in the actual field or under similar conditions to where you will be spraying.

Step 4. Drive the calibration distance at a safe operating speed several times to determine the average time to travel the course. **Note:** It is important that ALL attachments such as harrows or planters are in operation to ensure proper calibration. Write down the engine RPM, gear, speed and time required to travel the calibration distance. To ensure accuracy, drive the course at least twice and calculate the average time to travel the distance.

Step 5. With the sprayer parked and operating at the same engine speed used to drive the calibration distance (Step 4), adjust spray pressure to the desired setting. The recommended spray pressure setting can be found on the pesticide label or based on the nozzles selected.

Step 6. With the sprayer running, collect the spray from **all** nozzles that contribute to the desired spacing for the number of seconds that were required to travel the calibration distance in step 4. The number of nozzles that contribute to the spray area will depend on your application method:

a. **Broadcast Application:** All outlets are evenly spaced; however, because pressure differences can occur along the length of the boom, collect spray from all nozzlesfor the number of seconds required to travel the calibration distance.

b. **Band Application:** Spray from one or more nozzles contribute to cover a specific area. Collect spray from the total number of nozzles that contribute to the selected band width for the number of seconds required to travel the calibration distance

c. Directed Application/Row Application: Spray from one or more nozzles contributes to cover a specific area. Collect spray from the total number of nozzles that contribute to the selected width for the number of seconds required to travel the calibration distance.

The total number of fluid ounces collected is equal to the gallons per acre rate. The rate can be adjusted by adjusting the pressure, changing nozzles or by changing the applicator speed. If speed is adjusted, begin at step 4 and recalibrate.

Determining Tank Mix

To determine the amount of chemical to mix into the spray tank, divide the number of gallons in the tank by the broadcast application rate in gallons per acre (Step 6) and multiply by the labeled per acre application rate for the pesticide. Example: A sprayer has a 200-gallon tank, and it is calibrated to apply 20gallons per acre. The labeled rate is one pint of pesticide per acre.

a) 200-gallon tank/ 20 gallons per acre = 10 acres covered per tank

b) 10 acres X 1 pint per acre = 10 pints of chemical per tank

Determine the Total Number of Acres Covered by a Banded Application

Use the broadcast pesticide rates to mix into the tank for a banded application. Since a banded application sprays less area than a broadcast application, the total treated acres can be determined by dividing the treated band width by the total treated band width plus the untreated band area. Example: The above sprayer set to spray a 12-inch band over a 36-inch row spacing.

a) 12” band/36” row spacing = 0.33.

b) 0.33 X 10 acres per tank (broadcast) = 3.3 acres sprayed for every 10 acres covered.

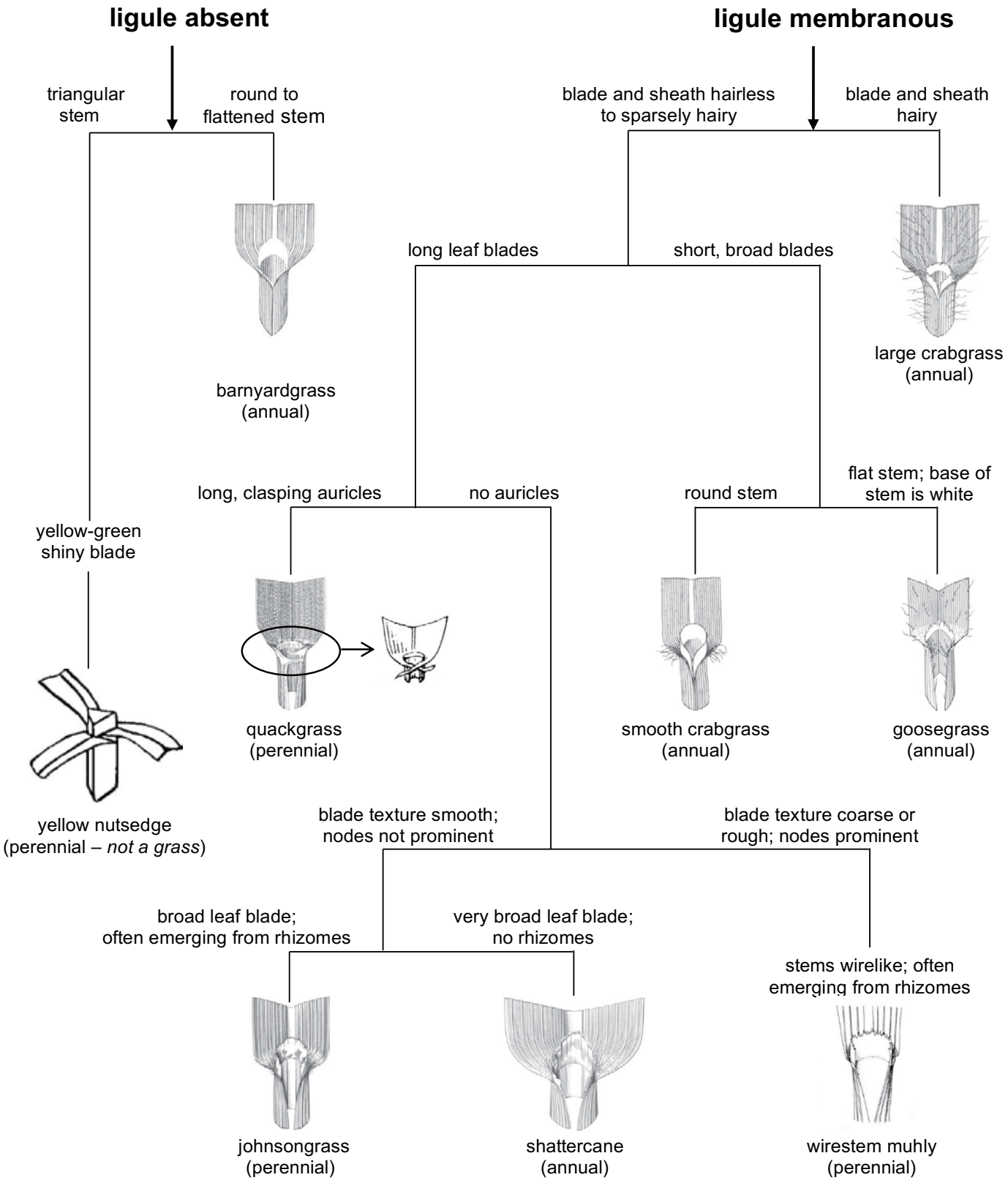
c) 10 acres/tank (broadcast)/0.33 acres sprayed in the band = 30.3 acres sprayed per tank.

Table 5.9 Calibration Distance Based on Sprayed Width (inches by nozzle)

Row spacing, nozzle spacing (broadcast) or band width (banded application) (inches)	Calibration distance (feet)
48	85.1
40	102.1
36	113.4
32	127.6
30	136.1
28	145.8
24	170.2
20	204.2
18	226.9
12	340.3
8	510.5

To determine a nozzle spacing not listed above, divide the band width in feet into 340.3.
Example: 7-inch band = 340.3 ÷ 7”/12” = 583.4
Taken with permission from Rutgers Cooperative Extension, Fact Sheet FS1085 by Stephen Komar, Bill Bamka, and Robert Mickel.

VEGETATIVE KEY: SEEDLING GRASS AND GRASSLIKE WEEDS – INCLUDING COMMON SUMMER ANNUAL SPECIES (p. 1 of 2 pages)



VEGETATIVE KEY: SEEDLING GRASS AND GRASSLIKE WEEDS – INCLUDING COMMON SUMMER ANNUAL SPECIES (p. 2 of 2 pages)

ligule hairlike

blade with hairs

blade with few or no hairs

blade hairy on upper and lower surfaces

blade hairy upper surface only

short hairs covering entire upper blade surface

few long hairs on upper blade surface near collar region

sheath hairless to sparsely hairy

short, fine velvetlike hairs on blade

giant foxtail (annual)

yellow foxtail (annual)

Texas panicum (annual)

annual

perennial

long, narrow blade; primarily spread by wiry stolons

bermudagrass (perennial)

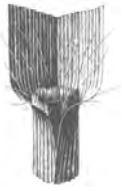
flat stem

round stem

collar margins occasionally hairy

relatively short, broad leaves

long, narrow leaves



sandbur (annual)

red horizontal marking in collar region; leaf almost perpendicular to stem

mid-vein is not prominent

prominent midvein is pale green to white

sheath margins hairy

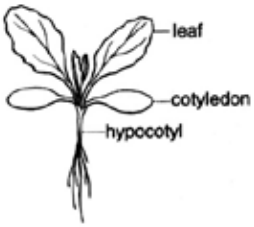
broadleaf signalgrass (annual)

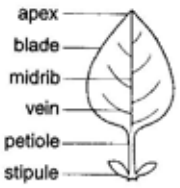
green foxtail (annual)

fall panicum (annual)

Grass drawings provided by Ciba-Geigy Limited, Basil, Switzerland

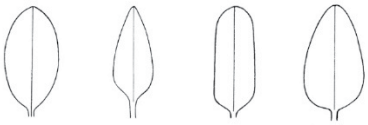
VEGETATIVE KEY: SEEDLING BROADLEAF WEEDS – COMMON SUMMER ANNUAL SPECIES
p. 1 of 3 pages





leaf parts

leaves are alternate



elliptic (spoon) | lanceo-late | oblong | ovate

leaf shapes

leaf arrangement: opposite

true leaves lobed

true leaves not lobed (entire)

true leaves rough textured

true leaves with 3-5 major lobes

true leaves with 5 or more major lobes (lacy appearance)

plant is size of silver dollar at 2-leaf stage

plant is size of quarter at 2-leaf stage

cotyledons are lanceolate, thick and waxy; leaves alternate after 1st true leaves

giant ragweed

common ragweed

common cocklebur

Individual plants drawn by Karen English-Loeb
Drawings of leaf arrangement, margins and shape provided by Ciba-Geigy, Limited, Basil, Switzerland

VEGETATIVE KEY: SEEDLING BROADLEAF WEEDS – COMMON SUMMER ANNUAL SPECIES
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leaves are alternate but not heart-shaped or lobed

leaf arrangement: alternate

heart-shaped leaf

lobed entire toothed (serrated)

types of leaf margins

true leaves 3 or more lobes

true leaves densely hairy; margins toothed

true leaves hairless to sparsely hairy; margins entire

plant has vining growth habit

plant does not have vining growth habit

cotyledons: one round and the other heart-shaped

mature leaves: coarsely toothed margins, primarily 3 lobed

cotyledons oval to round to heart shaped

cotyledons butterfly-shaped

plant has tendrils

cotyledon "wings" broad

cotyledons: large, rounded, thick

all leaves 3-lobed (1st leaf may be only slightly lobed)

mature leaves: fine-toothed margins, 3-5 shallow lobes

velvetleaf

spurred anoda

cotyledon "wings" broad

cotyledon "wings" long and narrow

burcucumber

tall morningglory

pitted morningglory

ivyleaf morningglory

VEGETATIVE KEY: SEEDLING BROADLEAF WEEDS – COMMON SUMMER ANNUAL SPECIES
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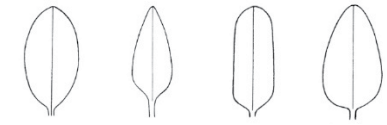
leaf arrangement: alternate

(leaves with various leaf shapes – not lobed)



elliptic (spoon) | lanceo-late | oblong | ovate

leaf shapes

true leaves hairy; margins toothed (first few leaves entire)

plants with distinctive odor

plants do not have odor

cotyledons have distinctive broad notch; older leaves may be lobed

petiole of third and older leaves has stipules (soft spines); older leaves lanceolate to oblong

wild mustard

prickly sida

tropic croton

true leaves hairless (or sparsely hairy); margins entire

true leaves elliptic or lanceolate

true leaves oval to ovate

plants with distinctive odor

jimsonweed

plants with ocrea

ocrea (papery sheath at stem nodes)

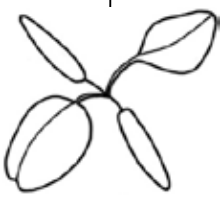
true leaves covered with mealy white “granules” or “frost”

Pennsylvania smartweed

common lambsquarters

true leaves without white “granules”

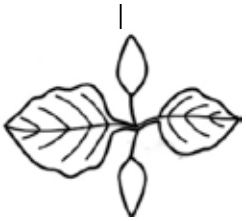
true leaves with notched tip



smooth pigweed or redroot pigweed

true leaves without notched tip

cotyledons ovate with distinctive pointed tip



eastern black nightshade

Corn Weed Management

Integrated Weed Management

An integrated approach to managing weeds in corn includes using cultural weed control, mechanical controls where applicable, and the judicious use of herbicides. Corn fields that are weed-free for the first 4 to 6 weeks after planting will often yield the same as fields that are weed-free for the entire growing season. This approach relies on starting with a clean seedbed and using residual soil-applied herbicides or mechanical control. Weeds that germinate with the crop but are controlled in a timely (4 to 5 weeks after planting) fashion will also not impact final yields. This POST herbicide approach relies upon effective and timely postemergence weed control. Also, it is not necessary to control all weeds in a field to achieve maximum yield. However, certain weeds can still be problematic at harvest even at low levels (e.g. burcucumber). Weed populations of 1 to 2 weeds per 10 square feet are sufficient to cause severe yield loss depending on the species. However, weed populations at 1 plant per 100 square feet will have no impact on final yield. The impact of weed populations between 1 and 10 per 100 square feet is difficult to predict. The decision to treat the field depends on the weed species present, crop vigor, weather conditions, and herbicide cost. For more comprehensive discussion of integrated weed management see the Integrated Weed Management Guide for Mid-Atlantic Grain Crops.

Chemical Weed Control

Herbicides are useful tools in most weed management programs and this chapter will focus on herbicides available for use in corn. They should be used to supplement, not replace, other methods or tools available. The following are definitions of terms you will find in this and similar publications on herbicides:

Early preplant (EPP) - The herbicide is applied at least 14 days before planting. EPP applications are generally used in no-till systems to control existing vegetation and provide residual control of early-emerging weed species.

Preplant - The herbicide is applied from 0 to14 days before planting. Preplant applications are generally used in no-till systems to control emerged weed species.

Preplant Incorporated (PPI) - The herbicide is applied to the soil after primary tillage, but before planting, and mechanically mixed with the top 1 to 3 inches of soil with one of a variety of secondary tillage implements.

Preemergence (PRE) - The herbicide is applied to the soil after the crop is planted but before emergence. Rainfall or irrigation is needed to move the herbicide into the zone of weed seed germination before weed emergence for maximum effectiveness. If adequate rainfall for herbicide activation does not occur, a shallow cultivation or rotary hoeing should be done to control weeds that have germinated.

Postemergence (POST) - The herbicide is applied to the foliage of the crop and weeds after they have emerged.

Post-directed (or **directed**) - Refers to use of special spray equipment to direct the spray at the weeds but avoid the spray coming in contact with as much of the crop as possible.

Residual activity - Herbicides that can be taken up by plants' roots and shoots and injure or kill the plant. All soil-applied herbicides have residual activity as well as many postemergence herbicides. Length of residual activity ranges from a few weeks to the entire growing season.

Translocated herbicide – These herbicides move throughout the plant and can cause injury to parts of the plants that do not come in direct contact with the herbicide spray.

Contact herbicide - These herbicides do not move throughout the plant. They cause injury only to those parts of the plant that comes in contact with the spray. Spray coverage is more critical for contact than translocated herbicides.

Non-selective herbicide - This refers to herbicides that control a broad-spectrum of plant species, including most crops and weeds. These herbicides are generally used with no-tillage production and are sprayed prior to planting when control of all plants is required.

Herbicide-Resistant Varieties

Some corn hybrids have been genetically enhanced to withstand herbicide applications that previously would have injured or killed corn. Genetically enhanced varieties allow herbicides to be used that provide a broader spectrum of control than would otherwise be available. Herbicide programs for genetically enhanced varieties also reduce the risk of crop injury associated with herbicide programs for conventional varieties.

LibertyLink corn is genetically engineered (GMO) to allow over-the-top applications of Liberty (glufosinate) herbicide. This program should provide broad-spectrum control of annual broadleaves and grasses of low to moderate pressure. Sequential applications or tank mixtures may be required for new weed flushes and perennials. This herbicide is becoming more important for the management of glyphosate resistant weeds such as horseweed and Palmer amaranth.

Roundup Ready corn was developed using genetic engineering techniques (GMO). It has an altered target site not sensitive to glyphosate and allow postemergence applications of glyphosate directly to corn. Glyphosate resistant weeds are becoming an increasing issue in Roundup Ready crops.

Enlist corn was developed using GMO to tolerate glyphosate and improved 2,4-D tolerance.

Herbicide Resistant Weeds in Corn

Herbicide resistant weeds are common in corn in the Mid-Atlantic region. Populations of herbicide resistant weeds are selected for by repeated use of the same or similar herbicide over a period of time. Resistance is most likely to occur with residual herbicides having one specific mode of action. Weed species with a very high amount of seed production and a variable genetic pool are more likely to develop resistant populations, for example common lambsquarters and pigweed species. Resistance management requires using herbicides with multiple modes of action, and integrating mechanical (tillage and cultivation) and cultural weed control (cover crops, narrow row spacing, proper crop fertility etc.) with chemical weed control.

Triazine-resistance. Weeds resistant to the Group 5 herbicides in the Mid-Atlantic region include common lambsquarters, Palmer, redroot and smooth pigweed, horseweed, scattered populations of barnyardgrass, giant foxtail, goosegrass, and suspected populations of common ragweed and velvetleaf. Atrazine and simazine are the primary products that are problematic in corn. A number of POST products can provide good control of TR weeds on corn.

For triazine-resistant (TR) pigweed control, include a Group 15 herbicide for residual control (acetochlor, dimethanamid, metolachlor, or pyroxasulfone) at planting. The Group 15 herbicides will suppress initial triazine-resistant pigweed, but in most years a postemergence application of a non-triazine herbicide will be needed for full-season control.

For triazine-resistant lambsquarters, some of the Group 15 herbicides will help suppress emergence (acetochlor and pyroxasulfon), but they are not as active on lambsquarters a pigweed. The Group 3 herbicide, pendimethalin can provide good control of TR lambsquarters when applied prior to emergence. In addition, residual control can be obtained with products such as mesotrione, or isoxaflutole.

ALS-resistance. Weeds resistant to the Group 2 herbicides in the Mid-Atlantic region include several pigweed species, common and giant ragweed, common chickweed, horseweed, Italian ryegrass, giant foxtail, Johnsongrass, and shattercane. The principle issue with most ALS-resistant weeds in corn is lack of efficacy with POST ALS inhibitor products. For example, do not rely on nicosulfuron or rimsulfuron for POST control of resistant foxtail, Johnsongrass, or shattercane. ALS-resistant johnsongrass and shattercane are a particular concern as only glyphosate and glufosinate are available for POST control in corn. Also, ALS-resistant broadleaves will not be controlled with halosulfuron or other Group 2 herbicides.

Glyphosate-resistance. Weeds resistant to the Group 9 herbicide glyphosate in the Mid-Atlantic region include Palmer amaranth and waterhemp, common and giant ragweed, and horseweed. In corn, all of these can be managed with alternative herbicides including the Group 4 growth regulators, the triazines if they are not Group 5 resistant, and several others including the Group 27 herbicides such as mesotrione and isoxaflutole.

Control of Roundup Ready Corn: Volunteers or Replanting. There are times when corn has to be removed from a field with the intention of replanting a corn crop. Tillage is one effective method, but it is not appropriate in no-tillage situations. Use of glyphosate is highly effective for non–Roundup Ready corn. But, the challenge is in removing Roundup Ready hybrids. There are limited herbicides to consistently kill small corn plants. Gramoxone SL, Liberty, and Select are three products that have shown the most activity. Research conducted in this region with Gramoxone and Select demonstrated that Select was the

most effective for corn 2 to 3 inches tall. For taller corn (4 to 6 inches tall), Gramoxone in combination with a photosystem II-inhibiting herbicide (metribuzin , Lorox, or atrazine) was the most effective. Liberty is a third option, but it will not control Liberty Link hybrids.

Select Max. up to 6 oz of Select Max with a nonionic surfactant at 0.25% v/v plus AMS at 2.5 to 4 lbs/A. Do not use a COC or MSO. Wait a minimum of 6 days from time of application until planting corn due to risk of crop injury.(Select Max will also control corn hybrids containing Roundup Ready and Liberty Link stacked traits.)

Gramoxone SL. 3 to 4.5 pt/A in combination with metribuzin (4 to 6 oz/A), Lorox (1 pt/A) or atrazone (1 lb/A). These photosystem II inhibitors are not added to control the corn but are used to slow down the Gramoxone activity, which helps provide more consistent control.

Liberty 280. 22 to 29 oz Liberty has not been as consistent for control corn as Gramoxone.

Table 5.10 - Corn Herbicides and Their Restrictions

Herbicide Trade Name	Herbicide Common Name	Herbicide group # (site of action)	Manufacturer	Restricted-Use Pesticide[1]	Water Quality Advisory[2]	Worker Reentry (Hours)[3]
2,4-D amine 4S	2,4-D amine	4	several	—	—	48
2,4-D LVE 4E	2,4-D LVE	4	several	—	—	12
Aatrex, Atrazine 4L/90DF	atrazine	5	Syngenta, others	yes	yes	12
Accent Q 54.5WG	nicosulfuron + safener	2	Corteva	—	—	4
Acuron 3.44SC	S-metolachlor + atrazine + mesotrione + bicyclopyrone	15/5/27/27	Syngenta	yes	yes	24
Acuron Flexi 3.26SC	S-metolachlor + mesotrione + bicyclopyrone	15/27/27	Syngenta	yes	yes	24
Aim 1.9EW/2EC	carfentrazone-ethyl	14	FMC	—	—	12
Anthem 2.15SE / Anthem Maxx 4.3SC	pyroxasulfone + fluthiacet	15/14	FMC	—	yes	12
Anthem ATZ 4.5SE	pyroxasulfone + fluthiacet + atrazine	15/14/5	FMC	yes	yes	12
Anthem Flex 4SE	pyroxasulfone + carfentrazone	15/14	FMC	—	yes	12
Armezon 2.8SC	topramezone	27	BASF	—	—	12
Armezon PRO 5.35EC	topramezone + dimethenamid	27/15	BASF	—	yes	12
Autumn Super 51WDG	iodosulfuron + thiencarbazone	2/2	Bayer CropScience	—	—	12
Axiom 68DF	flufenacet + metribuzin	15/5	Bayer CropScience	—	yes	12
Balance Flexx 2SC	isoxaflutole + safener	27	Bayer CropScience	yes	yes	12
Banvel 4S	dicamba	4	Arysta LifeScience	—	yes	24
Basagran 4S	bentazon	6	Arysta LifeScience	—	yes	12
Basis Blend 30DF	rimsulfuron + thifensulfuron	2/2	Corteva	—	—	4

Table 5.10 - Corn Herbicides and Their Restrictions (cont.)

Trade Name	Common Name	Herbicide group # (site of action)	Manufacturer	Restricted-Use Pesticide[1]	Water Quality Advisory[2]	Worker Reentry (Hours)[3]
Bicep II Magnum 5.5SC/ Cinch ATZ	S-metolachlor + atrazine + safener	15/5	Syngenta/ Corteva	yes	yes	24
Bicep Lite II Magnum 6SC/ Cinch ATZ Lite	S-metolachlor + atrazine + safener	15/5	Syngenta/ Corteva	yes	yes	24
Cadet 0.91EC	fluthiacet	14	FMC	—	yes	12
Callisto 4SC	mesotrione	27	Syngenta	—	—	12
Callisto Xtra 3.7SC	mesotrione + atrazine	27/5	Syngenta	yes	yes	12
Capreno 3.45SC	tembotrione + thiencarbazone + safener	27/2	Bayer CropScience	—	yes	12
Clarity 4S	dicamba	4	BASF	—	yes	24
Corvus 2.63SC	isoxaflutole + thiencarbazone + safener	27/2	Bayer CropScience	yes	yes	12
Curtail 2.38L	clopyralid + 2,4-D	4/4	Corteva	—	—	48
Defol 5L	Sodium chlorate	not classified	Drexel	—	—	12
Degree Xtra 4.04ME	acetochlor + atrazine	15	Monsanto	yes	yes	12
DiFlexx 4SC	dicamba + safener	4	Bayer CropScience	—	yes	24
DiFlexx DUO 1.53SC	dicamba + tembotrione + safener	4/27	Bayer CropScience	—	yes	24
Distinct 70DF	dicamba + diflufenzopyr	4/19	BASF	—	yes	12
Dual Magnum 7.62E	S-metolachlor	15	Syngenta	—	yes	24
Dual II Magnum 7.64ECinch	S-metolachlor + safener	15	Syngenta/ Corteva	—	yes	24
Durango DMA/DuraMax 4S	glyphosate	9	Corteva	—	—	4
Elevore	halauxifen	4	Corteva	—	yes	12
Engenia 5SL	dicamba (BAPMA salt)	4	BASF	yes	yes	24
Enlist Duo 3.3SL	2,4-D choline + glyphosate	4/9	Corteva	—	—	48
Enlist One 3.8SL	2,4-D choline	4	Corteva	—	—	48
Evik 80W	ametryn	5	Syngenta	—	—	12
Expert 4.88L	atrazine + S-metolachlor + glyphosate	5/15/9	Syngenta	yes	yes	12
FeXapan 2.9SL	dicamba	4	Corteva	yes	yes	24
Fierce 76WDG	pyroxasulfone + flumioxazin	15/14	Valent	—	yes	12
FulTime NXT 4.04EC	acetochlor + atrazine	15/5	Corteva	yes	yes	12
Gramoxone SL 2S	paraquat	22	Syngenta	yes	—	12–24
Guardsman Max 5L/G-Max Lite 5L	dimethenamid + atrazine	15/5	BASF	yes	yes	12
Halex GT 4.39EC	S-metolachlor + mesotrione + glyphosate[4]	15/27/9	Syngenta	—	yes	24

Table 5.10 - Corn Herbicides and Their Restrictions (cont.)

Trade Name	Common Name	Herbicide group # (site of action)	Manufacturer	Restricted-Use Pesticide[1]	Water Quality Advisory[2]	Worker Reentry (Hours)[3]
Harmony Extra SG 50WDG	thifensulfuron + tribenuron	2/2	Corteva	—	—	12
Harmony SG 50WDG	thifensulfuron	2	Corteva	—	—	4
Harness 7E	acetochlor + safener	15	Monsanto	—	yes	12
Harness MAX 3.85L	acetochlor + mesotrione	15/27	Monsanto	—	yes	12
Harness Xtra 5.6/6L	acetochlor + atrazine	15/5	Monsanto	yes	yes	12
Impact 2.8SC/Armezon	topramezone	27	AMVAC/BASF	—	—	12
ImpactZ 4.26SC	topramezone + atrazine	5/27	AMVAC	yes	yes	12
Instigate 46 WDG	rimsulfuron + mesotrione	2/27	DuPont	—	—	12
Keystone LA NXT 6SE/ Breakfree NXT Lite	acetochlor + atrazine	15/5	Corteva	yes	yes	12
Keystone NXT 5.6SE/ Breakfree NXT ATZ	acetochlor + atrazine	15/5	Corteva	yes	yes	12
Laudis 3.5SC	tembotrione	27	Bayer CropScience	—	yes	12
Liberty 280 2.34L[5]/Rely 280	glufosinate	10	BASF	—	—	12
Lightning 70DG[6]	imazethapyr + imazapyr	2/2	BASF	—	yes	12
Lorox 50DF/Linex 4L	linuron	5	Nova Source	—	—	24
Lumax EZ 3.67 SC/Lexar EZ 3.7SC	S-metolachlor + mesotrione + atrazine	15/27/5	Syngenta	yes	yes	24
Maestro 2E/Moxy (Buctril)	bromoxynil	6	Nufarm/ WinField	—	—	24
Marksman 3.2L	dicamba + atrazine	4/5	BASF	yes	yes	48
Metribuzin 75DF/4L	metribuzin	5	various	—	yes	12
NorthStar 47.4WG	primisulfuron + dicamba	2/4	Syngenta	—	—	12
Outlook 6EC	dimethenamid	15	BASF	—	yes	12
Panoflex 50WDG	thifensulfuron + tribenuron	2/2	Corteva	—	—	12
Peak 57WG	prosulfuron	2	Syngenta	—	yes	12
Permit 75WG	halosulfuron	2	Gowan	—	—	12
Permit Plus 74WDG	halosulfuron + thifensulfuron	2/2	Gowan	—	—	12
Prequel 45WG	isoxaflutole + rimsulfuron	27/2	DuPont	yes	yes	12
Princep, Simazine, 4L/90DF	simazine	5	Syngenta, others	—	yes	12
Prowl 3.3E	pendimethalin	3	BASF	—	—	24
Prowl H_2O 3.8CS	pendimethalin	3	BASF	—	—	24
Python 80WDG/Accolade	flumetsulam	2	Corteva/FMC	—	yes	12
Ready Master ATZ 4L	glyphosate + atrazine	9/5	Monsanto	yes	yes	12
Realm Q 39WDG	rimsulfuron + mesotrione + safener	2/27	Corteva	—	yes	12

Table 5.10 - Corn Herbicides and Their Restrictions (cont.)

Trade Name	Common Name	Herbicide group # (site of action)	Manufacturer	Restricted-Use Pesticide[1]	Water Quality Advisory[2]	Worker Reentry (Hours)[3]
Resicore 3.29SE	acetochlor + mesotrione + clopyralid + safener	15/27/4	Corteva	—	yes	12
Resolve 25DF	rimsulfuron	2	Corteva	—	—	4
Resolve Q 22.4WDG	rimsulfuron + thifensulfuron +safener	2/2	Corteva	—	—	4
Resource 0.86E	flumiclorac	14	Valent	—	—	12
Revulin Q 51.2WDG	nicosulfuron + mesotrione	2/27	Corteva	—	—	12
Roundup WeatherMax 4.5S/PowerMax 4.5S	glyphosate	9	Monsanto	—	—	4
Sequence 5.25EW	glyphosate + S-metolachlor	9/15	Syngenta	—	yes	24
Sharpen 2.85SC	saflufenacil	14	BASF	—	yes	12
Solstice 4SC	fluthiacet + mesotrione	14/27	FMC	—	—	12
Starane Ultra 2.8L	fluroxypyr	4	Corteva	—	—	12
Status 56WG	dicamba + diflufenzopyr + isoxadifen	4/19	BASF	—	yes	12
Steadfast Q 37.7WG	nicosulfuron + rimsulfuron+safener	2/2	Corteva	—	—	4
Stinger 3S	clopyralid	4	Corteva	—	yes	12
Stout 72.5WDG	nicosulfuron + thifensulfuron	2/2	Corteva	—	—	4
SureStart II 4.25SE/ TripleFLEX II	acetochlor + flumetsulam + clopyralid	15/2/4	Corteva/ Monsanto	—	yes	12
Surpass NXT 7E/ Breakfree NXT	acetochlor + safener	15	Corteva	—	yes	12
TopNotch 3.2ME	acetochlor + safener	15	Corteva	—	yes	12
Touchdown HiTech 5S	glyphosate	9	Syngenta	—	—	12
Touchdown Total 4.17S	glyphosate	9	Syngenta	—	—	12
ValorSX 51WDG	flumioxazin	14	Valent	—	—	12
Verdict 5.57EC	saflufenacil + dimethenamid	14/15	BASF	no	yes	12
Warrant 3CS	acetochlor	15	Monsanto	—	yes	12
Xtendimax 2.9SL	dicamba	4	Monsanto	yes	yes	24
Yukon 67.5WDG	halosulfuron + dicamba	2/4	Gowan	—	—	12
Zemax 3.67SC	S-metolachlor + mesotrione	15/27	Syngenta	—	yes	24
Zidua 85WDG	pyroxasulfone	15	BASF	—	yes	12
Zidua SC 4.17L	pyroxasulfone	15	BASF	—	yes	12

[1] Only licensed applicators may purchase and apply restricted-use pesticides. To become licensed, contact the Pennsylvania Department of Agriculture.

[2] These herbicides have properties that may result in ground or surface water contamination. Do not apply them in areas where soils are permeable or coarse and groundwater is near the surface. Practices should be followed to minimize the potential for dissolved runoff and/or runoff erosion. See the herbicide label for specific restrictions.

[3] If soil-applied products are injected or incorporated at application time, under certain circumstances the Worker Protection Standard allows workers to enter the treated area if they will have no contact with anything that has been treated. Personal protective equipment is required for early entry to treated areas if contact with treated soil, plants, or water is involved.

[4] For use on glyphosate-resistant corn hybrids only (Roundup Ready).

[5] For use on glufosinate-resistant corn hybrids only (Liberty Link).

[6] For use only on IMI (IR/IT) or Clearfield (CL) corn hybrids.

Table 5.11 - Corn Herbicide Prepackaged Mixes or Co-Packs, and Equivalents

Herbicide Trade Name	Components (ai/gal or lb)	If you apply (per acre)...	You have applied (ai)	Site of Action Number	An equivalent tank-mix of
Acuron 3.44SC	2.14 lb S-metolachlor	2.5 qt	1.34 lb S-metolachlor	15	1.4 pt Dual II Magnum 7.64E
	0.24 lb mesotrione		0.15 lb mesotrione	27	4.8 fl oz Callisto 4SC
	0.06 lb bicyclopyrone		0.038 lb bicyclopyrone	27	0.038 lb bicyclopyrone
	1 lb atrazine		0.625 lb atrazine	5	0.625 qt atrazine 4L
Acuron Flexi 3.26SC	2.86 lb S-metolachlor	2 qt	1.43 lb S-metolachlor	15	1.5 pt Dual II Magnum 7.64E
	0.32 lb mesotrione		0.16 lb mesotrione	27	5.12 fl oz Callisto 4SC
	0.08 lb bicyclopyrone		0.04 lb bicyclopyrone	27	0.04 lb bicyclopyrone
Anthem ATZ 4.5SE	4 lb atrazine	2 pt	1 lb atrazine	5	2 pt atrazine 4L
	0.485 lb pyroxasulfone		0.12 lb pyroxasulfone	15	3.7 fl oz Zidua 4.17SC
	0.014 lb fluthiacet		0.004 lb fluthiacet	14	0.6 fl oz Cadet 0.91EC
Anthem Flex 4SE	3.733 lb pyroxasulfone	3.5 fl oz	0.102 lb pyroxasulfone	15	3.1 fl oz Zidua 4.17SC
	0.267 lb carfentrazone		0.007 lb carfentrazone	14	0.47 fl oz Aim 2EC
Anthem Maxx 4.3SC	4.174 lb pyroxasulfone	4 fl oz	0.133 lb pyroxasulfone	15	4.1 oz Zidua 4.17SC
	0.126 lb fluthiacet		0.004 lb fluthiacet	14	0.56 oz Cadet 0.91EC
Armezon PRO 5.35EC	0.1 lb topramezon	24 fl oz	0.017 lb topramezon	27	0.76 fl oz Armezon 2.8SC
	5.25 lb dimethenamid		0.84 lb dimethenamid	15	18 fl oz Outlook 6EC
Autumn Super 51WDG	0.06 lb iodosulfuron	0.4 oz	0.002 lb iodosulfuron	2	0.024 oz ai iodosulfuron
	0.45 lb thiencarbazone		0.011 lb thiencarbazone	2	0.18 oz ai thiencarbazone
Axiom 68DF	0.544 lb flufenacet	16 oz	0.544 lb flufenacet	15	17 oz Define 4SC
	0.136 lb metribuzin		0.136 lb metribuzin	5	2.9 oz Metribuzin 75DF
Basis Blend 30DF	0.20 lb rimsulfuron	0.825 oz	0.01 lb rimsulfuron	2	0.64 oz Resolve 25DF
	0.10 lb thifensulfuron		0.005 lb thifensulfuron	2	0.16 oz Harmony SG 50DF
Bicep II Magnum 5.5SC/ Cinch ATZ	2.4 lb S-metolachlor	2.1 qt	1.26 lb S-metolachlor	15	1.33 pt Dual II Magnum 7.64E
	3.1 lb atrazine		1.63 lb atrazine	5	1.63 qt atrazine 4L

Table 5.11 - Corn Herbicide Prepackaged Mixes or Co-Packs, and Equivalents (cont.)

Product	Components (ai/gal or lb)	If you apply (per acre)...	You have applied (ai)	Site of Action Number	An equivalent tank-mix of
Bicep Lite II Magnum 6L/Cinch ATZ Lite	3.33 lb S-metolachlor	1.3 qt	1.08 lb S-metolachlor	15	1.13 pt Dual II Magnum 7.64E
	2.67 lb atrazine		0.87 lb atrazine	5	0.87 qt atrazine 4L
Callisto GT	0.38 lb mesotrione	2 pt	0.095 lb mesotrione	27	3.04 fl oz Callisto 4SC
	3.8 lb glyphosate		0.95 lb glyphosate	9	1.8 pt Touchdown
Callisto Xtra 3.7SC	0.5 lb mesotrione	24 fl oz	0.09 lb mesotrione	27	3 fl oz Callisto 4SC
	3.2 lb atrazine		0.6 lb atrazine	5	1.2 pt atrazine 4L
Capreno 3.45SC	2.88 lb tembotrione	3 fl oz	0.068 lb tembotrione	27	2.5 fl oz Laudis 3.5SC
	0.57 lb thiencarbazone		0.013 lb ai thiencarbazone	2	0.21 oz ai thiencarbazone
Corvus 2.63SC	1.88 lb isoxaflutole	5.6 fl oz	0.083 lb isoxaflutole	27	5.3 fl oz Balance Flexx 2SC
	0.75 lb thiencarbazone		0.033 lb thiencarbazone	2	0.52 oz ai thiencarbazone
Curtail 2.38L	0.38 lb clopyralid	2 pt	0.095 lb clopyralid	4	0.25 pt Stinger 3S
	2.0 lb 2,4-D		0.5 lb 2,4D	4	1.0 pt 2,4-D 4S
Degree Xtra 4.04ME	2.7 lb acetochlor	3 qt	2.03 lb acetochlor	15	2.3 pt Harness 7E
	1.34 lb atrazine		1.0 lb atrazine	5	1.0 qt atrazine 4L
DiFlexx Duo 1.53SC	1.26 lb dicamba	32 fl oz	0.32 lb dicamba	4	10.25 oz DiFlexx 4SC
	0.27 lb tembotrione		0.068 lb tembotrione	27	2.5 fl oz Laudis 3.5SC
Enlist Duo 3.3SL	1.6 lb 2,4-D choline salt	4.75 pt	0.95 lb ae 2,4-D	4	30 fl oz Enlist One 3.8SL
	1.7 lb glyphosate		1.0 lb ae glyphosate	9	32 fl oz Durango DMA
Expert 4.88L	1.74 lb S-metolachlor	3 qt	1.3 lb S-metolachlor	15	1.4 pt Dual II Magnum 7.64E
	2.14 lb atrazine		1.6 lb atrazine	5	1.6 qt atrazine 4L
	0.75 lb ae glyphosate		0.75 lb glyphosate	9	1.5 pt glyphosate 4S
Fierce 76WDG	0.335 lb flumioxazin	3 oz	1.0 oz flumioxazin	14	2.0 oz Valor SX 51WG
	0.425 lb pyroxasulfone		1.28 oz pyroxasulfone	15	1.5 oz Zidua 85WG
FulTime NXT 4.04CS	2.7 lb acetochlor	3 qt	2 lb acetochlor	15	2.5 qt TopNotch 3.2ME
	1.34 lb atrazine		1 lb atrazine	5	1 qt atrazine 4L
Guardsman Max 5L	1.7 lb dimethenamid	3.5 pt	0.74 lb dimethenamid	15	15.9 fl oz Outlook 6EC
	3.3 lb atrazine		1.44 lb atrazine	5	1.44 qt atrazine 4L
Halex GT 4.39EC	2.09 lb S-metolachlor	3.6 pt	0.94 lb S-metolachlor	15	1.0 pt Dual Magnum 7.62E
	0.209 lb mesotrione		0.09 lb mesotrione	27	3.0 fl oz Callisto 4SC
	2.09 lb glyphosate		0.94 lb glyphosate (ae)	9	24 fl oz Touchdown HiTech

Table 5.11 - Corn Herbicide Prepackaged Mixes or Co-Packs, and Equivalents (cont.)

Product	Components (ai/gal or lb)	If you apply (per acre)...	You have applied (ai)	Site of Action Number	An equivalent tank-mix of
Harness MAX 3.85L	3.52 lb acetochlor	2 qt	1.76 lb acetochlor	15	2 pt Harness 7E
	0.33 lb mesotrione		0.165 lb mesotrione	27	5.3 fl oz Callisto 4SC
Harness Xtra 6.0L	4.3 lb acetochlor	2 qt	2.15 lb acetochlor	15	2.46 pt Harness 7E
	1.7 lb atrazine		0.85 lb atrazine	5	0.85 qt atrazine 4L
Harness Xtra 5.6L	3.1 lb acetochlor	2.5 qt	1.94 lb acetochlor	15	2.21 pt Harness 7E
	2.5 lb atrazine		1.56 lb atrazine	5	1.56 qt atrazine 4L
Hornet 78.5 WDG/ Stanza	0.185 lb flumetsulam	5 oz	0.058 lb flumetsulam	2	1.15 oz Python 80WDG
	0.5 lb clopyralid		0.195 lb clopyralid	4	6.7 fl oz Stinger 3S
ImpactZ 4.26SC	4 lb atrazine	10.7 fl oz	0.33 lb atrazine	5	10.6 fl oz atrazine 4L
	0.26 lb topramezone		0.02 lb topramezone	27	1 fl oz Impact 2.8SC
Instigate 46WDG	0.0417 lb rimsulfuron	6 oz	0.016 lb rimsulfuron	2	1 oz Resolve 25WG
	0.417 lb mesotrione		0.16 lb mesotrione	27	5 fl oz Callisto 4SC
Keystone LA NXT 6SE or Breakfree NXT Lite	4.3 lb acetochlor	2.3 qt	2.47 lb acetochlor	15	2.7 pt Surpass NXT 7EC
	1.5 lb atrazine		1.43 lb atrazine	5	1.95 pt atrazine 4L
Keystone NXT 5.6SE or Breakfree NXT ATZ	3.1 lb acetochlor	2.5 qt	1.94 lb acetochlor	15	2.22 pt Surpass/ Breakfree NXT
	2.5 lb atrazine		1.57 lb atrazine	5	3.15 pt atrazine 4L
Lexar EZ 3.7SC	1.74 lb S-metolachlor	3 qt	1.3 lb S-metolachlor	15	1.36 pt Dual II Magnum 7.64E
	0.224 lb mesotrione		0.168 lb mesotrione	27	5.36 oz Callisto 4SC
	1.74 lb atrazine		1.3 lb atrazine	5	1.3 qt atrazine 4L
Lumax EZ 3.67SC	2.49 lb S-metolachlor	2.7 qt	1.67 lb S-metolachlor	15	1.75 pt Dual II Magnum 7.64E
	0.249 lb mesotrione		0.168 lb mesotrione	27	5.36 oz Callisto 4SC
	0.935 lb atrazine		0.625 lb atrazine	5	0.625 qt atrazine 4L
Marksman 3.2L	1.1 lb dicamba	3.5 pt	0.48 lb dicamba	4	0.96 pt Banvel 4S/ Clarity 4S
	2.1 lb atrazine		0.92 lb atrazine	5	1.84 pt atrazine 4L
NorthStar 47.4WDG	0.075 lb primisulfuron	5 oz	0.023 lb primisulfuron	2	0.5 oz Beacon 75WG
	0.399 lb dicamba		0.138 lb dicamba	4	4.0 oz Banvel 4S/Clarity 4S
Permit Plus 74WDG	0.662 lb halosulfuron	0.75 oz	0.031 lb halosulfuron	2	0.67 oz Permit 75WG
	0.078 lb thifensulfuron		0.004 lb thifensulfuron	2	0.12 oz Harmony 50SG
Prequel 45WG	0.15 lb rimsulfuron	1.66 oz	0.016 lb rimsulfuron	2	1 oz Resolve 25 WG
	0.30 lb isoxaflutole		0.04 lb isoxaflutole	27	0.66 oz isoxaflutole 75WG

Table 5.11 - Corn Herbicide Prepackaged Mixes or Co-Packs, and Equivalents (cont.)

Product	Components (ai/gal or lb)	If you apply (per acre)...	You have applied (ai)	Site of Action Number	An equivalent tank-mix of
Realm Q 38.75WDG	0.075 lb rimsulfuron	4 oz	0.019 lb rimsulfuron	2	1.2 oz Resolve 25WG
	0.313 lb mesotrione		0.078 lb mesotrione	27	2.5 fl oz Callisto 4SC
Resicore 3.29SE	2.8 lb acetochlor	2.5 qt	1.75 lb acetochlor	15	2 pt Surpass NXT 7E
	0.3 lb mesotrione		0.18 lb mesotrione	27	5.76 fl oz Callisto 4SC
	0.19 lb clopyralid		0.119 lb clopyralid	4	0.3 pt Stinger 3S
Resolve Q 22.4WDG	0.184 lb rimsulfuron	1.25 oz	0.014 lb rimsulfuron	2	0.9 oz Resolve 25DF
	0.04 lb thifensulfuron		0.003 lb thifensulfuron	2	0.1 oz Harmony 50SG
Revulin Q 51.2WDG	0.144 lb nicosulfuron	4 oz	0.58 oz nicosulfuron	2	1.1 oz Accent Q 54.5WG
	0.368 lb mesotrione		1.5 oz mesotrione	27	3 fl oz Callisto 4SC
Solstice 4SC	0.216 lb fluthiacet	3 fl oz	0.0051 lb fluthiacet	15	0.7 fl oz Cadet 0.91EC
	3.784 lb mesotrione		0.089 lb mesotrione	27	2.85 fl oz Callisto 4SC
Status 56WG	0.4 lb dicamba	5 oz	0.125 lb dicamba	4	4 fl oz Banvel 4S
	0.16 lb diflufenzopyr		0.05 lb diflufenzopyr	19	0.05 lb diflufenzopyr
Steadfast Q 37.7WG	0.125 lb rimsulfuron	1.5 oz	0.012 lb rimsulfuron	2	0.76 oz Resolve 25WG
	0.252 lb nicosulfuron		0.02 lb nicosulfuron	2	0.7 oz Accent Q 54.5WG
Stout 72.5WDG	0.675 lb nicosulfuron	0.75 oz	0.031 lb nicosulfuron	2	0.67 oz Accent 75DF
	0.05 lb thifensulfuron		0.002 lb thifensulfuron	2	0.05 oz Harmony 75DF
SureStart II 4.25SE or TripleFLEX II	3.75 lb acetochlor	2 pt	0.94 lb acetochlor	15	1.1 pt Surpass NXT 7E
	0.29 lb clopyralid		0.075 lb clopyralid	4	3.2 fl oz Stinger 3S
	0.12 lb flumetsulam		0.03 lb flumetsulam	2	0.6 oz Python 80WDG
Verdict 5.57EC	5.0 lb dimethenamide	13 fl oz	0.5 lb dimethenamide	15	11 fl oz Outlook 6EC
	0.57 lb saflufenacil		0.058 lb saflufenacil	14	2.6 fl oz Sharpen 2.85L
Yukon 67.5WDG	0.125 lb halosulfuron	4 oz	0.03 lb halosulfuron	2	0.67 oz Permit 75WG
	0.55 lb dicamba		0.125 lb dicamba	4	4.0 fl oz Clarity 4S
Zemax 3.67SC	3.34 lb S-metolachlor	2 qt	1.67 lb S-metolachlor	15	1.75 pt Dual II Magnum 7.64E
	0.33 lb mesotrione		0.165 lb mesotrione	27	5.36 fl oz Callisto 4SC

Table 5.12 - Relative Effectiveness of "Burndown" Treatments for Control of Weeds in No-Till Corn

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size or growth stage. Treatments are rated only for control of vegetation existing at the time of application.

Weed control rating: 10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65%
N = less than 55% or no control + = upper end of rating scale — = not applicable or no local data available

Herbicide[1]	Site of Action Number	Burdock, common	Chickweed[4]	Dandelion	Dock, Curly	Downy Brome	Evening Primrose, Cutleaf	Field Violet/Pansy	Annual Fleabanes	Foxtail	Garlic, Wild	Geranium, Carolina	Groundsel, common[2]	Hemp Dogbane, Dewberry, Milkweed, etc.	Henbit/ Dead-nettle	Horseweed/ Marestail[3,4]	Lambs-quarters	Mustards spp.	Quackgrass Sod	Ragweed, common	Smartweed	Thistle, Canada
2,4-D (spring-applied) (1 qt)	4	7	6	8	7	N	9	6	6	N	7	—	6	N	N	**8+**	**9**	**9**	N	**9**	7	8
2,4-D + dicamba (spring-applied)	4/4	8	8	8	7+	N	9	7	8	N	7	7+	7	6	6	**9**	**9**	**9**	N	**9**	**9**	**8+**
Atrazine	5	6	8	N	6	7	7	8	7+	7	N	**9**	**9**	N	8	**8**	N	8	8	**9**	**9**	6
Atrazine + 2,4-D	5/4	7+	8	**9**	7	7	9	8	7+	7	7	**9**	**9**	N	8	**9**	**9**	**9**	7	**9**	**9**	**8+**
Autumn Super + 2,4-D (fall-applied)	**2,4**	**9**	**9**[4]	**9**	7	N	9	6	8	N	—	—	8	N	**9**	**9**	—	**9**	N	—	—	6
Balance/Corvus/ Prequel	27/(2)	7	8	6	N	N	—	6	7	6	—	—	8	N	7+	7	7	8	N	7	6	6
Glyphosate (fall-applied)[5]	**9**	**8+**	**9**	**9**	**7**	**9**	7	7	8	—	**9**	8	**9**	**8+**	8	N	—	**9**	**9**	—	—	**9**
Glyphosate (spring-applied)[5]	9	7	**9**	6	**6**	**9**	6	6	7+	**9+**	8	7	**9**	7	6	N	**9**	**9**	8	**9**	7	8
Glyphosate + Atrazine	9/5	7+	**9**	7	**6**	**9**	6	8	7+	**9**	8	7	**9**	N	**9**	—	**9**	**9**	**9**	**9**	**9**	**8**
Glyphosate + 2,4-D or dicamba (fall-applied)	**9/4**	**9+**	**9**	**9**	**7**	**9**	**9+**	7	**9**[6]	—	**9**	8	**9**	**9**	**8+**[6]	**9**[6]	—	9[6]	**9**	—	—	**9+**
Glyphosate + 2,4-D or dicamba (spring-applied)	9,4	7+	**9**	8	**7**	**9**	9	8	8	**9+**	8	7	**9**	7+	**8+**	**9**	**9**	**9**	**9**	**9**	**8+**	**8+**
Glyphosate + Metribuzin	9/5	7	**9**	6	**6**	**9**	6	8	8	**9**	8	7	**9**	7	**8+**	N	**9**	**9**	**9**	**9**	**9**	8
Gramoxone	22	N	**8+**	N	N	7	7	8	6	**9**	6	8	**8+**	6	7	7	8	8	6	8	7	6

Table 5.12 - Relative Effectiveness of "Burndown" Treatments for Control of Weeds in No-Till Corn (cont.)

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size or growth stage. Treatments are rated only for control of vegetation existing at the time of application.

Weed control rating: 10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65%
N = less than 55% or no control + = upper end of rating scale — = not applicable

Herbicide[1]	Site of Action Number	Burdock, common	Chickweed[4]	Dan-delion	Dock, Curly	Downy Brome	Evening Primrose, Cutleaf	Field Violet/Pansy	Annual Flea-banes	Foxtail	Garlic, Wild	Geranium, Carolina	Groundsel, common[2]	Hemp Dogbane, Dewberry, Milkweed, etc.	Henbit/ Dead-nettle	Horseweed/ Marestail[3,4]	Lambs-quarters, TR	Mustards spp.	Quack-grass Sod	Ragweed, common	Smart-weed	Thistle, Canada
Gramoxone + 2,4-D or dicamba[5]	22/4	7	**9**	7	7	7	**9**	**8+**	7	**9**	7	8	**8+**	6	8	**8+**	**9**	**9**	6	**9**	**8+**	8
Gramoxone + Atrazine	22/5	6	**9**	N	6	8	7	8	7	**9**	6	8	**8+**	6	**9**	**8+**	8	**8+**	8	**9**	**9**	7
Gramoxone + Metribuzin	22/5	6	**9**	N	N	7	7	8	6	**9**	6	8	**8+**	6	8	8	8	**8+**	6	**9**	**9**	6
Harmony Extra	2,2	6	**9**	6	8	N	—	N	N	N	**8+**	—	**9**	6	8	7+[4]	**9**	**9**	N	6	**9**	8
Liberty	10	6	8	6	—	6	—	N	8	8	—	—	7	N	6	8	8	8	6	8	8	6
Lumax	15,5, 27	8	**9**	8	8	N	—	7	8	6	N	**8+**	**9**	N	8	8	**9**	8	N	**8+**	**9**	7
Sharpen	14	N	6	7	—	N	N	N	7+	N	—	—	8	N	6	8	8	8	N	8	8	6
Sharpen + glyphosate	14,9	7	**9**	8	**6**	**9**	6	6	8	**9+**	—	—	**9**	7	6	**9**	**9**	**9**	8	**9**	**9**	8
Valor SX/Fierce	14,(15)	N	**9**	7	N	8[7]	6	N	N	N	—	—	7	N	7	6	**9**	8	N	7	7	N

[1] See Table 5.3 for additional formulations or trade names containing some of these same active ingredients.

[2] Certain populations of common groundsel in the northeastern U.S. are resistant to triazine herbicides. Herbicide programs that contain bromoxynil (Maestro, Moxy, Buctril) or clopyralid (Stinger) provide good control of groundsel in-crop.

[3] Roundup, Touchdown, and other glyphosate products are not effective on glyphosate-resistant horseweed biotypes.

[4] Group 2 herbicides will not control ALS-resistant biotypes.

[5] Activity is reduced if applied in certain tank-mixes; glyphosate with photosynthesis inhibitors such as triazine herbicides; 2,4-D and Clarity with Gramoxone. May still be tank-mixed for convenience, but burndown is improved if applied separately.

[6] Based on control in early spring. Emergence of seedlings in the spring will reduce effectiveness.

[7] Valor provides control of germinating dandelion seedling; however, it is weak on dandelion when applied post.

Table 5.13 - Effectiveness of Herbicides for Control of Common Cash or Cover Crops in Spring Before Corn Establishment

Control ratings: 10 = 95-100%; 9 = 85-95%; 8 = 75-85%; 7 = 65-75%; 6 = 55-65%; and N = less than 55%; + = upper end of rating scale.

	Rate[1] (lb/acre)	Alfalfa[2]	Bluegrass/ timothy[2]	Bromegrass/ orchardgrass/ fescue[2]	Clover, crimson	Clover, red[2]	Clover, white[2]	Mustards/ Radish/ Rapeseed	Ryegrass, annual	Rye, cereal	Wheat, winter	Vetch, hairy
2,4-D ester	0.5	7+	N	N	7	8	6	8	N	N	N	**9**
	1	8	N	N	8	**9**	7	9	N	N	N	**10**
2,4-D ester +dicamba	0.5 + 0.5	**9+**	N	N	**8+**	**9**	**9**	8	N	N	N	**10**
Atrazine	1.0	N	6	6	6	6	6	6	6	6	6	7
	2.0	6	7	7	7	7	7	7	7	7	7	8
Clopyralid	0.25	**8+**	N	N	8	**9**	**9**	N	N	N	N	9
Dicamba	0.5	**9**	N	N	8	**9**	**9**	7	N	N	N	9
Glyphosate	0.75	6	**9**	8	8	7	6	7+	8	9	9	7
	1.5	7	**9+**	**8+**	**8+**	7+	7	**8+**	**9**	**9**	**9**	8
Glyphosate +2,4-D ester or	0.75 + 0.5	**8+**	**9**	8	**9**	8	8	9	8	**9**	**9**	**10**
+dicamba	0.75 + 0.5	**9**	**9**	8	**9**	**9**	**9**	8	8	**9**	**9**	**10**
Mesotrione + atrazine	0.168 + 1	7	6	6	8	7+	7+	8	6	6	6	7
Paraquat	0.5	N	7	6	8	7	7	8	6	7	8	7
	0.75	N	7+	7	**9**	8	7	8+	6	8	**8+**	8
Paraquat+ Atrazine or Metribuzin	0.5 + 1 or 0.25	7	**9**	8	**10**	**8+**	7	9 or 9	7	**8+**	**8+**	**9**
Paraquat + 2,4-D	0.75 + 0.5	7+	7	6	**9**	**8+**	8		6	8	**8+**	**10**

[1] 0.75 lb Glyphosate = 32 fl. oz of a 41% glyphosate; 0.5 lb paraquat = 2 pt Gramoxone SL; Clopyralid is a component of Stinger, and Surestart/Tripleflex.

[2] Application in the fall can improve control with some herbicides.

See Table 5.12 for relative effectiveness of these treatments. May need to combine with residual treatment or postemergence program (Tables 5.10 and 5.15) for complete no-till weed-control program.

Table 5.14 - Characteristics of "Burndown" Herbicides for No-Till Corn

Herbicide[1] Trade name	Herbicide Common name	Herbicide group # (site of action)	product/A	lb ai/A
2,4-D LVE 4E	**2,4-D ester**	**4**	**1 – 2 qt**	**1–2**
Enlist One 3.8SL	**2,4-D chloine**	**4**	**1.5–2 pts**	**0.71–0.95**

- Apply 7–14 days before planting or 3–5 days after planting for greater crop safety.
- Plant corn at least 1.5 inches deep.
- This product is poor on chickweed, henbit, and red deadnettle, and ineffective on all grasses.
- Add Clarity (dicamba) to increase efficacy on legume sods. A combination of 2,4-D + Clarity/Banvel controls most annual broadleaf weeds and alfalfa. Emerged perennial broadleaves are partially controlled. This combination is fair on chickweed, henbit, and red deadnettle, and ineffective on all grasses.
- Spray droplet size plays an important role in minimizing off-target movement. Nozzles that produce extremely coarse or ultra coarse droplets while limiting the amount of driftable fine droplets are necessary to limit spray drift. Comply with guidelines for drift management (see label for details).

Atrazine 90DF	**atrazine**	**5**	**1.8–2.2 lb**	**1.6–2**

- Apply 1.6–2 qt atrazine 4L prior to planting.
- Controls small emerged annual broadleaves and some grasses.
- Can be applied in liquid nitrogen as the carrier to improve burndown characteristics.

ATRAZINE USE RESTRICTIONS

Preplant or Preemergence

- On highly erodible soils (as defined by the U.S. Natural Resources Conservation Service):
- Fields where more than 30 percent of the soil surface is covered with plant residue at planting, apply a maximum of 2.0 lb of active ingredient per acre as a broadcast spray.
- Fields where less than 30 percent of the soil surface is covered with plant residue at planting, apply a maximum of 1.6 lb of active ingredient per acre as a broadcast spray.
- Apply a maximum of 2.0 lb of active ingredient per acre as a broadcast spray.

Postemergence

- If no atrazine was applied prior to crop emergence, use a maximum rate of 2.0 lb of active ingredient per acre.
- If a soil-applied application was made in the same calendar year, the combined preplant or preemergence and postemergence applications may not exceed 2.5 lb of active ingredient per acre.

Safety Precautions for Using Atrazine

- Do not mix, load, or apply within 50 feet of drinking water wells, livestock wells, agricultural drainage wells, irrigation wells, abandoned wells, or sinkholes.
- Do not mix or load within 50 feet of intermittent streams, perennial streams, rivers, lakes, or reservoirs.
- Do not apply within 200 feet of lakes or reservoirs.
- Do not apply within 66 feet of the points where surface water runoff enters intermittent streams, perennial streams, or rivers. The 66-foot buffers should be planted to a crop or seeded with grass on highly erodible land.
- *Restricted-use pesticide and water quality advisory.*

Table 5.14 - Characteristics of "Burndown" Herbicides for No-Till Corn (cont.)

Herbicide[1] Trade name	Herbicide Common name	Herbicide group # (site of action)	product/A	lb ai/A
Autumn Super 51WDG	**iodosulfuron**	**2**	**0.3–0.5 oz**	**0.001–0.002**
	thiencarbazone	**2**		**0.01–0.014**

- Autumn Super may be applied after fall harvest and up to 30 days prior to corn planting.
- Do not apply to frozen ground. Apply to actively growing weeds.
- Autumn Super will provide short-term residual control of small seeded broadleaves but will not provide season-long pre control of annual grasses and broadleaf weeds.
- Apply Autumn Super at 0.3–0.5 oz/A plus necessary adjuvants.
- For enhanced burndown activity, tank-mix with 2,4-D, glyphosate, paraquat, simazine, or metribuzin.
- Be cautious of crop rotation restrictions.

Clarity 4S	**dicamba (DGA salt)**			
Banvel 4S	**dicamba (DMA salt)**		**0.5–1 pt**	
Engenia 5SL	**dicamba (BAPMA salt)**		**0.5–1 pt**	
Xtendimax/FeXapan	**dicamba (DGA salt with**		**6.4–12.8 fl oz**	
2.9SL	**VaporGrip Technology)**	**4**	**11–22 fl oz**	**0.25–0.5 lb ae**

- Apply 7–14 days before planting or 3–5 days after planting for greater crop safety.
- Plant corn at least 1.5 inches deep.
- A combination of 2,4-D + dicamba controls most annual broadleaf weeds and alfalfa. Emerged perennial broadleaves are partially controlled. This combination is fair on chickweed, henbit, and red deadnettle, and ineffective on all grasses. Applications should be made while annual weeds are small (4 inches) and actively growing.
- Spray droplet size plays an important role in minimizing off-target movement. Nozzles that produce extremely coarse or ultra coarse droplets while limiting the amount of driftable fine droplets are necessary to limit spray drift. Comply with guidelines for drift management (see label for details).
- Dicamba can be difficult to completely remove from spray equipment and residue is capable of injuring sensitive plants. Follow label instructions concerning sprayer cleanout.
- *Engenia/FeXapan/XtendiMax are restricted use products, all dicamba formulaitons have water quality advisory.*

Enlist Duo 3.3SL	**2,4-D choline +**	**4**	**3.5 – 4.75 pt**	**0.7–0.95 ae**
	glyphosate	**9**		**0.74–1.0 ae**

- Can be used as a burndown application to corn with or without the Enlist trait to control broadleaves and grasses.
- Apply 7–14 days before planting for greater crop safety.
- Do not apply less than 10 gpa total spray solution and do not use nitrogen solutions as a carrier.
- Comply with guidelines for drift management (see label for details).
- For best results do not apply to light sandy soils as a pre application.
- Can be tank-mixed with residual herbicides.

Expert 4.88L	**S-metolachlor +**	**15**	**2.5–3.75 qt**	**1.09–1.63**
	atrazine +	**5**		**1.33–2.0**
	glyphosate	**9**		**0.63–0.94 ae**

- Expert is a premix of metolachlor (Dual II Magnum), atrazine, and glyphosate.
- The 3 qt. rate contains 1.3 lb s-metolachlor, 1.6 lb atrazine and 0.75 lb ae glyphosate.
- Expert can be used as a burndown/preprogram in corn or as an early post application in Roundup Ready hybrids.
- See Expert label for additional information.
- *Restricted-use pesticide and water quality advisory.*

Table 5.14 - Characteristics of "Burndown" Herbicides for No-Till Corn (cont.)

Herbicide[1] Trade name	Herbicide Common name	Herbicide group # (site of action)	product/A	lb ai/A
Glyphosate[2]	**glyphosate**	**9**	**See Table 5.2**	

Fall applications of glyphosate are better than spring applications for control of orchardgrass sods and quackgrass.

- If controlling orchardgrass sod in spring it is best to spray when sod is 6 to 10 inches tall.
- Use at least 1.13 lbs ae glyphosate or higher, especially if tank-mixing with preresidual herbicide and nitrogen carriers.
- Spring applications may be used for control of annual weeds.
- Using low-volume sprays may allow for a reduced rate.
- For control of small annual weeds or volunteer small grains, glyphosate may be used at reduced rates.
- Can be tank-mixed with residual herbicides such as atrazine. When tank-mixing glyphosate with residual herbicides, apply in 10–20 gal water/A or 10–60 gal liquid fertilizer nitrogen/A.
- Adding 2,4-D or dicamba improves control of large annual broadleaf weeds, dandelion, and alfalfa.
- Glyphosate may be applied in clear liquid nitrogen fertilizers and clear liquid complete-analysis fertilizers, but may be less effective on certain annual grasses and perennials.
- Do not use glyphosate with suspension-type liquid fertilizers.

Gramoxone SL 2S	**paraquat**	**22**	**2–4 pt**	**0.5–1**

- Apply in 20–60 gal/A for control of emerged annual weeds.
- Add 16–32 oz non-ionic surfactant/100 gal of spray.
- Adding 2,4-D or dicamba improves control of large annual broadleaf weeds and alfalfa. Alfalfa control is improved by applying 2,4-D or dicamba separately at least 1 day ahead of paraquat.
- Can be tank-mixed with residual herbicides; adding atrazine to paraquat can improve control of fescue and certain other perennial sods.
- Phosphate-containing liquid fertilizer solutions diminish paraquat activity if used as a carrier.
- Use appropriate precautions when handling paraquat to minimize exposure to the herbicide.
- Do not use flood jet tips larger than size 20 or spacing greater than 40 inches.
- *Gramoxone is a restricted-use pesticide.*

Harmony Extra SG 50DF	**thifensulfuron +**	**2**	**0.45–0.9 oz**	**0.009–0.018**
	tribenuron	**2**		**0.005–0.009**

- Adding Harmony Extra to glyphosate or 2,4-D can improve control of certain winter annual broadleaves and perennials.
- Must be applied in fall or early spring at least 14 days ahead of planting.

Metribuzin 75DF/4L	**metribuzin**	**5**	**2–4 oz DF**	**0.094–0.19**

- Include metribuzin as part of an herbicide program for burndown of existing vegetation prior to crop emergence.
- Metribuzin may be tank-mixed with 2,4-D LVE, Gramoxone, or glyphosate.
- Use a maximum of 4 oz DF if applying less than 10 days before planting or on soils with less than 2% organic matter.
- Do not use on coarse soils with less than 1.5% organic matter or on soils having pH 7.0 or greater.
- Plant corn at least 1.5 inches deep to avoid injury.
- *Water quality advisory.*

Table 5.14 - Characteristics of "Burndown" Herbicides for No-Till Corn (cont.)

Herbicide[1] Trade name	Herbicide Common name	Herbicide group # (site of action)	product/A	lb ai/A
Sharpen 2.85SC	**saflufenacil**	**14**	**1–3 fl oz**	**0.022–0.067**

- Sharpen may be applied as a preplant/burndown treatment from 14 days early preplant through preemergence timings.
- Apply Sharpen in a typical glyphosate burndown herbicide program to enhance the speed of burndown and increase weed spectrum including glyphosate-resistant horseweed.
- Depending on the rate, Sharpen can provide some short-term residual control of certain annual broadleaf weeds. Include necessary additives MSO or COC plus nitrogen solution or AMS to the spray mixture.
- Do not apply to emerged corn or if OP or carbamate insecticides are being used. Sharpen is a Group 14 herbicide, and due to concerns for long-term viability of this herbicide mode of action, extension specialists in the Mid-Atlantic region recommend not using it every year.
- This mode of action has greater utility in soybeans than corn, especially for control of glyphosate-resistant horseweed (marestail). As such, we suggest that Sharpen and other saflufenacil-containing products (e.g., Verdict, Optill) be used in soybean first and only in alternate years.
- The use of Sharpen in continuous corn should also be limited to every other year (alternating years with HPPD-containing herbicide [Group 27]) and avoided if Sharpen is used in soybean in a corn-soybean rotation.

Valor SX 51WDG	**flumioxazin**	**14**	**1–2 oz**	**0.51–1.02 oz**

- Valor may be included in a typical no-till burndown herbicide program to enhance the speed of burndown and increase weed spectrum.
- Corn can be planted 7 days after application if there is at least 25% soil residue cover and ¼ inch rainfall.
- Fierce 76WDG contains the active ingredients in Valor and Zidua and can be used in burndown programs; see Table 5.15 for additional details.
- Valor is a Group 14 herbicide, and due to concerns for long-term viability of this herbicide mode of action, extension specialists in the Mid-Atlantic region recommend not using it every year. This mode of action has greater utility in soybeans than corn, especially for control of glyphosate-resistant horseweed (marestail). As such, we suggest that Valor and other flumioxazin-containing products (e.g., Fierce, Valor XLT, Envive) be used in soybean first and only in alternate years.
- The use of Valor in continuous corn should also be limited to every other year (alternating years with HPPD-containing herbicide [Group 27]) and avoided if Valor is used in soybean in a corn-soybean rotation.

[1] See Table 5.1 for additional formulations or trade names containing some of these same active ingredients.

[2] Refer to current product label for active ingredient concentration and application rate (e.g., 1 qt/A glyphosate 4S = 22 fl oz/A Roundup WeatherMax).

Water Solubility and Residual Length Of Soil-Applied Herbicides

Solubility (parts per million; ppm): How many microliters of the herbicide will dissolve in 1 liter of water. The less soluble the herbicide, the more moisture (rain or irrigation) is needed to activate the herbicide and move it into the root zone. Solubility is used as a guideline for rainfall or irrigation required within a short time after application. Moisture needed also depends on the soil moisture at time of application.

Relative moisture levels to move herbicide into the soil to achieve optimum level of control:

Relative Moisture to Activate	ppm	Estimate Water to Activate*
Low	>500 ppm (very soluble)	0.33 inch
Medium	250-500 ppm	0.33-0.5 inch
High	100-250 ppm	0.5-0.75 inch
Very High	<100 ppm	>0.75 inch

*More water (additional irrigation) maybe necessary if soil is dry at time of application, soils with higher clay content, or high plant residues are present.

Relative duration of residual control is for comparison only based on herbicide half-life (length of time it takes for half the herbicide to break down). Herbicide breakdown results from chemical and/or microbial activity. Since the speed of breakdown is affected by a number of factors including soil pH, soil temperature, and soil moisture, duration can vary for herbicides based on the specific conditions. Residual activity is not the same as herbicide carryover.

Duration of residual control assumes 1) good activation; 2) no excessive rain or irrigation; and 3) weed species are sensitive to the herbicide(s) applied.

Table 5.15 - Water Solubility and Longevity Of Soil-Applied Herbicides

Herbicide Trade Name	Solubility (ppm)	Relative moisture amount required to activate	Duration of residual weed control
Atrazine	33	Very High	4-5 weeks
Balance Flexx	7	Very High	2-4 weeks
Callisto	1500	Low	2-4 weeks
Dual II Magnum Cinch	488	Medium	4-5 weeks
Harmony SG	pH5-223	High	1-2 weeks
	pH7-2240	Low	
Harness / Breakfree / Surpass	223	High	2-4 weeks
Intrro	242	High	2-4 weeks
Metribuzin	1,200	Low	2-4 weeks
Outlook	1,174	Low	2-4 weeks
Princep	5	Very High	4-5 weeks
Prowl / other Pendimethalin Formulations	1	Very High	4-5 weeks
Python	5,600	Low	4-6 weeks
Resolve SG	pH7-7300	Low	1-2 weeks
Stinger	1000	Low	1-3 weeks
Thiencarbazone-methyl	436	Medium	2-4 weeks
Topnotch	223	High	2-4 weeks
Valor SX	2	Very High	4-5 weeks
Zidua	3.49	Very High	4-5 weeks

Premixes	Constituents
Acuron	Dual II Magnum, Callisto, atrazine, bicyclopyrone
Acuron Flexi	Dual II Magnum, Callisto, bicyclopyrone
Anthem ATZ	Zidua, Cadet, atrazine
Anthem Flex	Zidua, Aim
Anthem Maxx	Zidua, Cadet
Bicep II Magnum /Cinch ATZ	Dual II Magnum (or Cinch), atrazine
Bicep Lite II Magnum	Dual II Magnum, atrazine
Bullet	Intrro, atrazine
Corvus	Balance Flexx, thiencarbazone
Fierce	Valor SX, Zidua
FulTime / Keystone / Breakfree ATZ	Topnotch (or Surpass), atrazine
Harness MAX	Harness, Callisto

Harness Xtra / Degree Xtra	Harness (or Degree), atrazine
Lumax EZ / Lexar EZ	Dual II Magnum, Callisto, atrazine
Resicore	Surpass, Callisto, Stinger
Resolve Q/Basis Blend	Resolve SG, Harmony SG
SureStart II / TripleFLEX II	Harness, Python, Stinger
Zemax	Dual II Magnum, Callisto, atrazine

Table 5.16 - Relative Effectiveness of Soil-Applied (Preemergence) Corn Herbicides[1]

Weed control rating:

10 = 95–100%
9 = 85–95%
8 = 75–85%
7 = 65–75%
6 = 55–65%
N = less than 55% or no control
\+ = upper end of rating scale
— = not applicable or no local data available

Crop tolerance:

E = excellent; almost never any crop injury observed
VG = very good; on rare occasion is crop injury observed
G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., seedling depth, seed slit closure, herbicide rate and application timing, adjuvants)
FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often duer to herbicide interactions with environmental conditions
F = fair; some crop injury is commonly observed

Grasses **Trade Name[1]**	**Site of Action Number**	**Barnyardgrass**	**Bermudagrass**	**Broadleaf signalgrass**	**Crabgrass**	**Fall Panicum**	**Foxtail spp.**	**Goosegrass**	**Johnsongrass (Seedling)**	**Johnsongrass (Rhizome)**	**Quackgrass**	**Shattercane**	**Texas panicum**	**Wirestem Muhly**	**Yellow Nutsedge**
Atrazine	5	7	N	N	7	6	6+	7	N	N	7+	6	N	6	6
Balance Flexx[2]	27	8	N	N	7	8	8[3]	N	7+	6	N	7+	N	N	N
Dual products Cinch	15	**9**	N	8	9	**8+**	**9**	**9+**	6	N	N	6	N	N	8
Harness, Surpass NXT, or TopNotch	15	**9**	N	8	**8+**	**8+**	**9**	**9+**	7	N	N	6	N	N	7+
Intrro	15	**9**	N	8	8	8	**9**	**9+**	6	N	N	6	N	N	7+
Outlook	15	**9**	N	7	8	**8+**	**9**	**9**	6	N	N	6	N	N	7+
Princep	5	**8+**	N	N	8	**8+**	8	8	6	N	7	6	N	8	6
Prowl	3	**8+**	N	8	**8+**	**8+**	8	8	7	N	N	7	7	N	6
Zidua	15	**8+**	N	8	9	8+	**8+**	**9+**	6	N	N	6	N	N	6
Mixtures															
Acuron	5/15/27	**8+**	N	8	**9**	**9**	**9**	**9+**	6	N	6	6	N	6	**8+**
Acuron Flexi	15/27/27	**9**	N	8	**9**	**9**	**9**	**9+**	6	N	N	6	N	N	**8+**
Anthem Flex/ Anthem Maxx	14/15	**8+**	N	8	**9**	**8+**	**8+**	**9+**	6	N	N	6	N	N	6
Anthem ATZ	5/14/15	**8+**	N	–	**9**	**8+**	**8+**	**9+**	N	N	6	6	N	6	6
Atrazine + Princep	5/5	**8+**	N	N	**8+**	**8+**	**8+**	8	6	N	**8+**	6	N	8	**8+**
Axiom	5/15	**9**	N	N	**9**	**8+**	**9**	8	6	N	N	6	N	N	6
Bicep, Bullet, Cinch ATZ, or Guardsman	5/15	**9**	N	8	**9**	**9**	**9**	**9+**	6	N	6	6	N	6	**8+**
Corvus	2/27	8	N	N	**8**	**8+**	**8+**	N	7+	7	N	7+	N	N	7

Table 5.16 - Relative Effectiveness of Soil-Applied (Preemergence) Corn Herbicides[1] (cont.)

Grasses Tradename[1]	Site of Action Number	Barnyardgrass	Bermudagrass	Broadleaf signalgrass	Crabgrass	Fall Panicum	Foxtail spp.	Goosegrass	Johnsongrass (Seedling)	Johnsongrass (Rhizome)	Quackgrass	Shattercane	Texas panicum	Wirestem Muhly	Yellow Nutsedge
Fierce	14/15	**8+**	N	–	**9**	**8+**	**9**	**9+**	6	N	N	6	N	N	6
Harness MAXX	15/27														
Harness Xtra, Degree Xtra, FulTime NXT, Keystone NXT, or Breakfree NXT ATZ	5/15	**9**	N	8	**9**	**9**	**9**	10	7	N	6	6	N	6	**8+**
Instigate	2/27	8	N	N	6	8	8	N	N	N	N	N	N	N	N
Lumax/Lexar	5/15/27	9	N	8	9	9	9	**9+**	6	N	6	6	N	6	**8+**
Prequel	2/27	8	N	N	7	8	8	N	7	6	N	7	N	N	N
Resicore	15/27/4	**9**	N	8	**8+**	**8+**	**9**	**9+**	7	N	N	6	N	N	7+
SureStart II/ TripleFLEX II	2/4/15	8	N	8	8	8	8	**9+**	6	N	N	6	N	N	6
Verdict	14/15	8	N	N	8	8	8	9	N	N	N	N	N	N	7+
Zemax	15/27	**9**	N	8	9	9	9	**9+**	6	N	N	6	N	N	**8+**

[1] See Table 5.5 and 5.10 for additional products that contain these active ingredients.

[2] Performance ratings based on full labeled rates.

[3] Herbicide is less effective on yellow foxtail: Balance-6, and Liberty-7.

[4] Degree Xtra may be less consistent on TR Lambsquarters control compared to other acetochlor products.

Table 5.16 - Relative Effectiveness of Soil-Applied (Preemergence) Corn Herbicides[1] (cont.)

Broadleaves Tradename[1]	Site of Action Number	Burcucumber	Cocklebur	Jimsonweed	Lambsquarters[2]	Marestail / Horseweed[5]	Annual Morningglory	Eastern Black Nightshade	Palmer Amaranth / Waterhemp[7]	Pigweed[2]	Common Ragweed[8]	Giant Ragweed[8]	Prickly Sida	Smartweed	Spurred Anoda	Velvetleaf	Corn Safety medium soils	Corn Safety coarse soils
Atrazine	5	6	**8+**	**9**	N	**9**	**8+**	**9**	**9+**	N	**9**	8	**9**	**9+**	8	8	E	E
Balance Flexx	27	7	N	8	**9**	**8+**	N	**9**	8	8	8	7	7	7+	–	**9**	F–G[3]	G
Dual Products, Cinch	15	N	N	N	6	N	N	7+	**8+**	8	6	N	N	N	N	N	G	G

Table 5.16 - Relative Effectiveness of Soil-Applied (Preemergence) Corn Herbicides on Grasses, Grasslike Species, and Broadleaf Weeds[1] (cont.)

Broadleaves Tradename[1]	Site of Action Number	Burcucumber	Cocklebur	Jimsonweed	Lambs-quarters[2]	Marestail / Horseweed[5]	Annual Morning Glory	Eastern Black Nightshade	Palmer Amaranth / Waterhemp[7]	Pigweed[2]	Common Ragweed[8]	Giant Ragweed[8]	Prickly Sida	Smartweed	Spurred Anoda	Velvetleaf	Corn Safety medium soils	Corn Safety coarse soils
Harness, Surpass NTX, or TopNotch	15	N	N	N	7	N	N	**8+**	8	**9**	7+	N	N	7	N	6	G	G
Intrro	15	N	N	N	6+	N	N	7+	**8+**	**8+**	6	N	N	6	N	N	G	G
Lorox	7	N	7+	7	**8+**	**7**	N	6	7	8	7	N	N	9	–	7	F–G	F
Outlook	15	N	N	N	6	N	N	7+	8	8	6	N	N	6	N	N	G	G
Princep	5	6	8	**9**	N	9	**9**	**9**	**9+**	N	**9+**	7	**9**	**9**	8	8	E	E
Prowl	3	N	N	6	9	N	N	N	8	8	N	N	N	8	N	8	G[3]	FG
Python	2	6	8	8	**8+**	N	N	7	N	**9**	7+	6	8	**8+**	7	8	F–G[3]	F
Zidua	15	N	N	7	8	N	N	8	9+	9	7+	N	7	6	N	7	G	G
Mixtures																		
Acuron	5/15/27	7	**9**	**9**	**9**	**9**	**9**	**9**	**9+**	**9**	**9**	**8+**	**9**	**9**	**9**	**9**	G	G
Acuron Flexi	15/27/27	N	6	8	**9**	**8+**	6	**8+**	**8+**	**8+**	7	7	N	**8+**	–	9	G	G
Anthem ATZ	5/14/15	6	**9**	**9**	8	**9**	**8+**	**9**	**9+**	**9**	**8+**	8	**9**	**9**	8	8	G	G
Anthem Flex/ Anthem Maxx	14/15	N	N	7	8	N	N	8	**9**	**9**	7+	6	6	7	N	7	G	G
Atrazine + Princep	5/5	7	**9**	**9+**	N	**9**	**9**	**9**	**9+**	N	**9**	**8+**	**9**	**9**	8	**8+**	E	E
Axiom	5/15	N	N	6	N	6	N	N	7	N	N	N	6+	6	–	N	G	FG
Basis Blend/ Resolve[6]	2/2	N	6	6	**8+**	N	N	N	N	**9**	N	N	N	6	–	6	F–G	F
Bicep, Bullet, Cinch ATZ, or Guardsman	5/15	6	**8+**	**9**	7	**9**	**8+**	**9**	**9+**	**8+**	**8+**	8	**9**	**9**	**9**	**8+**	G	G
Corvus	2/27	7	8	8	**9**	**8+**	7	**9**	8	**9**	7+	7+	7	**8+**	–	9	G	F
Fierce	14/15	N	6	8	**9**	**8+**	7+	**9**	**9**	**9**	7+	6	8	7	8	8	G	F
Harness MAXX	15/27																	
Harness Xtra, Degree Xtra[4], Fultime NXT, Keystone NXT, Breakfree NXT ATZ	5/15	6	**8+**	**9**	7+	**9**	**8+**	**9**	**9+**	**9**	**8+**	8	**9**	**9**	**9**	**8+**	G	G

Table 5.16 - Relative Effectiveness of Soil-Applied (Preemergence) Corn Herbicides on Grasses, Grasslike Species, and Broadleaf Weeds[1] (cont.)

Broadleaves Tradename[1]	Site of Action Number	Burcucumber	Cocklebur	Jimsonweed	Lambs-quarters[2]	Marestail / Horseweed[5]	Annual Morning Glory	Eastern Black Nightshade	Palmer Amaranth / Waterhemp[7]	Pigweed[2]	Common Ragweed[8]	Giant Ragweed[8]	Prickly Sida	Smartweed	Spurred Anoda	Velvetleaf	Corn Safety medium soils	Corn Safety coarse soils
Instigate	2/27	7	8	7	**9**	8	7	**9**	8	**9**	7+	7	7	**9**	-	**9**	G	F
Lexar	5/15/27	7	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**8+**	**8+**	**8+**	**9**	**9**	**9**	**9**	G	G
Lumax	5/15/27	6	**8+**	**9**	**9**	**9**	**8+**	**9**	**9**	**8+**	**9**	8	7+	**9**	**9**	**9**	G	G
Marksman	4/5	6+	8	**8+**	**8+**	**9**	**8+**	**9**	**9+**	**9**	**8+**	8	8	**9**	8	8	F–G	F
Prequel	2/27	7	6	8	**9**	**8+**	N	8	8	**9**	8	7	7	7	-	**9**	F–G	F
Prowl + Atrazine	3/5	6	**8+**	**9**	**9**	**9**	**8+**	**9**	**9+**	**9**	**8+**	8	**9**	**9+**	8	**9+**	G[3]	FG
Resicore	15/27/4	N	6	8	**9**	**9**	6	**8+**	**8+**	**8+**	7	7	N	**8+**	-	**9**	G	G
SureStart II/ TripleFLEX II	2/4/15	N	7	7	8	9	6	8	**8+**	**8+**	8	7+	7	8	-	8	G	F
Verdict	14/15	6	8	8	**9**	7+	8	**9**	**9**	**9**	8	8	7	**9**	-	8	G	G
Zemax	15/27	N	6	8	**9**	8	6	**8+**	**8+**	**8+**	7	7	N	**8+**	-	**9**	G	G

[1] See Table 5.5 and 5.10 for additional products that contain these active ingredients.

[2] Triazine-resistant (TR) biotypes of common lambsquarters and redroot/smooth pigweed are widespread in the region and thus triazine (Group 5) herbicides are not effective against these populations.

[3] See remarks in Table 5.17 and the herbicide label for specific management guidelines to maximize crop tolerance.

[4] Degree Xtra may be less consistent on lambsquarters control compared to other acetochlor products.

[5] ALS-resistant biotypes of marestail/horseweed are found in the region and thus Group 2 herbicides will not be effective against these populations.

[6] Corn stunting is likely with products that contain rimsulfuron if: 1) used on coarse-textured soils; 2) applied with 7 days of planting; and 3) growing conditions are less than ideal.

[7] Biotypes resistant to Groups 2 and 9 herbicides are common in the region; do not rely on Groups 2 or 9 herbicides to provide effective control.

[8] Biotypes resistant to Groups 2 and 9 herbicides are found in the region; Groups 2 or 9 herbicides may not provide effective control.

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn

See specific product label to determine correct rate for soil type and weed species found in each field.

- These treatments may be used in conventional, reduced-till, and no-till systems.
- Thiocarbamate herbicides (EPTC and butylate) are highly volatile and are lost if left on the soil surface.
- Other than EPTC, treatments may be applied preplant-incorporated or preemergence, unless stated otherwise.
- Incorporation reduces the need for timely rainfall after application and may improve control of certain weeds.
- The higher rates for a given soil may be required for no-till.
- In no-till situations, "burndown" herbicides may be required to control weeds or cover crops present at time of application. Tables 5.12, 5.13, and 5.14 list characteristics of "burndown" herbicides.
- EPP = early preplant means application prior to plant (in most cases it's 7-14 days before planting); PPI = applied to conventionally tilled soil than mechanically incorporated; PRE = preemergence (applied before the crop has emerged); EPOST = early postemergence (during the early stages of crop and weed growth)

Trade Name[1]	Common name	Site of Action Number	Application	Product/A	lb ai/A
Anthem ATZ 4.5SE	**pyroxasulfone +**	**15**	**EPP, PRE, or EPOST**	**1.75–4 pt**	**0.105–0.24**
	atrazine +	**5**			**0.88–2.0**
	fluthiacet	**15**			**0.004–0.008**

- Anthem ATZ is a premix of pryoxasulfone (Zidua), atrazine, and fluthiacet (Cadet) and provides control of several key annual grasses and broadleaves.
- Anthem ATZ can be applied preplant (surface or incorporated; burndown) up to 45 days before planting.
- The typical use rate is 2 pt/A on medium-textured soils. Rates can be adjusted for soil type or two-pass application programs.
- Anthem ATZ can be tank-mixed with certain other corn herbicides to broaden control spectrum.
- Anthem ATZ may be applied early postemergence from crop emergence to V4 corn stage, but tank-mix if weeds are emerged.
- Anthem ATZ may be applied in the fall.
- Other pyroxasulfone-containing products include Anthem Flex, Anthem Maxx, Fierce, and Zidua.
- *Water quality advisory.*

Anthem Flex	**pyroxasulfone +**	**15**	**EPP, PRE, or EPOST**	**3.5–6 fl oz**	**0.102–0.175**
	carfentrazone	**14**			**0.007–0.012**
Anthem Maxx 4.3SE	**pyroxasulfone +**	**15**	**EPP, PRE, or EPOST**	**3–6 fl oz**	**0.1–0.2**
	fluthiacet	**14**			**0.003–0.006**

- Fluthiacet (Cadet) or carfentrazone (Aim) does not provide any residual weed control.
- See Zidua (pyroxasulfone) entry for more details.

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Atrazine 4L	**atrazine**	**5**	**EPP or PRE**	**1–2 qt**	**1–2**

- Atrazine may be used at 1–2 qt/A. Most commonly used in combination with other herbicides at 1–1.5 qt.
- On highly erodible ground with less than 30% surface residue, no more than 1.6 qt may be applied prior to crop emergence.

ATRAZINE USE RESTRICTIONS

Preplant or Preemergence
- On highly erodible soils (as defined by the U.S. Natural Resources Conservation Service):
- Fields where more than 30 percent of the soil surface is covered with plant residue at planting, apply a maximum of 2.0 lb of active ingredient per acre as a broadcast spray.
- Fields where less than 30 percent of the soil surface is covered with plant residue at planting, apply a maximum of 1.6 lb of active ingredient per acre as a broadcast spray.
- Apply a maximum of 2.0 lb of active ingredient per acre as a broadcast spray.

Postemergence
- If no atrazine was applied prior to crop emergence, use a maximum rate of 2.0 lb of active ingredient per acre.
- If a soil-applied application was made in the same calendar year, the combined preplant or preemergence and postemergence applications may not exceed 2.5 lb of active ingredient per acre.

Safety Precautions for Using Atrazine
- Do not mix, load, or apply within 50 feet of drinking water wells, livestock wells, agricultural drainage wells, irrigation wells, abandoned wells, or sinkholes.
- Do not mix or load within 50 feet of intermittent streams, perennial streams, rivers, lakes, or reservoirs.
- Do not apply within 200 feet of lakes or reservoirs.
- Do not apply within 66 feet of the points where surface water runoff enters intermittent streams, perennial streams, or rivers. The 66-foot buffers should be planted to a crop or seeded with grass on highly erodible land.
- *Restricted-use pesticide and water quality advisory.*

Balance Flexx 2SC	**isoxaflutole + corn safener**	**27**	**EPP, PRE, or EPOST**	**3–6 fl oz**	**0.047–0.094**

- Balance Flexx contains isoxaflutole plus a corn safener (cyprosulfamide) and can be applied from preplant through early postemergence (up to V2 corn).
- The medium soil texture rate is 5 fl oz/A.
- Tank-mix with pregrass products (Define, Dual, Harness, TopNotch, Outlook, etc.) to improve residual grass control. Balance Flexx can be mixed with atrazine, 2,4-D, Gramoxone, or glyphosate plus COC or MSO to improve burndown activity on emerged weeds in a no-till setting.
- Early postemergence applications of Balance Flexx will likely not control weeds that are larger than one-leaf stage, but the addition of atrazine can improve control.
- Balance Flexx also can be used as a foundation herbicide in a planned pre herbicide followed by POST herbicide system.
- Do not apply with adjuvants, tank-mixtures with other herbicides or OP or carbamate insecticides, or use fluid fertilizer carriers after corn has emerged.
- To improve crop safety, it is best to plant corn at least 1.5 inches deep and make sure seed is completely covered and seed slit is firmed.
- *Restricted-use pesticide and water quality advisory.*

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Basis Blend 30WDG	**rimsulfuron +**	**2**	**PRE**	**0.825–1.25 oz**	**0.01–0.015**
	thifensulfuron	**2**			**0.005–0.008**

- Basis Blend is a mixture of rimsulfuron (Resolve) and thifensulfuron (Harmony SG).
- Soil application of Basis Blend is permitted in the Mid-Atlantic region, including Pennsylvania.
- Soil-applied Basis Blend is effective on triazine-resistant lambsquarters and pigweed.
- Corn stunting is commonly observed when Basis Blend is used on coarse-textured soils.
- Tank-mix with other products to broaden the spectrum of control.
- For additional remarks, see Basis Blend remarks in the postemergence herbicide for corn section.

Bicep II Magnum 5.5SC/Cinch ATZ or	**S-metolachlor + atrazine**			**1.3–2.6 qt**	**See Table 5-11 for ai rates**
Bicep Lite II Magnum 6SC/Cinch ATZ Lite or				**0.9–2.2 qt**	
Degree Xtra 4.04 ME or	**acetochlor + atrazine**			**2.9–3.7 qt**	
FulTime NXT 4.04CS or				**2.9–4.4 qt**	
Guardsman Max 5L or	**dimethenamide + atrazine**	**15, 5**	**EPP, PRE, or EPOST**	**2.4–4 pt**	
G-Max Lite 5L or				**2–3.5 pt**	
Harness Xtra 6L or	**acetochlor + atrazine**			**1.8–2.3 qt**	
Harness Xtra 5.6L				**1.4–3 qt**	
Keystone LA NXT 6SE/Breakfree NXT Lite or				**1.8–2.7 qt**	
Keystone NXT 5.6SE/Breakfree NXT ATZ				**1.4–3 qt**	

- These mixtures contain one of the chloroacetamide herbicides plus atrazine.
- Breakfree NXT Lite, Bicep Lite II Magnum, Cinch ATZ Lite, G-Max Lite, Harness Xtra 6L, and Keystone LA NXT are premixes of reduced-atrazine-rate ratios.
- The application rates based on soil texture for each of these products are listed in Table 5-18.
- These products may be applied to emerged corn in a water carrier; refer to Table 5-20 for maximum corn and weed size restrictions.
- Degree Xtra can be applied early POST in a UAN carrier if the temperature is below 85°F. Some corn leaf burn should be expected. Refer to label for more details. Do not include surfactants, crop oils, or other additives.
- See individual component sections in this table and atrazine use restrictions under that entry for additional information.
- *Restricted-use pesticides and water quality advisory.*

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
	isoxaflutole +	**27**			**0.049–0.083**
Corvus 2.63SC	**thiencarbazone +**	**2**	**EPP, PRE, or EPOST**	**3.33–5.6 fl oz**	**0.02–0.033**
	corn safener				

- Corvus is a premix of isoxaflutole, cyprosulfamide (Balance Flexx), and thiencarbazone (ALS-inhibitor herbicide that improves control of annual weeds) and can be applied from preplant through early postemergence (up to V2 corn) to provide residual control of annual broadleaves and grasses, especially when tank-mixed with atrazine.
- The typical use rate is 5.6 fl oz/A.
- Corvus can provide some control of small, emerged annual weeds (<6 inches) in no-till.
- To improve burndown activity on emerged weeds in a no-till setting, mix with atrazine, 2,4-D, Gramoxone, or glyphosate plus COC or MSO.
- Early postemergence applications of Corvus will control small, emerged weeds, but the addition of atrazine can improve control.
- Corvus also can be used as a foundation herbicide in a planned preherbicide followed by postherbicide system.
- Do not apply with adjuvants (COC or MSO), tank mixtures with other herbicides or OP or carbamate insecticides, or use fluid fertilizer carriers after corn has emerged.
- To improve crop safety, it is best to plant corn at least 1.5 inches deep and make sure seed is completely covered and seed slit is firmed.
- *Restricted-use pesticide and water quality advisory.*

Dicamba-containing products	**dicamba**	**4**	**PRE or EPOST**	**varies**	**0.5 lb ae**

- Dicamba may be applied after planting on medium- to fine-textured soils.
- Do not apply preemergence to soil containing less than 2% organic matter or to coarse-textured soils.
- Preemergence applications have a greater potential to injure corn under conditions of excessive moisture and cool temperatures.
- Crop tolerance is greatest to dicamba, and weeds are generally most susceptible when corn is from the spike to five-leaf stage of growth.

Dual II Magnum 7.64E/Cinch	**S-metolachlor**	**15**	**EPP or PRE**	**1–2 pt**	**0.96–1.9**

- Dual II Magnum/Cinch are similar in activity to Harness, Intrro, Outlook, and Surpass.
- Dual II Magnum/Cinch contains a crop-safening agent.
- These may be applied broadcast on up to 5-inch- tall corn prior to weed emergence.
- The medium soil texture rate is 1.67 pt for Dual II Magnum/Cinch .
- For early preplant applications or fields with heavy surface plant residue, the Dual II Magnum/Cinch rate may need to be increased by up to 20%.
- Incorporation improves control of yellow nutsedge.
- *Water quality advisory.*

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Fierce 76WDG	**pyroxasulfone +**	**15**	**EPP or PRE**	**3 oz**	**0.08**
	flumioxazin	**14**			**0.063**

- Fierce contains pyroxasulfone (Zidua) and flumioxazin (Valor) and can be used only in no-till or minimum-tilled fields where crop residue has not been incorporated into the soil and corn will be planted directly into a stale seedbed, cover crop, or previous crop residue.
- Apply Fierce at 3 oz/A to field corn early preplant.
- Corn must be planted between 7 and 30 days after application.
- When applied as part of a burndown program, Fierce must be tank-mixed with appropriate herbicides and adjuvants to control emerged weeds.
- In addition, Fierce provides residual control of several annual grass and broadleaf weeds, but other herbicides can be tank-mixed to improve control spectrum.
- Do not use on soils with less than 1% organic matter unless an activation rainfall (½ inch or more) has occurred between application and planting.
- Fierce also can be used as part of a fall burndown program.
- *Water quality advisory.*

Harness 7E	**acetochlor**	**15**	**EPP or PRE**	**1.25–3.0 pt**	**1–2.6.0**
Surpass NXT 7E/Breakfree NXT				**1.25–3.0 pt**	**1.09–2.6**
TopNotch 3.2CS				**2–3.75 qt**	**1.6–3.0**

- Harness, Surpass NXT, and TopNotch contain acetochlor.
- Acetochlor is similar in activity to Dual, Intrro, and Outlook, but is more active on certain broadleaf weeds.
- Acetochlor may be applied on up to 11-inch-tall corn depending on the tank-mix partner.
- The medium soil texture rate is about 2 pt/A for Harness, 2.25 pt for Surpass NXT/Breakfree NXT, and 2.25 qt for TopNotch.
- For early preplant applications or fields with heavy surface plant residue, the rate of acetochlor may need to be increased by up to 20%.
- Incorporation improves control of yellow nutsedge.
- *Restricted-use pesticide and water quality advisory.*

Harness MAX 3.85L	**acetochlor +**	**15**	**EPP or PRE**	**1.7–2.75 qt**	**1.5–2.42**
	mesotrione	**27**			**0.14–0.227**

- Controls many annual broadleaf and grass weeds but will not provide consistent control if grasses have already emerged.
- Can be applied PRE thru POST; when applied in a planned PRE followed by POST programs better weed control usually can be expected and more modes of action can be incorporated for better resistance management.
- Typical medium soil rate is 64 fl oz/A Harness MAX.
- It does not contain atrazine, so it provides a non-atrazine alternative for triazine-sensitive areas. However, other herbicides can be tank-mixed to broaden the weed control spectrum.
- Harness MAX can be applied to corn that is no more than 11 inches tall; use rates might need to be reduced for POST applications and include necessary adjuvants.
- See label for additional application guidelines.

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Instigate 46WDG	rimsulfuron +	2	EPP, PRE, or EPOST	5.25–7 oz	0.014–0.019
	mesotrione	27			0.14–0.187

- Instigate contains rimsulfuron (Resolve) and mesotrione (Callisto), the same active ingredients in Realm Q.
- Instigate can be applied from preplant to early post (V2).
- The typical soil-applied use rate is 6 oz/A and will provide some initial residual weed control of annual grasses and broadleaves, but it will likely need to be followed by a POST application of glyphosate (RR-corn), glufosinate (LL-corn), or conventional herbicides as needed.
- Tank-mix with atrazine or other products to improve control and spectrum.
- Crop injury may occur following an application of Instigate if there is a prolonged period of cold weather and/or in conjunction with wet soil.
- Regardless of pre and/or post applications, do not apply more than a total of 1 oz/A/season active ingredient rimsulfuron.
- Do not tank-mix Instigate with foliar-applied organophosphate insecticides such as Lorsban, malathion, parathion, etc., as severe crop injury may occur. To avoid crop injury or antagonism, apply these products at least 7 days before or 3 days after the application of Instigate. Do not apply Counter within 60 days of a preemergence or preplant application of Instigate because crop injury may result. Do not apply Instigate within 45 days of crop emergence where Counter was applied as a treatment because crop injury may occur.
- Do not apply another solo HPPD inhibitor POST herbicide (e.g., Callisto, Impact/Armezon, Laudis) to a field that has been treated with Instigate in the same season.

Lexar EZ 3.7SC or	S-metolachlor + mesotrione + atrazine	15, 27, 5	EPP, PRE, or EPOST	3–3.5 qt	See Table 5-11 for ai rates
Lumax EZ 3.67SC		15, 27, 5		2.7–3.25 qt	
Acuron 3.44SC	S-metolachlor + mesotrione + atrazine + bicyclopyrone	15, 27, 5		2.5–3 qt	
Acuron Flexi 3.26SC	S-metolachlor + mesotrione + bicyclopyrone	15, 27		2–2.25 qt	
or Zemax 3.67SC	S-metolachlor + mesotrione	15, 27		2–2.4 qt	

- Lexar EZ and Lumax EZ are mixtures of s-metolachlor (Dual II Magnum), mesotrione (Callisto), and atrazine.
- Acuron contains the same active ingredients as Lumax/Lexar with the addition of another Group 27 herbicide, bicyclopyrone. In general, it controls a broader weed spectrum and is better on ragweed, cocklebur, and annual morningglory, and effective on many annual broadleaves and some grasses compared to Lumax/Lexar.
- The typical use rates in all tillage systems are 3 qt/A Lexar EZ, 2.7 qt/A Lumax EZ, and 2.5 qt/A Acuron.
- These products may be applied broadcast on up to 12-inch-tall corn, but prior to annual grass emergence.
- Do not apply more than 3.5 qt/A Lexar EZ, 3.25 qt/A Lumax EZ, or 3 qt/A Acuron per growing season.
- Do not apply Lexar, Lumax, or Acuron early POST if the corn was treated with Counter insecticide. Do not tank-mix Lexar, Lumax, or Acuron with organophosphate (OP) or carbamate insecticides and apply as a foliar POST application. Do not make a foliar POST application of any OP or carbamate insecticide within 7 days before or 7 days after a Lexar EZ, Lumax EZ, or Acuron application, or severe corn injury may occur.
- Corn, soybeans, small grains, and sorghum may be planted the spring following Lexar EZ, Lumax EZ, or Acuron application.
- Zemax is similar to Lumax EZ but contains no atrazine. The typical use rate is 2 qt/A.
- *Restricted-use pesticide and water quality advisory.*

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Lorox 50DF	**linuron**	**7**	**PRE**	**0.7–1.0 lb**	**0.3–0.5**

- Lorox applied at 0.7 to 1.0 lb/A will help control lambsquarters.
- Do not incorporate.
- Plant corn at least 1.5 inches deep to minimize risk of crop injury.
- *May cause crop injury under adverse conditions*

Marksman 3.2L	**dicamba +**	**4**	**PRE or EPOST**	**2–3.5 pt**	**0.27–0.48**
	atrazine	**5**			**0.53–0.92**

- Marksman may be applied after planting on medium- to fine-textured soils.
- Do not apply preemergence on soil containing less than 2% organic matter or to coarse-textured soils.
- Preemergence applications have a greater potential to injure corn under excessive moisture or cool temperature conditions.
- Crop tolerance is greatest and weeds are generally most susceptible to Marksman when corn is from spike to five-leaf stage of growth.
- See remarks under atrazine.
- *Restricted-use pesticide and water quality advisory.*

Outlook 6.0E	**dimethenamid**	**15**	**EPP or PRE**	**10–21 fl oz**	**0.47–0.98**

- Outlook is similar in activity to Dual, Harness, Micro-Tech, and TopNotch.
- Outlook (dimethenamid) may be applied preemergence on up to 12-inch-tall corn prior to weed emergence.
- The medium soil texture rate is 16 fl oz/A for Outlook.
- For early preplant applications or fields with heavy surface plant residue, increase the Outlook rate by 1–2 fl oz/A.
- Lower use rates, 6–16 fl oz/A, may be used in situations where partial control or reduced length of residue control is required, such as early postemergence applications or preemergence applications followed by postemergence herbicides.
- Incorporation improves control of yellow nutsedge.
- *Water quality advisory.*

Prequel 45WG	**isoxaflutole +**	**27**	**EPP or PRE**	**1.66–2.5 oz**	**0.04–0.06**
	rimsulfuron	**2**			**0.016–0.024**

- Prequel is a premix of isoxaflutole (Balance Pro) and rimsulfuron (Resolve) that is designed to be used in a two-pass program.
- The typical use rate is 1.66 oz/A and will provide some initial residual weed control of annual grasses and broadleaves but will likely need to be followed by a postapplication of glyphosate (RR-corn), glufosinate (LL-corn), or conventional herbicides as needed.
- Tank-mixing with atrazine improves control and spectrum.
- Prequel can provide some control of small, emerged weeds in a no-till burndown setting, but it is recommended to tank-mix with 2,4-D, atrazine, glyphosate, or Gramoxone plus necessary adjuvants to improve control of larger weeds.
- Do not apply to emerged corn, or severe crop injury will occur.
- To improve crop safety, it is best to plant corn at least 1.5 inches deep and make sure seed is completely covered and seed slit is firmed. Be cautious of interactions with OP insecticides (e.g., Counter), which can cause corn injury.
- *Restricted-use pesticide and water quality advisory.*

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Princep 90DF	**simazine**	**5**	**EPP or PRE**	**1.1–3.3 lb**	**1–3**

- Princep is similar to atrazine but has better grass activity and less broadleaf control.
- Like atrazine, Princep can persist in soil and leave carryover residues.
- Use in combination with other herbicides to lower the necessary rate and broaden the weed spectrum.
- If using Princep in combination with atrazine, follow recrop restrictions.
- *Water quality advisory.*

Princep 90DF +	**simazine +**	**5**	**EPP or PRE**	**1.1–1.7 lb**	**1–1.5**
Atrazine 90DF	**atrazine**	**5**		**1.1–1.7 lb**	**1–1.5**

- Both simazine and atrazine have long soil residuals.
- Plant corn, sorghum, or sudangrass the following year.
- Simazine improves annual grass control; use 2:1 ratio of simazine to atrazine in fields with heavy grass pressure.
- See comments under atrazine.
- When tank-mixing or sequentially applying simazine and/or atrazine or products containing either active ingredient to corn, the total pounds of simazine and/or atrazine applied must not exceed 2.5 lb ai/acre per calendar year.
- *Atrazine is a restricted-use pesticide, and both atrazine and simazine have a water quality advisory.*

Prowl 3.3E	**pendimethalin**	**3**	**PRE or EPOST**	**1.8–4.0 pt**	**0.75–1.65**
Prowl H_2O 3.8CS	**pendimethalin**	**3**	**PRE or EPOST**	**2.0–4.0 pt**	**0.95–1.9**

- Plant corn at least 1.5 inches deep to avoid Prowl injury.
- Do not incorporate.
- Must be applied after planting up until corn reaches 30 inches tall.
- Preemergence applications can injure corn.
- Delaying application until spike stage helps maximize crop safety.
- Prowl H_2O is a water-based capsule suspension formulation that provides similar weed control as the older 3.3E product but causes less staining and odor.

Prowl 3.3E or	**pendimethalin**	**3**	**PRE or EPOST**	**1.8–3.6 pt**	**0.75–1.5**
H2O 3.8CS +	**pendimethalin**	**3**		**2.0–4.0 pt**	**0.95–1.9**
Atrazine 90DF	**atrazine**	**5**		**1.1–2.2 lb**	**1.0–2.0**

- Plant corn at least 1.5 inches deep to avoid Prowl injury.
- Do not incorporate.
- Must be applied after planting up until corn reaches 12 inches tall.
- Preemergence applications can injure corn.
- Delaying application until spike stage helps maximize crop safety.
- See remarks under atrazine.
- *Atrazine is a restricted-use pesticide and has a water quality advisory.*

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Python 80WDG/ Accolade	**flumetsulam**	**2**	**EPP or PRE**	**0.8–1.14 oz**	**0.04–0.057**

- Flumetsulam is available as a single active ingredient in Python WDG/Accolade.
- Apply before crop or weed emergence.
- Plant corn at least 1.5 inches deep.
- Do not use where soil pH is greater than 7.8, where organic matter is less than 1.5% or when extended cool, wet conditions exist.
- Apply all insecticides in a T band or a band to avoid serious crop injury.
- Do not use if Counter insecticide was applied. IMI corn hybrids will reduce the potential for crop injury.
- See Table 5.4 for recrop restrictions.
- To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (group 2) herbicides.
- *Water quality advisory.*

Resicore 3.29SE	**acetochlor +**	**27**	**EPP, PRE, or POST**	**2.25–3 qt**	**1.58–2.1**
	mesotrione +	**2**			**0.162–0.216**
	clopyralid + corn safener	**4**			**0.107–0.143**

- Resicore can be used with any field or silage corn hybrids.
- It controls many annual broadleaf and grass weeds but will not provide consistent control if grasses have already emerged.
- It can be applied PRE thru POST; when applied in a planned PRE followed by POST programs better weed control usually can be expected and more modes of action can be incorporated for better resistance management.
- The typical medium soil rate is 2.5 qt/ A Resicore.
- Resicore does not contain atrazine, so it provides a non-atrazine alternative for triazine-sensitive areas. However, atrazine, glyphosate, 2,4-D, and other herbicides can be tank-mixed with Resicore to broaden the weed control spectrum.
- It contains acetachlor, so be sure to follow acetachlor use restrictions for soil type, organic matter, and depth to water table.
- Adequate soil moisture is required for optimum herbicidal activity. If adequate soil moisture is not received within 7–10 days after a surface-applied treatment, a shallow cultivation is recommended.
- Observe the rotational restrictions on the label.
- If corn has received an at-plant phorate or terbufos insecticide application, POST applications of Resicore may cause severe injury. Refer to label for additional restrictions with insecticides.
- Do not make POST applications of Resicore using liquid fertilizer carriers or tank-mixed with OP insecticides otherwise severe crop injury will occur.
- Resicore can be applied to corn that is no more than 11 inches tall.

Resolve 25DF	**rimsulfuron**	**2**	**PRE**	**0.5–2.0 oz**	**0.0078–0.03**

- Resolve can be applied pre and may be tank-mixed with full or reduced rates of other soil-applied corn herbicides.
- Crop injury may occur following an application of Resolve if there is a prolonged period of cold weather and/or in conjunction with wet soil.
- Corn stunting is commonly observed when Resolve is used on coarse-textured soils.
- See additional comments about Resolve in Table 5.20 in the postemergence herbicides for corn section.

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
SureStart II 4.25SE or TripleFLEX II	acetochlor +	15	EPP, PRE, or EPOST	1.5–3 pt	0.71–1.41
	flumetsulan +	2			0.056–0.113
	clopyralid	4			0.022–0.045

- SureStart II or TripleFLEX II is intended to be used with Roundup Ready or LibertyLink field or silage corn hybrids.
- When applied PRE, it is designed to provide early season control of common annual grasses and broadleaf weeds to allow better timing of the in-crop application of glyphosate or glufosinate.
- The typical medium soil rate is 1.75 pt/ A SureStart II/TripleFLEX II. For longer residual control, use up to 3 pt/A.
- SureStart II/TripleFLEX II does not contain atrazine, so it provides a non-atrazine alternative for triazine-sensitive areas. However, atrazine, glyphosate, 2,4-D, and other herbicides can be tank-mixed with SureStart II/TripleFLEX II to broaden the weed control spectrum.
- It contains acetachlor, so be sure to follow acetachlor use restrictions for soil type, organic matter, and depth to water table.
- Adequate soil moisture is required for optimum herbicidal activity. If adequate soil moisture is not received within 7–10 days after a surface-applied treatment, a shallow cultivation is recommended.
- Observe the rotational restrictions on the label.
- Injury to corn has been observed when cool, wet soil conditions follow application.
- Apply soil insecticides in furrow, a T-band, or a band. To avoid serious crop injury if using OP insecticides, apply in a T-band or a band. Do not use if Counter or Thimet insecticide was applied. Refer to label for additional restrictions with soil insecticides.
- Corn must be planted at least 1.5 inches deep.
- Do not use as a soil treatment in fields with less than 1.5% organic matter unless the risk of crop injury is acceptable.

Verdict 5.57EC	saflufenacil +	14	EPP or PRE	10–16 fl oz	0.058–0.071
	dimethenamid	15			0.384–0.615

- Verdict can be used in a burndown program or in a planned PRE followed by POST herbicide system. In a burndown program it is best to include glyphosate and atrazine in addition to the necessary adjuvants (COC or MSO plus AMS or nitrogen solution) to improve control of emerged weeds including horseweed.
- The medium soil texture rate is 13 fl oz/A and will provide some initial residual weed control, but it will likely need to be followed by a POST application of glyphosate (RR-corn), glufosinate (LL-corn), or conventional herbicides as needed.
- The use of Verdict can follow a burndown application of Sharpen (1 fl oz/A).
- Do not apply Verdict to emerged corn or if OP or carbamate insecticides are being used.

Table 5.17 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Corn (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Zidua SC 4.17L or Zidua 85WDG	**pyroxasulfone**	**15**	**EPP or PRE**	**1.75–6.5 fl oz or 1.5–4.0 oz**	**0.05–0.21**

- Zidua contains the single active ingredient pyroxasulfone.
- Zidua has annual grass activity similar to Dual, Harness, Outlook, Surpass, etc., but also provides good control of several annual broadleaves.
- Zidua can be applied preplant (surface or incorporated) up to 45 days before planting or preemergence.
- The typical use rate is 4 fl oz/A SC (2.5 oz WDG) on medium-texture soils. Rates can be adjusted for soil type or two-pass application programs.
- Corn must be planted at least 1 inch deep.
- Zidua does not control existing weeds and must be activated by at least 1/2 inch of rainfall prior to weed germination; otherwise, effectiveness may be reduced.
- Zidua can be tank-mixed with atrazine or other corn herbicides to broaden weed control spectrum.
- Zidua may be applied in a carrier of water (5 gal/A or more) or liquid nitrogen fertilizer solution (20 gal/A or more). Also, it may be impregnated and applied on certain dry bulk fertilizers.
- Zidua may be applied early postemergence, but tank-mix if weeds are emerged.
- Zidua may be applied in the fall.
- Other pyroxasulfone-containing products include Anthem ATZ, Anthem Flex, Anthem Maxx, and Fierce.
- *Water quality advisory.*

[1] See Tables 5.5 and 5.10 for additional formulations or trade names containing some of these same active ingredients.

Table 5.18 - Corn Herbicide Preplant or Preemergence Rates Per Acre Based on Soil Texture and Organic Matter[1]

Trade Name	Site of Action Number	Unit	Coarse	Medium[1]	Fine	Course	Medium	Fine	Inc. for No-till	Max rate on HEL, less than 30% residue
			<1.5–3% Organic Matter			>3% Organic Matter				
Acuron 3.44SC	5/15/27/27	qt	2.5	2.5	2.5	3.0	3.0	3.0	no	N/A
Acuron Flexi 3.26SC	15/27/27	qt	2.0	2.0	2.0	2.25	2.25	2.25	no	—
Anthem ATZ 4.5SE	5/14/15	pt	1.75	2.0	2.25	2.0	2.25	2.5	no	3.2
Anthem Flex 4SC	14/15	fl oz	3.5	4.5	5.5	4.5	5.5	6.5	no	—
Anthem Maxx 4.3SC	14/15	fl oz	3.0	4.0	5.0	4.0	5.0	6.0	no	—
Atrazine 4L[2]	5	qt	1.25	1.5	1.5	1.25	1.5	2.04	no	1.6
Atrazine 90DF[2]	5	lb	1.4	1.67	1.67	1.4	1.67	2.24	no	1.8
Axiom 68DF	5/15	oz	13.0	16.0	20.0	15.0	18.0	22.0	1–2 oz	—
Balance Flexx 2SC	27	fl oz	3.0	6.0	6.0	4.0	6.0	6.0	no	—
Basis 75DF	2/2	oz	0.33	0.33	0.33	0.825	0.33	0.33	no	—
Basis Blend 30DF	2/2	oz	0.825	0.825	0.825	0.33	0.825	0.825	no	—
Bicep II Magnum 5.5SC/Cinch ATZ	5/15	qt	1.8	2.1	2.1	2.1	2.4	2.6	up to 25%	2.1

Table 5.18 - Corn Herbicide Preplant or Preemergence Rates Per Acre Based on Soil Texture and Organic Matter[1] (cont.)

Herbicide	Site of Action Number	Unit	Coarse	Medium[1]	Fine	Course	Medium	Fine	Inc. for No-till	Max rate on HEL, less than 30% residue
			<1.5–3% Organic Matter			>3% Organic Matter				
Bicep Lite II Magnum 6SC/Cinch ATZ Lite	5/15	qt	1.5	1.5	1.5	1.3	1.9	1.9	up to 20%	N/A
Bullet 4L	5/15	qt	2.5	3.0	3.75	3.0	3.75	4.0	20%	N/A
Corvus 2.63SC	2/27	fl oz	3.3[3]	5.6	5.6	5.6	5.6	5.6	no	—
Degree Xtra 4.04 ME	5/15	qt	2.0	3.0	3.2	2.0	3.2	3.7	up to 25%	N/A
Dual II Magnum 7.64E/Cinch	15	pt	1.33	1.67	1.67	1.33	2.0	2.0	up to 20%	—
Fierce 76WDG	14/15	oz	3.0	3.0	3.0	3.0	3.0	3.0	no	—
FulTime 4.04CS	5/15	qt	2.5	2.9	3.1	2.5	3.0	4.0	no	4.0
G-Max Lite 5L	5/15	pt	2.5	3.0	3.0	3.0	3.5	3.5	no	N/A
Guardsman Max 5L	5/15	pt	3.0	4.0	4.0	4.0	4.5	4.5	10–20%	3.9
Harness 7E	15	pt	1.5	2.0	2.0	1.75	2.0	2.25	up to 25%	—
Harness MAX	15/27	fl oz	55	64	64	60	64	75	no	—
Harness Xtra 6.0L	5/15	qt	1.8	2.0	2.3	2.0	2.3	2.3	up to 25%	N/A
Harness Xtra 5.6L	5/15	qt	1.8	2.0	2.3	1.8	2.3	2.6	up to 25%	2.5
Instigate 46WDG	2/27	oz	5.25	6.0	7.0	6.0	7.0	7.0	no	—
Intrro 4ME	15	qt	2.0	2.25	2.5	2.5	2.5	2.75	20%	—
Keystone LA NXT 6SE/Breakfree NXT Lite	5/15	qt	1.8	2.0	2.1	1.8	2.1	2.4	no	N/A
Keystone NXT 5.6 SE/ Breakfree NXT	5/15	qt	1.4	2.0	2.5	2.0	2.5	2.5	up to 20%	2.5
Lexar EZ 3.7SC	5/15/27	qt	3.0	3.0	3.0	3.5	3.5	3.5	no	N/A
Lumax EZ 3.67SC	5/15/27	qt	2.7	2.7	2.7	3.25	3.25	3.25	no	N/A
Outlook 6.0E	15	fl oz	14.0	16.0	18.0	16.0	16.0	18.0	add 1–2 oz	—
Prequel 45WG[4]	2/27	oz	1.66	1.66	1.66	1.66	1.66	1.66	no	—
Princep 4L	5	qt	1.0	2.5	2.7	1.0	2.7	3.0		
Princep 90DF	5	lb	1.1	2.6	3.0	1.1	3.0	3.3	no	—
Prowl 3.3E	3	pt	2.0	3.6	4.0	3.6	4.0	4.2	no	—
Prowl H_2O 3.8CS	3	pt	2.5	3.0	3.0	3.0	4.0	4.0	no	—
Python 80WDG/ Accolade	2	oz	0.8	0.89	1.0	0.89	1.0	1.1	no	—
Resicore 3.29SE	4/15/27	qt	2.25	2.5	2.75	2.5	2.75	30	up to 0.25 qt/A	—
Sharpen 2.85SC	14	fl oz	2.0	2.5	3.0	2.0	2.5	3.0	no	—

Table 5.18 - Corn Herbicide Preplant or Preemergence Rates Per Acre Based on Soil Texture and Organic Matter[1] (cont.)

Herbicide	Site of Action Number	Unit	Coarse	Medium[1]	Fine	Course	Medium	Fine	Inc. for No-till	Max rate on HEL, less than 30% residue
			<1.5–3% Organic Matter			>3% Organic Matter				
SureStart II 4.25SE/ TripleFLEX II	2/4/15	pt	1.5	1.75	2.0	1.75	1.75	2.0	no	—
Surpass NXT 7E	15	pt	1.5	2.0	2.25	2.0	2.5	2.5	up to 25%	—
Top Notch 3.2ME	15	qt	2.0	2.25	2.5	2.0	2.5	3.0	no	—
Verdict 5.57EC	14/15	fl oz	10	13	16	11.0	13	16	no	—
Zemax 3.67SC	15/27	qt	2.0	2.0	2.0	2.4	2.4	2.4	no	—
Zidua 85WDG	15	oz	2.0	2.5	2.5	2.5	2.5	3.0	no	—
Zidua SC 4.17L	15	fl oz	3.5	4.0	4.0	4.0	4.0	5.0	no	—

[1] Average soil type in most Mid-Atlantic areas.

[2] On highly erodible ground with less than 30% residue, apply no more than 1.6 qt/A or 1.8 lb/A of 90 DF (i.e., 1.6 lb ai).

[3] Reduce Corvus rate to 3.33 fl oz/A if soils are coarse and have < 2% organic matter.

[4] Prequel may be used up to 2.55 oz/A if necessary.

Table 5.19 - Maximum Corn, Weed Sizes, and recommended adjuvants for Delayed Preemergence/Early Postemergence Herbicide Applications

See specific herbicide label(s) for additional information on application.

- This type of application generally is used when weather conditions preclude use of standard preemergence program.
- For most products, do not apply in liquid fertilizer if corn has emerged.
- Poor control from residual herbicides may result if annual grasses such as foxtail and panicum have emerged at time of application; tank-mix with product that controls emerged grasses.
- Delayed preemergence/early postemergence programs can work well with herbicide-resistant corn hybrids now available (e.g., Roundup Ready, LibertyLink).
- When tank-mixing with other pesticides, follow the most restrictive product label.

Trade Name	Maximum Corn Size	Maximum Weed Size
Acuron	12 inches	3-inch broadleaves; inconsistent on emerged grasses
Acuron Flexi	30 inches	3-inch broadleaves
Anthem Maxx, Anthem ATZ	4 collars (V4)	2-inch broadleaves, before grass emergence
Atrazine	12 inches	1.5 inches
Axiom	before emergence	before emergence
Balance Flexx	2-leaf (V2)	1 true leaf stage
Bicep II Magnum	4-leaf or 2 collars	1- to 2-leaf
Corvus	2-leaf (V2)	<2 inches (in general)
Dual	5 inches	2-leaf
Dual II Magnum, Bicep II Magnum, Bicep Lite II Magnum, Cinch ATZ Lite	5 inches	2-leaf
Fierce	before emergence	2-inch broadleaves; by tank-mix partner for grasses

Table 5.19 - Maximum Corn, Weed Sizes, and recommended adjuvants for Delayed Preemergence/Early Postemergence Herbicide Applications (cont.)

See specific herbicide label(s) for additional information on application.

- This type of application generally is used when weather conditions preclude use of standard preemergence program.
- For most products, do not apply in liquid fertilizer if corn has emerged.
- Poor control from residual herbicides may result if annual grasses such as foxtail and panicum have emerged at time of application; tank-mix with product that controls emerged grasses.
- Delayed preemergence/early postemergence programs can work well with herbicide-resistant corn hybrids now available (e.g., Roundup Ready, LibertyLink).
- When tank-mixing with other pesticides, follow the most restrictive product label.

Herbicide	Maximum Corn Size	Maximum Weed Size
Guardsman Max/G-Max Lite	12 inches	1.5 inches broadleaves; before grass emergence
Halex GT	30 inches	4 inches
Harness, Harness MAX, Harness Xtra[1], or Degree Xtra	11 inches or by tank-mix partner	before broadleaf emergence, 2-leaf grasses or by tank-mix partner
Instigate	2-leaf (V2)	3 inches
Lexar EZ	12 inches	3-inch broadleaves; before grass emergence
Lumax EZ	12 inches	3-inch broadleaves; inconsistent on emerged grasses
Outlook	12 inches	before emergence or by tank-mix partner
Prequel	before emergence	before emergence
Princep	before emergence	before emergence
Prowl H_2O	30 inches	before weed emergence
Python WDG/Accolade	20 inches (V6)	before weed emergence
Resicore	11 inches	3-inch broadleaves
Resolve	12 inches	2-inch grasses; 3-inch broadleaves (in general)
SureStart II/TripleFLEX II	11 inches	limited activity on 1-inch broadleaves; before grass emergence
Surpass NXT, FulTime NXT, TopNotch, or Keystone NXT, Breakfree NXT ATZ[2]	11 inches or by tank-mix partner	before emergence or by tank-mix partner
Verdict	before emergence	before emergence
Zemax	30 inches (8-leaf)	3-inch broadleaves; before grass emergence
Zidua	early postemergence	before emergence or by tank-mix partner

[1] May be tank-mixed with Accent, Atrazine (Harness), Banvel or Clarity, Marksman, Permit, or Roundup (Roundup Ready corn).

[2] May be tank-mixed with a number of different products including Accent Q, Banvel or Clarity, Prowl, etc. See an herbicide label for specific information.

Table 5.20 - Recommended Adjuvants when Preemergence Herbicides are Used Early Postemergence

Trade Name	Recommended if corn has emerged and weeds are present	Optional
Acuron[1,2]	NIS (0.25% v/v) or COC[4] (1% v/v)	AMS 8.5 lb/100 gal
Acuron Flexi	NIS (0.25% v/v) or COC[4] (1% v/v)	
Anthem ATZ / Anthem Flex / Anthem Maxx	NIS (0.25% v/v) or COC (1-2 pts/A) or MSO (1-2 pts/A)	
Atrazine	label only mentions COC	
Balance Flexx	label states “Do not use COC or MSO or fully loaded glyphosate formulation”	
Bicep II Magnum	label mentions only NIS when tankmxed with specific herbicides	
Corvus	label states “Do not use COC or MSO"	
Guardsman Max/G-Max Lite	NIS (1-2 pts) or COC[5] (1 qt/A)	
Halex GT	NIS (1-2 qt/100 gal)	
Harness MAX[1,3]	NIS (1 qt/100 gal) or COC (1 gal/100 gal)	
Harness Xtra or Degree Xtra	not addressed on label	
Instigate	NIS or COC rates not specified	
Lexar EZ[1,2]	NIS (0.25% v/v) or COC (1% v/v)	
Lumax EZ[1,2]	NIS (0.25% v/v) or COC (1% v/v)	
Python WDG/Accolade	NIS (1 qt/100 gal) or COC (1 gal/100 gal	
Resicore	NIS (1 qt/100 gal) or COC[4] (1 gal/100 gal)	
FulTime NXT, TopNotch1, or Keystone NXT[1]	not addressed on label	
Zemax[1,2]	NIS (1 qt/100 gal) or COC[4] (1gal/100 gal)	

Table 5.21 - Relative Effectiveness of Postemergence Corn Herbicides[1]

Weed control rating:

10 = 95–100%
9 = 85–95%
8 = 75–85%
7 = 65–75%
6 = 55–65%
N = less than 55% or no control
+ = upper end of rating scale
— = not applicable or no local data available

Crop tolerance:

E = excellent; almost never any crop injury observed
VG = very good; on rare occasion is crop injury observed
G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., seedling depth, seed slit closure, herbicide rate and application timing, adjuvants)
FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often duer to herbicide interactions with environmental conditions
F = fair; some crop injury is commonly observed

Grasses Trade Name[1] (rate/A)	Site of Action	Barnyardgrass	Bermudagrass	Broadleaf signalgrass	Crabgrass	Fall Panicum	Foxtail spp.	Goosegrass	Johnsongrass (Seedling)	Johnsongrass (Rhizome)	Quackgrass	Shattercane	Texas panicum	Wirestem Muhly	Yellow Nutsedge
Postemergence															
Accent Q (0.9 oz)	2	**8+**	N	**9+**	7	**9**	**9**	N	**9**	**8+**	**8+**	**9**	**9**	7	6
Atrazine (1 qt)	5	8	N	7	6	6	7+	**9**	N	N	7	6	N	6	7
Basagran (1.5 pt)	6	N	N	N	N	N	N	N	N	N	N	N	N	N	8
Callisto (3 fl oz)	27	N	N	N	8[10]	N	N	N	N	N	N	N	N	N	8
Glyphosate[3,4] (0.75 lb ae)	9	**9+**	**9**	**10**	**9+**	**9+**	**9+**	**10**	**9+**	**9**	**9**	**9**	**9**	**9**	7
Impact/Armezon (0.75 fl oz)	27	7	N	N	8	8	**8+**	7	N	N	N	7	8	6	7
Laudis (3 fl oz)	27,4	8	N	8	8	N	**8+**	7	6	N	N	7+	8	6	7
Liberty[5] (28 fl oz)	10	8	N	7	8	7+	**9**[4]	N	8	6	6	8	8	7	6
Permit/Sandea (1 oz)	2	N	N	N	N	N	N	N	N	N	N	N	N	N	**9+**
Mixtures															
Basis Blend (0.83 oz)/ Resolve Q (1.25 oz)	2/2	8	N	8	6	**8+**	**8+**	N	**8+**	7	7+	**8+**	7	6	6
Capreno (3 fl oz)	2/27	8	N	6	8	8	**8+**	7	8	7	6	8	**9**	6	7
Halex GT (3.6 pt)	9/15/ 27	**9+**	N	**10**	**9+**	**9+**	**9+**	**10**	**9+**	**9**	**9**	**9**	**9**	**9**	8
Realm Q (4 oz)	2/27	8	N	8	8	**8+**	**8+**	N	**8+**	7	7+	**8+**	7	6	8
Revulin Q (4 oz)	2/27	**8+**	N	**9**	8	**9**	**9**	N	**9**	**8+**	**8+**	**9**	**9**	7	8
Steadfast Q (1.5 oz)	2/2	**8+**	N	**9+**	7	**9**	**9**	N	**9**	8	**9**	**9**	**9**	6+	6
Stout (0.75 oz)	2/2	**8+**	N	**9+**	7	**9**	**9**	N	**9**	**8+**	**8+**	**9**	**9**	7	6
Yukon (4 oz) / Permit Plus (0.75 oz)	2	N	N	N	N	N	N	N	N	N	N	N	N	N	9+

Control of Roundup Ready Corn: Volunteers or Replanting

There are times when corn has to be removed from a field with the intention of replanting a corn crop. Tillage is one effective method, but it is not appropriate in no-tillage situations. Use of glyphosate is highly effective for non–Roundup Ready corn. But, the challenge is in removing Roundup Ready hybrids. There are limited herbicides to consistently kill small corn plants. Gramoxone SL , Liberty , and Select are three

products that have shown the most activity. Research conducted in this region with Gramoxone and Select demonstrated that Select was the most effective for corn 2 to 3 inches tall. For taller corn (4 to 6 inches tall), Gramoxone in combination with a photosystem II-inhibiting herbicide (metribuzin , Lorox, or atrazine) was the most effective. Liberty is a third option, but it will not control Liberty Link hybrids.

Select Max: up to 6 oz of Select Max with a nonionic surfactant at 0.25% v/v plus AMS at 2.5 to 4 lbs/A. Do not use a COC or MSO. Wait a minimum of 6 days from time of application until planting corn due to risk of crop injury. (Select Max will also control corn hybrids containing Roundup Ready and Liberty Link stacked traits.)

Gramoxone SL: 3 to 4.5 pt/A in combination with metribuzin (4 to 6 oz/A), Lorox (1 pt/A) or atrazone (1 lb/A). These photosystem II inhibitors are not added to control the corn but are used to slow down the Gramoxone activity, which helps provide more consistent control.

Liberty 280: 22 to 29 oz Liberty has not been as consistent for control corn as Gramoxone.

[1] See Table 5.5 and 5.10 for additional products that contain these active ingredients.

[2] Large crabgrass only.

[3] For use on Roundup Ready corn varieties only.

[4] Glyphosate-containing products include Roundup, Touchdown, Durango, and many others; see Table 5.2.

[5] For use on glufosinate-resistant corn varieties only.

[6] Herbicide is less effective on yellow foxtail: Balance-6, and Liberty-7.

Table 5.21 - Relative Effectiveness of Postemergence Corn Herbicides[1] (cont.)

Broadleaves **Trade Name (rate/A)[1]**	**Site of Action Number**	**Burcucumber**	**Cocklebur**	**Jimsonweed**	**Lambs-quarters[2]**	**Marestail/Horseweed[3]**	**Annual Morning Glory**	**Eastern Black Nightshade**	**Palmer Amaranth / Waterhemp[8,9]**	**Pigweed[2]**	**Common Ragweed[8,9]**	**Giant Ragweed**	**Prickly Sida**	**Smartweed**	**Spurred Anoda**	**Velvetleaf**	**Corn Safety**
Postemergence																	
2,4-D (1 pt)	4	6	**9**	8	**9**	**7+**	**8**	7	**8**	**9**	**8+**	**7+**	**9**	7	–	8	F[4]
Accent Q (0.9 oz)	2	7	7	7	6	N	7	N	N	**9**	6	N	N	8	–	7	F–G
Aim (0.8) /Cadet (0.9)	14	N	N	N	9	N	**8+**	**9**	N	**9**	N	N	7	N	–	**9+**	G
Atrazine (1 qt)	5	8	**9**	**9**	N	N	**9**	**9**	**9+**	N	**9**	8	**8+**	**10**	–	8	VG
Basagran (1.5 pt)	6	N	**9**	**9**	8	6	N	N	N	6+	8	7	8	9	7	**8+**	G
Callisto (3 fl oz)	27	7+	**8+**	**9**	**9**	6	7+	**9**	**8+**	**8+**	8	8	6	**9**	8	**9**	G
Dicamba (0.25 lb ae)	4	7	**9**	**9**	**9**	**8+**	**8**	8	**8+**	**9**	**8+**	**7+**	8	**9**	–	8	F–G[4]
DiFlexx (8 fl oz))/DiFlexx Duo (32 fl oz)	4	7	**9**	**9**	**9**	**8+**	**9**	8	**8+**	**9**	**9**	**9**	8	**10**	–	8	G
Glyphosate[5,6] (0.75 lb ae)	9	**8+**	**9**	**9**	**8+**	N	7	8	N	**9**	**8+**[8]	8	7	**8+**	8	8	E
Harmony SG (0.125 oz)	2	7	7+	7	**9**	N	N	N	N	**9**	6	N	N	9	N	**8+**	G
Impact/Armezon (0.75 fl oz)	27	7+	**8+**	**9**	**9**	6	7+	**9**	**8+**	**8+**	8	8	6	9	–	**9**	VG
Laudis (3 fl oz)	27	7	**8+**	**9**	**9**	6	7	**9**	**8+**	**8+**	8	8	N	9	–	**9**	VG
Liberty[7] (22 fl oz)	10	8	**9**	**9**	**8+**	**9**	8	8	**9**	8	**9**	**8+**	8	**8+**	–	8	E
Maestro, Moxy, (Buctril) (1 pt)	6	8	**9**	**9**	**9**	6	8	**9**	N	7	7+	8	N	**9**	–	**8+**	F–G[4]

Table 5.21 - Relative Effectiveness of Postemergence Corn Herbicides[1] (cont.)

Broadleaves Trade Name (rate/A)[1]	Site of Action Number	Burcucumber	Cocklebur	Jimsonweed	Lambs-quarters[2]	Marestail/Horseweed[3]	Annual Morning Glory	Eastern Black Nightshade	Palmer Amaranth / Waterhemp[8,9]	Pigweed[2]	Common Ragweed[8,9]	Giant Ragweed	Prickly Sida	Smartweed	Spurred anoda	Velvetleaf	Corn Safety
Permit/Sandea (1 oz)	2	6	9	N	N	N	6	6	N	**9**	**9[9]**	8[9]	7	8	-	9	G
Resource (6 fl oz)	14	7	6	7	7	N	N	8	7	7+	8	6	7	6	-	9+	G
Stinger (0.5 pt)	4	N	**9**	8	6	7	N	7	N	6	**9+**	**9**	7	7	-	6	VG
Mixtures																	
Basis Blend (0.83 oz)	2/2	N	7	7	**8+**	N	6	N	N	**9**	7[9]	N	N	**9**	-	**9**	F–G
Capreno (3 fl oz)	2/27	7	**8+**	**9**	**9**	6	7	**9**	**8+**	**9**	8	8	6	**9**	-	**9**	G
Curtail	4/4	6	**9**	8	**9**	**7+**	**9**	7	**9**	**9**	**9**	**9+**	**9**	7	-	8	F
Halex GT (3.6 pt)	9/15/27	**8+**	**9**	**9**	**9+**	6	7+	**9+**	**8+**	**9**	**8+**	8	7	**9**	-	**9**	G
Marksman (3 pt)	4/5	8	**9**	**10**	**9**	**9**	**9**	**9**	**9**	**9**	**9+**	**9**	**9**	**10**	-	**9**	F–G
Northstar (5 oz)	2/4	8+	**9**	**9**	**9**	**8+**	**9**	**8**	7	**9**	**9+**	**9**	**8**	**9**	-	8+	F–G
Permit Plus (0.75 oz)	2/2	7	**9**	7	9	N	6	6	N	**9**	**9[9]**	8[9]	7	**9**	-	**9**	G
Realm Q (4 oz)	2/27	7+	**8+**	**9**	**9**	6	7+	**9**	**8+**	**9**	8	8	6	**9**	8	**9**	G
Resolve Q (1.25 oz)	2/2	N	7	7	**8+**	N	6	N	N	**9**	7[9]	N	N	**9**	-	**9**	G
Revulin Q (4 oz)	2/27	7+	**8+**	9	9	N	7+	9	**8+**	**9**	8	8	6	**9**	-	**9**	G
Status (5-8 oz)	4/19	7	**9**	**9**	**9**	**9**	**9**	**9**	**8+**	**9**	**9**	**9**	8	**9**	-	**9**	G
Steadfast Q (1.5 oz)	2/2	7	7	7	6	N	7	N	N	**9**	6	N	N	8	-	**8+**	F–G
Stout (0.5 oz)	2/2	7	7	7	**9**	N	7	N	N	**9**	6	N	N	**8+**	-	8	F–G
Yukon (4-8 oz)	2/4	6	**9**	**9**	**9**	**8+**	**9**	8	7	**9**	**9**	8	8	**9+**	-	**9**	F–G

[1] See Table 5.5 and 5.10 for additional products that contain these active ingredients.

[2] Triazine-resistant (TR) biotypes of common lambsquarters and redroot/smooth pigweed are widespread in the region and thus triazine (Group 5) herbicides are not effective against these populations.

[3] Most marestail populations in the region are glyphosate-resistant (Group 9); some populations are also resistant to ALS (Group 2) herbicides. For best management of marestail, control in the fall or with an effective burndown program before planting. There are several herbicides that provide effective residual activity. However, marestail control in-crop can be challenging since there are only a few herbicides that are effective postemergence. Make sure to apply herbicide before marestail reaches 8 inches tall. See Ch. 7 Problem Weeds for more details.

[4] See remarks in Table 5.17 and the herbicide label for specific management guidelines to maximize crop tolerance.

[5] For use on Roundup Ready corn varieties only.

[6] Glyphosate-containing products include Roundup, Touchdown, Durango, and many others; see Table 5.2.

[7] For use on glufosinate-resistant corn varieties only.

[8] Glyphosate resistance has been confirmed for this species and is widespread in the region.

[9] Group 2 (ALS) resistance is confirmed for this species and is widespread in the region.

Glyphosate resistant biotypes are common in the region; glyphosate will not control these biotypes

Triazine-resistant (Group 5) biotypes are common in the region; atrazine nor simazine will not control these biotypes.

ALS-resistant biotypes are present in the region, Group 2 herbicides will not control these biotypes.

Table 5.22 - Herbicide Effectiveness on Perennial Broadleaf Weeds

Performance ratings are based on seasonal control from early season application in corn.

Weed control rating:

10 = 95–100%
9 = 85–95%
8 = 75–85%
7 = 65–75%
6 = 55–65%
N = Less than 55% or no control
+ = upper end of rating scale
– = not applicable or no local data available

Crop tolerance:

E = excellent; almost never any crop injury observed

VG = very good; on rare occasion is crop injury observed

G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., seedling depth, seed slit closure, herbicide rate and application timing, adjuvants)

FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often due to herbicide interactions with environmental conditions

F = fair; some crop injury is commonly observed

Trade Name	Site of Action Number	Canada Thistle	Dandelion	Dewberry Species	Dock Species	Hedge Bindweed	Hemp Dogbane	Horsenettle	Jerusalem Artichoke	Milkweed	Mugwort	Poison Ivy	Pokeweed	Corn Tolerance
Postemergence														
2,4-D	4	7+	8	6	7+	8	7	6	7	6	6	7	7	F
Accent Q	2	6	N	8	N	7	6	6	6	6	N	–	7	F-G
Atrazine[1]	5	6	6	6	7	7+	6	6	N	N	N	6	6	VG
Callisto	27	8	7+	N	–	–	7	7+	–	7	?	–	7	G
Clarity/Banvel/DiFlexx	4	8	7+	6	8	**8+**	7	7	8	6	7+	7+	6	F-G
Glyphosate[2]	9	**8+**	7	8	8	7+	8	7	8	8	7	8	8	E
Marksman	4/5	**8+**	8	6	8	**8+**	7	8	8	6	7+	7+	7	F-G
Starane Ultra	4	N	N	N	N	8	**8+**	N	N	N	N	N	N	VG
Stinger	4	9	7	N	**8+**	N	N	6	**9**	N	8	7	N	VG
Mixtures														
Curtail	4/4	**9**	8	6	**8+**	8	7	6	**9**	6	8	7	7	F
Spirit + Clarity or 2,4-D	2/4	**8+**	8	6	7	8	7	7+	8	7	7+	–	8	F-G
Status	4/19	**8+**	**8+**	6	8	**8+**	7	7	8	7	7+	7+	8	G
Yukon	2/4	**8+**	8	6	7	8	7	7+	7	8	7+	?	8	F-G

[1] Ratings based on 1.6–2 lb/A rate.

[2] For use on Roundup Ready corn varieties only. Glyphosate-containing products include Roundup, Touchdown, Durango, and many others; see Table 5.2.

Table 5.23 - Comments on Postemergence Herbicides for Corn

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
2,4-D amine 4S	**2,4-D amine**	**4**	**0.5–1 pt**	**0.2–0.5**

- Use from time corn emerges until approximately 36 inches.
- Risk of 2,4-D injury increases as corn increases in size.
- Use 0.5 pt rate with drop nozzles after corn exceeds 8 inches in height.
- Corn is most susceptible to injury when growing rapidly.
- Adjust sprayer to minimize drift in order to prevent injury to non-target plants.

Accent Q 54.4WG	**nicosulfuron + safener**	**2**	**0.9 oz**	**0.031**

- Accent Q contains nicosulfuron plus isoxadifen (corn safener) and has similar utility as Accent 75DF; however, it is a different formulation and rates must be adjusted.
- The typical use rate of Accent Q is 0.9 oz/A and it controls many annual grasses and some broadleaves. Accent Q is weak on crabgrass.
- Apply to corn broadcast or directed up to 20 inches tall (V6) or directed up to 36 inches tall (V10).
- Include appropriate adjuvant in spray tank (see Table 5.23).
- Accent Q may be tank-mixed with certain herbicides. Do not tank-mix with Basagran, 2,4-D, or certain OP insecticides such as Lorsban, malathion, etc. Do not use Counter 15G. Do not use Counter 20CR in furrow or over the row at cultivation; may be banded, but may cause injury, especially on soils with less than 4% organic matter. The use of Dyfonate, Lorsban, Thimet may result in temporary injury. There are no precautions for Non-OP insecticides.
- Revulin Q is a premix that contains nicosulfuron + mesotrione.
- To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (group 2) herbicides.

Aim 2EC	**carfentrazone**	**14**	**0.5–1.0 fl oz**	**0.008–0.016**

- Apply to corn up to 8-leaf collar stage and when weeds generally are 1–4 inches tall.
- Include a nonionic surfactant (2 pt/100 gal).
- Tank-mix with other herbicides to increase weed control spectrum.

Atrazine 4L	**atrazine**	**5**	**1–2 qt**	**1–2**

- Apply before weeds are 1.5 inches tall and before corn reaches 12 inches in height.
- Add 1 qt crop oil concentrate/A to spray solution. Do not include oil if corn is under stress from prolonged cold, wet weather or other factors.
- Provides good to excellent residual control of susceptible broadleaf weeds.

ATRAZINE USE RESTRICTIONS

Postemergence

- If no atrazine was applied prior to crop emergence, use a maximum rate of 2.0 lb of active ingredient per acre.
- If a soil-applied application was made in the same calendar year, the combined preplant or preemergence and postemergence applications may not exceed 2.5 lb of active ingredient per acre.

Safety Precautions for Using Atrazine

- Do not mix, load, or apply within 50 feet of drinking water wells, livestock wells, agricultural drainage wells, irrigation wells, abandoned wells, or sinkholes.
- Do not mix or load within 50 feet of intermittent streams, perennial streams, rivers, lakes, or reservoirs.
- Do not apply within 200 feet of lakes or reservoirs.
- Do not apply within 66 feet of the points where surface water runoff enters intermittent streams, perennial streams, or rivers. The 66-foot buffers should be planted to a crop or seeded with grass on highly erodible land.
- *Restricted-use pesticide and water quality advisory.*

Basagran 4S	**bentazon**	**6**	**1.5–2.0 pt**	**0.75–1.0**

- Apply when weeds are small and actively growing.
- Split treatments may be required for yellow nutsedge and Canada thistle.
- Include the appropriate adjuvant in the spray tank (see Table 5.23).
- Basagran poses less threat to off-target plants from drift than 2,4-D or Clarity/Banvel.
- Basagran is weak on pigweed.

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
Basis Blend 30WDG	**rimsulfuron +**	**2**	**0.825 oz**	**0.01**
	thifensulfuron	**2**		**0.005**

- Basis Blend is a mixture of rimsulfuron (Resolve) and thifensulfuron (Harmony) (SG); however, its formulation is different from Basis 75DF; thus, the application rate has changed.
- Apply 0.825 oz/A Basis Blend to corn from spike stage through 2 collars (about 6 inches tall). Do not apply to corn having 3 fully emerged collars or corn over 6 inches tall.
- Basis Blend controls some small annual grasses and broadleaves. Will provide residual control of susceptible species.
- Basis Blend must include an adjuvant including an ammonium nitrogen fertilizer.
- Crop injury may occur following an application of Basis Blend if there is a prolonged period of cold weather and/or in conjunction with wet soil.
- Do not tank-mix with Basagran.
- Regardless of PRE and/or POST applications, do not apply more than a total of 1 oz/A/season active ingredient rimsulfuron.
- Do not tank-mix Basis Blend with foliar-applied organophosphate insecticides such as Lorsban, malathion, parathion, etc., as severe crop injury may occur. To avoid crop injury or antagonism, apply these products at least 7 days before or 3 days after the application of Basis Blend. Do not apply Counter within 60 days of a preemergence or preplant application of Basis Blend since crop injury may result. Do not apply Basis Blend within 45 days of crop emergence where Counter was applied as a treatment since crop injury may occur. There are no precautions for Force and Fortress.
- To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (Group 2) herbicides.

Cadet 0.91EC	**fluthiacet**	**14**	**0.4–0.9 fl oz**	**0.0028–0.006**

- Application timing to corn ranges from 2 visible collars (V2) until the corn is 48 inches tall (or prior to tasseling).
- Apply 0.4 to 0.6 fl oz/A with glyphosate (RR-corn) or glufosinate (LL-corn) or 0.5 to 0.9 fl oz when applied alone.
- Include the necessary spray additives (NIS or COC plus AMS or nitrogen solution).
- Applications should be made when susceptible broadleaf weeds are small.
- Cadet is very effective on velvetleaf (up to 36 inches tall), but other broadleaf weeds must be small to achieve control/suppression.
- Cadet does not provide residual weed control.
- Cadet can cause burning/speckling on the corn leaves.
- Cadet is similar to Aim herbicide.
- Solstice is a premix of Cadet and mesotrione (Callisto).

Callisto 4SC	**mesotrione**	**27**	**3 fl oz**	**0.094**

- Callisto can be applied postemergence at 3 fl oz/A to corn up to 30 inches tall (8-leaf stage).
- Always include crop oil concentrate and UAN or AMS in the spray mixture. Do not use methylated seed oil (MSO).
- Tank-mix with 0.25 to 1 lb ai/A of atrazine for much improved control and to broaden the spectrum of control. Local university data supports at least 0.5 lb ai/A of atrazine. Do not apply the tank mixture of Callisto and atrazine to corn greater than 12 inches tall. (Callisto Xtra is a premix of Callisto + atrazine.)
- Do not apply more than a total of 7.7 oz/A of Callisto/A/season. (i.e., 0.24 lb ai/A mesotrione).
- Callisto will provide residual control of susceptible weed species.
- Do not apply Callisto postemergence in a tank mix with emulsifiable concentrate grass herbicides.
- Do not apply Callisto postemergence: (1) if the crop was previously treated with Counter or Lorsban insecticide, (2) with any OP or carbamate insecticide, or (3) 7 days before or after an OP or carbamate insecticide was applied.
- Small grains may be planted 4 months after application. Corn, soybeans, and sorghum can be planted the year after application, 10-month restriction for alfalfa and 18-month restriction for clover. See Table 5.4 for additional rotational crops.
- Other postemergence premixes that contain mesotrione include:
  - Callisto GT (mesotrione + glyphosate)
  - Callisto Xtra (mesotrione + atrazine)
  - Halex GT (mesotrione + s-metolachlor + glyphosate)
  - Harness MAX (mesotrione + acetochlor)
  - Realm Q (mesotrione + rimuslfuron)
  - Revulin Q (mesotrione + nicosulfuron)
  - Solstice (mesotrione + fluthiacet)

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
Capreno 3.45SC	tembotrione +	27	3 fl oz	0.068
	thiencarbazone +	2		0.013
	corn safener			

- Capreno is a premix of tembotrione (Laudis), thiencarbazone (ALS-inhibitor herbicide that improves control of annual weeds), and cyprosulfamide (corn safener) and can be applied postemergence up to V7 corn stage to provide control of annual broadleaves and grasses, especially when tank-mixed with atrazine.
- The use rate is 3 fl oz/A in addition to COC and UAN or AMS in the spray mixture. (Do not use NIS or MSO.)
- For best results, apply Capreno when broadleaf weeds are less than 4 to 6 inches tall and grasses are less than 3 inches tall and not tillering.
- Tank-mix with 0.25 to 1 lb ai/A of atrazine for much improved control and to broaden the spectrum of control. Local university data supports at least 0.5 lb ai/A of atrazine. Do not apply the tank mixture of Capreno and atrazine to corn greater than 12 inches tall.
- Capreno can be tank-mixed with glyphosate or glufosinate to broaden control spectrum.
- Capreno will provide residual control of susceptible weed species.
- Do not use Capreno in the same season as OP insecticides such as Lorsban, Counter, Dyfonate, or Thimet.

Clarity 4S or Banvel 4S or Engenia 5SL or Xtendimax/FeXapan 2.9SL	dicamba (DGA salt) dicamba (DMA salt) dicamba (BAPMA salt) dicamba (DGA salt with VaporGrip Technology)	4	8–16 fl oz 0.5–1.0 pt 6.4–12.8 fl oz 11–22 fl oz	0.25–0.5

- May apply dicamba up to 1 pint before corn is 8 inches tall (5-leaf stage). Use 0.25 lb ae/A on corn between 8 and 36 inches.
- Take precautions to prevent drift of dicamba off the target site.
- Early postemergence applications are preferable for lambsquarters control.
- Applications should be made while annual weeds are small (4 inches) and actively growing.
- Spray droplet size plays an important role in minimizing off-target movement. Nozzles that produce extremely coarse or ultra coarse droplets while limiting the amount of driftable fine droplets are necessary to limit spray drift. Comply with guidelines for drift management (see label for details).
- Dicamba can be difficult to completely remove from spray equipment and residue is capable of injuring sensitive plants. Follow label instructions concerning sprayer cleanout.
- *Engenia/FeXapan/XtendiMax are restricted use products, all dicamba formulaitons have water quality advisory.*

Curtail 2.38L	clopyralid +	4	2 pt	0.095
	2,4-D	4		0.5 ae

- Curtail contains clopyralid (Stinger) and 2,4-D.
- Apply to corn less than 8 inches tall (V4).
- For increased control of Canada thistle, tank-mix Curtail with Stinger (2–6 fl oz).

DiFlexx 4SC	dicamba + safener	4	8–32 fl oz	0.25–1

- This safened dicamba product contains cyprosulfamide which is the same safener used in Balance Flexx and Corvus.
- Can be applied to field corn from spike stage to V6 (36 inches tall)
- The lower use rates (8—16 fl oz) are recommended for annual broadleaf weeds that are small and actively growing; while the mid and higher rates are recommended for larger annual weeds and established biennial and perennial species.
- The addition of UAN or AMS plus NIS or COC/MSO is recommended to improve control.
- See label for additional use details and restrictions.

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
DiFlexx Duo 1.53SC	**dicamba + safener +**	**4**	**24–40 fl oz**	**0.24–0.4**
	tembotrione	**27**		**0.051–0.085**

- DiFlexx Duo contains the active ingredients in DiFlexx (dicamba) and Laudis (tembotrione) and has activity on both broadleaf and grassy weeds.
- DiFlexx Duo can be applied from corn emergence to 36 inches tall or before V7 stage, whichever comes first.
- For best results apply before annual broadleaf weeds reach 6 inches tall and grasses, 3 inches tall.
- The addition of UAN or AMS plus MSO or COC is recommended to improve control.
- See label for additional use details and restrictions.

Enlist One 3.8SL	**2,4-D chloline**	**4**	**1.5–2.0 pt**	**0.71–0.95 ae**
Enlist Duo 3.3SL	**2,4-D choline +**	**4**	**3.5–4.75 pt**	**0.7–0.95 ae**
	glyphosate	**9**		**0.74–1.0 ae**

- **Enlsit Duo and Enlist One can only be applied post to corn with the Enlist trait** and has activity on both broadleaf and grassy weeds.
- Apply broadcast from corn emergence to 30 inches tall or before V8 stage, whichever comes first; use drop nozzles for corn heights 30 to 48” tall.
- Make one or two applications with a minimum of 12 days between applications.
- Apply in a broadcast spray volume from10 to 15 gpa for best results and do not use nitrogen solutions as a carrier.
- Spray droplet size plays an important role in minimizing off-target movement. Nozzles that produce extremely coarse or ultra coarse droplets while limiting the amount of driftable fine droplets are necessary to limit spray drift. Comply with guidelines for drift management (see label for details).
- See label for additional use details and restrictions.

Halex GT 4.39EC	**S-metolachlor +**	**15**	**3.6–4.0 pt**	**0.94–1.04**
	mesotrione +	**27**		**0.09–0.1**
	glyphosate	**9**		**0.9–1.04 ae**

- Halex GT contains s-metolachlor (Dual Magnum) + mesotrione (Callisto) + glyphosate (Touchdown HiTech) and can only be applied to glyphosate-resistant (RR) corn hybrids from emergence to 30 inches tall (8-leaf stage).
- For best results, apply to weeds before they are 4 inches tall.
- Include NIS and AMS in the spray mixture.
- Tank-mix with 0.25 to 1 lb ai/A of atrazine for much improved control and to broaden the spectrum of control. Local university data supports at least 0.5 lb ai/A of atrazine. Do not apply the tank mixture of Halex GT and atrazine to corn greater than 12 inches tall.
- Do not apply another HPPD-inhibitor herbicide (Callisto, Impact/Armezon, Laudis, Capreno) postemergence in the same season.
- Do not apply more than 4 pt/A Halex GT per season (0.0105 lb mesotrione, 1.05 lb S-metolachlor, and 1.05 lb glyphosate) or make more than 1 application per year.
- Halex GT will provide effective residual control of susceptible weed species.
- Halex GT is not recommended for use as a preplant or PRE application.
- Halex GT can be used in a planned PRE followed by POST herbicide program.
- Use caution if applying OP or carbamate insecticides 7 days before or after Halex GT application.
- See label for additional use restrictions.

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
Harmony SG 50WDG	**thifensulfuron**	**2**	**0.125 oz**	**0.063 oz**

- Harmony SG can be applied to 2–6 leaf corn (1–4 collars, up to 12 inches tall) at a rate of 1⁄8 oz/A.
- Harmony SG can be used in a tank-mix to control velvetleaf, pigweed, smartweed, wild mustard, and lambsquarters (including triazine-resistant species).
- Include the necessary adjuvants in the spray solution.
- Do not apply Harmony SG to normal or IT corn previously treated with Counter 15G or 20CR, Thimet, Dyfonate, Lorsban, or other OP insecticides, otherwise crop injury will result. No insecticide herbicide restriction with IR corn hybrids. There are no precautions for Fortress or Force insecticides.
- Harmony SG is an ALS (group 2) inhibitor herbicide. To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (group 2) herbicides.

Impact 2.8SC or Armezon 2.8SC	**topramezone**	**27**	**0.5–1.0 fl oz**	**0.011–0.022**

- Impact/Armezon is similar to Callisto but has more annual grass activity.
- Impact/Armezon can be applied postemergence at 0.5 to 0.75 fl oz/A to corn up to 45 days prior to corn harvest (use drop nozzles when necessary).
- Always include methylated seed oil (MSO) or crop oil concentrate (COC) and UAN or AMS in the spray mixture.
- Tank-mix with 0.25 to 1 lb ai/A of atrazine for much improved control and to broaden the spectrum of control. Local university data supports at least 0.5 lb ai/A of atrazine. Do not apply the tank mixture of Impact/Armezon and atrazine to corn greater than 12 inches tall.
- Impact/Armezon can be applied up to 1 fl oz/A for larger or harder to control weeds such as fall panicum, yellow foxtail, or seedling Johnsongrass.
- Impact/Armezon can be used in sequence after herbicides such as Balance, Lumax, Lexar, etc., but be cautious of rate restrictions. Impact/Armezon may be used after or in combination with all soil or foliar-applied insecticides registered for use in corn.
- Impact/Armezon will control/suppress crabgrass, foxtails, and other grass species but is weak on fall panicum.
- Corn can be planted any time after Impact/Armezon application, 3-month restriction for small grains, 9-month restriction for alfalfa, potato, soybean, and sorghum and 18 months for other crops. See Table 5.4 for other rotational crops.
- ImpactZ is a premix containing topramazone plus atrazine.
- Armezon PRO is a premix containing topramazone plus dimethenamid (Outlook) and can be applied over-the-top of corn for additional residual weed control

Laudis 3.5SC (tembotrione)	**tembotrione**	**27**	**3 fl oz**	**0.082**

- For best results apply Laudis at 3 fl oz/A when weeds are small (i.e., 1 to 3 inches tall).
- Methylated seed oil (MSO) or crop oil concentrate (COC) adjuvants are recommended by manufacturer. In addition, nitrogen fertilizer is required (UAN or AMS).
- Tank-mix with 0.25 to 1 lb ai/A of atrazine for much improved control and to broaden the spectrum of control. Local university data supports at least 0.5 lb ai/A of atrazine. Do not apply the tank mixture of Laudis and atrazine to corn greater than 12 inches tall.
- Laudis can be tank-mixed with other herbicides to improve weed control spectrum.
- Laudis will control/suppress crabgrass, foxtails, and other grass species, but it will not control fall panicum.
- Do not make more than two applications of Laudis in a growing season.
- Be cautious of crop rotation restrictions; see Table 5.4.
- See label for additional use details.

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
Liberty 280 2.34L	**glufosinate**	**10**	**22–32 fl oz**	**0.40–0.59**

- Liberty controls most annual grasses and broadleaves.
- Apply over the top to glufosinate-resistant (e.g., LibertyLink) corn only.
- Do not use post if Liberty was used prior to planting in a burndown application.
- Two postemergence applications of Liberty can be applied at least 10 to 14 days apart.
- Broadcast applications may be made from corn emergence until corn is in the V-5 stage of growth, whichever comes first.
- For best results, apply 22 to 32 fl oz of Liberty when weeds are 2 to 6 inches tall.
- Do not apply more than 87 fl oz/A/year.
- Liberty herbicide should generally follow a soil residual herbicide program and/or be tank-mixed with an appropriate postemergence product to broaden the spectrum of control.
- Applications should be made between dawn and 2 hours before sunset to avoid the possibility of reduced lambsquarters or velvetleaf control.
- Weed control can be reduced if application is made when heavy dew, fog, or mist are present or when weeds are under environmental stress.
- Liberty provides no soil residual activity.
- See Table 5.23 for adjuvant information. Include ammonium sulfate (AMS) at 3 lb/A (17 lbs/100 gal) but a lower rate is recommended if temperatures exceed 85 degrees (8.5 lbs/100 gal) to reduce risk of leaf burn. Do not add any surfactants or crop oils.

Maestro / Moxy 2E	**bromoxynil**	**6**	**1–1.5 pt**	**0.25–0.375**

- Apply to small actively growing weeds.
- Maestro or Moxy pose less threat to off-target plants from drift than 2,4-D or Clarity/Banvel.
- Bromoxynil is weak on pigweed.

Marksman 3.2L	**dicamba +**	**4**	**2–3.5 pt**	**0.27–0.48**
	atrazine	**5**		**0.53–0.92**

- Consider previous atrazine applications and do not exceed 2.5 lb (qt)/A/year. Marksman contains 1.1 plus 2.1 lb of dicamba and atrazine, respectively, per gal.
- Apply Marksman up to the 5-leaf stage of corn.
- Use 3.5 pt/A on medium-textured soils or 2 pt/A on coarse-textured soils.
- Corn tolerance is greatest to Marksman at the spike stage of growth.
- Be cautious of drift from Marksman.
- See additional restrictions under the atrazine entry.
- *Restricted-use pesticide and water quality advisory.*

Metribuzin 75DF	**metribuzin**	**5**	**2 oz**	**0.094**

- Metribuzin may be applied postemergence at the 2-oz rate in tank-mix combination with atrazine, Banvel, Clarity, Basagran, Buctril, Marksman, and 2,4-D for improved control of certain broadleaf weeds (e.g., velvetleaf).
- Observe precautions and limitations of tank-mix partners.
- *Water quality advisory.*

NorthStar 47.4WDG	**primisulfuron +**	**2**	**5 oz**	**0.023**
	dicamba	**4**		**0.138**

- NorthStar is a premix of primisulfuron (Beacon) plus the sodium salt of dicamba.
- NorthStar can be broadcast at 5 oz/A to corn 4 to 20 inches tall. Apply on a directed spray if corn is 20 to 36 inches tall.
- Include necessary adjuvants in the spray solution (Table 2-16).
- Do not apply if Counter was used. Do not make a foliar POST or soil application of any OP insecticide within 10 days before or 7 days after NorthStar application.
- To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (Group 2) herbicides.

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
Peak 57WG	**prosulfuron**	**2**	**0.25–1.0 oz**	**0.009–0.036**

- Peak is an ALS (group 2) herbicide and can be applied in field corn to control broadleaf weeds.
- Include necessary adjuvants in the spray mixture.
- Be cautious of interactions with certain OP insecticides.
- Refer to label for additional information on use and restrictions.

Permit 75WG or Sandea	**halosulfuron**	**2**	**0.67–1.33 oz**	**0.032–0.063**

- Apply to corn from spike through layby (last cultivation).
- The 0.67 oz rate is the standard rate for annual weed control.
- Permit/Sandea is excellent on yellow nutsedge, but is weak on common lambsquarters.
- Tank-mix with products such as Clarity/Banvel or 2,4-D to increase the weed control spectrum. Yukon is a prepackaged product containing Permit + dicamba.
- Permit/Sandea will provide residual control of susceptible weed species.
- Permit/Sandea has no insecticide use restrictions.
- To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (group 2) herbicides.

Permit Plus 74WDG	**halosulfuron +**	**2**	**0.75 oz**	**0.031**
	thifensulfuron	**2**		**0.004**

- The addition of thifensulfuron (Harmony SG) to halosulfuron (Permit) allows for a broader spectrum of control, especially at lambsquarter postemergence.
- Apply 0.75 oz/A plus necessary adjuvants to corn with 2–6 leaves (but with no more than 5 collars).
- Tank-mix to broaden control spectrum.
- Permit Plus contains two ALS-type (Group 2) herbicides. To prevent herbicide resistance, avoid repeated annual applications of ALS herbicides.

Realm Q 38.8WDG	**rimsulfuron +**	**2**	**4 oz**	**0.019**
	mesotrione +	**27**		**0.078**
	corn safener			

- Realm Q contains the active ingredients in Resolve and Callisto and the postemergence corn safener isoxadifen.
- For best results, apply Realm Q at 4 oz/A in a two-pass program and when weeds are small and prior to corn reaching 12 inches tall.
- Realm Q requires use of nitrogen fertilizer (AMS or UAN) in addition to COC or NIS.
- Make only one application per season.
- The addition of atrazine will improve postemergence weed control and is strongly recommended.
- Realm Q can be used alone, in combination with glyphosate on Roundup Ready corn or glufosinate on LibertyLink corn, or included in other POST herbicide programs to improve weed control spectrum.
- Realm Q will provide some residual as well as foliar control.
- Regardless of PRE and/or POST applications, do not apply more than a total of 1 oz/A/season active ingredient rimsulfuron and 3.85 oz/A/season active ingredient mesotrione.
- Do not tank-mix with an organophosphate insecticide. Do not apply to corn previously treated with Counter or Lorsban.

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
Resolve 25DF	**rimsulfuron**	**2**	**0.5–2.0 oz**	**0.0078–0.03**

- Resolve contains the single active ingredient rimsulfuron.
- Resolve can be applied pre or post in corn at 0.5–2.0 oz/A. Use the higher rate when applying as a tank-mix partner in a pre program. The typical use rate for post applications is 1 oz/A, plus the necessary adjuvants.
- Resolve alone will control small seedling weeds, grasses less than 2 inches and broadleaves less than 3 inches. Resolve will control crabgrass less than 0.5 inch tall.
- Resolve can be tank-mixed with glyphosate to provide residual control of broadleaf and grass weed species emerging after the application. Resolve may be tank-mixed with full or reduced rates of other corn herbicides as well.
- Do not apply Resolve to corn under stress due to crop injury.
- Refer to the Resolve label for all restrictions concerning increased injury when tank-mixed with organo-phosphate insecticides (Counter, Lorsban, or Thimet).
- Do not tank-mix with Basagran due to crop injury concern.
- Apply Resolve up to 12 inch tall corn or before the appearance of 6 or more collars, whichever is more restrictive.
- Resolve must be applied with a nonionic surfactant (NIS) and nitrogen fertilizer. Crop oil concentrate (COC) may be used in place of nonionic surfactant. When applying Resolve in tank-mixture with a glyphosate product that contains a “built-in” adjuvant system, the Resolve label does not recommend the use of extra adjuvants.
- To prevent herbicide resistance, avoid repeated annual applications of soil persistent ALS (group 2) herbicides.

Resolve Q	**rimsulfuron +**	**2**	**1.25 oz**	**0.014**
	thifensulfuron	**2**		**0.003**

- Do not confuse Resolve with Resolve Q. Resolve Q contains rimsulfuron (Resolve) plus thifensulfuron (Harmony SG) and a postemergence corn safener.
- Apply 1.25 oz/A postemergence to corn up to 20 inches tall.
- Applications made after weed emergence will provide contact control of labeled weeds and limited residual control of later emergence.
- For control of emerged weeds, include a nonionic surfactant and an ammonium nitrogen fertilizer. If applied in combination with a glyphosate or glufosinate herbicide that contains a built-in adjuvant system, no additional surfactant needs to be added.
- Resolve Q may be tank mixed with glyphosate or glufosinate herbicides if applications are made to corn hybrids containing appropriate herbicide tolerance genes, and can be tank-mixed with full or reduced rates of other products registered for use in corn.
- Resolve Q may be tank- mixed with full or reduced rates of preemergence grass and broadleaf herbicides to provide added residual activity. Do not tank-mix Resolve Q with Basagran.
- Resolve Q may negatively interact with certain OP insecticides, see label for specific details.
- To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (Group 2) herbicides.

Resource 0.86EC	**flumiclorac**	**14**	**4–6 fl oz**	**0.027–0.04**

- Apply to corn from 2-leaf to 10-leaf stage.
- Good on velvetleaf up to 30 inches tall.
- Tank-mix with other products such as Clarity/Banvel or atrazine to increase the weed control spectrum.

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
Roundup WeatherMax 4.5S or Touchdown Total 4S or Durango DMA or other glyphosate products	**glyphosate**	**9**	**22 fl oz or 24 fl oz or 24 fl oz or see Table 5.9-1a**	**0.75 lb ae or 0.75 lb ae or 0.75 lb ae**

- Apply over-the-top to Roundup Ready corn hybrids only.
- Apply from corn emergence through the V8 stage (or 30 inches) in a 10–20 GPA spray solution.
- Do not apply more than 32 oz/A (or 1.13 lb ae/A) Roundup WeatherMax in a single in-crop application or more than 64 oz/A/growing season (or 2.25 lb ai). (*Note: Adjust application rate if using glyphosate 3S or Touchdown; for example: 22 fl oz WeatherMax = 1 qt glyphosate/Touchdown. Refer to current product label for other use restrictions.)
- For corn grain and silage corn, two in-crop applications of Roundup can be made; allow 10 days between applications.
- For best results, apply a pre residual herbicide (e.g., Harness, Harness Xtra, Bicep, Fultime, Guardsman) followed by glyphosate when weeds are 4–6 inches tall (for best results tank mix with other post herbicides to improve weed control spectrum and to prevent glyphosate-resistant weed species.)
- Early postemergence programs that include glyphosate plus a residual herbicide also are an option, but may not be as consistent as the preemergence followed by the postemergence program.
- Be cautious of corn height restrictions for residual herbicides.
- Roundup WeatherMax does not require additional adjuvants in the spray tank under most conditions.
- Do not harvest silage for 50 days or grain for 7 days after last application.
- Refer to Table 5.2 for various glyphosate products and see specific product label for additional application information and restrictions.

Status 56WDG	**dicamba +**	**4**	**2.5–10 oz**	**0.063–0.25**
	diflufenzopyr +	**19**		**0.025–0.1**
	safener			

- Status contains dicamba (Clarity) plus another plant growth regulator (diflufenzopyr) and the postemergence corn safener isoxadifen.
- Apply Status at 5 oz/A to 4- to 36-inch-tall corn (V2–V10).
- Status can be tank-mixed with glyphosate at 2.5 oz/A. Use higher rates for more difficult to control weeds. Do not exceed a total of 12.5 oz/A per season.
- Include a non-ionic surfactant at 1 qt plus 5 qt of UAN (28–34% nitrogen) per 100 gallons of water (COC or MSO may be used instead of NIS).
- Status is effective on many broadleaf weeds.
- Do not tank-mix with products that contain 2,4-D, dicamba, or clopyralid.
- Refer to product label for additional precautions.
- *Water quality advisory.*

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
Steadfast Q 37.7WG	**nicosulfuron +**	**2**	**1.5 oz**	**0.02**
	rimsulfuron +	**2**		**0.012**
	corn safener			

- Steadfast Q also contains a 2:1 ratio of nicosulfuron to rimsulfuron in addition to the postemergence corn safener isoxadifen.
- Apply Steadfast Q at 1.5 oz/A to corn up to 20 inches tall (6 collars) and while weeds are young and actively growing.
- Steadfast Q is weak on crabgrass, especially if >1 inch tall. Always include the necessary adjuvants in the spring mixture.
- Steadfast Q can be tank-mixed to improve control and increase weed spectrum.
- Do not tank-mix with Basagran, 2,4-D, or certain OP insecticides such as Lorsban, malathion, etc. Do not use Counter 15G. Do not use Counter 20CR in furrow or over the row at cultivation; may be banded, but may cause injury, especially on soils with less than 4% organic matter. The use of Dyfonate, Lorsban, Thimet may result in temporary injury. There are no precautions for non-OP insecticides.
- To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (Group 2) herbicides.
- See Table 5-5 for recrop restrictions.

Stinger 3S	**clopyralid**	**4**	**0.25–0.66 pt**	**0.093–0.25**

- Apply to corn up to 24 inches tall. Use 0.25–0.5 pt/A for ragweed, cocklebur and Jerusalem artichoke and 0.33–0.66 pt/A for Canada thistle.
- Delay planting soybeans for 18 months following Stinger application.
- *Water quality advisory.*

Stout 72.5WDG	**nicosulfuron +**	**2**	**0.5–0.75 oz**	**0.031**
	thifensulfuron	**2**		**0.002**

- Stout contains nicosulfuron (Accent) and thifensulfuron (Harmony SG).
- The typical use rate for Stout is 0.75 oz/A and must include a crop oil concentrate (COC) or a non-ionic surfactant (NIS) in the spray mixture as well as a nitrogen fertilizer (UAN or AMS).
- Stout can be applied up to 16 inch tall corn or to corn with less than 6 collars, whichever is more restrictive.
- Stout will not control crabgrass species.
- Do not tank-mix Stout with Basagran due to crop safety concerns. Do not tank-mix with 2,4-D due to reduced grass control.
- Refer to Stout label for restrictions regarding OP insecticides such as Counter, Lorsban, Malathion, and Thimet. Do not tank-mix with other ALS-inhibitor herbicides unless stated on herbicide label.
- Refer to product label for additional use restrictions.
- To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (Group 2) herbicides.

Table 5.23 - Comments on Postemergence Herbicides for Corn (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
SureStart II 4.25SE or TripleFLEX II	**acetochlor +**	**15**	**1.5–3.0 pt**	**0.71–1.41**
	flumetsulam +	**2**		**0.056–0.113**
	clopyralid	**4**		**0.023–0.045**

- SureStart II/TripleFLEX II can be applied up to the early POST stage (11-inch-tall corn) and is intended to be used with Roundup Ready or LibertyLink field or silage corn hybrids.
- When applied PRE, it is designed to provide early season control of common annual grasses and broadleaf weeds to allow better timing of the in-crop application of glyphosate or glufosinate.
- The use rate on medium-textured soils ranges from 1.5 to 1.75 pints/A, but for longer residual control, use up to 3 pt/A.
- SureStart II/TripleFLEX II does not contain atrazine, so it provides a non-atrazine alternative for triazine-sensitive areas. However, atrazine and other herbicides can be tank-mixed with SureStart II/TripleFLEX II to broaden the weed control spectrum.
- SureStart II/TripleFLEX II can be tank-mixed with glyphosate (in Roundup Ready corn) or glufosinate (LibertyLink corn) to provide broader spectrum of POST weed control.
- Applications should be made to weeds 2 inches or less in height.
- Make sure to plant corn 1.5 inches deep and be cautious of interactions with certain OP insecticides that may cause crop injury.
- See label for additional details.

Warrant 3CS	**acetochlor**	**15**	**1.5–3.0 qt**	**1.13–2.25**

- Warrant can be tank-mixed with glyphosate and post applied to emerged corn to provide residual control of annual weeds.
- Warrant does not control emerged weeds.
- The typical use rate is 1.5 qt/A.
- *Water quality advisory.*

Yukon 67.5WDG	**halosulfuron +**	**2**	**4–8 oz**	**0.03**
	dicamba	**4**		**0.125**

- Yukon is a premix of halosulfuron (Permit) plus the sodium salt of dicamba.
- Yukon can be applied at 4–8 oz/A to corn from spike to 36 inches tall; use drop nozzles when necessary. (The 4 oz/A Yukon rate equals 0.67 oz/A Permit plus 4 fl oz/A Clarity.)
- Include necessary adjuvants in the spray solution (Table 5-26).
- Yukon has no insecticide use restrictions.
- To prevent herbicide resistance, avoid repeated annual applications of soil-persistent ALS (Group 2) herbicides.

[1] See Table 5.5 and 5.10 for additional formulations or trade names containing some of these same active ingredients.

Table 5.24 - Weed Sizes for Postemergence Corn Herbicides

This table lists postemergence corn herbicides, their rates, and heights of weed species that are controlled or suppressed. This table is only a "quick reference"; refer to the herbicide label for additional information on application and timing.

Grasses	Barnyardgrass	Bermudagrass	Broadleaf Signal Grass	Crabgrass	Fall Panicum	Foxtail spp.	Goosegrass	Johnsongrass (Seedling)	Johnsongrass (Rhizome)	Quackgrass	Shattercane	Texas Panicum	Wirestem Muhly	Yellow Nutsedge
Herbicide (rate/A)	**Height Range (inches) at Application**													
Accent Q (0.9 oz)	<4	-	≤2	–	<4	<4	-	<12	<18	<10*	<12	≤3	<8*	–
Basis Blend (0.825 oz)	1–2	-	-	–	1–2	1–2	-	–	–	–	–	-	–	–
Callisto (3 fl oz)	–	-	-	≤2	–	–	-	–	–	–	–	-	–	–
Capreno (3 fl oz)	<5	-	≤5	<3	<5	<3	-	<5	–	–	<12	≤3	–	–
Glyphosate (0.75 ae)	4–6	L*	4-6	4–6	4–6	4–6	4-6	4–6	4–6	4–6	4–6	4-6	4–6	4–6
Halex GT (3.6 pt)	<4	-	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Impact/Armezon (0.75 fl oz)	≤4	-	≤3*	≤3	≤3*	3–4[1]	≤3	4*	–	–	–	≤3*	–	–
Laudis (3 fl oz) / DiFlexx Duo (32 fl oz)	1–5	-	1-4	1–3	–	1–3	1–3	1–5	–	–	1–6	1-3	–	–
Liberty[2] (22 fl oz)	≤3	-	≤3	≤3	≤3	≤62	≤2	≤3	–	–	≤6	≤4	–	*
Liberty[2] (29 fl oz)	≤5	-	≤5	≤5	≤5	≤12	≤3	≤5	–	*	≤8	≤6	*	*
NorthStar (5 oz)	–	-	-	–	1–3	1–3*	-	4–12*	8–16*	4–8*	4–12	-	–	1–4*
Permit (1.0 oz)	–	-	≤2*	–	–	–	-	–	–	–	–	-	–	4–12
Realm Q (4.0 oz)	1–2	-	≤2*	≤0.5	1–2	1–2	-	1–2*	–	1–2*	1–4	-	–	1–2*
Require Q (4 oz)	1–2	-		0.5	1–2	1–2		*	–	*	1–4		–	*
Resolve (1 oz)	1–2	-	1-2*	≤0.5	1–2	1–2	-	1–2*	–	1–2*	1–4	-	–	1–2*
Resolve Q (1.25 oz)	1–2	-	1-2*	0.5	1–2	1–2	-	*	–	*	1–4	-	–	*
Revulin Q (4 oz)	1-4	-	≤2	≤2	<4	≤4	-	<12	<18	<10*	<12	<3	<6*	-
Steadfast Q (1.5 oz)	<4	-	≤2	<1*	<4	<4	≤2	<12	<12	<8*	<6	≤4	<4*	–
Stout (0.75 oz)	≤4	-	≤2	–	≤3	≤4	-	≤12	≤18	≤10*	≤12	≤3	≤8*	–
Yukon (6–8 oz)	–	-	-	–	–	–	-	–	–	–	–	-	–	1–12

* Suppression only; additional control measures may be necessary.
[1] Yellow foxtail suppression only.
[2] For use on LibertyLink/GR corn hybrids only.
[5] For use on Roundup Ready corn hybrids only.

Table 5.24 - Weed Sizes for Postemergence Corn Herbicides (cont.)

This table lists postemergence corn herbicides, their rates, and heights of weed species that are controlled or suppressed. This table is only a "quick reference"; refer to the herbicide label for additional information on application and timing.

Broadleaves	Bur Cucumber	Cocklebur	Jimson Weed	Lambs Quarters	Marestail/Horseweed	Annual Morning Glory	Eastern Black Night Shade	Palmer Amaranth/Waterhemp	Pigweed	Common Ragweed	Giant Ragweed	Smartweed	Spurred anoda	Velvetleaf
Herbicide (rate/A)	**Maximum Height (inches) at Application**													
2,4–D[1]	–	6	3	4	4	6	2	4	4	6	6	–	-	2
Accent Q (0.9 oz)	3	–	3	–	–	2	–	--	4	–	–	4	-	–
Aim (0.5 oz)	–	–	–	4	–	2–3 lvs	4	--	4	–	–	–	-	36
Atrazine[1] (2 qt)	4	4	4	–	4*	4	4	4	–	4	4	4	-	2
Basagran (2 pt)	–	10	10	2*	–	–	–	–	–	3	6	10	4	5
Basis Blend (0.825 oz)	–	–	–	3	–	–	–	3	3	–	–	3	-	3
Cadet (0.9 fl oz)	3	–	2	3*	–	3	2	2*	4	–	–	2	4*	36
Callisto, Solstice (3 fl oz)	–	5	5	5	3*	5*	5	3*	5	5*	5	5	-	5
Capreno (3 fl oz)	<6*	<6	<6	<6	–	<6*	<6	<6	<6	<6	<6	<6	-	<6
Clarity/Banvel[1]	4	4	4	4	4	4	4	4	4	4	4	6	-	2
DiFlexx (8 fl oz)	3	3	3	3	3	3	3	3	3	3	3	3	3	3
DiFlexx Duo (32 fl oz)	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6
Glyphosate (0.75 ae)	6	6	6	6	6*	6	6	6	6	6	6	6	3	6
Halex GT (3.6 pt)	<4	<4	<4	<4	<4	<4	<4	<4*	<4	<4	<4	<4	<4	<4
Harmony SG (0.125 oz)	–	–	–	4	–	–	–	4	12	–	–	6	-	6
Impact/Armezon (0.75 fl oz)	–	8	6	6	–	6*	6	6*	6	6	8	3	-	8
Laudis (3 fl oz)	<6*	<6	<6	<6	–	<6*	<6	<6	<6	<6	<6	<6	-	<6
Liberty[2] (22 fl oz)	6	6	6	4	4*	6	6	--	3*	6	6	6	3	3*
Liberty[2] (29 fl oz)	10	14	10	6	6	8	8	4*	4*	10	12	14	5	4*
Maestro, Moxy (Buctril) (1.5–2 pt)	4	10	6	8	4*	4	6	--	2	6	6	6	-	5
Marksman[1]	4	6	6	4	6	6	6	6	4	6	6	8	-	6
NorthStar (5 oz)	4	6	6	4	4	3*	6	4	5	9	9	4	-	4
Permit/Sandea (0.67 oz)	3*	9	–	2*	–	–	–	--	3	9	3	2	-	9
Permit/Sandea (1–1.33 oz)	12*	14	–	2*	–	3*	–	--	6	12	6	2	-	12
Permit Plus (0.75 oz)	3*	9	4*	4	–	3*	–	4	12	9	3	6	-	9
Realm Q (4 oz)	5	5	5	5	5*	5*	5	5	5	5	5	5	-	5
Resolve (1 oz)	–	3*	–	3*	–	3*	–	--	3	3*	–	3*	-	3*

Table 5.24 - Weed Sizes for Postemergence Corn Herbicides (cont.)

This table lists postemergence corn herbicides, their rates, and heights of weed species that are controlled or suppressed. This table is only a "quick reference"; refer to the herbicide label for additional information on application and timing.

Broadleaves	Bur Cucumber	Cocklebur	Jimson Weed	Lambs Quarters	Marestail/Horseweed	Annual Morning Glory	Eastern Black Night Shade	Palmer Amaranth/ Waterhemp	Pigweed	Common Ragweed	Giant Ragweed	Smartweed	Spurred anoda	Velvetleaf
Herbicide (rate/A)	**Maximum Height (inches) at Application**													
Resolve Q (1.25 oz)	–	1–3*	–	1–3*	–	1–3*	–	--	1–3	1–3*	–	1–3*	-	1–3
Resource[3] (6 oz)	–	–	–	3 lvs	–	–	–	3 lvs	3 lvs	3 lvs	–	–	-	6 lvs
Revulin Q (4 oz)	<2	<5	<5	<5	–	<5	<5	<5	<5	<5	<5	<5	-	<5
Roundup Weather Max[4] (22 fl oz)	6	6	6	6	6*	6	6	6	6	6	6	6	3	6
Status[1] (5 oz)	4	4	4	4	4	4	4	4	4	4	4	4	-	4
Steadfast Q (1.5 oz)	4	4*	4	4*	–	4	–	--	4	–	–	4*	-	4*
Stout (0.75 oz)	3	–	3	4	–	2–3	–	--	4	–	–	4	-	4
Yukon (4–8 oz)	12*	14	4	6	4	6	6	3	12	12	6	3	-	12

*Suppression only, additional control measures may be necessary.

[1] No sizes given on label, sizes listed above are best estimates.

[2] For use on glufosinate-resistant corn hybrids only.

[3] Resource label refers to weed size by number of leaves (lvs).

[4] For use on Roundup Ready corn hybrids only.

Table 5.25 - Postemergence Herbicide Application Restrictions for Corn

Trade Name	Over-the-Top Application	Use of Drop Nozzles	Comments
2,4-D	<8 inches tall	0.5 pt: 8–36 inches tall	Some 2,4-D formulations allow application up to tasseling.
Accent Q	20 inches tall (free-standing) or <6 collars (V6 stage)	20–36 inches tall or V6 to V10 stage	—
Aim	Up to 8-leaf collar stage (V8)	Up to 14-leaf collar stage	Use drop nozzles or directed sprayers that target weeds but spray away from the corn whorl.
Armezon PRO	Up to 30 inches tall (or 8-corn leaf stage)	When necessary	Do not make application within 45 days of corn harvest or after V8 corn growth stage
Atrazine	12 inches tall	—	—
Banvel, Clarity , Engenia or Xtendimax/ FaXapan	1 pt: 8 inches tall or 5 leaves	—	Do not apply dicamba near soybeans if corn is >24 inches tall, or if soybeans are >10 inches tall or have begun to bloom.
	0.5 pt: 8–36 inches tall or 15 days before tassel emergence		
Basagran	No restrictions	—	—

Table 5.25 - Postemergence Herbicide Application Restrictions for Corn (cont.)

Herbicide	Over-the-Top Application	Use of Drop Nozzles	Comments
Basis Blend	Spike to 4 leaves (2 collars) or 0.5–6 inches tall	—	Do not apply to corn >6 inches tall or having 3 collars.
Cadet	Up to 48 inches tall	When necessary	Apply before tasseling.
Callisto, Callisto GT, Solstice	Up to 30 inches tall (or 8-corn leaf stage)	—	—
Callisto Xtra	12 inches tall	—	—
Capreno	Up to V6 (6 collars)	to V7 (7 collars)	—
Curtail	<8 inches tall	—	—
DiFlexx/ DiFlexx Duo	Spike to V6 or 36 inches tall	V7-V10	Apply 15 days prior to tasseling.
Enlsit Duo	Up to 30 inches tall (V8)	30–48 inches tall	Apply to Enlist corn hybrids only.
Glyphosate products	Up to 30 inches tall (V8 stage)	30 – 48 inches tall	Apply to Roundup Ready hybrids only.
Halex GT	Emergence to 30 inches tall (8-leaf stage)	—	—
Harmony SG	2–6 leaves up to 12 inches tall (1 to 4 collars)	—	Do not apply to corn >12 inches tall or having 4 collars.
Harness MAX	Up to 11 inches tall	—	—
Impact/ Armezon	Up to 45 days prior to corn harvest	When necessary	—
Laudis	Emergence up to V8 stage	—	—
Liberty 280	Emergence to V5 (5 developed collars)	>20–36 inches tall	Apply to Liberty Link or GR corn hybrids only.
Maestro, Moxy (Buctril)	1 pt: emergence to tassel 1.5 pts: 4 leaves to tassel	—	Postemergence application before 3-leaf stage may result in corn leaf burn.
Marksman	Emergence to 5-leaf stage or up to 8 inches tall	—	—
Metribuzin	Emergence to pretassel	When necessary	See tank-mix partner.
NorthStar	4–20 inches or 6 collars	>20–30 inches tall	—
Peak	4–30 inches tall (6 collars)	When necessary	—
Permit	Spike to 48 inches tall	When necessary	If tank-mixed: with 2,4-D, apply to corn up to 8 inches tall; with Banvel or Clarity, apply to corn up to 36 inches tall.
Permit Plus	2- to 6-leaf corn (1–5 collars)	—	Do not apply to corn with more than 6 leaves (5 collars).
Realm Q	Up to 20 inches tall but with no more than 6 collars	—	—
Resicore	Up to 11 inches tall	—	—
Resolve	Up to 12 inches tall (<6 collars)	—	—
Resolve Q	Up to 20 inches tall (<6 collars)	—	—

Table 5.25 - Postemergence Herbicide Application Restrictions for Corn (cont.)

Herbicide	Over-the-Top Application	Use of Drop Nozzles	Comments
Resource	2-leaf to 10-leaf stage (collars must be visible)	When necessary, to direct below corn leaves	—
Revulin Q	Up to 20 inches tall (<6 collars)	—	—
Roundup products	Up to 30 inches tall (V8 stage)	—	Apply to Roundup Ready hybrids only.
Status	4–36 inches tall (V2–V10)	—	Do not apply within 15 days before tassel emergence.
Steadfast Q	Up to 20 inches tall (6 collars)	—	Best if applied when corn is <12 inches tall.
Stout	Up to 16 inches tall (<6 collars)	—	—
Sure Start II/ TripleFLEX II	Up to 11 inches tall	—	—
Touchdown	Emergence through V8 stage	—	Apply to Roundup Ready hybrids only.
Warrant	Emergence to 30 inches tall	When necessary	Does not control emerged weeds; tank-mix with glyphosate in RR corn.
Yukon	Spike to 36 inches tall	When necessary	—

Table 5.26 - Spray Additives and Rainfastness for "Burndown" and Postemergence Corn Herbicides

Trade Name	Adjuvant(s)[1]	Rate	Rainfastness (hours)
2,4-D amine 2,4-D LVE	none, except in certain tank-mixes	—	6–8 1–2
Accent Q	crop oil concentrate or nonionic surfactant plus nitrogen solution or ammonium sulfate	1 gal/100 gal 1–2 qt/100 gal 2–4 qt/A or 2–4 lb/A	4
Aim/Cadet	nonionic surfactant or crop oil concentrate plus ammonium sulfate or nitrogen solution (optional)	2 pt/100 gal 1 gal/100 gal 2–4 lb/A 2–4 gal/100 gal	1
Atrazine	crop oil concentrate	1 gal/100 gal	1–2
Banvel	nonionic surfactant or nitrogen solution	1 qt/100 gal 2–4 qt/A	4
Basagran[2]	crop oil concentrate plus nitrogen solution or ammonium sulfate	2 pt/A 1 gal/A 2.5 lb/A	8
Basis Blend	crop oil concentrate or nonionic surfactant plus nitrogen solution or ammonium sulfate	1–2 gal/100 gal 1–2 qt/100 gal 2–4 qt/A 2–4 lb/A	
Callisto#, Callisto Xtra#, Solstice	crop oil concentrate plus nitrogen solution or ammonium sulfate	1 gal/100 gal 2.5 gal/100 gal 8.5 lb/100 gal	1
Callisto GT	nonionic surfactant plus ammonium sulfate (optional)	1–2 qt/100 gal 8.5–17 lb/100 gal	1

Table 5.26 - Spray Additives and Rainfastness for "Burndown" and Postemergence Corn Herbicides (cont.)

Herbicides.	Adjuvant(s)[1]	Rate	Rainfastness (hours)
Capreno[#]	crop oil concentrate plus nitrogen solution or ammonium sulfate	1 gal/100 gal 1.5 qt/A 1.5 lb/A or 8.5 lb/100 gal	1
Clarity[3]	nonionic surfactant or crop oil concentrate plus nitrogen solution	1 qt/100 gal 1 gal/100 gal 2–4 qt/A	4
DiFlexx	nonionic surfactant or crop oil concentrate or methylated seed oil plus nitrogen solution or ammonium sulfate	1 qt/100 gal 1–2 pt/A 1–2 pt/A 2–4 qt/A 8.5–17 lb/100 gal	4
DiFlexx Duo[#]	methylated seed oil or crop oil concentrate plus nitrogen solution or ammonium sulfate	1 gal/100 gal 1 gal/100 gal 1.5 qt/A 8.5–17 lb/100 gal	4
Durango/Duramax DMA	no NIS/COC required ammonium sulfate (optional)	8.5–17 lb/100 gal	1
Engenia	See label for details		4
Glyphosate (if not fully loaded with formulation adjuvants)	nonionic surfactant plus ammonium sulfate (optional)	2 qt/100 gal 8.5–17 lb/100 gal	6
Gramoxone SL	nonionic surfactant or crop oil concentrate	1 pt/100 gal 1 gal/100 gal	0.5
Halex GT	nonionic surfactant plus ammonium sulfate	1–2 qt/100 gal 8.5–17 lb/100 gal	1–6
Harness MAX	non-ionic surfactant or crop oil concentrate plus ammonium sulfate (optional)	1 pt/100 gal 1 gal/100 gal 8.5–17 lb/100 gal	1-6
Harmony SG[#]	nonionic surfactant or crop oil concentrate plus nitrogen solution or ammonium sulfate	1 qt/100 gal 1 gal/100 gal 2–4 qt/A 2–4 lb/A	1
Impact/Armezon	methylated seed oil or crop oil concentrate plus nitrogen solution or ammonium sulfate	1.0–1.5 gal/100 gal 1.0–1.5 gal/100 gal 1.25–2.5 gal/100 gal 8.5 lb/100 gal	1
Laudis[#]	methylated seed oil (MSO) or crop oil concentrate plus nitrogen solution or ammonium sulfate	1 gal/100 gal 1 gal/100 gal 1–5 qt/A 1.5 lb/A	1
Liberty 280	ammonium sulfate	3 lb/A	4
Maestro, Moxy, (Buctril)[4]	nonionic surfactant or crop oil concentrate or nitrogen solution	1 qt/100 gal 1 gal/100 gal 1–4 gal/100 gal	1

Table 5.26 - Spray Additives and Rainfastness for "Burndown" and Postemergence Corn Herbicides (cont.)

Herbicides.	Adjuvant(s)[1]	Rate	Rainfastness (hours)
Marksman[5]	nonionic surfactant or crop oil concentrate or nitrogen solution or ammonium sulfate	1 qt/100 gal 1 gal/100 gal 2–4 qt/A 2–2.5 lb/A	4
NorthStar	non-ionic surfactant or crop or vegetable oil concentrate plus nitrogen solution or ammonium sulfate (optional)	1 qt/100 gal 1–4 pt/A 2–4 qt/A	4
Peak	crop oil concentrate	1 gal/100 gal	4
Permit/Permit Plus	nonionic surfactant or crop oil concentrate	1–2 qt/100 gal 1 gal/100 gal	4
Realm Q	crop oil or modified seed oil concentrate or nonionic surfactant plus nitrogen solution or ammonium sulfate	1 gal/100 gal 1 qt/100 gal 2 qt/A 2 lb/A	4
Resolve/Resolve Q	crop oil or modified seed oil concentrate or nonionic surfactant plus nitrogen solution or ammonium sulfate	1 gal/100 gal 1 qt/100 gal 2 qt/A 2 lb/A	4
Resource	crop oil concentrate plus nitrogen solution (optional)	1 pt/A	1
Revulin Q	crop oil concentrate plus nitrogen solution or ammonium sulfate	1 gal/100 gal 2 qt/A 2 lb/A	4
Roundup/Glyphosate	nonionic surfactant plus ammonium sulfate (optional)	2 qt/100 gal 8.5–17 lb/100 gal	6
Roundup PowerMax/Roundup WeatherMax	no NIS/COC required ammonium sulfate (optional)	— 8.5–17 lb/100 gal	<1
Status	nonionic surfactant or crop oil concentrate or methylated seed oil plus nitrogen solution or ammonium sulfate	1 qt/100 gal 1–2 pt/A 1–2 pt/A 5 qt/100 gal 5–17 lb/100 gal	4
Steadfast Q	crop oil concentrate or nonionic surfactant plus nitrogen solution or ammonium sulfate	1 gal/100 gal 1–2 qt/100 gal 2 qt/A 2 lb/A	4
Stinger	none	—	6–8
Stout	crop oil or modified seed oil concentrate or nonionic surfactant plus nitrogen solution or ammonium sulfate	1 gal/100 gal 1 qt/100 gal 2 qt/A 2 lb/A	4
Touchdown Total	no NIS/COC required plus ammonium sulfate (optional)	— 8.5–17 lb/100 gal	1–6
Touchdown HiTech	nonionic surfactant plus ammonium sulfate (optional)	1 qt/100 gal 8.5–17 lb/100 gal	1–6

Table 5.26 - Spray Additives and Rainfastness for "Burndown" and Postemergence Corn Herbicides (cont.)

Herbicides.	Adjuvant(s)[1]	Rate	Rainfastness (hours)
Xtendimax/FeXapan	See label for details		4
Yukon	nonionic surfactant or crop oil concentrate plus nitrogen solution or ammonium sulfate (optional)	1–2 qt/100 gal 1 gal/100 gal 2–4 qt/A 2–4 lb/A	

[#] Refer to the label if tankmixing with glyphosate (Roundup Ready corn) or glufosinate (Liberty Link corn) for additional adjuvant precautions.

[1] In general, nonionic surfactants should contain at least 80% surface active agent; crop or vegetable oil concentrates should be nonphytotoxic, containing at least 15% approved emulsifier; nitrogen solution is an ammonium-based fertilizer such as 28%, 30%, or 32% N; and ammonium sulfate should be spray-grade dry ammonium sulfate (21-0-0). 10-34-0 also may be used with some products.

[2] Use crop oil concentrate if lambsquarters, common ragweed, Canada thistle, yellow nutsedge, or field bindweed are present. Include nitrogen solution if velvetleaf is the primary target.

[3] Do not use COC after corn exceeds 5 inches tall. Adjuvant addition depends on tank-mix partner.

[4] When Maestro, Moxy (Buctril) is applied alone, spray additives generally are not needed and may cause excessive leaf burn.

[5] Do not use COC if corn has emerged.

The following treatments are applied prior to harvest to control established weeds in order to aid in the harvesting process. See specific product label to determine correct rate, timing, weed species controlled, and other restrictions with this type of application.

Table 5.27 - Comments on Harvest Aid Herbicides for Corn

Trade Name[1]	Common Name	Site of Action Number	Product/A	lb ai/A
2,4-D LV4	**2,4-D ester**	**4**	**1–2 pt**	**0.5–1.0**
• Apply 1–2 pt/A after the hard dough or dent stage to suppress large weeds that may interfere with harvest and to decrease production of weed seeds. • Use higher rate on larger weeds and those under stress. • Do not forage or feed corn fodder for 7 days after application.				
Aim 2EC	**carfentrazone**	**14**	**2 fl oz**	**0.031**
• May be applied 3 days before harvest. • Use as a harvest aid to desiccate certain broadleaf weeds. • Apply in 10 gal/A water. • Include necessary adjuvants (MSO or COC plus AMS) and make sure spray coverage is sufficient (≥15 gpa), otherwise poor control will result. • See label for additional details				
Defol 5 L	**sodium chlorate**	**Not classified**	**4.8 qt**	**6**
• Defol products are labeled for preharvest applications to desiccate problem weeds in early maturing corn. • Apply at least 14 days before anticipated harvest date. • Apply in 10 to 20 gal/A water with an appropriate adjuvant (NIS or COC). • Desiccation of morningglory and other vine-weeds may be erratic. • Do not graze treated fields or feed fodder, forage or residual grain within 14 days of application. • Refer to product label for additional details.				

Table 5.27 - Comments on Harvest Aid Herbicides for Corn (cont.)

Herbicide Trade Name[1]	Herbicide Common Name	Site of Action Number	Product/A	lb ai/A
Glyphosate	**glyphosate**	**9**	**see Table 5.2**	**up to 0.75 lb ae**

- Glyphosate products are labeled for preharvest applications in corn.
- They can be applied from a week or more prior to harvest.
- Apply when grain has 35% or less moisture and after maximum kernel fill is complete and corn is physiologically mature.
- Adjuvants (NIS or COC plus AMS) can be added to the spray solution to improve performance.
- Do not apply to corn for seed.
- Refer to product label for application restrictions.

Gramoxone SL 2S	**paraquat**	**22**	**1.2–2 pt**	**0.3–0.5**

- Apply after corn is mature and black layer has formed.
- Make application at least 7 days before harvest.
- Use lower rates in most cases as a harvest aid, otherwise the 2 pt/A rate can be used to desiccate mature broadleaves and grasses over 18 inches tall.
- Include a nonionic surfactant (1 qt/100 gal) in the spray solution.

[1] See Table 5.10 for additional formulations or trade names containing some of these same active ingredients.

Table 5.28 - Grazing and Forage Restrictions for Corn Herbicides

These products restrict grazing and/or foraging (silage) following their use in corn.

	Graze	Silage/Grain
Corn Herbicide	**(Days After Treatment)**	
2,4-D	7	7
Accent Q	30	30
Acuron	45	60
Acuron Flexi	45	60
Anthem ATZ	60	70
Anthem Maxx	30	70
Atrazine	60	60
Basagran	12	12
Basis Blend	30	30
Cadet	30	90
Callisto Xtra	60	60
Capreno	45	45
Clarity, Banvel, Engenia, Xtendimax/FeXapan	after milk stage	after milk stage
Corvus	45	45
Curtail	40	40
DiFlexx/DiFlexx Duo	45	45
Enlist Duo	50	50
Enlist One	not specified	30
Glyphosate (spot treatment)	14	14
Glyphosate[1]	50	50/7
Gramoxone (POST directed)	do not graze	do not feed

Table 5.28 - Grazing and Forage Restrictions for Corn Herbicides (cont.)

These products restrict grazing and/or foraging (silage) following their use in corn.

	Graze	Silage/Grain
Corn Herbicide	**(Days After Treatment)**	
Halex GT	45	45
Harmony SG	30	30
Harness MAX	60	60
Impact/Armezon	45	45
Instigate	45	45
Laudis	45	45
Lexar	45	60
Liberty[2]	70	70
Meastro, Moxy (Buctril)	30	30
Metribuzin	60	60
NorthStar	30	45/60
Outlook	40	40
Permit/Sandea/Permit Plus/Yukon	30	30
Prequel	30	30
Prowl H_2O	21	21
Python	45	45
Realm Q	45	45/70
Resicore	45	45
Resolve/Resolve Q	30	30
Resource	28	28
Revulin Q	45	45
Sharpen	80	80
Status	72	32/72
Steadfast Q	30	30
Stinger	40	40
Stout	30	30
SureStart II/TripleFlex II	45	45/85
Verdict	80	80
Warrant	40	40
Zidua	—	—

[1] For use only with Roundup Ready corn hybrids.

[2] For use only with LibertyLink corn hybrids.

Sorghum Weed Management

Integrated Weed Management

An integrated approach to managing weeds in sorghum includes using cultural weed control, mechanical controls where applicable, and the judicious use of herbicides. Sorghum fields that are weed free for the first 4 to 6 weeks after planting will often yield the same as fields that are weed free for the entire growing season. This approach relies on starting with a clean seedbed and using residual soil-applied herbicides or mechanical control. Weeds that germinate with the crop but are controlled in a timely fashion (4 to 5 weeks after planting) will also not impact final yields. This POST herbicide approach relies on effective and timely postemergence weed control. Also, it is not necessary to control all weeds in a field to achieve maximum yield.

Plant sorghum in a timely fashion to ensure the crop emerges uniformly and achieves rapid early growth. Seeding sorghum in narrow (15-inch) rows will improve overall weed control since the crop canopy will close the rows sooner and help to outcompete smaller weeds.

Chemical Weed Control

Herbicides are useful tools in most weed management programs. This chapter will focus on herbicides available for use in sorghum. They should be used to supplement, not replace, other methods or tools available. The following are definitions of terms you will find in this and similar publications on herbicides:

Early preplant (EPP). The herbicide is applied at least 14 days before planting. EPP applications are generally used in no-till systems to control existing vegetation and provide residual control of early emerging weed species.

Preplant. The herbicide is applied from 0 to14 days before planting. Preplant applications are generally used in no-till systems to control emerged weed species.

Preplant Incorporated (PPI). The herbicide is applied to the soil after primary tillage, but before planting, and mechanically mixed with the top 1 to 3 inches of soil with one of a variety of secondary tillage implements.

Preemergence (PRE). The herbicide is applied to the soil after the crop is planted but before emergence. Rainfall or irrigation is needed to move the herbicide into the zone of weed seed germination before weed emergence for maximum effectiveness. If adequate rainfall for herbicide activation does not occur, a shallow cultivation or rotary hoeing should be done to control weeds that have germinated.

Postemergence (POST). The herbicide is applied to the foliage of the crop and weeds after they have emerged.

Post-directed (or directed). Refers to use of special spray equipment to direct the spray at the weeds but avoid it coming in contact with as much of the crop as possible.

Residual activity. Herbicides that can be taken up by a plant's roots and shoots and injure or kill the plant. All soil-applied herbicides, as well as many postemergence herbicides, have residual activity. Herbicide degradation (breakdown) is the result of chemical and/or microbial activity, which can and be dependent on soil pH, soil temperature, and soil moisture levels. Since degradation is dependent on a number of factors, length of residual activity can vary for herbicides based on the specific environmental conditions. Length of residual activity ranges from a few weeks to the entire growing season.

Translocated herbicide. These herbicides move throughout the plant and can cause injury to parts of the plants that do not come in direct contact with the herbicide spray.

Contact herbicide. These herbicides do not move throughout the plant. They cause injury only to those parts of the plant that come in contact with the spray. Spray coverage is more critical for contact than translocated herbicides.

Non-selective herbicide. This refers to herbicides that control a broad spectrum of plant species, including most crops and weeds. These herbicides are generally used with no-tillage production and sprayed prior to planting when control of all plants is required.

Herbicide-resistant hybrids. This refers to grain sorghum varieties that have been developed to withstand herbicide application that previously would have injured or killed sorghum. These enhanced varieties have been obtained through traditional breeding methods and exclusively include Inzen hybrids.

Inzen grain sorghums are non-GMO breeding lines developed to be tolerant to nicosulfuron, a sulfonylurea herbicide (Group 2). Weed biotypes resistant to Group 2 herbicides are widespread in the region.

Herbicide-resistant Weeds in Sorghum

Herbicide-resistant weeds are common in sorghum in the Mid-Atlantic region. Populations of herbicide-resistant weeds are selected for by repeated use of the same or similar herbicide over a period of time. Resistance is most likely to occur with residual herbicides having one specific mode of action. Weed species with a very high amount of seed production and a variable genetic pool are more likely to develop resistant populations—for example, common lambsquarters and pigweed species. Resistance management requires using herbicides with multiple modes of action and integrating mechanical (tillage and cultivation) and cultural weed control (cover crops, narrow row spacing, proper crop fertility, etc.) with chemical weed control.

Triazine-resistance. Weeds resistant to the Group 5 herbicides in the Mid-Atlantic region include common lambsquarters, redroot and smooth pigweed, and scattered populations of barnyardgrass, giant foxtail, goosegrass, and suspected populations of common ragweed and velvetleaf. Atrazine is the primary product that is problematic in sorghum. Careful selection of soil-applied and/or POST herbicides can provide good control of triazine-resistant (TR) weeds in sorghum.

For TR pigweed control, include a Group 15 herbicide for residual control (acetochlor, dimethenamid, or metolachlor) at planting. The Group 15 herbicides will suppress initial TR pigweed, but in most years a postemergence application of a non-triazine herbicide will be needed for full-season control.

For TR lambsquarters, some of the Group 15 herbicides will help suppress emergence (acetochlor), but they are not as active on lambsquarters as they are on pigweed. In addition, residual control can be obtained with products such as mesotrione.

ALS-resistance. Weeds resistant to the Group 2 herbicides in the Mid-Atlantic region include several pigweed species, common and giant ragweed, common chickweed, horseweed, Italian ryegrass, giant foxtail, Johnsongrass, and shattercane. The principal issue with most ALS-resistant weeds in sorghum is lack of efficacy with POST ALS-inhibitor products. ALS-resistant broadleaves will not be controlled with halosulfuron or prosulfuron, other Group 2 herbicides. Group 2 herbicides can be used in a wide range of crops and application timings. Be sure to consider all herbicide applications when developing an herbicide-resistance management strategy.

Glyphosate-resistance. Weeds resistant to the Group 9 herbicide glyphosate in the Mid-Atlantic region include Palmer amaranth and waterhemp, common and giant ragweed, and horseweed. In sorghum, this could pose a problem in no-till if these biotypes are present at the time of burndown applications. If they are, be sure to include an alternate herbicide group to ensure these species are controlled prior to planting.

No-till Weed Management

Successful production of no-till sorghum requires control of existing vegetation (cover crops and weeds) at planting and summer annual weeds that emerge after planting. Existing vegetation is traditionally controlled by the non-selective herbicides, which are often tank-mixed with residual herbicides. However, in many fields the presence of winter annual weeds, such as horseweed, requires an application while these plants are small and more susceptible to non-selective herbicides; this may require an application 3 to 5 weeks prior to planting. Some residual herbicides, such as Lumax or Bicep, can enhance burndown weed control. However, when the products are applied 14 to 28 days before sorghum planting, they provide residual weed control for only a week or two after planting sorghum. In fields with weeds that are difficult to control, an application of a non-selective herbicide and 2, 4-D should be used early to control winter annuals weeds, and a second application of the residual herbicides maybe need at the time of sorghum planting. This second application will improve overall weed control.

Management of Johnsongrass and Shattercane

Johnsongrass, shattercane, and sorghum are closely related, and there are no satisfactory broadcast treatments currently available for controlling either species in grain sorghum. The only alternative available for rhizome Johnsongrass control is spot spraying glyphosate. Grain sorghum should not be planted in fields infested with Johnsongrass or shattercane.

Table 5.29 - Sorghum Herbicides and Their Restrictions

Trade Name	Common Name	Site of Action Number	Manufacturer	Restricted-Use Pesticide[1]	Water Quality Advisory[2]	Worker Reentry (Hours)[3]
2,4-D amine 4S	2,4-D amine	4	several	—	—	48
2,4-D LVE 4E	2,4-D LVE	4	several	—	—	12
Aatrex, Atrazine 4L/90DF	atrazine	5	Syngenta, others	yes	yes	12
Aim 2EC	carfentrazone-ethyl	14	FMC	—	—	12
Banvel 4S	dicamba	4	Arysta LifeScience	—	yes	24
Basagran 4S	bentazon	6	Arysta LifeScience	—	yes	12
Bicep II Magnum 5.5SC/Cinch ATZ	S-metolachlor + atrazine + safener	15/5	Syngenta/Corteva	yes	yes	24
Callisto 4SC	mesotrione	27	Syngenta	—	—	12
Clarity 4S/Banvel 4S	dicamba	4	Arysta LifeScience/BASF	—	yes	24
Degree Xtra 4.04ME / FulTime NXT 4.04EC	acetochlor + atrazine	15/5	Bayer CropScience/ Corteva	yes	yes	12
Dual Magnum 7.62EC	S-metolachlor	15	Syngenta	—	yes	24
Dual II Magnum 7.64EC/Cinch	S-metolachlor + safener	15	Syngenta/Corteva	—	yes	24
Durango DMA/ DuraMax 4S	glyphosate	9	Corteva	—	—	4
Engenia 5SL	dicamba (BAPMA salt)	4	BASF	yes	yes	24
Facet L 1.5L	quniclorac	4	BASF	—	—	12
FeXapan 2.9SL	dicamba	4	Corteva	yes	yes	24
Gramoxone SL 2S	paraquat	22	Syngenta	yes	—	12–24
Guardsman Max 5L/G-Max Lite 5L	dimethenamid + atrazine	15/5	BASF	yes	yes	12
Halex GT 4.39EC	S-metolachlor + mesotrione + glyphosate	15/27/9	Syngenta	—	yes	24
Huskie 2.06EC	pyrasulfotole + bromoxynil	27/6	Bayer CropScience	—	yes	24
Lorox 50DF/Linex 4L	linuron	5	Nova Source	—	—	24
Lumax EZ 3.67SC/ Lexar EZ 3.7SC	S-metolachlor + mesotrione + atrazine	15, 27, 5	Syngenta	yes	yes	24
Maestro 2EC (Buctril)	bromoxynil	6	NuFarm	—	—	24
Marksman 3.2L	dicamba + atrazine	4/5	BASF	yes	yes	48
Outlook 6E	dimethenamid	15	BASF	—	yes	12
Peak 57WG	prosulfuron	2	Syngenta	—	yes	12
Permit 75WG	halosulfuron	2	Gowan	—	—	12
Roundup WeatherMax 4.5S/ PowerMax 4.5S	glyphosate	9	Bayer CropScience	—	—	4
Prowl H_2O 3.8CS/ Prowl 3.3E	pendimethalin	3	BASF	—	—	24

Table 5.29 - Sorghum Herbicides and Their Restrictions (cont.)

Trade Name	Common Name	Site of Action Number	Manufacturer	Restricted-Use Pesticide[1]	Water Quality Advisory[2]	Worker Reentry (Hours)[3]
Sandea 75WG	halosulfuron	2	Gowan	—	—	12
Sequence 5.25EW	glyphosate + S-metolachlor	9/ 15	Syngenta	—	yes	24
Sharpen 2.85SC	saflufenacil	14	Corteva	—	yes	12
Starane Ultra 2.8L	fluroxypyr	4	Dow AgroSciences	—	—	24
Touchdown Total 4.17S	glyphosate	9	Syngenta	—	—	12
Verdict 5.57EC	saflufenacil + dimethenamid-P	14/15	BASF	no	yes	12
Warrant 3CS	acetochlor	15	Bayer CropScience	—	yes	12
Xtendimax 2.9SL	dicamba	4	Bayer CropScience	yes	yes	24
Yukon 67.5WDG	halosulfuron + dicamba	2/4	Gowan	—	—	12
Zemax 3.67EC	S-metolachlor + mesotrione	15/27	Syngenta	—	yes	24
Zest 75WDG[4]	nicosulfuron	2	Corteva	—	yes	4

[1] Only licensed applicators may purchase and apply restricted-use pesticides. To become licensed, contact your state Department of Agriculture.

[2] These herbicides have properties that may result in groundwater or surface water contamination. Do not apply them in areas where soils are permeable or coarse and groundwater is near the surface. Practices should be followed to minimize the potential for dissolved runoff and/or runoff erosion. See the herbicide label for specific restrictions.

[3] If soil-applied products are injected or incorporated at application time, under certain circumstances the Worker Protection Standard allows workers to enter the treated area if they will have no contact with anything that has been treated. Personal protective equipment is required for early entry to treated areas if contact with treated soil, plants, or water is involved.

[4] For use on grain sorghum containing the Inzen herbicide tolerance trait only.

Table 5.30 - Sorghum Herbicide Prepackaged Mixes or Co-Packs, and Equivalents

Trade Name	Components (ai/gal or lb)	If you apply (per acre)	You have applied (ai)	Site of Action Number	An equivalent tank-mix of
Bicep II Magnum 5.5SC/ Cinch ATZ	2.4 lb S-metolachlor	2.1 qt	1.26 lb S-metolachlor	15	1.33 pt Dual II Magnum 7.64EC
	3.1 lb atrazine		1.63 lb atrazine	5	1.63 qt atrazine 4L
Bicep Lite II Magnum 5.5SC/Cinch ATZ Lite	.33 lb s-metolachlor	1.5 qt	1.25 lb s-metolachlor	15	1.31 pt Dual II Magnum 7.64EC
	2.67 lb atrazine		1 lb atrazine	5	1 qt atrazine 4L
Degree Xtra 4.04ME	2.7 lb acetochlor	2.5 qt	1.67 lb acetochlor	15	31.8 qt Degree 3.8ME
	1.34 lb atrazine		0.83 lb atrazine	5	0.8 qt atrazine 4L
FulTime NXT 4.04CS	2.7 lb acetochlor	3 qt	2 lb acetochlor	15	2.1 qt TopNotch 3.2ME
	1.34 lb atrazine		1 lb atrazine	5	0.8 qt atrazine 4L
G-Max Lite 5L	2.25 lb dimethenamid-P	3 pt	0.84 lb dimethenamid-P	15	18.1 fl oz Outlook 6EC
	2.75 lb atrazine		1.03 lb atrazine	5	1.03 qt atrazine 4L

Guardsman Max 5L	1.7 lb dimethenamid-P 3.3 lb atrazine	3.5 pt	0.74 lb dimethenamid-P 1.44 lb atrazine	15 5	15.9 fl oz Outlook 6EC 1.44 qt atrazine 4L
Huskie 2.06EC	0.31 lb pyrasulfotole 1.75 bromoxynil	13 fl oz	0.031 lb pyrasulfotole 0.178 bromoxynil	27 6	0.031 lb pyrasulfotole 11.4 fl oz Maestro 2EC (Buctril)
Lexar EZ 3.7SC	1.74 lb S-metolachlor 0.224 lb mesotrione 1.74 lb atrazine	3 qt	1.3 lb S-metolachlor 0.168 lb mesotrione 1.3 lb atrazine	15 27 5	1.36 pt Dual II Magnum 7.64EC 5.36 oz Callisto 4SC 1.3 qt atrazine 4L
Lumax EZ 3.67SC	2.49 lb S-metolachlor 0.249 lb mesotrione 0.935 lb atrazine	2.7 qt	1.67 lb S-metolachlor 0.168 lb mesotrione 0.625 lb atrazine	15 27 5	1.75 pt Dual II Magnum 7.64EC 5.36 oz Callisto 4SC 0.625 qt atrazine 4L
Marksman 3.2L	1.1 lb dicamba 2.1 lb atrazine	3.5 pt	0.48 lb dicamba 0.92 lb atrazine	4 5	0.96 pt Banvel 4S/ Clarity 4S 1.84 pt atrazine 4L
Verdict 5.57EC	5.0 lb dimethenamid-P 0.57 lb saflufenacil	10 fl oz	0.38 lb dimethenamid-P 0.045 lb saflufenacil	15 14	8.5 fl oz Outlook 6EC 2.0 fl oz Sharpen 2.85L
Yukon 67.2WDG	0.125 lb halosulfuron 0.55 lb dicamba	4 oz	0.03 lb halosulfuron 0.125 dicamba	2 4	0.67 Permit/Sandea 75 WG 4 fl oz Clarity 4S

Table 5.31 - Relative Effectiveness of "Burndown" Herbicides for No-Till Sorghum

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size or growth stage. Delaying applications, thus treating larger weeds, will result in reduced control. Treatments are rated only for control of vegetation existing at the time of application. Add preemergence herbicides as required for the specific situation.

Weed control rating: 10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65% N = less than 55% or no control
-- = no local data available

Trade Name[1]	Site of Action Number	Alfalfa	Brome, Downy	Burdock, Common	Canada Thistle	Chickweed	Dandelion	Dock, Curly	Field Violet/Pansy	Fleabanes, Annual	Foxtail, spp	Garlic, Wild	Geranium, Carolina	Groundsel, Common[2]	Hemp, Dogbane, Dewberry, Milkweed, etc.	Henbit/Deadnettle	Horseweed/ Marestail[3]	Lambsquarters	Mustards spp.	Quackgrass	Ragweed, Common	Smartweed	Canada Thistle
Atrazine	5	6	7	6	6	8	N	6	8	7+	7	N	**8+**	**9**	N	8	8	**9**	8	8	**9**	**9**	6
Dicamba	4	**9**	N	7	8	6	8	6	6	6	N	7	–	6	N	N	**8+**	**9**	N	N	**9**	7	8
Glyphosate[4]	9	7	**9**	7	8	**9**	6	6	6	7+	**9+**	7	8	**9**	7	6	8	**9**	**9**	8	**9**	7	8
Glyphosate + Atrazine	5/9	7+	**9**	7+	8	**9**	7	6	8	7+	**9**	6	**8+**	**9**	N	**9**	**9**	**9**	**9**	**9**	**9**	**9**	8
Glyphosate + dicamba	**9/4**	**8+**	**9**	7+	**8+**	**9**	8	7	8	8	**9+**	8	7	**9**	7+	**8+**	**9**	**9**	**9**	**9**	**9**	**9**	**8+**
Gramoxone	22	N	7	N	6	**8+**	N	N	8	6	**9**	6	8	**8+**	6	7	7	8	**9**	6	8	**9**	6
Gramoxone + Atrazine	22/5	7	8	6	7	**9**	N	6	8	7	**9**	6	**9**	**8+**	6	**9**	**8+**	**9**	8	8	**9**	7	7
Lumax / Lexar	5/15/ 27	6	N	8	7	**9**	8	8	7	8	6	N	**8+**	**9**	N	8	8	**9**	**9**	N	**8+**	7	7
Sharpen	14	N	N	N	6	6	7	–	N	7+	N	–	–	8	N	6	8	8	**9**	N	8	**9**	6
Sharpen + glyphosate	14/9	7	**9**	7	8	**9**	8	6	6	8	**9+**	–	8	**9**	7	6	**9**	**9**	8	8	**9**	**9**	8

1. See generic herbicide table for additional formulations or trade names containing some of these same active ingredients; see Table 5.2 (glyphosates table) and Table 5.5 (generics table).

2. Certain populations of common groundsel in the northeastern U.S. are resistant to triazine herbicides. Herbicide programs that contain Maestro (Buctril) provide good control of groundsel in-crop.

3. Roundup, Touchdown, and other glyphosate products are not effective on glyphosate-resistant horseweed biotypes.

4. Activity is reduced if applied in certain tank-mixes; Roundup or Touchdown with photosynthesis inhibitors such as triazine herbicides; Clarity with Gramoxone. May still be tank-mixed for convenience, but burndown is improved if applied separately.

Table 5.32 - Comments on "Burndown" Herbicides for No-Till Sorghum

May need to be combined with residual treatment or postemergence program for complete no-till weed control program.

Trade Name[1]	Common Name	Site of Action Number	Sorghum Type	Product/A	lb ai/A
Atrazine 90DF or 4L	**atrazine**	**5**	**grain, forage**	**1.8–2.2 lb or 1.6 - 2 qts**	**1.6–2**

- Labeled for grain and forage sorghum.
- Sorghum is not as tolerant as corn to atrazine; labels do not recommend use on coarse-textured soils and has precautions for use on medium and fine-textured soils with less than 1% organic matter.
- Controls small emerged annual broadleaves and some grasses.
- Can be applied in liquid nitrogen as the carrier to improve burndown characteristics.
- Tank-mixing with paraquat improves burndown control; however, this can antagonize glyphosate activity on some species.
- Premixes containing atrazine include Bicep II Magnum, Bullet, Degree Xtra, Lumax, Lexar and others; atrazine rates differ among these products, refer to their labels for amount of atrazine.
- Observe atrazine use restrictions; see atrazine entry in the soil-applied comments table.
- *Restricted-use pesticide and water quality advisory.*

Banvel 4S	**dicamba (DGA salt)**	**4**	**grain, forage**	**8 oz**	**0.25**
Clarity 4S	**dicamba (DMA salt)**			**8 oz**	
Engenia 5SL	**dicamba (BAPMA salt)**			**6.4 oz**	
Xtendimax/FeXapan 2.9SL	**dicamba (DGA salt with VaporGrip Technology)**			**11 oz**	

- Labeled for grain and forage sorghum.
- Tank mix with glyphosate or paraquat to broaden spectrum of control.
- Wait at least 15 days between application and planting to reduce risk of injury.
- Include a non-ionic surfactant (NIS) to improve control.
- Spray droplet size plays an important role in minimizing off-target movement. Nozzles that produce extremely coarse or ultra-coarse droplets while limiting the amount of driftable fine droplets are necessary to limit spray drift. Comply with guidelines for drift management (see label for details).
- Dicamba can be difficult to completely remove from spray equipment and residue is capable of injuring sensitive plants. Follow label instructions concerning sprayer cleanout.
- *Water quality advisory. Engenia, XtendiMax, and FeXapan are restricted-use pesticides.*

Gramoxone SL 2S	**paraquat**	**22**	**grain**	**2–4 pt**	**0.5–1.0**

- Apply in 20–60 gal/A for control of emerged annual weeds.
- Addition of atrazine will often improve paraquat performance.
- Adding dicamba improves control of large annual broadleaf weeds and alfalfa. Alfalfa control is improved by applying dicamba separately at least 1 day ahead of paraquat.
- Can be tank-mixed with residual herbicides; adding atrazine to paraquat can improve control of fescue and certain other perennial sods.
- Phosphate-containing liquid fertilizer solutions diminish paraquat activity if used as a carrier.
- Use appropriate precautions when handling paraquat to minimize exposure to the herbicide.
- Do not use flood jet tips larger than size 20 or spacing greater than 40 inches.
- *Restricted-use pesticide.*

Table 5.32 - Comments on "Burndown" Herbicides for No-Till Sorghum (cont.)

May need to be combined with residual treatment or postemergence program for complete no-till weed control program.

Herbicide Trade Name[1]	Herbicide Common Name	Herbicide group # (site of action)	Sorghum type	product/A	lb ai/A
Glyphosate[2]	**glyphosate**	**9**	**grain, forage**	**varies with formulation**	**0.75-1.5 ae**

Use at least 1.13 lbs ae glyphosate or higher, especially if tank-mixing with residual herbicide.

- Spring applications may be used for control of annual weeds.
- Using low-volume sprays may allow for a reduced rate.
- Can be tank-mixed with residual herbicides such as atrazine. When tank-mixing glyphosate with residual herbicides, apply in 10–20 gal water/A or 10–60 gal liquid fertilizer nitrogen/A.
- Adding dicamba improves control of large annual broadleaf weeds, dandelion, and alfalfa.
- Glyphosate may be applied in clear liquid nitrogen fertilizers and clear liquid complete-analysis fertilizers, but may be less effective on certain annual grasses and perennials.
- Do not use glyphosate with suspension-type liquid fertilizers.

Lexar EZ 3.67SC	**mesotrione + S-metolachlor + atrazine**	**27 15 5**	**grain**	**3 qt**	**0.168 1.3 1.3**
Lumax EZ 3.7SC	**mesotrione + S-metolachlor + atrazine**	**27 15 5**	**grain**	**2.7 qt**	**0.168 1.68 0.63**

- Labeled for grain sorghum only.
- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (group 15).
- Apply prior to sorghum emergence; application to emerged sorhgum will result in severe injury.
- Applying either product less than 7 days before sorghum planting will increase the risk of crop injury, especially if irrigation or rainfall is received following the application.
- Injury symptoms include temporary bleaching of newly emerging sorghum leaves or in extreme conditions, stunting or partial stand loss.
- Lexar or Lumax will improve performance of paraquat, but can antagonize glyphosate on some weed species.
- *Restricted-use pesticides and water quality advisory*

Sharpen 2.85SC	**saflufenacil**	**14**	**grain**	**1–2 fl oz**	**0.022–0.044**

- Labeled for grain sorghum only.
- Sharpen may be applied as a preplant/burndown treatment from 14 days early preplant through preemergence timings. Do not apply to emerged sorghum.
- Apply Sharpen in a typical glyphosate burndown herbicide program to increase weed spectrum control including glyphosate-resistant horseweed.
- Include necessary additives methylated seed oil (MSO) plus nitrogen solution or ammonium sulfate (AMS) to the spray mixture.
- Verdict is a prepackaged mixture containing Sharpen.
- Sharpen will provide very short residual activity at the rates labeled for sorghum.

[1] See Table 5.4 (generics table) for additional herbicides that contain these active ingredients.

[2] Consult specific product label for active ingredient concentration and application rate; various formulations of this herbicide are available (e.g., 1 qt/A glyphosate = 22 fl oz/A WeatherMAX); see Table 5-2 (glyphosates table).

Solubility (parts per million; ppm) refers to how many microliters of the herbicide will dissolve in 1 liter of water. The less soluble the herbicide, the more moisture (rain or irrigation) is needed to activate the herbicide and move it into the root zone. Solubility is used as a guideline for rainfall or irrigation required within a short time after application. Moisture needed also depends on the soil moisture at time of application.

Relative moisture levels to move herbicide into the soil to achieve optimum level of control

Relative Moisture to Activate	ppm	Estimate Water to Activate*
Low	>500 ppm (very soluble)	0.33 inch
Medium	250-500 ppm	0.33-0.5 inch
High	100-250 ppm	0.5-0.75 inch
Very High	<100 ppm	>0.75 inch

*More water (additional irrigation) maybe necessary if soil is dry at time of application, soils with higher clay content, or high plant residues are present.

Relative duration of residual control is for comparison only based on herbicide half-life (length of time it takes for half the herbicide to break down). Herbicide breakdown results from chemical and/or microbial activity. Since the speed of breakdown is affected by a number of factors, including soil pH, soil temperature, and soil moisture, duration can vary for herbicides based on the specific conditions. Residual activity is not the same as herbicide carryover.

Duration of residual control assumes 1) good activation; 2) no excessive rain or irrigation; and 3) weed species are sensitive to the herbicide(s) applied

Table 5.33 - Water Solubility and Longevity of Soil-Applied Herbicides

Trade Name	Solubility (ppm)	Relative moisture required to activate	Duration of Residual Weed Control
Atrazine	33	Very High	4-5 weeks
Callisto	1500	Low	2-4 weeks
Dual II Magnum / Cinch	488	Medium	4-5 weeks
Linex / Lorox	75	Very High	4-5 weeks
Outlook	1,174	Low	2-4 weeks
TopNotch/Warrant	223	High	2-4 weeks

Premixes	
Bicep II Magnum/Cinch ATZ	Dual II Magnum (or Cinch), atrazine
Bicep Lite II Magnum	Dual II Magnum, atrazine
FulTime NXT	Topnotch, atrazine
Guardsman	Outlook, atrazine
G-Max Lite	Outlook, atrazine
Halex GT	Dual II Magnum, Callisto, glyphosate
Lumax EZ / Lexar EZ	Dual II Magnum, Callisto, atrazine
Verdict	Outlook, Sharpen
Zemax	Dual II Magnum, Callisto

Ratings are based on labeled application rates for the soil type and timely rainfall or irrigation to incorporate the herbicides. Ratings are also based on control 3 to 4 weeks after application. Length of effective control (residual control) beyond 4 weeks after application often declines. Results may differ with variations in soil type, temperature, rainfall, soil moisture, soil organic matter, and soil pH. For ratings on herbicide combinations not listed, see the component parts.

Table 5.34 - Relative Effectiveness of Soil-Applied Herbicides on Individual Species[1]

Weed control rating:	**Crop tolerance:**
10 = 95–100%	E = excellent; almost never any crop injury observed
9 = 85–95%	VG = very good; on rare occasion is crop injury observed
8 = 75–85%	G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., seedling depth, seed slit closure, herbicide rate and application timing, adjuvants)
7 = 65–75%	
6 = 55–65%	FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often due to herbicide interactions with environmental conditions
N = less than 55% or no control	
– = no local data	F = fair; some crop injury is commonly observed

Grasses **Tradenames[1]**	**Site of Action Number**	**Barnyardgrass**	**Bermudagrass**	**Broadleaf Signalgrass**	**Crabgrass**	**Fall Panicum**	**Foxtail spp.**	**Goosegrass**	**Johnsongrass (Seedling)**	**Johnsongrass (Rhizome)**	**Quackgrass**	**Shattercane**	**Texas panicum**	**Wirestem Muhly**	**Yellow Nutsedge**
Atrazine	5	7	N	N	7	6	6+	7	N	N	7+	6	N	6	6
Bicep, Bullet, Cinch ATZ, G-Max Lite or Guardsman	5/15	**9**	N	8	**9**	**9**	**9**	**9+**	6	N	6	6	N	6	**8+**
Degree Xtra, FulTime NXT	5/15	**9**	N	8	**8+**	**9**	**9**	**9+**	7	N	6	6	N	6	**8+**
Dual products, Cinch	15	**9**	N	8	**9**	**8+**	**9**	**9+**	6	N	N	6	N	N	8
Halex GT	15/27/9	**9**	N		**9+**	**9+**	**9+**	**10**	**9+**	**9**	**9**	**9**	**9**	**9**	8
Linex / Lorox	7	6	N	N	6	6	6	6	N	N	N	N	N	N	N
Lumax/Lexar	5/15/27	**9**	N	8	**9**	**9**	**9**	**9+**	6	N	6	6	N	6	**8+**
Outlook	15	**9**	N	8	8	**8+**	**9**	**9**	6	N	N	6	N	N	7+
Verdict	14/15	8	N	N	8	8	8	**9**	N	N	N	N	N	N	6
Warrant	15	**9**	N	8	**8+**	**8+**	**9**	**9+**	7	N	N	6	N	N	7+

[1] Performance ratings based on full labeled rates. See Table 5-4 (generics table) for additional herbicides that contain these active ingredients.

Table 5.34 - Relative Effectiveness of Soil-Applied (Premergence) Sorghum Herbicides on Individual Weed Species[1] (cont.)

Weed control rating:

10 = 95–100%

9 = 85–95%

8 = 75–85%

7 = 65–75%

6 = 55–65%

N = less than 55% or no control

– = no local data

Crop tolerance:

E = excellent; almost never any crop injury observed

VG = very good; on rare occasion is crop injury observed

G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., seedling depth, seed slit closure, herbicide rate and application timing, adjuvants)

FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often due to herbicide interactions with environmental conditions

F = fair; some crop injury is commonly observed

Broadleaves **Tradenames[1]**	**Site of Action Number**	**Burcucumber**	**Cocklebur**	**Jimsonweed**	**Lambsquarters[2]**	**Horseweed/Marestail**	**Morningglory, Annual**	**Nightshade, Eastern Black**	**Palmer amaranth / Waterhemp**	**Pigweed**	**Ragweed, Common**	**Ragweed, Giant**	**Sida, Prickly**	**Smartweed**	**Spurred Anoda**	**Velvetleaf**	**Sorghum Tolerance, Medium Soils**	**Sorghum Tolerance, Coarse Soils**
Atrazine	5	6	**8+**	**9**	**9+**	**9**	**8+**	**9**	**9+**	N	**9**	8	**9**	**9+**	8	8	E	G
Bicep Products, Cinch ATZ, G Max Lite or Guardsman	5/15	6	**8+**	**9**	**9**	**8+**	**8+**	**9**	**9+**	**8+**	**8+**	8	**9**	**9**	**9**	**8+**	G	G
Degree Xtra[3]/ Fultime NXT	5/15	6	**8+**	**9**	**9**	N	**8+**	**9**	**9+**	**9**	**8+**	8	**9**	**9**	**9**	**8+**	G	FG
Dual Products, Cinch	15	N	N	N	6	N	N	7+	8+	8	6	N	N	N	N	N	G	G
Halex GT	15/27/9	**8+**	**9**	**9**	**9**	**9**	7+	**9+**	**8+**	**9**	**8+**	8	**9**	**9**	–	**9**	–	–
Lexar	5/15/27	7	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**8+**	**8+**	**8+**	**9**	**9**	**9**	**9**	G	F
Linex / Lorox	7	6	7	7	**8+**	–	6	6	**9**	**9**	7+	6	7+	8	6	7	G	G
Lumax	5/15/27	6	**8+**	**9**	**9**	**9**	**8+**	**9**	**9**	**8+**	**9**	8	7+	**9**	**9**	**9**	G	F
Outlook	15	N	N	N	6	N	N	7+	8	8	6	N	N	6	N	N	G	G
Verdict	14/15	6	8	8	**9**	7+	8	**9**	**9**	**9**	**8**	8	7	**9**	–	8	G	G
Warrant	15	N	N	N	7	N	N	**8+**	**8**	**9**	7+	N	N	7	N	6	G	FG

[1] See Table 5.4 (generics table) for additional herbicides that contain these active ingredients.

[2] Triazine-resistant (TR) biotypes of common lambsquarters and redroot/smooth pigweed are widespread in the region, and thus triazine (Group 5) herbicides are not effective against these populations.

[3] Degree Xtra may be less consistent on TR lambsquarters control compared to other acetochlor products.

Table 5.35 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Sorghum

See specific herbicide label to determine correct rate for soil type and weed species found in each field.

These treatments may be used in conventional, reduced-till, and no-till systems; treatments may be applied preplant-incorporated or preemergence, unless stated otherwise.

Incorporation reduces the need for timely rainfall after application and may improve control of certain weeds.

Higher rates for a given soil may be required for no-till.

In no-till situations, “burndown” herbicides may be required to control weeds or cover crops present at time of application.

EPP= early preplant means application prior to plant (in most cases it’s 7-14 days before planting); PPI= applied to conventionally tilled soil than mechanically incorporated; PRE= preemergence (applied before the crop has emerged); EPOST=early postemergence (during the early stages of crop and weed growth)

Trade name[1]	Common name	Site of Action Number	Application	Product/A	lb ai/A
Atrazine 4L	**atrazine**	**5**	**EPP, PPI, PRE**	**1–2 qt**	**1–2**
Atrazine 90DF	**atrazine**	**5**	**EPP, PPI, PRE**	**1.1–2.2 lb**	**1–2**

- Sorghum is not as tolerant to atrazine as corn.
- Labeled for grain and forage sorghum.
- Atrazine may be used at 1–2 qt/A. Usually used in combination with other herbicides at 1–1.5 qt.
- Can be applied to emerged sorghum up to 12 inches tall.
- On highly erodible ground with less than 30% surface residue, no more than 1.6 qt may be applied prior to crop emergence.
- Heavy rain immediately following application tends to cause excessive concentrations in seed furrow, result in higher risk of injury.
- Do not apply to coarse-textured soils (i.e. sand, loamy sand, and sandy loam), or injury may occur.
- Do not apply to medium- or fine-textured soils having less than 1% organic matter or injury may occur.
- *Restricted-use pesticide and water quality advisory.*

ATRAZINE USE RESTRICTIONS

Preplant or Preemergence

- On highly erodible soils (as defined by the U.S. Natural Resources Conservation Service):
  - Fields where more than 30 percent of the soil surface is covered with plant residue at planting, apply a maximum of 2.0 lb of active ingredient per acre as a broadcast spray.
  - Fields where less than 30 percent of the soil surface is covered with plant residue at planting, apply a maximum of 1.6 lb of active ingredient per acre as a broadcast spray.
  - Apply a maximum of 2.0 lb of active ingredient per acre as a broadcast spray.

Safety Precautions for Using Atrazine

- Do not mix, load, or apply within 50 feet of drinking water wells, livestock wells, agricultural drainage wells, irrigation wells, abandoned wells, or sinkholes.
- Do not mix or load within 50 feet of intermittent streams, perennial streams, rivers, lakes, or reservoirs
- Do not apply within 200 feet of lakes or reservoirs.
- Do not apply within 66 feet of the points where surface water runoff enters intermittent streams, perennial streams, or rivers. The 66-foot buffers should be planted to a crop or seeded with grass on highly erodible land.

Table 5.35 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Sorghum (cont.)

Trade name[1]	Common name	Site of Action Number	Application	Product/A	lb ai/A
Bicep II Magnum 5.5L/Cinch ATZ	S-metolachlor +	15	EPP, PPI, PRE, EPOST	1.3–2.1 qt	0.78–1.26
	atrazine	5			0.99–1.6
Bicep Lite II Magnum 6SC/Cinch ATZ Lite	S-metolachlor +	15	EPP, PPI, PRE	1.1–1.5 qt	0.92–1.25
	atrazine	5			0.73–1
Guardsman Max 5L or G-Max Lite 5L	dimethenamid-P +	15	EPP, PPI, PRE, EPOST	2.4–4 pt	1.5–2.5
	atrazine	5		2–3.5 pt	1.25–2.19

- Labeled for grain or forage sorghum.
- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (group 15).
- Not labeled for use on coarse-textured soils with less than 1% organic matter.
- Bicep Lite II Magnum, G-Max Lite, and Cinch ATZ Lite are premixes of reduced-atrazine-rate ratios. .
- See individual component sections in this table and atrazine use restrictions for additional information.
- *Restricted-use pesticides and water quality advisory.*

Callisto 4SC	mesotrione	27	EPP, PRE	6.0–6.4 fl oz	0.188–0.2

- Labeled for grain sorghum only.
- Do not apply to sorghum grown on sand, loamy sand, or sandy loam soils due to risk of sorghum injury.
- Do not apply to emerged sorghum or injury will occur.
- Applying Callisto less than 7 days before planting will increase risk of crop injury, especially if irrigation or rainfall is received following application. Applying more than 7 days prior to planting will reduce risk of injury.
- Do not apply more than 21 days prior to planting.
- If applied prior to planting, minimize disturbance of the herbicide treated soil during planting process.

Degree Xtra 4.04 ME/ FulTime NXT 4.04CS	acetochlor +	15	EPP, PPI, PRE	2.0–3.7 qt	1.3–2.4
	atrazine	5	EPP, PPI, PRE	2.0–3.7 qt	0.6–1.23

- Labeled for grain sorghum only.
- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (group 15).
- Do not apply pre-plant incorporated on coarse- or medium-textured soils.
- These products can be applied to emerged sorghum up to 11 inches in height
- See individual component sections in this table and atrazine use restrictions and acetochlor restrictions.
- *Restricted-use pesticides and water quality advisory.*

Table 5.35 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Sorghum (cont.)

Trade name[1]	Common name	Site of Action Number	Application	Product/A	lb ai/A
Dual II Magnum 7.64EC/Cinch	**S-metolachlor**	**15**	**EPP, PPI, PRE**	**1–1.67 pt**	**0.96–1.6**

- Labeled for forage and grain sorghum.
- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (group 15).
- Dual II Magnum/Cinch are similar in activity to Outlook or Warrant.
- Dual II Magnum/Cinch contains a crop-safening agent.
- Incorporation improves control of yellow nutsedge.
- A prepackaged mixture with glyphosate is available as Sequence: label mention preplant or preemergence application only.
- *Water quality advisory.*

Halex GT 4.39EC	**S-metolachlor +**	**15**	**EPP, PRE**	**4–6 pt**	**1.05–1.57**
	mesotrione +	**27**			**0.105–0.157**
	glyphosate	**9**			**1.05–1.57**

- Labeled for grain sorghum only.
- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (Group 15).
- For best results, apply to weeds before they are 4 inches tall and from 21 days before planting up through planting but prior to crop emergence.
- Include NIS and AMS in the spray mixture.
- Atrazine can be tank-mixed with Halex GT.
- Not labeled for use on coarse-textured soils.
- Do not apply Halex GT to ground that has been or will be treated with Callisto in the same season.
- Do not apply more than 6 pt/A Halex GT per season (0.0157 lb mesotrione, 1.57 lb s-metolachlor, and 1.57 lb glyphosate).
- Use caution if applying OP or carbamate insecticides 7 days before or after Halex GT application.
- See label for additional use restrictions.

Linex 4L Lorox 50DF	**linuron**	**7**	**PRE**	**0.625–2.0 pts 0.5–2.0 lbs**	**0.25–1.0**

- Label does not specify sorghum type.
- Apply as tank mixture with other labeled herbicides.
- Apply after planting, but before crop emergence.
- Plant seed at least 1 inch deep or crop injury may occur.

Table 5.35 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Sorghum (cont.)

Trade name[1]	Common name	Site of Action Number	Application	Product/A	lb ai/A
Lexar EZ 3.7SC	**S-metolachlor + mesotrione + atrazine**	**15, 27, 5**	**EPP, PRE**	**3.0 qt**	**1.3 0.168 1.3**
Lumax EZ 3.67SC	**S-metolachlor + mesotrione + atrazine**	**15, 27, 5**	**EPP, PRE**	**2.7 qt**	**1.68 0.168 0.63**
Zemax 3.67SC	**S-metolachlor + mesotrione**	**15, 27, 5**	**EPP, PRE**	**2.0 qt**	**1.67 0.168**

- Labeled for grain sorghum only.
- Applying less than 7 days before sorghum planting will increase the risk of crop injury, especially if irrigation or rainfall is received shortly after application.
- The label does not recommend application to sorghum grown on sandy soils (sand, sandy loam, or loamy sands).
- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (group 15).
- Do not apply to emerged sorghum or severe injury will occur. See individual component sections in this table and atrazine use restrictions.
- *Lexar and Lumax are restricted-use pesticides and water quality advisory.*

Outlook 6.0EC	**dimethenamid-P**	**15**	**EPP, PPI or PRE**	**12–21 fl oz**	**0.56–0.98**

- Labeled for grain sorghum only.
- Outlook is similar in activity to Dual II Magnum.
- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (group 15).
- Outlook may be applied to sorghum up to 12-inch-tall; Outlook will not control weeds that have emerged.
- Outlook is not recommended for coarse-textured soils due to limited residual control.
- For early preplant applications or fields with heavy surface plant residue, increase Outlook rate, see label.
- Verdict contains dimethenamid-P, but will need additional Outlook added to provide consistent residual control; see Verdict label.
- Incorporation improves control of yellow nutsedge.
- *Water quality advisory.*

Verdict 5.57EC	**saflufenacil + dimethenamid-P**	**14, 15**	**EPP, PPI, or PRE**	**10 fl oz**	**0.38 + 0.045**

- Labeled for grain sorghum only.
- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (group 15).
- Verdict can be used in a burndown program or as a preemergence treatment. If used in a burndown program, it is best to include glyphosate and atrazine in addition to the necessary adjuvants (methylated seed oil [MSO] plus ammonium sulfate [AMS] or nitrogen solution) to improve control of emerged weeds including horseweed.
- Amount of dimethenamid-P in Verdict is low, additional Outlook can be included to improve residual control, refer to label for additional Outlook rates.
- Do not apply Verdict to emerged sorghum, or severe injury will occur.
- The use of Verdict can follow a burndown application of Sharpen (1 fl oz/A).
- *Water quality advisory*

Table 5.35 - Comments on Preplant or Preemergence Herbicides for Conventional, Min-, or No-Till Sorghum (cont.)

Trade name[1]	Common name	Site of Action Number	Application	Product/A	lb ai/A
Warrant 3CS	**acetochlor**	**15**	**EPP, PPI, or PRE**	**1.5–3.0 qt**	**1.125–2.25**

- Labeled for forage and grain sorghum
- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (group 15).
- Acetochlor is similar in activity to Dual II Magnum or Outlook, but is more active on certain broadleaf weeds.
- Warrant may be applied on up to 11-inch-tall corn depending on the tank-mix partner; but Warrant alone will not control emerged weeds.
- For early preplant applications or fields with heavy surface plant residue, the rate of acetochlor may need to be increased, refer to label.
- *Water quality advisory.*

Acetochlor Use Restrictions

- Do not apply within 50 feet of any well where depth to groundwater is 30 feet or less: sands with less than 3% organic matter; loamy sands with less than 2% organic matter; or sandy loams with less than 1% organic matter
- Do not mix or load within 50 feet of any wells, streams, rivers, lakes, or reservoirs
- Do not apply under conditions that favor runoff or wind erosion of soil containing this product to non-target areas.

[1] See Table 5-4 (generics table) for additional herbicides that contain these active ingredients.

Table 5.36 - Sorghum Herbicide Preplant or Preemergence Rates Per Acre Based on Soil Texture and Organic Matter

This table shows application rates for products applied alone. Rates may vary if tank-mixed with other products, if weed infestations are heavy, or if used in conservation tillage situations. See specific product label for additional information on application rates and use.

Trade Name	Trade Name Site of Action Number	Unit	Coarse	Medium	Fine	Coarse	Medium	Fine	Inc. for No-till
			< 3% Organic Matter			>3% Organic Matter			
Atrazine 4L	5	qt	Not recommended	1.6	1.6	Not recommended	1.6	1.6	yes
Atrazine 90DF	5	lb	Not recommended	1.8	1.8	Not recommended	1.8	1.8	yes
Bicep II Magnum 5.5SC/Cinch ATZ	5/15	qt	Do not use	2.1	2.1	Do not use	2.1	2.1	yes
Bicep II Lite Magnum 6SC/ Cinch ATZ Lite	5/15	qt	Do not use	1.5	1.5	Do not use	1.5	1.5	yes
Callisto 4SC	27	fl oz	Do not use	6.0	6.0	Do not use	6.0	6.0	no
Degree Xtra 4.04 ME	5/15	qt	2.0	2.5	2.75	2.3	3.0	3.7	no
Dual II Magnum 7.64EC/Cinch	15	pt	1.33	1.67	1.67	1.3	1.67	1.67	yes

Table 5.36 - Sorghum Herbicide Preplant or Preemergence Rates Per Acre Based on Soil Texture and Organic Matter (cont.)

Herbicide		Unit	Coarse	Medium	Fine	Coarse	Medium	Fine	Inc. for No-till
			< 3% Organic Matter			>3% Organic Matter			
FulTime 4.04CS	5/15	qt	2.0	2.5	2.9	2.5	3.0	3.2	no
Guardsman Max	5/15	pt	2.5	3.0	4.0	3.0	4.0	4.5	yes
G-Max Lite	5/15	pt	2.0	2.5	3.0	2.5	3.0	3.5	yes
Halex GT 4.39EC	15/27/9	qt	Do not use	4.0	4.0	Do not use	4.0	4.0	no
Lexar EZ 3.7SC	5/15/27	qt	Do not use	3.0	3.0	Do not use	3.0	3.0	no
Linex 4L	7	pt	1.0	1.25	1.5	1.25	1.5	1.75	no
Lorox 50DF	7	lb	1.0	1.25	1.5	1.25	1.5	1.75	no
Lumax EZ 3.67SC	5/15/27	qt	Do not use	2.7	2.7	Do not use	2.7	2.7	no
Outlook 6.0EC	15	fl oz	14	18	18	16	18	20	yes
Sequence 5.25EW	9/15	pt	3.5	3.75	3.75	3.5	3.75	4.0	no
Verdict 5.57EC	14/15	fl oz	10	10	10	10	10	10	yes
Warrant 3CS	15	qt	1.5	1.75	3.0	2.0	2.5	2.75	no
Zemax 3.67SC	15/27	qt	Do not use	2.0	2.0	Do not use	2.0	2.0	no

Table 5.37 - Relative Effectiveness of Postemergence Herbicides on Individual Weed Species

Ratings are based on labeled application rates and weeds at 4-inch height. Results may differ with variations in weed size, temperature, rainfall soil moisture, and good spray coverage. Ratings are based only on postemergence activity and do not reflect possible residual activity. For ratings on herbicide combinations not listed, see the component parts.

Weed control rating:	**Crop tolerance:**
10 = 95–100%	E = excellent; almost never any crop injury observed
9 = 85–95%	VG = very good; on rare occasion is crop injury observed
8 = 75–85%	G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., seedling depth, seed slit closure, herbicide rate and application timing, adjuvants)
7 = 65–75%	
6 = 55–65%	FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often duer to herbicide interactions with environmental conditions
N = less than 55% or no control	
– = no data available for this area	F = fair; some crop injury is commonly observed

Table 5.37 - Relative Effectiveness of Postemergence Herbicides on Individual Weed Species (con't)

Trade Names[1] (rate/A)	Site of Action Number	Barnyardgrass	Bermudagrass	Broadleaf signalgrass	Crabgrass	Fall Panicum	Foxtail spp.	Goosegrass	Johnsongrass (Seedling)	Johnsongrass (Rhizome)	Quackgrass	Shattercane	Texas panicum	Wirestem Muhly	Yellow Nutsedge
Atrazine (1 qt)	5	7+	N	7	6	6	7+	6	N	N	7	6	N	6	7
Basagran (1 qt)	6	N	N	N	N	N	N	N	N	N	N	N	N	N	8
Facet (>26 fl oz)	4	8	N	8	7	6	7	–	N	N	N	N	–	N	N
Huskie (12.8 fl oz)	6/27	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Linex/Lorox (POST directed)	7	7	–	8	8	8	8	**8+**	8	–	–	–	8	–	**6**
Permit (0.67 oz)	2	N	N	N	N	N	N	N	N	N	N	N	N	N	**9+**
Yukon (4 oz)	2	N	N	N	N	N	N	N	N	N	N	N	N	N	**9+**

Table 5.37 - Relative Effectiveness of Postemergence Herbicides on Individual Weed Species (cont.)

Trade Names[1] (rate/A)	Herbicide Group (Mode of Action)	Burcucumber	Cocklebur	Jimsonweed	Lambsquarters	Annual Morning Glory	Eastern Black Nightshade	Palmer amaranth / Waterhemp	Pigweed	Common Ragweed	Giant Ragweed	Prickly Sida	Smartweed	Spurred anoda	Velvetleaf	Sorghum Safety
2,4-D (1pt)	4	6	**9**	8	**9**	**9**	7	**9**	**9**	**9**	**9**	**9**	7	–	8	F
Aim (0.5 oz)	14	N	N	N	6	6	8	7	7	N	N	6	N	–	**9**	FG
Atrazine (1 qt)	5	8	**9**	**9**	**9+**	**9**	**9**	**9+**	N	**9**	8	**8+**	**9+**	–	8	FG
Basagran (1 qt)	6	N	**9**	**9**	8	N	N	N	6+	8	7	8	**9**	7	**8+**	FG
Clarity/Banvel (8 fl oz)	4	7	**9**	**9**	**9**	**9**	8	**9**	**9**	**9**	**9**	8	**9+**	–	8	F
Facet[2] (>26 fl oz)	4	–	–	–	6[2]	7	–	N	N	6[2]	6[2]	–	N	–	6[2]	G
Huskie (12.8 fl oz)	6/27	–	**8+**	7+	**9**	8	**8+**	8	8	8	7	–	**8+**	–	8	G
Linex / Lorox (POST-directed)	7	–	**8+**	**8+**	**8+**	8	–	**9**	**9**	**9**	–	8	7		**8+**	FG
Maestro (1.5 pt)	6	8	**9**	**9**	**9**	8	**9**	N	7	7+	8	N	**9**	–	**8+**	F
Marksman (1 qt)	4/5	8	**9**	**9+**	**9**	**9**	**9**	**9**	**9**	**9+**	**9**	**9**	**9+**	–	**9**	FG
Peak (0.75 oz)	2	–	N	8	8	7	–	**9**	**9**	**9**	6	6	7	–	**8+**	G
Permit / Sandea (0.67 oz)	2	6	**9**	N	N	6	6	**9**	**9**	**9**	8	7	8	–	**9**	G
Starane Ultra (6.4 fl oz)	4	–	**8+**	–	–	**8+**	6	7+	7+	**8+**	**8+**	–	–	–	**8+**	G
Yukon (4 oz)	2/4	6	**9**	**9**	**9**	**9**	8	**9**	**9**	**9**	8	8	**9+**	–	**9**	FG

[1] See Table 5-4 (generics table) for additional herbicides that contain these active ingredients.
[2] L-s, Facet is labeled for suppression of this species on weeds less than 2-inches tall.

Table 5.38 - Comments on Postemergence Herbicides for Sorghum

The following herbicides can be added with postemergence herbicides to improve residual weed control. They will not provide control of emerged weeds, so they should be applied to weed-free soil surface or with products that will provide postemergence control of weeds present at time of application. Consult labels when tank-mixing with any herbicide. Some pesticides or adjuvants used in combination with the following herbicides could increase the chance of soybean injury.

Trade Name[1]	Common Name	Site of Action Number	Sorghum Type	Application Timing	Product/A	lb ai/A
Dual Magnum 7.62EC	**S-metolachlor**	**15**	**grain, forage**	**POST**	**1–1.67pt**	**0.95–1.59**

- Application timing is not specified on label.
- Do not make more than one application per year.
- Make applications at least 75 days before harvest.
- *Water quality advisory.*

Prowl 3.3EC/ Prowl H2O 3.8CS	**pendimethalin**	**3**	**grain only**	**4-inch growth stage up to layby**	**2.4–3.6pt 1.5–3pt**	**1–1.5**

- Do not apply preplant incorporated or preemergence.
- Do not make more than one application per year.
- Do not apply on sorghum planted in double-row beds.
- Do not replant sorghum if crop loss occurs.
- Do not apply in liquid fertilizer.
- Use only where adequate tillage is practiced to provide good seed coverage and plant seeds at least 1 inch deep, or crop injury may occur.
- Prior to application, crop must be cultivated in such a manner as to throw at least 1 inch of soil over the base of the crop plants to prevent direct contact of Prowl with the zone of brace root formation.

Warrant 3CS	**acetochlor**	**15**	**grain, forage**	**before 11 inches**	**1.5–3qt**	**1.125–2.25**

- Acetochlor is similar in activity to Dual, but is more active on certain broadleaf weeds.
- Do not apply POST using sprayable fluid fertilizer, or injury will occur.

The following treatments are applied after sorghum emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

2,4-D amine 4S	**2,4-D amine**	**4**	**grain only**	**6 to 15 inches Over 8” drops recommended**	**1 pt**	**0.5**

- Sorghum is not as tolerant to 2,4-D as corn.
- Apply between 6- and 15-inch tall sorghum; if sorghum is over 8-inches tall consider drop nozzles to keep spray off the foliage; do not treat during the boot, flowering, or dough stages.
- Do not apply during periods of rapid growth (high soil moisture, warm temperatures, recent nitrogen application) due to increased risk of crop injury.
- Make only one application per season to emerged sorghum.
- 2,4-D is volatile, be cautious of off-target movement.
- Surfactants can increase risk of injury, be cautious of surfactant use when tank mixing with other herbicides.
- 2,4-D does not provide any residual weed control.

Table 5.38 - Comments on Postemergence Herbicides for Sorghum (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Sorghum Type	Application Timing	Product/A	lb ai/A
Aim 2EC	**carfentrazone**	**14**	**grain only**	**4 inches to boot stage**	**0.5 fl oz**	**0.008**

- At rate labeled for Aim 2EC, control is limited to weeds less than 3-inches tall, or morningglory with no more than 3 leaves, and velvetleaf up to 4 inches.
- Application timing is 4 inches tall to just prior to boot stage; but application should be based on small weeds.
- Tank-mix with other herbicides to increase weed control spectrum.
- Aim does not provide residual weed control.
- Use a non-ionic surfactant (NIS); do not use crop oil concentrate (COC) on emerged sorghum with either formulation.

Atrazine 4L	**atrazine**	**5**	**grain, forage**	**Before 12 inches**	**0.75–2.0 qts**	**0.75–2.0**
Atrazine 90DF	**atrazine**	**5**		**Before 12 inches**	**0.83–2.2 lbs**	**0.75–2.0**

- Apply before sorghum exceeds 12 inches; apply before weeds are 1.5 inches tall.
- Sorghum is not as tolerant as corn to atrazine.
- If no atrazine was applied prior to sorghum emergence, maximum application rate is 2 qts/A. If POST application is following an earlier atrazine application, total atrazine amount cannot exceed 2.5 lbs active ingredient.
- Length of residual control depends on rate applied.
- Add 1 qt crop oil concentrate (COC)/A to spray solution. Do not include oil if sorghum is under stress from prolonged cold, wet weather or other factors.

ATRAZINE USE RESTRICTIONS

Safety Precautions for Using Atrazine

- Do not mix, load, or apply within 50 feet of drinking water wells, livestock wells, agricultural drainage wells, irrigation wells, abandoned wells, or sinkholes.
- Do not mix or load within 50 feet of intermittent streams, perennial streams, rivers, lakes, or reservoirs.
- Do not apply within 200 feet of lakes or reservoirs.
- Do not apply within 66 feet of the points where surface water runoff enters intermittent streams, perennial streams, or rivers. The 66-foot buffers should be planted to a crop or seeded with grass on highly erodible land.
- *Restricted-use pesticide and water quality advisory.*

Basagran 4S	**bentazon**	**6**	**grain, forage**	**Before heading**	**1.5–2.0 pts**	**0.75–1.0**

- Apply to sorghum before heading or blooming; however, Basagran needs to be applied when weeds are small and actively growing.
- Basagran is weak on pigweed species, including Palmer amaranth.
- Tank-mix with atrazine to broaden spectrum of control
- Label recommends use of crop oil concentrate.
- Split treatments may be required for yellow nutsedge and Canada thistle.
- Basagran does not provide residual weed control.
- *Water quality advisory.*

Table 5.38 - Comments on Postemergence Herbicides for Sorghum (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Sorghum Type	Application Timing	Product/A	lb ai/A
Bicep II Magnum 5.5SC	**s-metolachlor**	**15**	**grain, forage**	**3-leaf growth stage up to 12 inches**	**1.3–2.1 qt**	**0.78–1.26**
	atrazine	**5**				**0.99–1.6**

- Use sorghum seed treated with an approved seed safener for chloroacetamide herbicides (Group 15).
- Do not apply more than a total of 2.58 qt of Bicep II Magnum/A/season (i.e. 1.55 lb ai/A s-metolachlor and 1.97 lb ai/A atrazine).
- If other products containing s-metolachlor have been applied, the combined total amount of s-metolachlor resulting from all applications must not exceed 1.7 lb ai/A/calendar year.
- See individual component sections in this table and atrazine use restrictions for additional information.
- Tank-mix with other herbicides to increase weed control spectrum.
- Make applications at least 75 days before harvest.
- Add 1 qt crop oil concentrate (COC)/A to spray solution. The addition of UAN or AMS is recommended to improve control.
- *Restricted-use pesticides and water quality advisory.*

Clarity 4S Banvel 4S Engenia 5SL Xtendimax/FeXapan 2.9SL	**dicamba (DGA salt) dicamba (DMA salt) dicamba (BAPMA salt) dicamba (DGA salt with VaporGrip Technology)**	**4**	**grain, forage**	**Spike to 15 inches; Over 8 inches drops are recommended**	**8 fl oz 8 fl oz 6.4 fl oz 11 fl oz**	**0.25**

- May apply dicamba up to 0.25 lb ae/A from spike stage but before it is 15-inches tall; for best performance when sorghum is in the 3- to 5- leaf stage; use drop nozzles if sorghum is taller than 8 inches to avoid spray getting into the whorl.
- Applications during periods of rapid growth may increase the risk of injury.
- Clarity, Engenia, Xtendimax, and FeXapan formulation reduces the risk of off-target movement, but potential risks still exist.
- Under most situations, dicamba does not provide acceptable levels of residual weed control.
- Banvel provides minimal residual weed control.
- *Water quality advisory. Engenia, XtendiMax, and FeXapan are restricted-use pesticides.*

Facet 1.5L	**quinclorac**	**4**	**grain only**	**Before 12 inches tall**	**22–32 fl oz**	**0.25–0.375**

- Sorghum stage is from emergence up to 12-inches tall.
- For best activity apply with atrazine at 0.5 to 1 lb ai to weeds less than 2 inches tall.
- Add 1 qt crop oil concentrate or methylated seed soil for better weed control. Ammonium sulfate (AMS) or urea ammonium nitrate (UAN) can also be added for improved efficacy. Non-ionic surfactant (NIS) plus a nitrogen source (AMS) may be used when Facet is tank mixed with products that restrict use of crop oil concentrates.
- Facet can provide residual control of susceptible weed species.

Table 5.38 - Comments on Postemergence Herbicides for Sorghum (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Sorghum Type	Application Timing	Product/A	lb ai/A
Huskie 2.06EC	**pyrasulfotole + bromoxynil**	**27 6**	**grain, forage**	**3 leaves to 30 inches tall (prior to flag leaf emergence)**	**12.8–16 fl oz**	**0.21–0.26**

- Application timing for sorghum stage is 3-leaf up to 30 inches and/or prior to flag leaf emergence.
- Huskie label does not require a surfactant. Nonionic surfactant (NIS) and ammonium sulfate (AMS) can be included under challenging growing conditions, or if tank-mix partner requires an additive.
- Huskie can be tank-mixed with atrazine at 0.25 to 1.0 lb ai to improve and broaden spectrum of control; see atrazine entry in this table for precautions.
- Addition of atrazine with Huskie is recommended for most situations.
- Two applications of Huskie can be applied POST, but there must be an interval of 11 days between Huskie applications.
- Crop injury can occur if Huskie is applied to fields treated with mesotrione (Lumax or Lexar).
- *Water quality advisory.*

Maestro (Buctril) 2E	**bromoxynil**	**6**	**grain, forage**	**4 leaves to preboot stage**	**1–1.5 pt**	**0.25–0.375**

- Apply to sorghum between 4-leaf stage and up to preboot stage; however, Maestro needs to be applied when weeds are small and actively growing.
- When applied alone, Maestro does not need any additional surfactant; when tank-mixing, it can be applied in combination with surfactants or crop oil concentrate.
- Maestro is weak on pigweed species, including Palmer amaranth.
- Maestro does not provide residual weed control.

Marksman 3.2L	**dicamba +**	**4**	**grain, forage**	**Before 12 inches tall**	**0.75 - 1 qt**	**0.20–0.27**
	atrazine	**5**				**0.39–0.53**

- Apply Marksman before sorghum reaches 12-inches in height; label recommends application to sorghum in 2- to 3-leaf stage.
- Applications during period of rapid growth increases risk of injury.
- If no atrazine was applied prior to sorghum emergence, total atrazine amount cannot exceed 2 lb ai/A. If POST application is following an earlier atrazine application, total atrazine amount cannot exceed 2.5 lb ai/A.
- Do not add crop oil when applying to emerged sorghum.
- Be cautious of drift from Marksman (dicamba component).
- Marksman provides very short period of residual control.
- See additional restrictions under the atrazine entry.
- *Restricted-use pesticide and water quality advisory.*

Table 5.38 - Comments on Postemergence Herbicides for Sorghum (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Sorghum Type	Application Timing	Product/A	lb ai/A
Peak 57WG	**prosulfuron**	**2**	**grain only**	**5 to 30 inches tall; over 20 inches drops are recommended**	**0.5–1.0 oz**	**0.018–0.036**

- Application timing is between 5 and 30 inches tall, and prior to head emergence; use drop nozzles after sorghum is 20 inches tall. Application should focus on weed size rather than crop stage.
- Tank mix with other labeled POST herbicides to broaden spectrum of control.
- Peak applications should include a non-ionic surfactant (NIS). Crop oil concentrate can be included if tank mix partner recommends COC.
- Refer to label for additional information on use and restrictions.
- Peak will provide residual control of susceptible species.
- Peak is an ALS (group 2) herbicide and there is wide-spread resistant to group 2 herbicides in the region. To prevent herbicide resistance, avoid repeated annual applications of ALS (group 2) herbicides.
- *Water quality advisory.*

Permit 75WG or Sandea 75WG	**halosulfuron**	**2**	**grain only**	**2 leaves to before head emergence**	**0.67–1.0 oz**	**0.031–0.047**

- Apply from 2-leaf stage but before grain head emergence.
- The 0.67 oz rate is the standard rate for annual weed control.
- Permit/Sandea is excellent on yellow nutsedge, but is weak on common lambsquarters.
- Tank mix with other labeled POST herbicides to broaden spectrum of control. Yukon is a prepackaged product containing Permit + dicamba.
- Permit/Sandea should be applied with non-ionic surfactant (NIS); use of crop oil concentrate (COC) increases risk of crop injury.
- Permit/Sandea will provide residual control of susceptible species.
- ALS-resistant biotypes of marestail/horseweed are found in the region and thus Group 2 herbicides will not be effective against these populations. To prevent herbicide resistance, avoid repeated annual applications of ALS (Group 2) herbicides.

Starane Ultra 2.8L	**fluroxypyr**	**4**	**grain, forage**	**3- to 7-leaf stage; use drops for 8-leaf to boot stage**	**0.4 pt**	**0.14**

- Timing for broadcast application 3-leaf of sorghum through 7-leaf stage, and drop nozzles from 8-leaf to boot stage.
- Can be tank-mixed with other labeled herbicides can be included to broaden spectrum of control.
- Surfactants not needed; Starane Ultra is applied alone, but may be used when required by tank-mixed partner.
- Two applications of Starane Ultra can be made.
- Starane Ultra will not provide residual weed control.

Table 5.38 - Comments on Postemergence Herbicides for Sorghum (cont.)

The following treatments are applied after corn emergence to control established weeds. See specific product label to determine correct rate for soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Site of Action Number	Sorghum Type	Application Timing	Product/A	lb ai/A
Yukon 67.5WDG	**halosulfuron +**	**2**	**grain only**	**2 to 15 inches tall; use drops after 8-leaf stage**	**4–6 oz**	**0.03 + 0.125**
	dicamba	**4**				

- Yukon is a premix of halosulfuron (Permit) plus the sodium salt of dicamba.
- Yukon can be applied from 2-leaf through 15 inch tall sorghum; use drop nozzles after sorghum is 8 inches tall.
- Include non-ionic surfactant (NIS); crop oil concentrate (COC) can be used, but increases the risk of injury.
- See entry for each component of Yukon for more information.
- ALS-resistant biotypes of marestail/horseweed are found in the region and thus Group 2 herbicides will not be effective against these populations. To prevent herbicide resistance, avoid repeated annual applications of ALS (Group 2) herbicides.
- Yukon will provide residual control of susceptible species.

Zest 75WDG	**nicosulfuron**	**2**	**grain only**	**5- to flag-leaf stage**	**0.67–1.33 oz**	**0.031–0.062**

- Labeled on Inzen grain sorghum only; conventional sorghum hybrids will be killed if treated with Zest!
- Do not plant Inzen grain sorghum in fields known to have ALS-resistant johnsongrass or shattercane.
- Do not tank-mix with Huskie, or injury will occur.
- Two applications of Zest can be applied POST, but there must be an interval of 7 days between Zest applications.
- Zest should be applied with non-ionic surfactant (NIS), or crop oil concentrate (COC) except when mixed with 2,4-D or dicamba.
- Risk of crop injury is higher with early POST application or when cool weather conditions prevail. Zest may cause temporal yellowing to Inzen sorghum but will recover quickly.
- Zest does not provide residual weed control.
- ALS-resistant biotypes of marestail/horseweed are found in the region and thus Group 2 herbicides will not be effective against these populations. To prevent herbicide resistance, avoid repeated annual applications of ALS (Group 2) herbicides.
- See zest.dupont.com for required Inzen Stewardship training to utilize Zest on Inzen sorghum.

POST-DIRECTED						
Linex 4L or	**linuron**	**6**	**label does not specify**		**1–2 pts**	**0.5–1.0**
Lorox 50DF					**1–2 lbs**	

- Post-directed application only. Do not apply over the top of emerged sorghum.
- Use only when there is sufficient differential between height of sorghum and weeds so that weeds are thoroughly covered and upper leaves of sorghum and whorl are not exposed to spray or drift.
- Include a non-ionic surfactant (NIS).
- Weeds should be treated prior to 2-inch-tall grass weeds and 6-inch broadleaf weeds.
- Linex/Lorox will provide residual control of susceptible species.

[1] See Table 5-4 (generics table) for additional herbicides that contain these active ingredients.

Table 5.39 - Weed Sizes for Postemergence Sorghum Herbicides

This table lists postemergence sorghum herbicides, their rates, and height ranges of weed species that are controlled or suppressed. This table is only a "quick reference"; refer to the herbicide label for additional information on application and timing.

Grasses **Trade Names (rates/A)**	**Barnyardgrass**	**Bermudagrass**	**Broadleaf signal grass**	**Crabgrass spp.**	**Fall Panicum**	**Foxtail spp.**	**Goosegrass**	**Johnsongrass (Seedling)**	**Johnsongrass (Rhizome)**	**Quackgrass**	**Shattercane**	**Texas panicum**	**Wirestem Muhly**	**Yellow Nutsedge**
	----------height range (inches) at application ----------													
Atrazine (2 pt)	L-s[1]	–[2]	–	L-s	–	L-s	–	–	–	–	–	–	–	–
Basagran (2 pt)	–	–	–	–	–	–	–	–	–	–	–	–	–	8
Facet (>26 fl oz)	2	–	2	2	–	2	–	–	–	–	–	–	–	–
Linex/Lorox (directed)	2	–	2	2	2	2	2	–	–	–	–	2	–	–
Permit (0.67 oz)	–	–	–	–	–	–	–	–	–	–	–	–	–	6
Yukon (4 oz)	–	–	–	–	–	–	–	–	–	–	–	–	–	6
Zest (0.67 oz)	4	–	2	2	4	4	–	–	–	–	–	3	–	–

[1] L-s species is on the atrazine label as suppression.
[2] – = indicate weed size is not on the herbicide label.

Table 5.39 - Weed Sizes for Postemergence Sorghum Herbicides (cont.)

Broadleaves **Trade Names (rates/A)**	**Bur cucumber**	**Cocklebur**	**Jimson weed**	**Lambs quarters**	**Morningglory, Annual**	**Nightshade, Eastern Black**	**Palmer amaranth/ Waterhemp**	**Pigweed spp.**	**Ragweed, Common**	**Ragweed, Giant**	**Prickly sida**	**Smartweed**	**Spurred anoda**	**Velvetleaf**
	---------- maximum height at application (inches) ----------													
2,4–D[1]	–	6	3	4	6	2	4	4	6	6	–	–	–	2
Aim (0.5 oz)	–	–	–	3	3 lvs	4	2	4	–	–	–	–	–	4
Atrazine[1] (2 pt)	4	4	4	6	4	4	4	–	4	4	4	4	–	2
Basagran (2 pt)	–	10	10	2*	–	–	–	–	3	6	4	10	4	5
Dicamba[1]	4	4	4	4	4	4	4	4	4	4	4	6	–	2
Facet (>26 fl oz)	–	–	–	–	2	–	–	–	2-s	2-s	–	–	–	2-s
Huskie (12.8 fl oz)	4	4	–	4	4	4	4	4	4	4	–	–	–	4
Linex / Lorox directed	–	6	–	6	6	–	6	6	6	–	6	6	–	–
Maestro / Buctril (1.5–2 pt)	4	10	6	8	4	6	–	2	6	6	–	6	–	5
Marksman[1] (1 qt)	4	6	6	6	6	6	6	4	6	6	4	8	–	6
Peak (0.75 oz)	4-s*	10	6	4	4-s*	–	4	5	10	3	3-s*	4	–	6
Permit/Sandea (0.67 oz)	3*	9	–	2*	–	–	--	3	9	3	3	2	–	9
Starane Ultra[2]	–	8	8	–	8	8-s*	–	–	8	8	–	–	–	8
Yukon (4–8 oz)	2-5	9-14	2-4	2-4	2-6	2-4	4-6	3-6	9-12	3-6	2-4	2-4	–	9-12

*Suppression only, additional control measures may be necessary.
[1] No sizes given on label, sizes listed above are best estimates.
[2] Starane Ultra label states that susceptible broadleaf species will be controlled if treated before they reach height of 8 inches.

Table 5.40 - Herbicide Effectiveness on Perennial Broadleaf Weeds

Performance ratings are based on seasonal control from a postemergence application in sorghum.

Weed control rating: 10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65% N = less than 55% or no control – = no local data available

Broadleaves Trade Names (rate/A)	Site of Action Number	Canada Thistle	Dandelion	Dewberry spp.	Dock spp.	Hedge Bindweed	Hemp Dogbane	Horsenettle	Jerusalem Artichoke	Milkweed	Mugwort	Poison Ivy	Pokeweed
2,4-D (1 pt)	4	7+	8	6	7+	8	6	6	7	6	6	7	7
Atrazine (1.5 lb ai)	5	6	6	6	7	7+	6	6	N	N	N	6	6
Basagran + atrazine (1 qt + 1 qt)	5/6	8	7	N	7+	7+	6	7	6+	N	N	7	6
Clarity/Banvel (8 fl oz) Engenia (6.4 fl oz) Xtendimax/FeXapan (11 fl oz)	4	8	7+	6	8	**8+**	7	7	8	6	7+	7+	6
Huskie + atrazine (12.8 fl oz + 0.75 lb ai)	27/6/5	L-s	L-s	–	L-s	–	–	–	L-s	–	–	–	–
Marksman (1 qt)	4/5	**8+**	8	6	8	**8+**	7	8	8	6	7+	7+	7
Peak + Clarity (0.75 oz + 8 fl oz)	2/4	L-s	–	–	–	–	L-s	–	–	–	–	–	–
Starane Ultra (0.4 pt)	4	N	N	N	N	8	**8+**	N	N	N	N	N	N
Yukon (6 oz)	2/4	**8+**	8	6	7	8	7	7+	7	8	7+	–	8

[1] Herbicide label lists this species for partial control.

Table 5.41 - Spray Additives and Rainfastness for Burndown and Postemergence Sorghum Herbicides.

Trade Name	Adjuvant(s)[1]	Rate	Rainfastness (hours)
2,4-D amine	none, except in certain tank-mixes	–	6–8
Aim/Cadet	non-ionic surfactant or	2 pt/100 gal	1
	crop oil concentrate	1 gal/100 gal	
	plus ammonium sulfate or	2–4 lb/A	
	nitrogen solution (optional)	2–4 gal/100 gal	
Atrazine	crop oil concentrate	1 gal/100 gal	1–2
Banvel	non-ionic surfactant or	1 qt/100 gal	4
	nitrogen solution	2–4 qt/A	

Table 5.41 - Spray Additives and Rainfastness for Burndown and Postemergence Sorghum Herbicides (con't)

Trade Name	Adjuvant(s)[1]	Rate	Rainfastness (hours)
Basagran[2]	crop oil concentrate	2 pt/A	8
	plus nitrogen solution or	1 gal/A	
	ammonium sulfate	2.5 lb/A	
Clarity[3]	non-ionic surfactant or	1 qt/100 gal	4
	crop oil concentrate plus	1 gal/100 gal	
	nitrogen solution	2–4 qt/A	
Engenia	see label for details		4
Facet	crop oil concentrate or	1 gal/100 gal	6
	methylated seed oil	1–2 pt/A	
	plus nitrogen solution or	2.5 gal/100 gal	
	ammonium sulfate	8.5 lb/100 gal	
Glyphosate (if not fully loaded with formulation adjuvants)	non-ionic surfactant	2 qt/100 gal	6
	plus ammonium sulfate (optional)	8.5–17 lb/100 gal	
Gramoxone SL	non-ionic surfactant or	1 pt/100 gal	0.5
	crop oil concentrate	1 gal/100 gal	
Huskie	non-ionic surfactant	1–2 qt/100 gal	1–6
	plus nitrogen solution (optional)		
Maestro (Buctril)[4]	crop oil concentrate or	1 gal/100 gal	1
	nitrogen solution	1–4 gal/100 gal	
Marksman[5]	non-ionic surfactant or	1 qt/100 gal	4
	crop oil concentrate or	1 gal/100 gal	
	nitrogen solution or	2–4 qt/A	
	ammonium sulfate	2–2.5 lb/A	
Peak	crop oil concentrate	1 gal/100 gal	4
Permit	non-ionic surfactant or	1–2 qt/100 gal	4
	crop oil concentrate	1 gal/100 gal	
	plus nitrogen solution (optional)		
+ 2,4-D, Banvel, Clarity, Maestro, or Marksman	non-ionic surfactant		
+ atrazine	crop oil concentrate	1 gal/100 gal	
Roundup/Glyphosate	non-ionic surfactant	2 qt/100 gal	6
	plus ammonium sulfate (optional)	8.5–17 lb/100 gal	
Roundup PowerMAX/Roundup WeatherMAX	no NIS/COC required	–	<1
	ammonium sulfate (optional)	8.5–17 lb/100 gal	
Sharpen	methylated seed oil	1 gal/100 gal	4
	plus nitrogen solution or	2–4 qt/A	
	ammonium sulfate	8.5–17 lb/100 gal	
XtendiMax/FeXapan	See label for details		4

Table 5.41 - Spray Additives and Rainfastness for Burndown and Postemergence Sorghum Herbicides (con't)

Trade Name	Adjuvant(s)[1]	Rate	Rainfastness (hours)
Yukon	non-ionic surfactant or	1–2 qt/100 gal	4
	crop oil concentrate	1 gal/100 gal	
	plus nitrogen solution or	2–4 qt/A	
	ammonium sulfate (optional)	2–4 lb/A	

[1] In general, non-ionic surfactants should contain at least 80% surface active agent; crop or vegetable oil concentrates should be nonphytotoxic, containing at least 15% approved emulsifier; nitrogen solution is an ammonium-based fertilizer such as 28%, 30%, or 32% N; and ammonium sulfate should be spray-grade dry ammonium sulfate (21-0-0). 10-34-0 also may be used with some products.

[2] Use crop oil concentrate if lambsquarters, common ragweed, Canada thistle, yellow nutsedge, or field bindweed are present. Include nitrogen solution if velvetleaf is the primary target.

[3] Do not use COC after sorghum exceeds 5 inches tall. Adjuvant addition depends on tank-mix partner.

[4] When Maestro is applied alone, spray additives generally are not needed and may cause excessive leaf burn.

[5] Do not use COC if sorghum has emerged.

Table 5.42 - Grain Harvest and Forage Restrictions for Sorghum Herbicides

	Forage	Grain
Trade Name	**(Days After Treatment)**	
2,4-D amine 4S	30	30
2,4-D LVE 4E	30	30
Aatrex, Atrazine 4L/90DF	60 PRE / 45 POST	60 PRE / 45 POST
Aim 2EC	not specified	not specified
Banvel 4S	do not graze or feed prior to mature grain stage	30
Basagran 4S	12	not specified
Bicep II Magnum 5.5EC	60 PRE/ not specified POST	75
Bullet 4ME	70	not specified
Callisto 4SC	not labeled for forage	not specified
Cinch ATZ	60	not specified
Clarity 4S	do not graze or feed prior to mature grain stage	30
Degree Xtra 4.04ME	not labeled for forage	60
Dual II Magnum 7.64EC/Cinch	75	75
Engenia 5SL	do not graze or feed prior to mature grain stage	not specified
Facet L 1.5L	not specified	not specified
FeXapan 2.9SL	do not graze or feed prior to mature grain stage	30
FulTime NXT 4.04EC	60	not specified

Table 5.42 - Grain Harvest and Forage Restrictions for Sorghum Herbicides (cont.)

	Forage	Grain
Sorghum Herbicide	**(Days After Treatment)**	
Huskie 2.06EC	7	60
Intrro 4EC	70	not specified
Lexar EZ 3.7SC	not specified	not specified
Lorox 50DF/Linex 4L	90	75
Lumax EZ 3.67SC	45	not specified
Maestro 2EC	45	not specified
Marksman 3.2L	21	60 PRE / 45 POST
Outlook 6EC	60	80
Peak 57WG	30 graze / 40 silage	60
Permit 75WG	30	30
Prowl 3.3EC	not labeled for forage	not specified
Prowl H2O 3.8CS	not labeled for forage	not specified
Sandea 75WG	30	30
Sharpen 2.85SC	70	not specified
Starane Ultra 2.8L	40	70
Verdict 5.57EC	70	not specified
Warrant 3CS	60	not specified
Xtendimax 2.9SL	do not graze or feed prior to mature grain stage	30
Yukon 67.5WDG	30	30
Zest 75WDG	not specified	30

Table 5.43 - Comments on Harvest-Aid Herbicides for Sorghum

Treatments are based on broadcast application, not wiper-bar or rope-wick applications.

Trade Name	Common Name	Site of Action Number	Product/A	lb ai/A
Aim 2EC	**carfentrazone**	**14**	**1 fl oz**	**0.016**

- Use as a harvest aid to desiccate a limited number of broadleaf weed species.
- Application shall be made when the crop is mature and the grain has begun to dry down.
- Use with a crop oil concentrate @ 1% v/v (1 gal/100 gal).
- Can be tank-mixed with glyphosate to improve the spectrum of control.
- Apply in 10 gal/A water.
- Include necessary adjuvants and make sure spray coverage is sufficient, otherwise poor control will result.
- Allow at least three days between application and harvest.

Table 5.43 - Chemical Options for Harvest-Aid in Sorghum (cont.)

Treatments are based on broadcast application, not wiper-bar or rope-wick applications.

Herbicide Trade name	Herbicide Common name	Herbicide group # (site of action)	product/A	lb ai/A
Defol 5	**sodium chlorate**		**4.8 qt**	**6.0**

- Labeled to dry weeds and to facilitate harvest.
- Apply to sorghum 7 to 10 days before anticipated harvest, when sorghum is mature and ready to harvest.
- Use lower rates when grain moisture is low and weather is clear and dry; use higher rates when conditions for desiccation is poor.
- Apply in at least 5-10 gallons of water by air, and 10 to 20 gallons of water with ground application.

Glyphosate	**glyphosate**	**9**	**varies with formulation**	**0.75–1.5**

- Apply glyphosate to sorghum at 30% grain moisture.
- Apply glyphosate in 10–20 gallons of water/A to control weeds that may interfere with harvest or to control perennials such as quackgrass or Canada thistle.
- Allow a minimum of 7 days between application and harvest.
- Do not use on sorghum grown for seed.
- Will not control glyphosate-resistant weeds.
- See Table 5.2 for more information on various glyphosate formulations.

Soybean Weed Management

Integrated Weed Management

The foundation of soybean weed management is a residual soil-applied herbicide program followed by a timely postemergent herbicide. Make residual soil-applied herbicide application as close to planting as possible and make postemergent applications 3 to 4 weeks after planting. This approach relies on effective and timely postemergence weed control. Also, it is not necessary to control all weeds in a field to achieve maximum yield; weeds that germinate with the crop but are controlled in a timely fashion (3 to 4 weeks after planting) will not impact final yields. Weed populations of 20 to 30 weeds per 100 square feet are sufficient to cause yield loss. However, weed populations of 10 plants per 100 square feet will have no impact on final yield. The impact of weed populations between 10 and 20 per 100 square feet is difficult to predict. The decision to treat the field depends on the weed species present, crop vigor, weather conditions, and herbicide cost.

Planting soybeans in narrow rows (15 inches or less) will improve overall weed control since the crop canopy will close the rows sooner than wide rows and help to outcompete smaller weeds.

Chemical Weed Control

Herbicides are useful tools in most weed management programs. They should be used to supplement, not replace, other methods or tools available. The following are definitions of terms you will find in this and similar publications on herbicides:

Early preplant (EPP) - The herbicide is applied at least 14 days before planting. EPP applications are generally used in no-till systems to control existing vegetation and provide residual control of early emerging weed species.

Preplant - The herbicide is applied from 0 to 14 days before planting. Preplant applications are generally used in no-till systems to control existing vegetation and should include residual herbicides.

Preplant Incorporated (PPI) - The herbicide is applied to the soil after primary tillage but before planting, and mechanically mixed with the top 1 to 3 inches of soil with one of a variety of secondary tillage implements.

Preemergence (PRE) - The herbicide is applied to the soil after the crop is planted but before emergence. Rainfall or irrigation is needed to move the herbicide into the zone of weed seed germination before weed emergence for maximum effectiveness. If adequate rainfall for herbicide activation does not occur, a shallow cultivation or rotary hoeing should be done or postemergence herbicide applied to control weeds that have germinated.

Postemergence (POST) - The herbicide is applied to "over-the-top" of the crop and weeds after they have emerged.

Residual activity/soil-applied herbicide - These herbicides can be taken up by a plant's roots and shoots and injure or kill the plant. All soil-applied herbicides, as well as many postemergence herbicides, have residual activity. Length of residual activity ranges from a few weeks to the entire growing season.

Translocated herbicide - These herbicides move throughout the plant and can cause injury to the parts of the plants that do not come in direct contact with the herbicide spray.

Contact herbicide - These herbicides do not move throughout the plant. They cause injury to only those parts of the plant that come in contact with the spray. Spray coverage is more critical for contact than translocated herbicides. Therefore, a spray volume of 15 gallons per acre or more is recommended.

Non-selective herbicide - These herbicides control a broad spectrum of plant species, including most crops and weeds. These herbicides are generally used with no-tillage production and sprayed prior to planting when control of all plants is required.

Herbicide-resistant Varieties

Some soybean varieties have been genetically enhanced to withstand herbicide applications that previously would have injured or killed soybeans. Some of these enhanced varieties were developed by genetic engineering, while others were developed through traditional breeding methods. Genetically enhanced varieties allow herbicides to be used that provide a broader spectrum of control than would otherwise be available while reducing the risk of crop injury. Herbicide-resistant soybean varieties include LibertyLink, LibertyLink GT27, Roundup Ready, and STS and Bolt.

LibertyLink soybeans are GMO soybeans developed for over-the-top application of Liberty. This is a broad-spectrum weed control program, but it does not provide any residual weed control. Tank mixtures are necessary when fields are infested with late emerging weed species such as Palmer amaranth.

LibertyLink GT27 soybeans are GMO soybeans developed to be resistant to Liberty, glyphosate, and BalanceBean herbicides. Both Liberty and glyphosate provide non-selective broad spectrum weed control but do not provide residual control. BalanceBean provides residual control but does not provide postemergence control.

Roundup Ready soybeans were developed to allow over-the-top application of glyphosate, providing broad-spectrum control of annual broadleaf, grasses, and perennials weeds. Exclusive use of glyphosate has led to the selection of glyphosate-resistant weed biotypes.

STS and Bolt soybeans are non-GMO soybeans developed to be resistant to sulfonylurea herbicides (Group 2). STS were developed for their tolerance to Harmony (thifensulfuron) and Classic (chlorimuron). Bolt soybeans were developed for tolerance to Resolve (rimsulfuron). These varieties have the Roundup Ready trait as well. Weed biotypes resistant to Group 2 herbicides are widespread in the region.

Xtend soybeans are genetically engineered (GMOs) to allow preemergence and over-the-top application of dicamba. Xtend soybeans are also Roundup Ready. Three different dicamba products (Engenia, XtendiMax, and FeXapan) specially formulated for reduced drift are labeled for Xtend soybeans. All other dicamba products are not allowed. In addition, a number of stewardship guidelines are required, including using low-drift nozzles, at least 10 GPA carrier, and making applications only when certain environmental conditions exist to reduce the potential for off-site movement. In the Mid-Atlantic region, this technology is best suited for burndown application in no-till for control of winter annual weeds, including horseweed/marestail. Over-the-top application and use in double-crop soybeans is not encouraged due to greater concern for off-target movement.

Herbicide-resistant Weeds in Soybeans

Herbicide-resistant weeds are common in the Mid-Atlantic region. Populations of herbicide-resistant weeds are selected for by repeated use of the same herbicide site of action over a period of time. Resistance is most likely to occur when one specific mode of action is used repeatedly, exclusively, and frequently. Weed species with a very high amount of seed production and a variable genetic pool are more likely to develop resistant populations—for example, common lambsquarters and pigweed species. Resistance management requires using herbicides with multiple modes of action and integrating mechanical (tillage and cultivation) and cultural weed control (cover crops, narrow row spacing, proper crop fertility, etc.) with chemical weed control.

ALS resistance - Weeds resistant to the Group 2 herbicides in the Mid-Atlantic region include several pigweed species, common and giant ragweed, common chickweed, horseweed, Italian ryegrass, giant foxtail, Johnsongrass, and shattercane.

Glyphosate resistance - Weeds resistant to the Group 9 herbicide glyphosate in the Mid-Atlantic region include Palmer amaranth and waterhemp, common and giant ragweed, and horseweed. In soybeans, all of these can be managed with alternative herbicides, including those in Group 14 (PPO herbicides), Group 5 (triazine), Group 10 (requires LibertyLink soybeans), or Group 4 (requires Xtend soybeans).

PPO resistance - Weed resistant to Group 14 herbicides include common ragweed. This is not widespread in the region, but there are a few fields with biotypes resistant to Groups 14, 2, and 9. The only option in these fields is applying metribuzin at planting and using either LibertyLink soybeans and applying Liberty or Xtend soybeans and applying Engenia, Xtendimax, or FeXapan in a timely fashion.

Triazine resistance - Weeds resistant to the Group 5 herbicides in the Mid-Atlantic region include common lambsquarters, Palmer amaranth, redroot and smooth pigweed, horseweed, scattered populations of barnyardgrass, giant foxtail, goosegrass, and suspected populations of common ragweed and velvetleaf. Metribuzin is the primary triazine herbicide in may premixes. For triazine-resistant (TR) pigweed control, include a Group 14 (flumioxazin or sulfentrazone) or Group 15 herbicide (acetochlor, dimethenamid, metolachlor, or pyroxasulfone) at planting.

For TR lambsquarters, some of the Group 15 herbicides will help suppress emergence (acetochlor and pyroxasulfone), but they are not as active on lambsquarters as they are on pigweed. The Group 14 herbicides provide better control.

No-till Weed Management

Successful production of no-till soybeans requires control of existing vegetation at planting (cover crops and weeds) and summer annual weeds that emerge after planting. Existing vegetation is traditionally controlled by the non-selective herbicides, which are often tank-mixed with residual herbicides. However, in many fields the presence of winter annual weeds, such as horseweed, requires an application while these plants are small and more susceptible to non-selective herbicides; this may require an application 3 to 5 weeks prior to planting. Some residual herbicides, such as Canopy or Envive, can enhance burndown weed control. However, when the products are applied 14 to 28 days before soybean planting, they provide residual weed control for only a week or two after planting soybeans. In fields with weeds that are difficult to control, an application of a non-selective herbicide and 2,4-D should be used early to control winter annuals weeds, and a second application of the residual herbicides should be made at the time of soybean planting. This second application will improve overall weed control.

Weed Management for Soybeans Planted After Wheat or Barley

Weed control for soybeans grown after a small grain crop has additional considerations. As with full-season no-till, the fields should be treated to kill all weeds present at the time of planting. This includes winter annual weeds as well as summer annual weeds. The situation may involve controlling weeds that have been cut off and damaged during the small grain harvest operation, leaving little leaf surface to be treated. Plants maybe present that are resistant to both glyphosate and Group 2 herbicides (e.g., Palmer amaranth and horseweed). Summer annual species may be present that require an application of glyphosate or a Group 1 herbicide (Select, etc.). Herbicides that delay soybean planting, such as 2,4-D or Sharpen on coarse-textured soils are seldom used. Local research shows that a combination of glyphosate plus Liberty before planting provides good control of many troublesome species without impacting grass control.

Postemergence weed control needs to be timely. Since late emerging weeds are often not as competitive as weeds emerging in the early summer, plants emerging 4 weeks after planting soybean often do not impact yields. Since double-cropped soybeans are treated in the late summer, be sure to observe crop rotations with herbicides. A 9-month crop rotation may be too short of an interval to treat soybeans postemergence and allow for an early spring-planted crop.

Management of Glyphosate Resistant Horseweed

Many of the horseweed populations in the region are glyphosate resistant, but in addition to glyphosate resistance, many populations in the region are also resistant to the ALS inhibitors (Classic, FirstRate, etc.). The most economical treatments for control include 2,4-D ester at 2 pints per acre applied to small plants (less than 3-inch rosettes) to ensure effective control. Engenia, Xtendimax, and FeXapan are also effective options when applied to small plants and do not have a planting restriction for Xtend soybeans. Elevore is also an effective option, but has a 14 day planting restriction. Herbicides containing saflufenacil, such as Sharpen, will also provide excellent horseweed control if applied to small plants. A primary goal for horseweed management in soybean should be effective control of emerged plants prior to planting since there are very few options to control it once soybeans have emerged.

Management of Palmer Amaranth

Palmer amaranth control is difficult because (1) it emerges throughout the summer; (2) it grows rapidly, so once the plants emerge there are only a few weeks before it becomes too tall to control; and (3) many of the populations are resistant to glyphosate as well as Group 2 herbicides.

Effective management of Palmer amaranth requires a residual soil-applied herbicide applied within 7 to 10 days of planting and at the full labeled rates. Applying residual herbicides 2 weeks or more ahead of planting means there is a limited period of control once soybeans are planted. Postemergence applications must be made timely to small susceptible Palmer amaranth plants—according to various trials, within 4 weeks after the soil-applied herbicides were applied. The most consistent options have been fomesafen (Reflex or Flexstar GT) or Liberty (with LibertyLink soybeans). The postemergence herbicide applications should include a product that provides residual control of Palmer amaranth, such as fomesafen (Reflex), Dual, Outlook, Warrant, or Zidua. In double-cropped soybeans, rotation intervals may limit the use of Reflex, so Ultra Blazer or Cobra can be used but these do not provide residual control.

Table 5.44 - Soybean Herbicides and Their Restrictions

Restricted Use pesticides can be purchased and used only by licensed applicators. To become licensed, contact your states's Department of Agriculture.

Herbicides with Water Quality Advisory have properties that may result in ground or surface water contamination. Do not apply them in areas where soils are permeable or coarse and groundwater is near the surface. Practices should be followed to minimize the potential for runoff in ground water and/or runoff erosion. See the herbicide label for specific restrictions.

Worker Reentry is the minimum time between application and reentry into a treated area. If soil-applied products are injected or incorporated at application time, under certain circumstances the Worker Protection Standard allows workers to enter the treated area if they will have no contact with anything that has been treated. Personal protective equipment is required for early entry to treated areas if contact with treated soil, plants, or water is involved.

Trade Name[1]	Common Name	Site of Action Number	Manufacturer	Restricted-Use Pesticide	Water Quality Advisory	Worker Reentry (hours)
2,4-D amine 4S	2,4-D amine	4	several	–	–	48
2,4-D LVE 4E	2,4-D LVE	4	several	–	–	12
Afforia 50.8WG	flumioxazin + thifensulfuron + tribenuron	14, 2, 2	Corteva	–	–	12
Aim 2EC	carfentrazone ethyl	14	FMC	–	–	12
Anthem 2.15SE	pyroxasulfone + fluthiacet	15, 14	FMC	–	yes	12
Anthem Maxx 4.3SC	pyroxasulfone + fluthiacet	15, 14	MC	–	yes	12
Assure II 0.88E/Targa	quizalofop	1	Corteva/Gowan	–	–	12
Authority Assist 4L	sulfentrazone + imazethapyr	14, 2	FMC	–	yes	12
Authority Elite 7E / BroadAxe XC	sulfentrazone + S-metolachlor	14, 15	FMC/Syngenta	–	yes	24
Authority First 70DF / Sonic	sulfentrazone + cloransulam	14, 2	FMC	–	yes	12
Authority MTZ 45DF	sulfentrazone + metribuzin	14, 5	FMC	yes	yes	12
Authority Supreme 4.16SC	sulfentrazone + pyroxasulfone	14, 15	FMC	–	yes	12
Authority XL 70WG / Authority Maxx 66WG	sulfentrazone + chlorimuron	14, 2	FMC	–	yes	12
Basagran 4S	bentazon	6	Arysta LifeScience	–	yes	12
Boundary 6.5EC	S-metolachlor + metribuzin	15, 5	Syngenta	–	yes	12
BroadAxe XC 7E / Authority Elite	sulfentrazone + S-metolachlor	14, 15	Syngenta/FMC	–	yes	24
Butyrac 200 2E	2,4-DB	4	Bayer CropScience	–	yes	48
Cadet 0.91EC	fluthiacet	14	FMC	–	yes	12
Canopy 75DF	chlorimuron + metribuzin	2, 5	Corteva	–	yes	12

Table 5.44 - Soybean Herbicides and Their Restrictions (cont.)

Trade Name[1]	Common Name	Site of Action Number	Manufacturer	Restricted-Use Pesticide	Water Quality Advisory	Worker Reentry (hours)
Canopy Blend 58.3DG	chlorimuron + metribuzin	2, 5	Corteva	–	yes	12
Canopy EX 29.5WDG	chlorimuron + tribenuron	2, 2	Corteva	–	–	12
Clarity 4S	dicamba (DGA Salt)	4	BASF	–	yes	24
Classic 25DF	chlorimuron	2	Corteva	–	–	12
Cobra 2E/Phoenix	lactofen	14	Valent	–	–	12
Command 3ME	clomazone	13	FMC	–	–	12
Dual II Magnum 7.62EC	S-metolachlor	15	Syngenta	–	yes	24
Durango DMA 4S[2]/ Duramax 4S[2]	glyphosate	9	Corteva	–	–	4
Elevore 0.572SC	halauxifen	4	Corteva	–	yes	12
Engenia 5S[5]	dicamba BAMPA Salt	4	BASF	yes	yes	24
Enlist One 3.8SL	2,4-D choline	4	Corteva	–	–	48
Enlite 48WDG	chlorimuron + flumioxazin + thifensulfuron	2, 14, 2	Corteva	–	–	12
Envive 41.3WDG	chlorimuron + flumioxazin + thifensulfuron	2, 14, 2	Corteva	–	–	12
Extreme 2.17L[2]	imazethapyr + glyphosate	2, 9	BASF	–	yes	48
FeXapan/XtendiMax 2.9S[3]	dicamba DGA Salt withVaporGrip	4	FMC/Bayer	yes	yes	24
Fierce 76WDG	pyroxasulfone + flumioxazin	15, 14	Valent	–	yes	12
Fierce XLT 62.41WDG	pyroxasulfone + flumioxazin + chlorimuron	15, 14, 2	Valent	–	yes	12
FirstRate 84WDG	cloransulam	2	Corteva	–	yes	12
Flexstar GT 3.5 2.82L[2]	fomesafen + glyphosate	14, 9	Syngenta	–	yes	24
Fusilade DX 2E	fluazifop	1	Syngenta	–	–	12
Fusion 2.56E	fluazifop + fenoxaprop	1, 1	Syngenta	–	–	24
Gangster (co-pack)/ Surveil (co-pack)	flumioxazin + cloransulam	14, 2	Valent	–	yes	12
Gramoxone SL 2S	paraquat	22	Syngenta	yes	–	12
Harmony SG 50WDG	thifensulfuron	2	Corteva	–	–	4
Interline 2.34SL[4]	glufosinate	10	United Phosphorus Inc	–	–	12

Table 5.44 - Soybean Herbicides and Their Restrictions (cont.)

Trade Name[1]	Common Name	Site of Action Number	Manufacturer	Restricted-Use Pesticide	Water Quality Advisory	Worker Reentry (hours)
LeadOff 33.4WDG	rimsulfuron + thifensulfuron	2, 2	Corteva	–	–	4
Liberty 280 2.34SL[4]	glufosinate	10	BASF	–	–	12
Lorox 50DF/Linex 4L	linuron	7	Nova Source	–	–	24
Marvel 3L	fluthiacet + fomesafen	14, 14	FMC	–	yes	24
Metribuzin 75DF/4L	metribuzin	5	various	–	yes	12
OpTill 68WG	saflufenacil + imazethapyr	14, 2	BASF	–	yes	12
Outlook 6EC	dimethenamid	15	BASF	–	yes	12
Panoflex 50WDG	thifensulfuron + tribenuron	2, 2	Corteva	–	–	12
Permit Plus 74WDG[5]	halosulfuron + thifensulfuron	2, 2	Gowan	–	–	12
Poast 1.5E	sethoxydim	1	BASF	–	–	12
Poast Plus 1E	sethoxydim	1	BASF	–	–	12
Prefix 5.3EC	S-metolachlor + fomesafen	15, 14	Syngenta	–	yes	24
Prowl 3.3E / Prowl H_2O 3.8CS	pendimethalin	3	BASF	–	–	12
Pursuit 2S	imazethapyr	2	BASF	–	yes	12
Python 80WDG / Accolade	flumetsulam	2	Corteva/FMC	–	yes	12
Raptor 1S	imazamox	2	BASF	–	–	4
Reflex 2E / Flexstar 1.88E	fomesafen	14	Syngenta	–	yes	24
Resource 0.86EC	flumiclorac	14	Valent	–	–	12
Roundup WeatherMax/ PowerMax 4.5S[2]	glyphosate	9	Bayer	–	–	4
Rowel 51WDG / Valor SX	flumioxazin	14	Bayer/ Valent	–	–	12
Rowel FX 40.3WDG / Valor XLT	chlorimuron + flumioxazin	2, 14	Bayer/ Valent	–	–	12
Scepter 70DG	imazaquin	2	AMVAC	–	–	12
Select 2E/Max 0.97E	clethodim	1	Valent	–	–	12
Sequence 5.25EW[2]	S-metolachlor + glyphosate	15, 9	Syngenta	–	yes	24
Sharpen 2.85SC	saflufenacil	14	BASF	–	yes	12
Sonic 70WG/Authority First 70DF	sulfentrazone + cloransulam	14, 2	Corteva	–	yes	12
Spartan 4F	sulfentrazone	14	FMC	–	yes	12
Spartan Charge	sulfentrazone + carfentrazone	14, 14	FMC	–	yes	12

Table 5.44 - Soybean Herbicides and Their Restrictions (cont.)

Trade Name[1]	Common Name	Site of Action Number	Manufacturer	Restricted-Use Pesticide	Water Quality Advisory	Worker Reentry (hours)
Storm 4S	acifluorfen + bentazon	14, 6	United Phosphorus, Inc.	–	yes	48
Surveil 48WG (co-pack)/ Gangster	flumioxazin + cloransulam	14, 2	Corteva	–	yes	12
Synchrony XP 28.4WDG[5]	chlorimuron + thifensulfuron	2, 2	Corteva	–	–	12
Touchdown HiTech 5S[2]	glyphosate	9	Syngenta	–	–	12
Touchdown Total 4.17S[2]	glyphosate	9	Syngenta	–	–	12
Treflan 4E, Tri-4, Trific, Trilin	trifluralin	3	Corteva	–	–	12
Trivence 61.3WDG	chlorimuron + flumioxazin + metribuzin	2, 14, 5	Corteva	–	yes	12
Ultra Blazer 2S	acifluorfen	14	United Phosphorus, Inc.	–	yes	48
Valor SX 51WDG/Valor EZ 4SC/Rowel 51WDG	flumioxazin	14	Valent/Valent/ Bayer	–	–	12
Valor XLT 40.3WDG/Rowel FX 40.3WDG	chlorimuron + flumioxazin	2, 14	Valent/Bayer	–	–	12
Verdict 5.57EC	saflufenacil + dimethenamid	14, 15	BASF	-	yes	12
Warrant 3CS	acetochlor	15	Bayer	–	yes	12
Warrant Ultra 3.45CS	acetochlor + fomesafen	14, 15	Bayer	–	yes	24
Xtendimax 2.9S/FeXapan[3]	dicamba DGA Salt withVaporGrip	4	Bayer/FMC	yes	yes	24
Zidua 85WDG/ Zidua SC 4.17SC	pyroxasulfone	15	BASF	–	yes	12
Zidua PRO 4.09SC	imazethapyr + pyroxasulfone + saflufenacil	2, 15, 14	BASF	–	yes	12

[1] Generic alternatives to some of these products are available. See Table 5.44 (generics table) for additional herbicides that contain these active ingredients.

[2] May be applied over the top on glyphosate-resistant soybean varieties only.

[3] For use at planting and over-the-top of dicamba-resistant soybean varieties only.

[4] For use on glufosinate-resistant soybean varieties only.

[5] For use on STS or Bolt soybean varieties only.

Table 5.45 - Soybean Herbicide Prepackaged Mixes, or Co-Packs, and Equivalents

Trade Name	Components (ai or ae/gal or lb)	If you apply (per acre)	You have applied (ai or ae lb / A)	Site of Action Number	An equivalent tank-mix of
Afforia 50.8 WG	0.408 lb flumioxazin	2.5 oz	0.064 flumioxazin	14	2 oz Valor SX 51WDG
	0.05 lb thifensulfuron		0.008 thifensulfuron	2	0.17 oz Harmony 75DF
	0.05 lb tribenuron		0.008 tribenuron	2	0.25 oz Express 50DF
Anthem 2.15SE	2.087 lb pyroxasulfone	6 fl oz	0.098 pyroxasulfone	15	3.02 fl oz Zidua 4.17SC
	0.063 lb fluthiacet		0.003 fluthiacet	14	0.42 fl oz Cadet 0.91E
Anthem Maxx 4.3SC	4.174 lb pyroxasulfone	3 fl oz	0.098 pyroxasulfone	15	3.02 fl oz Zidua 4.17SC
	0.126 lb fluthiacet		0.003 fluthiacet	14	0.42 fl oz Cadet 0.91E
Authority Elite 7SE or BroadAxe XC	0.7 lb sulfentrazone	28 fl oz	0.153 sulfentrazone	14	4.9 fl oz Spartan 4L
	6.3 lb S-metolachlor		1.38 S-metolachlor	15	1.45 pt Dual Magnum 7.62EC
Authority First70DF	0.621 lb sulfentrazone	6.45 oz	0.25 sulfentrazone	14	8 fl oz Spartan 4F
	0.079 lb cloransulam		0.032 cloransulam	2	0.6 oz FirstRate 84WDG
Authority MTZ 45DF	0.18 lb sulfentrazone	16 oz	0.18 sulfentrazone	14	5.76 fl oz Spartan 4F
	0.27 lb metribuzin		0.27 metribuzin	5	5.8 oz metribuzin 75DF
Authority Supreme 4.16SC	2.08 lb sulfentrazone	7 fl oz	0.114 sulfentrazone	14	3.65 fl oz Spartan 4F
	2.08 lb pyroxasulfone		0.114 pyroxasulfone	15	3.5 fl oz Zidua 4.17SC
Authority XL 70WG	0.62 lb sulfentrazone	7.0 oz	0.27 sulfentazone	14	8.64 fl oz Spartan 4F
	0.08 lb chlorimuron		0.035 chlorimuron	2	2.24 oz Classic 25DF
Boundary 6.5L	5.25 lb S-metolachlor	2 pt	1.24 S-metolachlor	15	1.3 pt Dual Magnum 7.26EC
	1.25 lb metribuzin		0.314 metribuzin	5	6.7 oz metribuzin 75DF
Canopy 75DF	0.107 lb chlorimuron	5 oz	0.033 chlorimuron	2	2.14 oz Classic 25DF
	0.643 lb metribuzin		0.2 metribuzin	5	4.27 oz metribuzin 75DF
Canopy Blend 58.3DG	0.083 lb chlorimuron	6.5	0.033 chlorimuron	2	2.14 oz Classic 25DF
	0.5 lb metribuzin		0.2 metribuzin	5	4.27 oz metribuzin 75DF
Canopy EX 29.5WDG	0.227 lb chlorimuron	2.2 oz	0.031 chlorimuron	2	2 oz Classic 25DF
	0.068 lb tribenuron		0.009 tribenuron	2	0.2 oz Express 75DF
Envive 41.3WDG	0.292 lb flumioxazin	3.5 oz	0.064 flumioxazin	14	2.0 oz Valor SX 51WDG
	0.029 lb thifensulfuron		0.006 oz thifensulfuron	2	0.14 oz Harmony 75DF
	0.092 lb chlorimuron		0.020 chlorimuron	2	1.3 oz Classic 25DF
Extreme 2.17L	0.17 lb imazethapyr	3 pt	0.063 imazethapyr	2	4.0 fl oz Pursuit 2L
	1.48 lb ae glyphosate		0.56 lb ae glyphosate	9	1.5 pt Roundup 4S
Fierce 76WDG	0.335 lb flumioxazin	3 oz	0.063 flumioxazin	14	2.0 oz Valor SX 51WDG
	0.425 lb pyroxasulfone		0.08 pyroxasulfone	15	2.46 fl oz Zidua 4.17SC

Table 5.45 - Soybean Herbicide Prepackaged Mixes or Co-Packs, and Equivalents (cont.)

Trade Name	Components (ai or ae/gal or lb)	If you apply (per acre)	You have applied (ai or ae lb / A)	Site of Action Number	An equivalent tank-mix of
Fierce XLT 62.41WDG	0.3117 lb pyroxasulfone	4 oz	0.78 pyroxasulfone	15	2.39 fl oz Zidua 4.17SC
	0.2457 lb flumioxazin		0.061 flumioxazin	14	1.93 oz Valor SX 51WDG
	0.0667 lb chlorimuron		0.017 chlorimuron	2	1.07 oz Classic 25DF
Flexstar GT3.5L	0.56 lb fomesafen	4.5 pt	0.315 fomesafen	14	1.3 pt Reflex 2E
	2.26 lb ae glyphosate		1.28 lb ae glyphosate	9	1.3 qt Touchdown Total 4.17S
Fusion 2.67E	2 lb fluazifop	8 fl oz	0.125 fluazifop	1	8.0 fl oz Fusilade DX 2E
	0.67 lb fenoxaprop		0.042 fenoxaprop	1	0.042 lb fenoxaprop
Gangster CoPack	flumioxazin	3 oz	0.080 flumioxazin	14	2.5 oz Valor SX 51WDG
	cloransulam		0.026 cloransulam	2	0.5 oz FirstRate 84WDG
Marvel 3L	0.117 lb fluthiacet	7.25 fl oz	0.007 fluthiacet	14	0.9 fl oz Cadet 0.91E
	2.883 lb fomesafen		0.163 fomesafen	14	10.4 fl oz Reflex 2E
OpTill 68WG	0.502 lb imazethapyr	2.0 oz	0.063 mazethapyr	2	4.0 fl oz Pursuit 2L
	0.178 lb saflufenacil		0.022 saflufenacil	14	1.0 fl oz Sharpen 2.85SC
Panther Pro 4.23SC	3.0 lb metribuzin	12 fl oz	0.28 metribuzin	5	5.97 oz metribuzin 75DF
	0.67 lb flumioxazin		0.063 flumioxazin	14	1.98 oz Valor SX 51WDG
	0.56 lb imazethapyr		0.053 imazethapyr	2	3.39 fl oz Pursuit 2L
Permit Plus	0.662 lb halosulfuron	1.25 oz	0.052 halosulfuron	2	1.1 oz Permit 75WDG
	0.078 lb thifensulfuron		0.006 thifensulfuron	2	0.128 oz Harmony 75DF
Prefix 5.3EC	4.34 lb S-metolachlor	2 pt	1.05 S-metolachlor	15	1.1 pt Dual Magnum 7.62EC
	0.95 lb fomesafen		0.24 fomesafen	14	0.95 pt Reflex 2E
Sequence 5.25EW	2.25 lb ae glyphosate	3.5 pt	0.98 lb ae glyphosate	9	1.88 pt Touchdown Total 4.17S
	3 lb S-metolachlor		1.31 lb S-metolachlor	15	1.38 pt Dual Magnum 7.62EC
Sonic 70DF	0.621 lb sulfentrazone	6.45 oz	0.25 sulfentrazone	14	8 fl oz Spartan 4F
	0.079 lb cloransulam		0.032 cloransulam	2	0.6 oz FirstRate 84WDG
Spartan Charge	3.15 lb sulfentrazone	8.5 fl oz	0.21 lb sulfentrazone	14	6.69 fl oz Spartan 4F
	0.35 lb carfentrazone		0.023 lb carfentrazone	14	1.49 fl oz Aim 2EC
Storm 4S	2.67 lb bentazon	1.5 pt	0.50 bentazon	6	1.0 pt Basagran 4S
	1.33 lb acifluorfen		0.25 acifluorfen	14	1.0 pt Blazer 2S
Surveil 48WDG	0.36 lb flumioxazin	3.5 oz	0.080 lumioxazin	14	2.5 oz Valor SX 51WDG
	0.12 lb cloransulam		0.026 cloransulam	2	0.5 oz FirstRate 84WDG

Table 5.45 - Soybean Herbicide Prepackaged Mixes or Co-Packs, and Equivalents (cont.)

Trade Name	Components (ai or ae/gal or lb)	If you apply (per acre)	You have applied (ai or ae lb / A)	Site of Action Number	An equivalent tank-mix of
Synchrony XP 28.4WDG	0.215 lb chlorimuron	0.375 oz	0.005 chlorimuron	2	0.32 oz Classic 25DF
	0.069 lb thifensulfuron		0.0014 thifensulfuron	2	0.03 oz Harmony 75DF
Trivence 61.3WDG	0.039 lb chlorimuron	8 oz	0.020 chlorimuron	2	1.25 oz Classic 25DF
	0,128 lb flumioxazin		0.064 flumioxazin	14	2.0 oz Valor 51WDG
	0.446 lb metribuzin		0.22 metribuzin	5	4.7 oz metribuzin 75DF
Valor XLT 40.3WDG or Rowel FX	0.3 lb flumioxazin	3.5 oz	0.065 flumioxazin	14	2.1 oz Valor SX 51WDG
	0.103 lb chlorimuron		0.022 chlorimuron	2	1.44 oz Classic 25DF
Verdict 5.57EC	5.0 lb dimethenamid	5.0 fl oz	0.19 dimethenamid	15	4.0 fl oz Outlook 6EC
	0.57 lb saflufenacil		0.022 saflufenacil	14	1.0 fl oz Sharpen 2.85SC
Warrant Ultra 3.45CS	2.82 lb acetochlor	3 pt	1.06 acetochlor	15	2.8 pt Warrant 3CS
	0.631 lb fomesafen		0.24 fomesafen	14	15 fl oz Reflex 2E
Zidua PRO 4.09SC	2.28 lb pyroxasulfone	6 fl oz	0.107 pyroxasulfone	15	3.28 fl oz Zidua 4.17SC
	1.33 lb imazethapyr		0.063 imazethapyr	2	4 fl oz Pursuit 2L
	0.48 lb saflufenacil		0.022 saflufenacil	14	1 fl oz Sharpen 2.85SC

Table 5.46 - Relative Effectiveness of "Burndown" Herbicides for Control of Weeds in No-Till Full-Season Soybeans

Relative effectiveness of herbicides on individual weeds which are commonly present prior to planting soybeans are listed in this table. Ratings are based on labeled application rates and weed size or growth stage; which often means an application is made weeks prior to planting. Delaying applications will result in reduced control. Treatments are rated only for control of vegetation existing at the time of application.

Weed control rating:

10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65% N = less than 55% or no control

— = not applicable or no local data available + = upper end of rating scale

Herbicide[1]	Site of Action Number	Brome, Downy	Burdock, Common	Chickweed[2]	Dandelion	Dock, Curly	Evening Primrose, Cutleaf	Field Violet/Pansy	Fleabanes, Annual	Foxtail, spp.	Garlic, Wild	Geranium, Carolina	Groundsel, common[3]	Hemp, Dogbane, Dewberry, Milkweed, etc.	Henbit/Deadnettle	Horseweed/Marestail[2,3]	Lambsquarters	Mustards spp.	Quackgrass Sod	Ragweed, Common[2]	Smartweed	Thistle, Canada
2,4 (spring-applied) (1 lb ae/a)	4	N	7	6	8	7	**9**	6	7	N	7	–	6	N	N	**8+**	**9**	**9**	N	**9**	7	8
Dicamba (spring-applied) (0.5 lb ae/a)[4]	4	N	7	6	7	8	8	6	7	N	7	–	6	N	N	**9**	**9+**	6	N	**9**	8	8

Table 5.46 - Relative Effectiveness of "Burndown" Herbicides for Control of Weeds in No-Till Full-Season Soybeans (cont.)

Herbicide[1]	Site of Action Number	Brome, Downy	Burdock, Common	Chickweed[2]	Dandelion	Dock, Curly	Evening Primrose, Cutleaf	Field Violet/Pansy	Fleabanes, Annual	Foxtail, spp.	Garlic, Wild	Geranium, Carolina	Groundsel, Common[3]	Hemp, Dogbane, Dewberry, Milkweed, etc.	Henbit/Deadnettle	Horseweed/Marestail[2,3]	Lambsquarters	Mustards spp.	Quackgrass Sod	Ragweed, Common[2]	Smartweed	Thistle, Canada
Elevore	4	N	–	N	–	N	N	N	–	N	6	–	–	–	**8**	**9**	**9**	6	N	**9**	–	6
Glyphosate (fall-applied)[3]	9	**9**	**8+**	**9**	**9**	7	7	7	8	–	**9**	8	**9**	**8+**	**8**	**8+**[3]	–	**9**	**9**	–	–	**9**
Glyphosate (spring-applied)[3]	9	**9**	7	**9**	6	6	6	6	7+	**9+**	8	**7**	**9**	7	6	8[3]	**9**	8	8	**9**	7	8
Glyphosate + 2,4-D or dicamba (fall-applied)[3]	9/4	**9**	**9+**	**9**	**9**	7	**9+**	7	**9**[6]	–	**9**	8	**9**	**9**	**8+**[5]	**9+**[3]	–	**9**[4]	**9**	–	–	**9+**
Glyphosate + 2,4-D or dicamba (spring-applied)[3]	9/4	**9**	7+	**9**	8	7	**9**	7+	8	**9+**	8	**7**	**9**	7+	**8+**	**9**[3]	**9**	**9**	**9**	**9**	**8+**	**8+**
Glyphosate + Metribuzin	9/5	**9**	7	**9**	6	6	6	8	8	**9**	8	**7**	**9**	7	**8+**	**8+**	**9**	**9**	**9**	**9**	**9**	8
Gramoxone	22	7	N	**8+**	N	N	7	8	6	**9**	6	**8**	**8+**	6	7	7	8	8	6	8	7	6
Gramoxone + 2,4-D or dicamba[3]	22/4	7	7	**9**	7	7	**9**	**8+**	7	**9**	**7**	**8**	**8+**	6	8	**8+**	**9**	**9**	6	**9**	**8+**	8
Gramoxone + Metribuzin	22/5	7	6	**9**	N	N	8	8	6	**9**	**6**	**9**	**8+**	6	8	8	8	**8+**	6	**9**	**9+**	6
Harmony Extra	2/2	N	6	**9**[2]	6	8	7	N	N	N	**8+**	**–**	**9**	6	8	7+	**9**	**9**	N	6[2]	**9+**	8
Liberty	10	6	6	8	6	–	–	N	8	8	–	–	7	N	6	8	8	8	6	8	8	6
Sharpen	14	N	N	6	7	–	N	N	7+	N	–	–	8	N	6	8	8	8	N	8	8	6
Sharpen + glyphosate	14/9	**9**	7	**9**	8	**–**	6	6	8	**9+**	**–**	**–**	**9**	7	6	**9**	**9**	**9**	8	**9**	**9**	8
Valor	14	–	N	**9**	7[5]	N	6	**8+**	N	N	–	–	7	N	7	6	**9**	8	N	7	7	N

[1] See Table 5.4 (generics table) for additional herbicides that contain these active ingredients.

[2] Harmony Extra will not control ALS (group 2) resistant chickweed, horseweed/marestail, or common ragweed.

[3] Roundup and other glyphosate products are not effective on glyphosate-resistant horseweed biotypes.

[4] Ratings based on dicamba rate (0.5 lb ae/a) for dicamba resistant soybeans.

[5] Activity is reduced if applied in certain tank-mixes, Roundup and other glyphosate products with photosynthesis inhibitors such as triazine herbicides, or 2,4-D/dicamba with Gramoxone. May still be tank-mixed for convenience, but burndown is improved if applied separately.

[6] Based on control in early spring. Emergence of seedlings in the spring will reduce full-season control.

[7] Valor provides control of germinating dandelion seedling; however, it is weak on dandelion when applied POST.

Table 5.47 - Relative Effectiveness of Herbicides for Control of Common Cash or Cover Crops in the Spring before Planting Soybeans

Cover cropcontrol rating: 10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65%
N = less than 55% or no control + = upper end of rating scale

Herbicide	Rate (lb ai/acre)[1]	Alfalfa[2]	Bluegrass/ Timothy[2]	Bromegrass/ Orchardgrass/ Fescue[2]	Clover, Crimson	Clover, Red[2]	Clover, White	Mustards/ Radish/ Rapeseed	Ryegrass, Annual	Rye, Cereal	Wheat, Winter	Vetch, Hairy
2,4-D ester	0.5	7+	N	N	7	8	6	7+	N	N	N	**9**
	1	8	N	N	8	**9**	7	**8+**	N	N	N	**10**
dicamba	0.5	**9**	N	N	8	**9**	**9**	**8+**	N	**N**	**N**	**9**
Glyphosate	0.75	6	**9**	8	8	7	6	6	8	**9**	**9**	7
	1.5	7	**9+**	**8+**	**8+**	7+	7	7+	9	**9**	**9**	8
Glyphosate +2,4-D ester	0.75 + 0.5	**8+**	**9**	8	**9**	8	8	8	8	**9**	**9**	**10**
Glyphosate + dicamba	0.75 + 0.5	**9**	**9**	8	**9**	**9**	**9**	7	8	**9**	**9**	**10**
Paraquat	0.5	N	7	6	8	7	7	7	6	7	8	7
	0.75	N	7+	7	**9**	8	7	8	6	8	**8+**	8
Paraquat + 2,4-D	0.75 + 0.5	7+	**7**	6	**9**	**8+**	7	8	6	8	**8+**	**10**
Paraquat + dicamba	0.75 + 0.5	**9**	7	6	**10**	**8+**	8	**8+**	7	8	**8+**	**10**
Paraquat + metribuzin	0.5 + 0.25	7	**9**	8	**10**	**8+**	8	**8+**	7	**8+**	**8+**	**9**

[1] 0.75 lb Glyphosate = 32 fl. oz of a 41% glyphosate; 0.5 lb paraquat = 2 pt Gramoxone SL; see Table 5.2 (glyphosate table) for more information on glyphosate formulations.

[2] Application in the fall can improve control with some herbicides.

Table 5.48 - Comments on "Burndown" Herbicides for No-till Soybeans

In no-till situations, "burndown" herbicides may be required to control weeds or cover crops present at time of application. See appropriate tables for relative effectiveness of "burndown" herbicides.

Fall applications are one strategy to manage difficult-to-control winter annuals. Winter annuals are more susceptible in the fall because they are (1) smaller; (2) have not been stressed by cold weather; and (3) air and soil temperatures are higher than in early spring so plants are "actively" growing. However, many species may have a prolonged germination period and seedlings could emerge after a fall application. There has been interest in including a residual herbicide with the non-selective to reduce the likelihood of weed emergence. Products labeled for this use are:

Authority First	Authority XL	Autumn Super	Canopy EX
Envive	Fierce XLT	Gangster	Valor XLT

Refer to product label for rates and precautions for fall applications. Note, many of these products have rotational restrictions that require only soybeans can be planted in the spring after fall applications.

University of Delaware and University of Maryland research has not found a residual herbicide that will consistently provide residual control over the winter and early spring, as most fields will still require an additional "burndown" application before planting. Furthermore, this approach leaves the soil surface bare over the winter and early spring months and therefore exposed to wind and water erosion.

Residual Herbicides That Can Enhance Pre-Plant Burndown Control

Products containing cloransulam (FirstRate), chlorimuron (Classic), and thifensulfuron (Harmony) have some activity on emerged broadleaf weeds and can improve pre-plant burndown control. However, these products will not control ALS-resistant biotypes. When using a herbicide with one of these active ingredients as part of a burndown program, use full-labeled rates, follow label recommendations for adjuvants, and apply to small, actively growing weeds. If relying on these herbicides to provide residual weed control, applications should be made within 7 to 10 days of planting.

Prepackage mixtures containing these specific active ingredients include:

Table 5.48 - Comments for "Burndown" Herbicides for No-Till Soybean (cont.)

cloransulam (FirstRate)	chlorimuron (Classic)	thifensulfuron (Harmony)	flumioxazin (Valor)
Authority First	Authority XL	Afforia	Afforia
Gangster	Canopy DF/Blend	Canopy EX	Envive
Sonic	Canopy EX	Envive	Fierce
Surveil	Envive	Synchrony	Fierce XLT
	Fierce XLT		Gangster
	Synchrony XP		Surveil
	Trivence		Trivence

Table 5.48 - Comments for "Burndown" Herbicides for No-Till Soybean (cont.)

Trade Name	Common Name	Site of Action Number	Product/A	lb ai/A
2,4-D 4L formulations ** (many trade names)	**2.4-D**	**4**	**0.5–2.0 pt**	**0.25–1.0 lb ae**

- For spring applications, the 1 qt rate of 2,4-D has been more effective and more consistent than lower rates. Applications made 30 days preplant have been more effective on horseweed than applications made 14 days preplant.
- Apply 2,4-D ester (LVE) at 1 qt at least 30 days before planting, 1 pt or less at least 7 days ahead of planting or up to 2 pt at least 30 days before planting; some LVE formulations allow a 15-day interval between application and planting soybean (i.e. Salvo, Shredder E-99, Weedone 650).
- 2,4-D amine at 1 qt should be applied 30 days before planting and at 1 pt or less at least 15 days ahead of planting.
- Add 2,4-D to paraquat or glyphosate for added burndown of hard to control broadleaf weeds.
- Use 2,4-D for added control or suppression of mustard spp., plantains, horseweed, and 2,4-D susceptible annual broadleaf weeds.
- Do not apply 2,4-D prior to planting soybeans if you are not prepared to accept the results of soybean injury, including possible loss of stand and yield.
- **The risk of injuring sensitive plants via off-target movement is much less when these products are used early burndown prior to planting full-season soybean in the spring compared to burndown applications prior to planting double-crop soybean during the summer months.**
- **Spray droplet size plays an important role in minimizing off-target movement. Nozzles that produce extremely coarse or ultra coarse droplets while limiting the amount of driftable fine droplets are necessary to limit spray drift. Consult labels for approved nozzles.**
- **2,4-D can be difficult to completely remove from spray equipment and residue is capable of injuring sensitive plants. Follow label instructions concerning sprayer cleanout.**
- **Cotton, grapes, pepper, sweetpotato, tobacco, tomato, watermelon, and many other crops are very sensitive to 2,4-D. Follow application instructions on label to avoid injuring neighboring plants.**
- **See labels for details on drift management, including recommended nozzles and pressures, wind speed, boom height, temperature inversions, buffers, susceptible plants, and spray equipment cleanout.**

Table 5.48 - Comments for "Burndown" Herbicides for No-Till Soybean (cont.)

Trade Name	Common Name	Site of Action Number	Product/A	lb ai/A
Banvel 4S	**dicamba DMA Salt**			**0.5–1 pt**
Clarity 4S	**dicamba DGA Salt**			**0.5–1pt**
Engenia 5S	**dicamba BAPMA Salt**	**4**		**6.4–12.8 fl oz**
Xtendimax 2.9S/ FeXapan	**dicamba DGA Salt with VaporGrip**			**11–22 fl oz**

- Applications made 30 days preplant have been more effective on horseweed than applications made 14 days preplant.
- Apply Banvel at least 30 days before planting. Following application of Clarity, Engenia, FeXapan, and XtendiMax and a minimum accumulation of 1 inch of rainfall or overhead irrigation, wait at least 14 days before planting for 0.25 lb ae per acre or less and 28 days for 0.5 lb ae per acre. Do not apply dicamba prior to planting soybeans if you are not prepared to accept the results of soybean injury, including the possible loss of stand and yield.
- Engenia, FeXapan, and XtendiMax may be applied through planting of Xtend soybean varieties only. See **Engeniatankmix.com, xtendimaxapplicationrequirements.com**, and **www.fexapanapplicationrequirements.dupont.com** for approved adjuvants, drift reduction agents, nozzles, and other tank mixes.
- Add dicamba to paraquat or glyphosate for added burndown of hard-to-control broadleaf weeds.
- Use dicamba for added control of horseweed and dicamba-susceptible annual broadleaf weeds.
- Dicamba has little to no activity on mustard species including rapeseed and is not recommended for control of these weeds, even when tank-mixed with glyphosate.
- The risk of injuring sensitive plants via off-target movement is much less when these products are used early burndown or prior to planting full-season soybean in the spring compared to burndown applications prior to planting double-crop soybean during the summer months.
- Spray droplet size plays an important role in minimizing off-target movement. Nozzles that produce extremely coarse or ultra-coarse droplets while limiting the amount of driftable fine droplets are necessary to limit spray drift. Consult labels for approved nozzles.
- Dicamba can be difficult to completely remove from spray equipment and residue is capable of injuring sensitive plants. Follow label instructions concerning sprayer cleanout.
- Cotton, grapes, lima bean, pea, pepper, snap bean, soybean, sweet potato, tobacco, tomato, watermelon, and many other crops are very sensitive to dicamba. Follow application instructions on label to avoid injuring neighboring plants.
- See federal and supplemental labels for details on drift management, including recommended nozzles and pressures, wind speed, boom height, temperature inversions, buffers, susceptible plants, and spray equipment cleanout.
- *Water quality advisory.*
- Engenia, Xtendimax, and FeXapan are *restricted use pesticides.*

Canopy 75DF	**chlorimuron +**		**4–8 oz**	**0.026–0.053**
Canopy Blend 58.3DG	**metribuzin**	**2 + 5**	**5–9 oz**	**0.16–0.32**

- Metribuzin will enhance the activity of paraquat or glufosinate when used as a tankmixture for burndown weed control.
- See comments in preemergence section.

	chlorimuron +			**0.016–0.047**
Canopy EX 29.5DG	**tribenuron**	**2**	**1.1–3.3 oz**	**0.0047–0.013**

- Apply with glyphosate or Gramoxone to no-till fields, any time after harvest in the fall at 2.2 to 3.3 oz/A up to 14 days before soybean planting, or 1.1 to 2.2 oz/A up to 7 days before soybean planting; consult label for details.
- For best results apply to annual weeds less than 3 inches in height or diameter and perennial weeds less than 6 inches in height or diameter.
- The addition of 1 pint/A of 2,4-D ester is recommended, and is required for some species.
- Applications must include either a crop oil concentrate or a nonionic surfactant. Crop oil concentrate is the required adjuvant unless tank-mixing with a product that precludes its use.
- On soils with pH 7.0 or less, Canopy EX can be applied at rates of 1.5 - 3.3 oz/A., and will provide residual control or suppression of several winter and summer annual weeds through normal planting dates, but will not provide season-long control.

Table 5.48 - Comments for "Burndown" Herbicides for No-Till Soybean (cont.)

Trade Name	Common name	Site of Action Number	product/A	lb ai/A
Elevore	**halauxifen-methyl**	**4**	**1 oz**	**0.004 lb ae**

- Must be applied at least 14 days prior to planting.
- Tank-mix with glyphosate or Gramoxone to improve spectrum of control.
- Use Elevore for marestail/horseweed control.

Glyphosate[1]	**glyphosate**	**9**	**varies by formulation and acid equivalent**	**0.36–3 lb ae**

- Fall applications of glyphosate are better than spring applications for control of orchardgrass sods and quackgrass. Spring applications of may be used to control annual weeds. For control of most annual weeds, apply 0.75–1.13 lb ae/acre.
- Glyphosate may be applied in clear liquid nitrogen fertilizers and clear liquid complete-analysis fertilizers. Do not use glyphosate with suspension-type liquid fertilizers.
- Use rates vary by product, formulation, and weed size. Higher rates are usually recommended for annual weeds taller than 6 inches.
- To aid in the control of marestail/horseweed, mustard species, common lambsquarters, common ragweed, and other emerged, susceptible broadleaf weeds, 2,4-D or dicamba may be added.
- Glyphosate is available in some pre-packaged mixtures, but glyphosate rate may not be adequate for "burndown" control.

[1]Consult specific product label for active ingredient concentration and application rate; various formulations of this herbicide are available (e.g., 1 qt/A glyphosate = 22 fl oz/A WeatherMax).

Gramoxone SL	**paraquat**	**22**	**2.0–4.0 pt**	**0.48–1.0**

- Use appropriate precautions when handling paraquat to minimize exposure to the herbicide.
- Apply in 20 to 60 gallons of water per acre; increase gallonage as density of stubble, crop residue or weeds increases.
- Rate is dependent on weed size (see label). Paraquat may not control weeds taller than 6 inches.
- 2,4-D at 0.5-0.75 pint per acre may be added to this program for additional control of marestail (horseweed), common lambsquarters, common ragweed, and other emerged, susceptible broadleaf weeds.
- Phosphate-containing liquid fertilizers diminish paraquat activity.
- The addition of metribuzin will improve overall control with paraquat (this includes Glory, TriCor, Boundary, Canopy, Trivence, and Authority MTZ).
- *Restricted Use Pesticide.*

Liberty 280 2.34 SL	**glufosinate**	**10**	**32–43 oz**	**0.53–0.66**

- Liberty 280 may be applied as a burndown treatment prior to the planting or emergence of any soybean variety.
- Apply a minimum of 32 fl oz/A to young, actively growing weeds; burndown and in-crop applications may not exceed 87 fl oz/A per season.
- Warm temperatures, high humidity, and bright sunlight improve the performance of Liberty 280. Weed control may be reduced when applications are made to weeds under stress from drought or cool temperatures.
- Liberty 280 performs better as a POST herbicide or burndown for double-cropped soybeans compared to burndown applications in April.
- Liberty 280 must be applied with ammonium sulfate at the rate of 3 lb/A.
- Uniform, thorough spray coverage is necessary to achieve consistent weed control; do not use nozzles that produce large droplets; use at least 15 gal/A, 20 gal/A if dense vegetation is present.

Table 5.48 - Comments for "Burndown" Herbicides for No-Till Soybean (cont.)

Trade Name	Common Name	Site of Action Number	product/A	lb ai/A
Sharpen 2.85SC	**saflufenacil**	**4**	**1.0–2.0 oz**	**0.022–0.044**

- Sharpen may be applied as a burndown treatment from 44 days early preplant through preemergence timings as directed on the label.
- Apply Sharpen in a typical glyphosate or glufosinate burndown herbicide program to increase weed spectrum, including glyphosate-resistant horseweed; 1.5 oz provides more consistent horseweed control than lower rates.
- The label requires use of methylated seed oil (MSO) plus a nitrogen source such as ammonium sulfate (AMS).
- On coarse-textured soils with less than 2% organic matter: a minimum of 30 days between application of 1 to 1.5 oz of Sharpen and soybean planting is required; minimum of 44 days between application of 2.0 oz of Sharpen and soybean planting.
- All other soils: no waiting period of 1 oz of Sharpen in applied; minimum of 14 days between applications of 1.5 oz of Sharpen and planting on all other soil types; and 30 days if 2 oz of Sharpen is used.
- Do not apply during soybean cracking stage or after emergence as severe crop damage will occur. Control of emerged grasses will require adding an additional herbicide.
- Do not apply Sharpen with other Group 14 herbicides such as sulfentrazone or flumioxazin as a tank-mix or sequential application within 30 days or crop injury may result with coarse-textured soils with less than 2% o.m.; and a minimum of 14 days on all other soil types (see label).
- Local research indicate limited residual control with Sharpen at rates and use pattern for soybeans.
- Sharpen is a Group 14 herbicide and due to concerns for long-term viability of this herbicide mode of action, extension specialists in the Mid-Atlantic region recommend not using it every year. This mode of action has greater utility in soybeans than corn and especially for control of glyphosate-resistant horseweed (marestail). As such, we suggest that Sharpen and other saflufenacil-containing products (e.g., Verdict, OpTill) be used in soybean and only in alternate years. The use of Sharpen in continuous corn should also be limited to every other year (alternating years with HPPD-containing herbicide [Group 27]).

Valor SX 51WDG/ Rowel 51WDG	**flumioxazin**	**14**	**1–2.5 oz**	**0.032–0.08 lb**

- Valor may be included in a typical burndown herbicide program to enhance the speed of burndown and increase weed spectrum.
- Valor has fair to good postemergence activity on field pansy/violet.
- Premixes containing Valor: Valor XLT contains chlorimuron (Classic) and can also be used as a PRE/burndown treatment; Fierce XLT is similar to Valor XLT but also contains pyroxasulfone (Zidua); Envive contains chlorimuron (Classic) and thifensulfuron (Harmony); Gangster or Surveil contain (cloransulam (FirstRate).

[1] See Table 5.2 (glyphosate formulations) for information on various formulations of this herbicide.

Table 5.49 - Water Solubility and Longevity of Soil-Applied Herbicides

Solubility (parts per million; ppm): How many microliters of the herbicide will dissolve in 1 liter of water. The less soluble the herbicide, the more moisture (rain or irrigation) is needed to activate the herbicide and move it into the root zone. Solubility is used as a guideline for rainfall or irrigation required within a short time after application. Moisture needed also depends on the soil moisture at time of application.

Relative moisture levels to move herbicide into the soil to achieve optimum level of control.

Relative Moisture to Activate	ppm	Estimate Water to Activate*
Low	>500 ppm (very soluble)	0.33 inch
Medium	250-500 ppm	0.33-0.5 inch
High	100-250 ppm	0.5-0.75 inch
Very High	<100 ppm	>0.75 inch

*More water (additional irrigation) maybe necessary if soil is dry at time of application, soils with higher clay content, or high plant residues are present.

Relative duration of residual control is for comparison only. Based on herbicide half-life (length of time it takes for half the herbicide to break down). Herbicide breakdown results from chemical and/or microbial activity. Since the speed of breakdown is affected by a number of factors including soil pH, soil temperature, and soil moisture, duration can vary for herbicides based on the specific conditions. Residual activity is not the same as herbicide carryover.

Duration of residual control assumes 1) good activation; 2) no excessive rain or irrigation; and 3) weed species are sensitive to the herbicide(s) applied.

Trade Name	Solubility (ppm)	Relative Moisture Amount Required to Activate	Duration of Residual Control
Classic	pH 5: 11 pH 6.5: 450 pH 7: 1,200	Very High Medium Low	4-5 weeks
Command	1,100	Low	2-4 weeks
Dual II Magnum	530	Medium	4-5 weeks
Express	pH 5: 48 >pH 7: >2040	Very High Low	1-2 weeks
FirstRate	pH 5: 3 pH 7: 184	Very High High	2-4 weeks
Harmony SG	pH 5: 223 >pH 7: >2,240	High Low	1-2 weeks
Lorox / Linex	75	Very High	4-5 weeks
Metribuzin	1,200	Low	4-5 weeks
Outlook	1,174	Low	2-4 weeks
Prowl / other pendimethalin formulations	1	Very High	4-5 weeks
Pursuit	1,400	Low	4-6 weeks
Python	5,600	Low	4-6 weeks

Table 5.49 - Water Solubility and Longevity of Soil-Applied Herbicides (cont.)

Trade Name	Solubility (ppm)	Relative Moisture Amount Required to Activate	Duration of Residual Control
Reflex / Flexstar	600,000	Low	2-4 weeks
Sharpen	pH5 : 30	Very High	1-3 weeks
	pH7 : 2100	Low	
Spartan	780	Low	4-6 weeks
Treflan / other formulations	1	Very High	4-5 weeks
Valor SX	2	Very High	4-5 weeks
Warrant	223	Medium	4-5 weeks
Zidua	3.49	Very High	4-5 weeks

Premix	Constituents	Premix	Constituents
Afforia	Valor SX, Harmony SG, Express	Gangster / Surveil	Valor SX, FirstRate
Anthem / Anthem Maxx	Cadet, Zidua	OpTill	Sharpen, Pursuit
Authority First / Sonic	Spartan, FirstRate	Permit Plus	Harmony SG, Sandea
Authority Supreme	Spartan, Zidua	Prefix	Dual, Reflex
Authority MTZ	Spartan, metribuzin	Sequence	Dual, glyphosate
Authority XL	Spartan, Classic	Synchrony XP	Classic, Harmony SG
Boundary	Dual, metribuzin	Trivence	Classic, Valor SX, metribuzin
Canopy DF / Blend	Classic, metribuzin	Valor XLT	Valor SX, Classic
Canopy EX	Classic, Express	Verdict	Sharpen, Outlook
Envive	Classic, Valor SX, Harmony SG	Warrant Ultra	Warrant, Reflex
Fierce	Valor SX, Zidua		

Table 5.50 - Relative Effectiveness of Soil-Applied Herbicides

Ratings are based on labeled application rates for the soil type and timely rainfall or irrigation to incorporate the herbicides. Ratings are also based on weed control 3 to 4 weeks after application. Length of effective control (residual control) beyond 4 weeks after application often declines. Results may differ with variations in soil type, temperature, rainfall, soil moisture, soil organic matter, and soil pH. For ratings on herbicide combinations not listed, see the component parts.

Weed control rating:
10 = 95–100%
9 = 85–95%
8 = 75–85%
7 = 65–75%
6 = 55–65%
N = less than 55% or no control
+ = upper end of rating scale

Crop tolerance:
E = excellent; almost never any crop injury observed
VG = very good; on rare occasion is crop injury observed
G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., seedling depth, seed slit closure, herbicide rate and application timing, adjuvants)
FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often duer to herbicide interactions with environmental conditions
F = fair; some crop injury is commonly observed

Grasses **Trade Name**	**Site of Action Number**	**Barnyard-grass**	**Bermudagrass**	**Broadleaf signalgrass**	**Crabgrass**	**Fall Panicum**	**Foxtails**	**Goosegrass**	**Johnsongrass (Seedling)**	**Johnsongrass (Rhizome)**	**Quackgrass**	**Shattercane**	**Texas panicum**	**Volunteer Corn**	**Wirestem Muhly**	**Yellow Nutsedge**
Command[1]	13	**8+**	6	**9.5**	**8+**	**9**	**9**	**9+**	8	N	7	**7**	8	7	N	N
Dual products	15	**9**	N	8	**9**	**8+**	**9**	**9+**	6	N	N	6	6	N	N	8
Lorox / Linex	7	6	N	N	6	N	N	7	6	N	N	6	N	N	6	6
Metribuzin	5	6	N	N	6	N	N	6	6	N	N	6	N	N	N	6
Outlook	15	**9**	N	**7**	**8+**	**8+**	**9**	**9**	6	N	N	6	6	N	N	7+
Prowl	3	**8+**	N	**9**	**8+**	**9**	**8+**	**9**	7	N	N	7	8	N	N	6
Pursuit	2	8	N	N	7	7	8	–	6	N	N	6	–	6	N	7
Treflan[1]	3	**9**	N	**9**	**9**	**9**	**9**	**9**	8	7	7	8	**8+**	6	N	N
Warrant	15	**8+**	N	7	8	8	**8+**	**8+**	6	N	N	N	N	N	N	6
Zidua	15	**9**	N	**8+**	**9**	**8+**	**9**	**9+**	6	N	N	6	7	N	N	6
Mixtures																
Anthem / Anthem Maxx	14/15	**9**	N	**8+**	**9**	**8+**	**9**	**9+**	6	N	N	6	7	N	N	6
Authority Elite / BroadAxe	14/15	**9**	N	8	**9**	**8+**	**9**	**9+**	6	N	N	6	6	N	N	7
Boundary	5/15	**8+**	N	**7**	**8+**	8	**8+**	**9**	N	N	N	N	N	N	N	7
Canopy DF/ Canopy Blend	2/5	6	N	6	6	N	N	–	N	N	N	8	–	7	N	7
Fierce / Fierce XLT	14/15/(2)	**9**	N	8	**9**	**8+**	**9**	**9+**	6	N	N	6	7	N	N	6
OpTill	2/15	8	N	N	7	7	8	–	6	N	N	8	6	6	N	6
Prefix	14/15	**9**	N	8	**9**	**8+**	**9**	**9+**	6	N	N	6	6	N	N	7+
Warrant Ultra	14/15	**8+**	N	7	8	8	**8+**	**8+**	6	N	N	N	N	N	N	6

[1] Command 4E, Treflan and trifluralin require incorporation; Command 3ME may be applied preemergence and not incorporated.

Table 5.50 - Relative Effectiveness of Soil-Applied Herbicides on Individual Weed Species (cont.)

Broadleaves																		
Trade Names	**Herbicide Group (Mode of Action)**	**Burcucumber**	**Cocklebur**	**Horseweed / Marestail[1]**	**Jimsonweed**	**Lambsquarters[2]**	**Morningglory, Annual**	**Nightshade, Eastern Black**	**Palmer Amaranth / Waterhemp[1]**	**Pigweed[2]**	**Ragweed, Common[3]**	**Ragweed, Giant**	**Sida, Prickly**	**Smartweed**	**Spurred Anoda**	**Velvetleaf**	**Soybean Tolerance / Med. Soils**	**Soybean Tolerance / Coarse Soils**
Command[4]	13	N	7+	N	**9**	**9+**	N	6	6	6	8	N	**8+**	**8+**	**9+**	**9+**	E	E
Dual products/ Cinch	15	N	N	N	N	6	N	7+	**8+**	8	6	N	N	N	N	N	E	E
FirstRate	2	N	**8+**	**9[2]**	8	**9**	8	N	N	**9[2]**	**9[3]**	8	7	8	**9**	**8+**	E	E
Lorox / Linex	7	N	7+	7	7	**8+**	N	7	7	8	6	N	7+	**9**	N	7	G	FG
Metribuzin	5	6	8	**8+**	8	**9**	N	N	**9**	**8+**	7	N	**8+**	**9**	7	8	G	FG
Outlook	15	N	N	N	N	6	N	7+	8	8	6	N	N	6	N	N	VG	VG
Prowl	3	N	N	N	6	**9**	N	N	8	8	N	N	N	8	N	**8+**	VG	G
Pursuit	2	6	8	–	8	8	7	8	N	**9[2]**	7+[3]	6	8	**9**	–	8	VG	VG
Reflex	14	N	8	N	8	8	7	8	**9**	**9**	**9**	6	7	7	N	6	E	VG
Spartan	1	N	N	**8+**	6	**8+**	**9**	8	**9**	**9**	7	6	6	7	–	8	VG	VG
Treflan[4]	3	N	N	N	N	**9**	N	N	**9**	**9**	N	N	N	6	N	7+	E	E
Valor	14	N	6	**8+**	8	**9**	7+	**9**	**9**	**9**	7+	6	8	7	8	7	VG	G
Warrant	15	N	N	N	N	6	N	7	8	8	6	N	N	N	N	N	VG	G
Zidua	15	N	N	N	7	8	N	8	**9**	**9**	7	6	6	7	N	6	VG	VG
Mixtures																		
Afforia	2/2/14	N	6	**8+**	8	**9**	7+	**9**	**9**	**9**	8	7	8	7	8	7	G	FG
Anthem/ Anthem Maxx	14/15	N	N	N	7	8	N	8	**9**	**9**	7	6	6	7	N	6	VG	VG
Authority Elite/ BroadAxe	14/15	N	6	**8+**	6	**9**	8	8	**9**	**9**	7	6	6	7	–	7+	VG	VG
Authority First/ Sonic	2/14	N	8	**8+**	8	**8+**	8	8	**9**	**9**	**8+**	7	7+	7+	**9**	8	VG	VG
Authority MTZ	5/15	6	8	**8+**	**8+**	**9**	8	8	**9**	**9**	8	N	**8+**	**9**	7	8	G	FG
Authority XL	2/14	7	**8+**	**8+**	8	**8+**	**9**	8	**9**	**9**	8	6	8	**8+**	8	8	G	FG
Boundary	5/15	N	7+	N	7+	**8+**	N	6	**8+**	**8+**	7	N	**8+**	**8+**	7	7	G	G
Canopy DF/ Canopy Blend	2/5	7	**9**	**8+**	**9**	**9**	7+	6	**9**	**9+**	7+	8	**9**	**9**	8	**9**	FG	F
Envive	2/2/14	7	**8+**	**8+**	**9**	**9**	7+	**9**	**9**	**9**	8	7	**8+**	**8+**	8	**8+**	G	F
Fierce	14/15	N	6	**8+**	8	**9**	7+	**9**	**9**	**9**	7	6	8	7	8	7	G	F
Fierce XLT	2/14/15	7	**8+**	**8+**	**9**	**9**	8	**9**	**9**	**9**	8	8	**8+**	**8+**	8	**8+**	G	F

Table 5.50 - Relative Effectiveness of Soil-Applied Herbicides on Individual Weed Species (cont.)

Broadleaves Trade Names	Herbicide Group (Mode of Action)	Burcucumber	Cocklebur	Horseweed / Marestail[1]	Jimsonweed	Lambsquarters[2]	Morningglory, Annual	Nightshade, Eastern Black	Palmer Amaranth / Waterhemp[1]	Pigweed[2]	Ragweed, Common[3]	Ragweed, Giant	Sida, Prickly	Smartweed	Spurred Anoda	Velvetleaf	Soybean Tolerance / Med. Soils	Soybean Tolerance / Coarse Soils
Gangster (co-pack)/ Surveil	2/14	N	**8+**	**8+**	8	**9**	8	**9**	**9**	**9**	**9**	8	8	8	8	**8+**	G	F
OpTill	2/14	6	8	6	8	**9**	7	8	**9**	**9**	7+	6	8	**9**	–	**8**	G	G-F
Prefix	14/15	N	N	N	8	8	6	7+	8	8	7+	6	7	7	N	6	E	VG
Trivence	2/5/14	7	**9**	**8+**	**9**	**9**	8	**9**	**9**	**9**	8	7	**9**	**9**	8	**9**	G	F
Valor XLT	2/14	7	**8+**	**8+**	**9**	**9**	7+	**9**	**9**	**9**	8	7	**8+**	**8+**	8	**8+**	G	F
Warrant Ultra	14/15	N	N	N	**8**	**8**	6	7+	8	8	7+	6	7	7	N	6	VG	G

See Table 5.4 (generics table) for additional herbicides that contain these active ingredients

[1] Biotypes resistant to Group 2 herbicides are common in the region; do not rely on Group 2 herbicides to provide effective control.

[2] Triazine-resistant (Group 5) lambsquarters and pigweed are common in the region; metribuzin will not control these biotypes.

[3] Common ragweed biotypes resistant to Group 2 herbicides have been confirmed in Delaware, Maryland, New Jersey, and Virginia.

[4] Command 4E, Treflan, and trifluralin require incorporation; Command 3ME may be applied preemergence and not incorporated.

Table 5.51 - Comments on Preplant or Preemergence Herbicides for Conventional, Minimum, or No-Till Soybeans.

See specific product label to determine correct rate for soil type, tillage practices, and weed species found in each field.

Mechanical incorporation reduces the need for timely rainfall after application and may improve control of certain weeds. Mechanical incorporation will improve weed control when no rainfall or irrigation occurs within 7 to 10 days after planting.

In no-till situations, “burndown” herbicides may be required to control weeds or cover crops present at time of application.

EPP= early preplant means application at least 7 days prior to plant; PPI= applied to conventionally tilled soil than mechanically incorporated; PRE= preemergence (applied before the crop has emerged).

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Anthem 2.15SC **Anthem Maxx 4.3SC**	**pyroxasulfone +** **fluthiacet**	**15** **14**	**EPP, PPI, or PRE**	**5–11 oz** **2–5.5 oz**	**0.081–0.179** **0.04–0.088**

- Fluthiacet (Cadet) does not provide any residual weed control.
- See Zidua entry for details.

Table 5.51 - Comments on Preplant or Preemergence Herbicides for Conventional, Minimum, or No-Till Soybeans (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Authority products	**sulfentrazone**	**14**	**EPP, PPI, or PRE**	**varies**	**0.132–0.309**

- Spartan contains the single active ingredient sulfentrazone, but products that include sulfentrazone are branded as "Authority"; several premixed products contain sulfentrazone (Authority/Spartan).
- Each of these products contains different active ingredients and/or ratios. See various tables in this guide and product labels for additional details about these products.
- Rates are based on region, soil type, and soil organic matter. Applications made after soil-cracking occurs or crop emergence will result in severe crop injury; soybean stunting may occur if excessive rainfall occurs after application but before soybeans emerge.
- Sulfentrazone provides good control of yellow nutsedge.
- Observe labeled rotational crop restrictions for all products containing sulfentrazone.
- Sulfentrazone becomes more available when soil pH exceeds 7.0, increasing the risk of soybean injury.
- Refer to label regarding applications with/or in sequence with Sharpen and other group 14 herbicides.
- Products that contain sulfentrazone include: Authority Assist (Authority + Pursuit), Authority Elite/BroadAxe (Authority + Dual), Authority First/Sonic (Authority + FirstRate), Authority MTZ (Authority + metribuzin), Authority Supreme (Authority + Zidua), Authority XL/Maxx (Authority + Classic), and Spartan Charge (Authority + Aim).
- *Water quality advisory.*

Authority Elite 7E or BroadAxe XC	**sulfentrazone + S-metolachlor**	**14 15**	**EPP, PPI, or PRE**	**19.0 – 38.7 fl oz**	**0.104–0.153 0.94–1.87**

- Authority Elite and BroadAxe XC are the same products.
- See Dual and Authority entries for comments.
- *Water quality advisory.*

Authority First 70DF / Sonic	**sulfentrazone + cloransulam**	**14 2**	**EPP, PPI, or PRE**	**6.45 – 8 oz**	**0.25–0.31 0.032–0.04**

- Authority First and Sonic are identical products.
- See entries for FirstRate and Authority for more comments.

Authority MTZ 45WDG	**sulfentrazone + metribuzin**	**14 5**	**EPP, PPI, or PRE**	**12 – 18 oz**	**0.135–0.202 0.202–0.304**

- See Authority and metribuzin entry for comments.
- *Water quality advisory.*

Authority Supreme 4.16SC	**sulfentrazone pyroxasulfone**	**14 15**	**EPP, PPI, or PRE**	**6 – 11.5 fl oz**	**0.098–0.187 0.098–0.187**

- See ntries for Authority and Zidua for more comments.
- *Water quality advisory.*

Authority XL 70WG	**sulfentrazone + chlorimuron**	**14 2**	**EPP, PPI, or PRE**	**3.0 – 9.0 oz**	**0.116–0.347 0.015–0.045**

- Authority XL is a premix of Authority (sulfentrazone) + Classic (chlorimuron) and can be used as a burndown and/or preemergence application.
- For burndown, Authority XL may be tankmixed with glyphosate, Gramoxone, or 2,4D plus COC or MSO to increase activity.
- See Authority entry for additional comments.

Table 5.51 - Comments on Preplant or Preemergence Herbicides for Conventional, Minimum, or No-Till Soybeans (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Boundary 6.5EC	**S-metolachlor + metribuzin**	**15 5**	**EPP, PPI, or PRE**	**1.2–3 pt**	**0.74–1.9 0.188–0.469**

- See metribuzin and Dual entry for comments.
- The amount of Dual in this premix is low compared to amount recommended when applied by itself.
- *Water quality advisory.*

Canopy 75DF Canopy Blend 58.3 WDG	**chlorimuron + metribuzin**	**2 5**	**EPP, PPI, or PRE**	**4.0–7.0 oz 5.1–9.0 oz**	**0.027–0.047 0.16–0.28**

- Apply prior to soybean emergence. Do not use on sand or any soil with less than 0.5% organic matter
- Do not apply more than 2.25 oz/A if soil pH is 7.0 or higher.
- Observe rotational crop restrictions. Do not use on soils with a pH greater than 6.8, or carryover injury may result the following year.
- Observe labeled rotational crop restrictions for all products containing chlorimuron (Classic).
- Adding chlorimuron to metribuzin improves control of common ragweed, cocklebur, velvetleaf, jimsonweed, and annual morningglory.
- *Water quality advisory.*

Command 3ME	**clomazone**	**13**	**EPP or PRE**	**1.33–2.67 pt**	**0.5–1.0**

- Command 3ME must be used as a preemergence soil-applied treatment without incorporation.
- Do not apply within 1,200 feet of towns; residential areas; commercial fruit, nut, or vegetable production; or commercial greenhouses or nurseries.
- Do not apply during temperature inversions or when wind speed is greater than 10 mph. Apply in a minimum spray volume of 10 gal/A. Use coarse sprays to reduce drift.
- Observe labeled rotational crop restrictions.

Dual II Magnum 7.62EC	**S-metolachlor**	**15**	**EPP, PPI, or PRE**	**1.0–2.0 pt**	**0.95–1.9**

- Dual and Cinch are similar in activity to Outlook, Zidua, and Warrant. Dual II Magnum contains a crop safening agent for corn.
- For early preplant applications or fields with heavy surface plant residue, Dual rate may need to be increased by up to 20%.
- Incorporation improves control of yellow nutsedge.
- Dual can be applied after soybean emergence, but Dual will not control emerged weeds.
- *Water quality advisory.*

Table 5.51 - Comments on Preplant or Preemergence Herbicides for Conventional, Minimum, or No-Till Soybeans (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Envive 41.3DG	**flumioxazin + chlorimuron + thifensulfuron**	**14 2 2**	**EPP or PRE**	**2.5–5.3 oz /A**	**0.044–0.094 0.015–0.031 0.004–0.009**

- Do not mechanically incorporate into the soil after application.
- Can be tank-mixed with products such as Command or pendimethalin for improved grass control.
- Envive label allows tank-mixes with group 15 herbicides if soybeans are planted no-till into wheat or corn stubble.
- Do not apply if soybeans have begun to emerge.
- Products containing flumioxazin have specific tank-cleaning instructions on the label or in technical bulletins to help avoid contaminant injury from spray tank residues.
- Envive can to provide some burndown and residual weed control when applied 2 weeks before planting up to 3 days after planting (before soybean emergence), but often needs to be tank-mixed with glyphosate and/or 2,4-D to achieve complete burndown.
- Refer to label regarding applications with/or in sequence with Sharpen and other group 14 herbicides.
- See Valor entry for more information.

Fierce 76WDG	**pyroxasulfone + flumioxazin**	**15 14**	**EPP or PRE**	**3–3.75 oz**	**0.08–0.13 0.063–0.105**
Fierce XLT 62.41WDG	**pyroxasulfone + flumioxazin+ chlorimuron**	**15 14 2**	**EPP or PRE**	**3.75–5.25 oz**	**0.073–0.102 0.057–0.08 0.016–0.022**

- See Zidua and Valor entry for comments.
- Fierce XLT improves morningglory control compared to Fierce due to addition of chlorimuron.
- Products containing flumioxazin have specific tank-cleaning instructions on the label or in technical bulletins to help avoid contaminant injury from spray tank residues.
- *Water quality advisory.*

FirstRate 84WDG	**cloransulam**	**2**	**EPP, PPI, or PRE**	**0.6–0.75 oz**	**0.031–0.039**

- Cloransulam provides good control of several annual broadleaves including common lambsquarters, pigweed, common ragweed, velvetleaf, and cocklebur. Common ragweed is commonly resistant to FirstRate and other group 2 herbicides in the region.
- FirstRate water-dispersible packets are not soluble in liquid fertilizer solutions; premixing in water is required.
- Gangster and Surveil are copacks that contain flumioxazin (Valor) and cloransulam (FirstRate).
- Gangster/Surveil can be applied as a fall (after October 15) or spring preplant treatment or preemergence.
- *Water quality advisory.*

Gangster / Surveil (co-pack) / Surveil 48WDG	**flumioxazin + cloransulam**	**14 2**	**EPP or PRE**	**2.5–3.0 oz 0.5–0.6 oz /3.5–4.2 oz**	**0.08–0.096 0.026–0.031**

- Gangster and Surveil are co-packs that contain flumioxazin (Valor) and cloransulam (FirstRate); Surveil 48WDG is a single product containing both active ingredients.
- Do not mechanically incorporate.
- Products containing flumioxazin have specific tank-cleaning instructions on the label or in technical bulletins to help avoid contaminant injury from spray tank residues.
- See FirstRate and Valor entries for more comments.
- *Water quality advisory*

Table 5.51 - Comments on Preplant or Preemergence Herbicides for Conventional, Minimum, or No-Till Soybeans (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Lorox 50DF / Linex 4L	**linuron**	**7**	**EPP or PRE**	**0.75–2.0 lb 1 to 2 pt**	**0.38–1.0**

- Do not mechanically incorporate.
- Do not use on sands or loamy sands, or on soils with less than 0.5% organic matter.
- Do not apply after soybean emergence.
- Provide good agitation in tank before and during application.
- Follow labeled directions regarding soybean planting depth.
- Do not plant any crop not on label within 4 months of application.

Metribuzin 75DF	**metribuzin**	**5**	**EPP, PPI, or PRE**	**4–8 oz**	**0.2–0.4**

- Do not use on sands or loamy sands or on soils with less than 0.5% organic matter, or crop injury may result. If used on coarse textured soils with less than 2% organic matter or if heavy rainfall follows soon after application, severe stand losses can occur.
- Rates on coarse-textured soils in lower portion of the Eastern Shore and Delaware should be no more than 4 oz.
- Soybean varieties have different levels of tolerance to metribuzin; refer to product label for list of susceptible varieties.
- Do not apply after soybean emergence.
- Metribuzin is a triazine (Group 5) herbicide and does not control triazine-resistant weeds.
- Potential for crop injury may increase if atrazine was used the previous year due to the additive effect of residual atrazine and metribuzin.
- Plant at least 1.5 inches deep.
- *Water quality advisory.*

OpTill 68WG	**saflufenacil + imazethapyr**	**14 2**	**EPP or PRE**	**2.0 oz**	**0.022 0.063**

- On coarse-textured soils with less than 2% organic matter, a minimum of 30 days between application of OpTill or OpTill PRO and soybean planting is required.
- OpTill or OpTill PRO may be applied as a preplant burndown application from early spring through preemergence; do not apply if soil cracking has begun or soybeans have emerged.
- In a burndown program it is best to include glyphosate or glufosinate in addition to the necessary adjuvants (COC or MSO plus AMS or nitrogen solution) to improve control of emerged weeds, including horseweed.
- Do not apply OpTill (PRO) with any other Group 14 herbicide (flumioxazin, sulfentrazone, fomesafen) as a tankmix or sequential application within 30 days, or crop injury may result.
- Postemergence herbicides containing a Group 14 herbicide (Reflex or Flexstar GT) can be applied 14 days after soybean emergence.
- An additional 0.5 oz of Sharpen can be tankmixed with OpTill, but an additional 14 days is required between application and planting (additional Sharpen is not allowed with OpTill PRO).
- Outlook at 10 fl oz is lower than recommended rates for medium and fine textured soils.

Table 5.51 - Comments on Preplant or Preemergence Herbicides for Conventional, Minimum, or No-Till Soybeans (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Outlook 6.0EC	**dimethenamid**	**15**	**EPP, PPI, or PRE**	**10–21 fl oz**	**0.47–0.98**

- Outlook is similar in activity to Dual, Zidua, and Warrant.
- For early preplant applications or fields with heavy surface plant residue, increase Outlook rate by 1–2 fl oz/A.
- Incorporation improves control of yellow nutsedge.
- Do not exceed a rate of 12 oz/A of Outlook on coarse soils with less than 1.5% organic matter. PPI applications are not recommended on these soils. Outlook will have have very short residual when used on coarse-textured soils.
- Outlook can be applied after soybean emergence (up to 5PthP trifoliate), but Outlook will not control emerged weeds.
- OpTill PRO is a co-pack of OpTill and Outlook.
- *Water quality advisory.*

Prefix 5.3EC	**S-metolachlor + fomesafen**	**15 4**	**EPP, PPI, or PRE**	**2–3 pt**	**0.73–1.1 0.16–0.24**

- Prefix contains S-metolachlor (Dual Magnum) and fomesafen (Reflex) for annual grass, nutsedge, and broadleaf control. The ratio of fomesafen in this product is relatively low, below what is typically recommended for soil-applications.
- In most situations, Prefix provides foundational weed control but will likely need to be followed by additional weed control measures.
- Be cautious of restrictions associated with fomesafen use in consecutive years and use rates that vary across the region. Refer to label for additional use restrictions.
- Prefix followed by sequential applications of Reflex are prohibited; use of fomesafen as a postemergence treatment is preferable to use as a soil-application.
- Refer to label regarding applications with/or in sequence with Sharpen and other group 14 herbicides.

Prowl 3.3E	**pendimethalin**	**3**	**EPP, PPI, or PRE**	**1.2–3.6 pt**	**0.5–1.5**
Prowl H_20 3.8CS	**pendimethalin**	**3**	**EPP, PPI, or PRE**	**2–3 pt**	**0.95–1.4**

- Prowl 3.3E: do not exceed 2.4 pt/A rate when using surface application.
- Under certain environmental conditions, preemergence applications may cause callus tissue development at soil line, resulting in brittle soybean stems and increase incidence of lodging.
- Prowl (all formulations) should be applied pre-plant incorporated (PPI) north of I-80 due to stem callus and possible lodging concerns.
- Do not apply to emerged soybeans.
- Generic EC formulations are available; consult individual labels for rates and restrictions.

Pursuit 2S	**imazethapyr**	**2**	**EPP, PPI, or PRE**	**4 fl oz**	**0.063**

- Adequate soil moisture is necessary for optimum activity.
- Do not plant corn until 8.5 months after application. Consult label for other rotational restrictions. Do not apply products containing chlorimuron during the same season, or injury to rotational crops may result.
- *Water quality advisory.*

Table 5.51 - Comments on Preplant or Preemergence Herbicides for Conventional, Minimum, or No-Till Soybeans (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Python 80WDG	**flumetsulam**	**2**	**EPP or PRE**	**0.8–1.33 oz**	**0.04–0.066**

- Python may be tank mixed with other herbicides to broaden the spectrum of control. Check individual herbicide labels for potential tankmix partners.
- Do not apply where soil pH is greater than 7.8.
- Do not apply to emerged soybeans.
- *Water quality advisory.*

Reflex 2E				**1–1.5 pt**	
	fomesafen	**14**	**EPP or PRE**		**0.25–0.375**
Flexstar 1.88E				**1.06–1.6 pt**	

- Apply Reflex/Flexstar for broadleaf weed control; tank mix with residuals that will improve annual grass activity.
- Be cautious of restrictions associated with fomesafen use in consecutive years and the use rates that vary across the region. Refer to label for additional use restrictions.
- Use of fomesafen as a postemergece treatment is preferable to use as a soil application.
- Refer to label regarding tank-mixtures.
- *Water quality advisory.*

Treflan 4E	**trifluralin**	**3**	**PPI**	**1.0–2.0 pt**	**0.5–1.0**

- Incorporate thoroughly to a depth of 2–3 inches within 24 hours of application. Label recommends twopass incorporation.
- Plant soybeans after early season adverse weather has passed.
- Do not plant deeper than 2 inches.

	chlorimuron +	**2**			**0.014–0.023**
Trivence 61.3WDG	**flumioxazin +**	**14**	**EPP or PRE**	**6.0–10.0 oz**	**0.048–008**
	metribuzin	**5**			**0.169–0.282**

- Do not mechanically incorporate Trivence into the soil after application.
- Do not apply Trivence if beans have begun to emerge.
- Trivence has some burndown activity, but it should be tankmixed with glyphosate or paraquat in most cases.
- Trivence can be tankmixed with products such as Command or pendimethalin for improved grass control. Do not tank-mix Trivence with S-metolachlor (Dual, Boundary) or dimethenamid (Outlook) if application is made within 14 days of planting.
- Splashing soil from irrigation or heavy rainfall may cause injury to newly emerged soybeans. Do not irrigate when soybeans are cracking.
- Products containing flumioxazin have specific tankcleaning instructions on the label or in technical bulletins to help avoid contaminant injury from spray tank residues.
- Refer to label regarding applications with/or in sequence with Sharpen and other Group 14 herbicides.
- See Valor SX entry for additional information and mode of action statement.

Table 5.51 - Comments on Preplant or Preemergence Herbicides for Conventional, Minimum, or No-Till Soybeans (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Valor SX 51WDG Valor EZ 4SC Rowel 51WDG	**flumioxazin**	**14**	**EPP or PRE**	**2.0–2.5 oz 2.0–2.5 fl oz**	**0.063–0.08 oz**

- Valor may be tankmixed with certain herbicides to broaden weed control spectrum.
- Do not use more than 3 oz/A of Valor SX or Valor EZ per season.
- Rate is dependent upon weed species targeted, soil type, and soil organic matter; refer to label.
- Do not mechanically incorporate Valor into the soil after application.
- Do not apply products containing flumioxazin if beans have begun to emerge. Splashing soil from irrigation or heavy rainfall may cause injury to newly emerged soybeans.
- Valor SX or Valor EZ tank-mixed with S-metolachlor (Dual, Boundary) or dimethenamid (Outlook) must be applied a minimum of 14 days prior to planting. Or, Valor SX or Valor EZ may be applied 14 days prior to planting followed by one of these products applied at planting.
- Valor at 1–2.5 oz/A, can enhance the speed of burndown and increase weed spectrum of typical burndown herbicide programs.
- Refer to label regarding applications with, or in sequence, with Sharpen and other group 14 herbicides.
- Gangster and Surveil are copacks that contain flumioxazin (Valor) and cloransulam (FirstRate). Other premix products that contain flumioxazin include Afforia, Envive, Fierce, Fierce XLT, Trivence, and Valor XLT.
- Products containing flumioxazin have specific tank cleaning instructions on the label or in technical bulletins to help avoid contaminant injury from spray tank residues.

Valor XLT 40WDG Rowel FX 40WDG	**flumioxazin + chlorimuron**	**14 + 2**	**EPP or PRE**	**3.0–5.0 oz/A**	**0.056–0.094 0.019–0.032**

- Do not mechanically incorporate into the soil after application.
- Can be tank-mixed with products such as Command or pendimethalin for improved grass control.
- Do not tank-mix Valor XLT with S-metolachlor (Dual, Boundary) or dimethenamid (Outlook) if application is made with 14 days of planting.
- Products containing flumioxazin have specific tank-cleaning instructions on the label or in technical bulletins to help avoid contaminant injury from spray tank residues.
- Refer to label regarding applications with, or in sequence, with Sharpen and other Group 14 herbicides.
- See Valor entry for more information.

Warrant 3CS	**acetochlor**	**15**	**EPP or PRE**	**1.25–2.0 qt**	**0.94–1.5**

- Warrant can be soil applied for residual control of certain annual grasses and broadleaves.
- Warrant can be applied after soybean emergence (up to R2 stage) but will not control emerged weed seedlings.
- Do not mechanically incorporate Warrant prior to planting (PPI).
- Warrant Ultra is a prepackaged mixture of Warrant and Reflex; however, the ratio of fomesafen in this product is relatively low, below what is typically recommended for soil-applications.
- *Water quality advisory.*

Table 5.51 - Comments on Preplant or Preemergence Herbicides for Conventional, Minimum, or No-Till Soybeans (cont.)

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Zidua 85WDG **Zidua 4.17SC**	**pyroxasulfone**	**15**	**EPP, PPI, or PRE**	**1.5–3.5 oz** **2.5–5.75 fl oz**	**0.08–0.186** **0.081–0.187**

- Zidua has annual grass activity similar to Dual, Harness, Outlook, Warrant, etc. but also provides control of several annual broadleaves.
- Zidua can be applied as an early pre-plant application up through planting and then as an early POST application from first to third trifoliate stage. Zidua will not control emerged weed seedlings.
- Must be activated by at least 0.5 inch of rainfall prior to weed germination or effectiveness may be reduced.
- Zidua can be tankmixed with other herbicides to increase the spectrum of control.
- Refer to the labels for rotations restrictions (most vegetables have an 18-month rotational restriction); see Table 5.5 (crop rotation table).
- Fierce is a prepackaged mixture of Zidua and Valor; Fierce XLT is Zidua, Valor, and Classic.

	pyroxasulfone +	**15**			**0.08–0.107**
	imazethapyr +	**2**	**EPP or PRE**	**4.5–6.0 fl oz**	**0.047–0.062**
Zidua PRO 4.09SC	**saflufenacil**	**14**			**0.017–0.023**

- On coarse-textured soils with less than 2% organic matter, a minimum of 30 days between application of Zidua PRO and soybean planting is required.
- Zidua PRO may be applied as a preplant burndown application from early spring through preemergence; do not apply if soil cracking has begun or soybeans have emerged.
- In a burndown program it is best to include glyphosate or glufosinate in addition to the necessary adjuvants (COC or MSO plus AMS or nitrogen solution) to improve control of emerged weeds, including horseweed.
- Do not apply Zidua PRO with any other Group 14 herbicide (flumioxazin, sulfentrazone, fomesafen) as a tank ¬mixture or sequential application within 14 days of planting, or crop injury may result.
- Postemergence herbicides containing a Group 14 herbicide (Reflex or Flexstar GT) can be applied 14 days after soybean emergence.
- Outlook at 10 fl oz is lower than recommended rates for medium- and fine-textured soils.

[1] See Table 5.4 (generics table) for additional herbicides that contain these active ingredients.

Table 5.52 - Soybean Herbicide Preplant or Preemergence Rates Based on Soil Texture and Organic Matter

The herbicide rates presented are for conventionally tilled soils for the given soil texture and organic matter levels. This table shows application rates for products applied alone. Rates may vary if tank-mixed with other products and/or if weed infestations are heavy, or if used in conservation tillage situations. See specific product label for additional information on application rates and uses.

			<3% Organic Matter			≥3% Organic Matter			
Trade Name	**Site of Action**	**Unit/A**	**Coarse**	**Medium**	**Fine**	**Coarse**	**Medium**	**Fine**	**Inc. for No-Till**
Afforia	2, 2, 14	oz	2.5	2.5	2.5	2.5	2.5	2.5	no
Anthem 2.15SE	14, 15	fl oz	6	8	9	6.5	9	10.5	no
Anthem Max 4.3SC	14,15	fl oz	3	4	4.5	3.25	4.5	5.25	no
Authority Elite 7E / BroadAxe XC	14, 15	fl oz	25	28	28	25	28	34	no
Authority First 70WDG or Sonic	2, 14	oz	6.45	6.45	6.45	8.0	8.0	8.0	no
Authority MTZ 45WG	5, 14	oz	12	16	18	14	18	20	no
Authority Supreme 4.16SC	14, 15	fl oz	6–6.9	6–9.8	7–11.5	6.9	7–9.8	8–11.5	no
Authority XL 70WG	2, 14	oz	5.3	7	8	5.3	7.5	8.5	no
Boundary 6.5EC	5, 15	pt	1.25	2	2.5	1.5	2.5	2.75	yes
Canopy 75DF	2, 5	oz	4	5	6	4	5	7	no
Canopy Blend 58.3WDG	2, 5	oz	5.1	6.4	7.75	5.1	6.4	9.0	no
Command 3ME	13	pt	1.25	2	2.67	1.25	2.67	2.67	no
Dual Magnum 7.64EC	15	pt	1.25	1.33	1.33	1.25	1.33	1.67	yes
Envive 41.3WDG	2, 2, 14	oz	3.5	3.5	4	3.5	4	5	no
Fierce 76WDG	14, 15	oz	3	3	3	3	3	3	no
Fierce XLT 62.41WDG	2, 14, 15	oz	4	4	4.75	4	4.5	5	no
FirstRate 84WDG	2	oz	0.6	0.6	0.6	0.75	0.75	0.75	no
Flexstar 1.88E	14	pt	1.3-1.6[1]	1.3-1.6[1]	1.3-1.6[1]	1.3-1.6[1]	1.3-1.6[1]	1.3-1.6[1]	no
Gangster / Surveil (co-pack)	2, 14	oz	3	3.6	3.6	3	3.6	3.6	no
Linex 4L	7	pt	1.25	1.3	1.75	1.5	1.75	2.0	no
Lorox 50DF	7	lb	1.25	1.3	1.75	1.5	1.75	2.0	no
Metribuzin 75DF	5	oz	4	8	10	4	11	12	no
OpTill 68WG	2, 14	oz	2.0	2.0	2.0	2.0	2.0	2.0	no
Outlook 6.0E	15	fl oz	14	16	18	14	16	18	no
Prefix 5.3E	14, 15	pt	2.0	2.25	2.5	2.25	2.5	2.5	yes
Prowl 3.3E	3	pt	1.8	2.4	2.4	1.8	2.4	3	yes
Prowl H_2O 3.8CS	3	pt	1.5	2.0	2.0	1.5	2.0	2.5	yes
Pursuit 2S	2	fl oz	4.0	4.0	4.0	4.0	4.0	4.0	no

Table 5.52 - Soybean Herbicide Preplant or Preemergence Rates Based on Soil Texture and Organic Matter (cont.)

The herbicide rates presented are for conventionally tilled soils for the given soil texture and organic matter levels. This table shows application rates for products applied alone. Rates may vary if tank-mixed with other products and/or if weed infestations are heavy, or if used in conservation tillage situations. See specific product label for additional information on application rates and uses.

		Unit	<3% Organic Matter			≥3% Organic Matter			
Herbicide	**Herbicide group #**		**Coarse**	**Medium**	**Fine**	**Coarse**	**Medium**	**Fine**	**Inc. for No-Till**
Reflex 2E	14	pt	1.25-1.5[1]	1.25-1.5[1]	1.25-1.5[1]	1.25-1.5[1]	1.25-1.5[1]	1.25-1.5[1]	no
Spartan 4F	14	fl oz	6	8	10	8	10	12	no
Surveil 48WG	2, 14	oz	3.5	4.2	4.2	3.5	4.2	4.2	no
Treflan 4E	3	pt	1.0	1.5	2.0	1.5	1.5	2.0	no
Trivence 61.3WDG	2, 5, 14	oz	7	8	8	7	8	8	no
Valor 51WDG / Rowel 51WDG	14	oz	2.5	2.5	2.5	2.5	2.5	2.5	no
Valor XLT 40.3WDG / Rowel FX 40.3 WDG	2, 14	oz	3	3.5	4	3	4	4.5	no
Warrant 3CS	15	qt	1.5	1.5	1.5	1.5	1.5	1.5	no
Warrant Ultra	14, 15	fl oz	48	50	50-60[2]	48	60-70[2]	60-70[2]	no
Zidua 81WDG	15	oz	2	2.5	3	2	2.5	3	no
Zidua SC 4.17SC	15	fl oz	3.3	4.1	4.9	3.3	4.1	4.9	no
Zidua PRO 4.09SC	15, 2, 14	fl oz	6	6	6	6	6	6	no

[1] Do not use on sands or loamy sands or on soils with less than 0.5% organic matter, or crop injury may result. If used on coarse-textured soils with less than 2% organic matter or if heavy rainfall follows soon after application, severe stand losses can occur. Rates on coarse-textured soils should be no more than 4 oz.

[2] Maximum rate depends on the location; refer to label for rates based on area use map.

Table 5.53 - Herbicides Commonly Used after Soybean Emergence (POST)

Comparable residual activity is given for comparison purposes only. The data are based on herbicide half-life, which is the length of time it takes for half the herbicide to break down. Herbicide degradation (break-down) is the result of chemical and/or microbial activity, which can be dependent on soil pH, soil temperature and soil moisture levels. Since degradation is dependent on a number of factors, length of time can vary for herbicides based on the specific environmental conditions. Residual activity is <u>not</u> the same as herbicide carryover. Herbicide rates maybe less with POST applications than PRE so duration of residual control may not be as long.

Postemergence (POST) Activity	
Translocated herbicide	These herbicides move throughout the plant and can cause injury to parts of the plants that are did not come in direct contact with the herbicide spray.
Contact herbicide	These herbicides do not move throughout the plant. They cause injury only to those parts of the plant that comes in contact with the spray. Spray coverage is more critical for contact than translocated herbicides.

Group 1 herbicides only control grass weed species (no activity on yellow nutsedge).

Group 15 herbicides do not control weeds that are emerged at time of application.

Table 5.53 - Herbicides Commonly Used after Soybean Emergence (POST) (cont.)

Residual Activity
none
short= 1 to 2 weeks of residual control
yes= over 2 weeks of residual control

Herbicide Trade Name	Herbicide Group # (site of action)	POST Activity	Residual Activity[1]

Residual Activity
none
short= 1 to 2 weeks of residual control
yes= over 2 weeks of residual control

Trade Name	Site of Action Number	POST Activity	Residual Activity[1]
Assure II / Targa	1	translocated	none
Basagran	6	contact	none
Cadet	14	contact	none
Classic	2	translocated	broadleaf only
Cobra	14	contact	none
Dual Magnum	15	none	yes
Engenia/FeXapan/ Xtendimax	4	translocated	none
FirstRate	2	translocated	yes
Fusilade DX	1	translocated	none
glyphosate	9	translocated	none
halosulfuron	2	translocated	broadleaf only
Harmony SG	2	contact	none
Liberty 280	10	contact	none
Poast	1	translocated	none
Pursuit	2	translocated	yes
Raptor	2	translocated	yes
Reflex/Flexstar	14	contact	none
Resource	14	contact	none
Select Max	1	translocated	none
Ultra Blazer	14	contact	none
Warrant	15	none	yes
Zidua	15	none	yes

[1] Residual activity: none; short = 1 to 2 weeks of residual control; yes = over 2 weeks of residual control. See Table 5-7 for more information.

Table 5.53 - Herbicides Commonly Used after Soybean Emergence (POST) (cont.)

Herbicide Pre-mixes	Site of Action Number	Constituent Products
Anthem Maxx	14, 15	fluthiacet, pyroxasulfone
Extreme	9, 2	glyphosate, Pursuit
Flexstar GT	9, 14	glyphosate, Reflex
Permit Plus	2, 2	halosulfuron (Permit/Sandea), Harmony
Prefix	15, 14	Dual Magnum, Reflex
Sequence	9, 15	glyphosate, Dual Magnum
Storm	6, 14	Basagran, Ultra Blazer
Synchrony	2, 2	Harmony, Classic
Warrant Ultra	15, 14	Warrant, Reflex

Table 5.54 - Relative Effectiveness of Postemergence Herbicides on Individual Weed Species

Ratings are based on labeled application rates and weeds at 4 inches in height. Results may differ with variations in weed size, temperature, rainfall, soil moisture, and spray coverage. Ratings are based only on postemergence (POST) activity and do not reflect possible residual activity. For ratings on herbicide combinations not listed, see the component parts. Ratings assume good growing conditions and proper usage of adjuvants.

Weed control rating:
10 = 95–100%
9 = 85–95%
8 = 75–85%
7 = 65–75%
6 = 55–65%
N = less than 55% or no control
+ = upper end of rating scale

Crop tolerance:
E = excellent; almost never any crop injury observed
VG = very good; on rare occasion is crop injury observed
G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., herbicide rate and application timing, adjuvants)
FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often duer to herbicide interactions with environmental conditions
F = fair; some crop injury is commonly observed

Grasses Trade Name (rates/A)	Site of Action Number	Barnyard-grass	Bermudagrass	Broadleaf signalgrass	Crabgrass	Fall Panicum	Foxtails, spp.	Goosegrass	Johnsongrass (Seedling)	Johnsongrass (Rhizome)	Quackgrass	Shattercane	Texas panicum	Volunteer Corn	Wirestem Muhly	Yellow Nutsedge
Assure II (8 fl oz)	1	**9**	**9**	**9**	**8+**	**9**	**9+**[1]	**9**	**9**	**9**	**9**	**9+**	**8+**	**9+**	6	N
Basagran (1 qt)	6	N	N	N	N	N	N	N	N	N	N	N	N	N	N	7+
Classic (0.67 oz)	2	N	N	N	N	N	N	N	N	N	N	6	N	6	N	8
Fusilade DX (12 fl oz)	1	**9**	**9**	**9**	**8+**	**9**	**8+**	**9**	**9**	**9**	**9**	**9+**	**8+**	**9+**	**8+**	N
Glyphosate (0.75 lb ae)[2]	9	**9+**	**9**	**9+**	**9+**	**9**	**9+**	**9+**	**9+**	**9**	**9**	**9**	**9+**	**9+**[3]	**9**	7
Liberty (32 fl oz)[4]	10	8	6	**8+**	**8+**	**8+**	**8+**[1]	6	**9**	6	6	9	8	7[5]	7	6
Poast (1 – 1.5 pt)[6]	1	**9+**	**8+**	**9+**	**9**	**9**	**9+**	**9**	**8+**	8	8	**8+**	**9+**	8	7	N
Pursuit (4 fl oz)	2	8	N	8	7	8	**8+**[1]	N	**9**	7	6	**9**	6	6	N	7

Table 5.54 - Relative Effectiveness of Postemergence Herbicides on Individual Weed Species (cont.)

Grasses **Trade Name (rates/A)**	**Herbicide Group (Mode of Action)**	**Barnyard-grass**	**Bermudagrass**	**Broadleaf signalgrass**	**Crabgrass**	**Fall Panicum**	**Foxtails**	**Goosegrass**	**Johnsongrass (Seedling)**	**Johnsongrass (Rhizome)**	**Quackgrass**	**Shattercane**	**Texas panicum**	**Volunteer Corn**	**Wirestem Muhly**	**Yellow Nutsedge**
Raptor (5 fl oz)	2	8	N	8	7	**8**	**8+**[1]	N	**8+**	7	N	**8+**	6	8	N	6
Select (8 fl oz)	1	**9**	**9**	**9+**	**9**	**9**	**9+**	**9**	**9**	**9**	**8+**	**9**	**9+**	**9**	**8+**	N
Mixtures																
Extreme (3 pt)[2]	2/9	**9+**	**8+**	**9**	**9+**	**8+**	**9+**	**8+**	**9+**	**9**	**8+**	**9**	**9**	**9**[3]	**9**	6
Flexstar GT (4.5 pt)[2]	9/14	**9+**	**9**	**9+**	**9+**	**9**	**9+**	**9+**	**9+**	**9**	**9**	**9**	**9+**	**9+**[3]	**9**	7
Fusion (8 fl oz)	1/1	**9**	**9**	**9**	**8+**	**9**	**9**[1]	**9**	8	8	8	8	**8+**	8	6	N
Permit Plus (0.75 oz)[7]	2/2	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**9+**
Storm (1.5 pt)	6/14	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**7+**
Synchrony (0.75 oz)[7]	2/2	N	N	N	N	N	N	N	6	N	N	6	N	6	N	8

[1] Herbicide is less effective on yellow foxtail compared to giant foxtail. Ratings for yellow foxtail: Assure II/Targa = 7; Fusion = 8; Liberty = 6 Pursuit = 6; Raptor = 6
[2] For use on glyphosate-resistant soybean varieties only.
[3] Glyphosate will not control Roundup Ready corn.
[4] For use on glufosinate-resistant soybean varieties only.
[5] Liberty will not control Liberty Link corn, nor many hybrids with Bt traits.
[6] Rates for Poast on annual grasses is 1 pt and 1.5 pt for perennial grasses.
[7] For use on STS, Bolt, or non-STS soybean varieties; a lower rate must be used on non-STS varieties.

Table 5.54 - Relative Effectiveness of Postemergence Herbicides on Individual Weed Species (cont.)

Broadleaves **Trade Name (rates/A)**	**Site of Action Number**	**Burcucumber**	**Cocklebur**	**Horseweed / Marestail**[1,2]	**Jimsonweed**	**Lambsquarters**	**Morningglory, Annual**	**Nightshade, Eastern Black**	**Palmer Amaranth / Waterhemp**[1,2]	**Pigweed**[1]	**Ragweed, Common**[2,3]	**Ragweed, Giant**	**Sida, Prickly**	**Smartweed**	**Spurred Anoda**	**Velvetleaf**	**Soybean Tolerance**
Basagran (1 qt)	6	N	**9**	N	**9**	8	N	N	6	6	8	7	8	**9**	**8+**	**8+**	FG
Cadet (0.9 oz)	14	N	N	N	N	7	7	7	7	7	N	N	7	N	**7**	**9+**	F
Classic (0.67 oz)	2	8	**9+**	7[1]	**9**	7	7	N	N[1]	**9**[1]	8[3]	7+	N	**8+**	N	8	F
Cobra (12.5 fl oz)	14	8	8	N	**9**	7	8	**8+**	**9**	**9**	**9**	**8+**	6	7	7	**8+**	F
Engenia (12.8 fl oz)/ Xtendimax (22 fl oz)[4]	4	7	**9**	**8+**	**9**	**9**	8	8	**8+**	**8+**	**8+**	7+	8	**8+**	8	8	VG
FirstRate (0.3 oz)	2	6	**9**	8[1]	8	N	**8+**	N	N	N	**9**[3]	**9**	N	8	**9**	**9**	VG

Table 5.54 - Relative Effectiveness of Postemergence Herbicides on Individual Weed Species (cont.)

Trade Name (rates/A)	Site of Action Number	Burcucumber	Cocklebur	Horseweed / Marestail[1,2]	Jimsonweed	Lambs quarters	Annual Morningglory	Eastern Black Nightshade	Palmer Amaranth / Waterhemp[1,2]	Pigweed[1]	Common Ragweed[2,3]	Giant Ragweed	Prickly Sida	Smartweed	Spurred anoda	Velvetleaf	Soybean Tolerance
Broadleaves																	
Glyphosate (0.75 lb ae)[5]	9	**8+**	**9**	6[2]	**9**	**8+**	8	8	N[2]	**9+**	**9[2]**	8	8	**8+**	**9**	8	E
Harmony SG (0.125 oz)[6]	2	7	7+	N	7	**9**	N	N	N	**9[4]**	6[3]	N	N	**9**	**N**	**8+**	--[7]
Liberty (32 fl oz)[8]	10	8	**9**	**8+**	**9**	**9**	8	8	**8+**	**8+**	**9**	**8+**	8	**8+**	7+	8	VG
Pursuit (4 fl oz)[1]	2	6	**9**	N	8	7	7+	**8+**	N[1]	**9[4]**	8[3]	6	6	**8+**	7	**9**	FG
Raptor (5 fl oz)[1]	2	6	**9**	N	8	**8+**	7	**8+**	N[1]	**9[4]**	8[3]	8	6	8	7	**9**	G
Reflex/Flexstar (1.25 pt)	14	7	8	N	**9**	6	8	8+	**9**	**9**	**9**	8	N	8	6	7+	FG
Resource (6 fl oz)	14	6	6	N	7	7	N	8	7+	7+	7+	6	6	6	6	**9+**	FG
Ultra Blazer (1.5 pt)	14	7	8	N	**9**	7	8	8	**9**	**9**	**9**	8	N	**8+**	6	7+	F
Mixtures																	
Extreme (3 pts)[5]	2/9	8	**9**	6[2]	**9**	**8+**	7+	8	N[1,2]	**9**	**8+[2,3]**	8	7	**8+**	**8+**	**9**	VG
Flexstar GT (4.5 pt)[5]	9/14	**8+**	**9**	6[2]	**9**	**8+**	8	8	**9[2]**	**9**	**9[2]**	**9**	8	**8+**	**9**	**8+**	F
Permit Plus (0.75 oz) [6]	2/2	7	**9**	N	7	**9**	6	6	N[1]	**9[1]**	**9[3]**	8	7	**9**	**–**	**9**	--[7]
Storm (1.5 pt)	6/14	6	8	N	**9**	7	7+	7	**8+**	**8+**	**8+**	7	7	**8+**	8	8	FG
Synchrony (0.75 oz)[6]	2/2	**8+**	**9+**	8[1]	**9**	**9**	7	N	N[1]	**9+[1]**	8[3]	7+	N	**9**	**N**	**9**	--[7]

[1] Group 2 resistance has been confirmed for this species and it is widespread in the region; Group 2 herbicides will not control these biotypes.

[2] Glyphosate resistance has been confirmed for this species and is widespread in the region.

[3] Common ragweed biotypes resistant to Group 2 herbicides have been confirmed in the region..

[4] For use on dicamba-resistant (Xtend) soybean varieties only.

[5] For use on glyphosate-resistant soybean varieties only.

[6] For use on STS, Bolt, or non-STS soybean varieties; a lower rate must be used on non-STS varieties.

[7] Excellent crop tolerance for STS or Bolt varieties, but fair or worse ratings if used on non-STS varieties.

[8] For use on glufosinate-resistant soybean varieties only.

Table 5.55 - Effectiveness of Postemergence Herbicides on Perennial Broadleaf Weeds in Soybean (Based on Seasonal Control)

Weed control rating:

10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65% N = less than 55% or no control

– = no local data available + = upper end of rating scale

Trade Name	Site of Action Number	Canada Thistle	Dandelion	Dewberry	Dock spp.	Groundcherry	Hedge Bindweed	Hemp Dogbane	Horsenettle	Jerusalem Artichoke	Common Milkweed	Poison Ivy	Pokeweed
Basagran	6	7	N	N	7	N	7	N	6	6+	N	N	N
Blazer, Cobra, Reflex	14	6	N	N	6	6	7	6	7	6	6	N	7
Classic	2	7	7	7	7	–	8	7	7	7+	6	6	7+
Engenia/ XtendiMax[1]	**4**	8	7+	6	8	7	**8+**	7	7	8	6	7+	7+
Glyphosate (broadcast)[2]	**9**	**9**	7	8	8	7+	8	**8+**	8	8	8	8	**8+**
Glyphosate (wiper application)[3]	9	7	N	N	N	6	N	7+	N	7+	7+	6	**8+**
Pursuit/Raptor	2	6	7	6	7	–	7+	7	8	7	6	6	6
Synchrony	2/2	7+	7	7	6	–	7	7	N	7+	7+	6	7+

[1] For use on dicamba-resistant (Xtend) soybean varieties only.

[2] Broadcast applications of certain glyphosate products for use on glyphosate-resistant soybean varieties only. Refer to product label use restrictions. Information on various glyphosate formulations can be found in Table 5-2 (glyphosate table)..

[3] Mix 1/3 glyphosate product with 2/3 water. Two passes in opposite directions is most effective.

Table 5.56 - Weed Sizes for Postemergence Soybean Herbicides

This table lists postemergence soybean herbicides, their rates, and height ranges of weed species that are controlled or suppressed. This table is only a "quick reference"; refer to the herbicide label for additional information on application and timing. Postemergence grass herbicide rates may vary if tank-mixed with broadleaf herbicides due to antagonism. Split applications should be made if target growth stages for broadleaves and grasses do not correspond or if grasses to be managed are difficult-to-control species such as perennials. For split-applications, it is best to apply post-grass herbicides 24 hours before or about 7 days after broadleaf herbicide application.

Herbicides	*Assure II/Targa*[1]			*Fusillade DX*[1,2]			*Fusion*[1,2]			*Liberty*		*Poast*[1]				*Pursuit 2L*		*Raptor*		**Glyphosate Select/Clethodim**[4,5]			
		alone	**w/BH**		**alone**	**w/BH**		**alone**	**w/BH**			**alone**	**w/BH**	**alone**	**w/BH**							**alone**	**w/BH**
GRASSES Annuals	**grass size (in.)**	**rate/A —(fl oz)—**		**grass size (in.)**	**rate/A**[6] **—(fl oz)—**		**grass size (in.)**	**rate/A**[6] **—(fl oz)—**		**grass size (in.)**	**rate/A (fl oz)**	**gr. size**[6] **—(in)—**		**rate/A**[6] **—(fl oz)—**		**grass size (in.)**	**rate/A (fl oz)**	**grass size (in.)**	**rate/A (fl oz)**	**grass size (in.)**	**rate/A (lb ae/A)**	**grass size (in.)**	**rate/A**[6] **—(fl oz)—**	
Barnyard-grass	2–6	8	S[7]	2–3	12	12	2–4	8	10	3	22	<4	—	18	—	1–3	4	2–5	5	4–8	0.75	1–4	4	—
										5	29	<8	4	24	24							2–8	6	8–10
											<12[8]	—	36	—	—									
Crabgrass	2–6	8	S[7]	1–2	12	12	1–4	8	10	3	22	<6	4	24	24	1–3	4	2–4*	5	4–8	0.75	1–4	4–5	—
										5	29	<8[8]	—	36	—							2–6	6	8–10
Foxtail, giant	2–4	5	5	2–6	12	12	2–8	7	10	6	22	<4	18	—	—	1–6	4	2–6	5	4–8	0.75	1–4	4	—
	2–8	7	7				≤16[8]	8–14	—	12	29	<8	6	24	24							2–12	6	8–10
												<16	36	—	—									
Foxtail, green	2–4	7	8	2–4	12	12	2–4	8	10	6	22	<4	18	—	—	1–3	4	2–6	5	4–8	0.75	2–8	6	8–10
										12	29	<8	6	24	24									
												<16[8]	36	—	—									
Foxtail, yellow	2–4	7	S[7]	2–4	12	12	2–4	8	10	3	22	<8	6	24	24	1–3	4	2–6	5	4–8	0.75	2–8	6	8–10
										4	29	<16[8]	—	36	—									
Goose-grass	2-6	7	8	2-4	8		2-4	8	8-12	2	22	6		16	—	—	—	2-4	5			2-6	6	

Table 5.56 - Weed Sizes for Postemergence Soybean Herbicides (cont.)

This table lists postemergence soybean herbicides, their rates, and height ranges of weed species that are controlled or suppressed. This table is only a "quick reference"; refer to the herbicide label for additional information on application and timing. Postemergence grass herbicide rates may vary if tank-mixed with broadleaf herbicides due to antagonism. Split applications should be made if target growth stages for broadleaves and grasses do not correspond or if grasses to be managed are difficult-to-control species such as perennials. For split-applications, it is best to apply post-grass herbicides 24 hours before or about 7 days after broadleaf herbicide application.

Herbicides	*Assure II/Targa*[1]			*Fusillade DX*[1,2]			*Fusion*[1,2]			*Liberty*		*Poast*[1]				*Pursuit 2L*		*Raptor*		**Glyphosate**		**Select/Clethodim**[4,5]		
		alone	**w/BH**		**alone**	**w/BH**		**alone**	**w/BH**			**alone**	**w/BH**	**alone**	**w/BH**								**alone**	**w/BH**
GRASSES Annuals	**grass size (in.)**	**rate/A —(fl oz)—**		**grass size (in.)**	**rate/A[6] —(fl oz)—**		**grass size (in.)**	**rate/A[6] —(fl oz)—**		**grass size (in.)**	**rate/A (fl oz)**	**gr. size[6] —(in)—**		**rate/A[6] —(fl oz)—**		**grass size (in.)**	**rate/A (fl oz)**	**grass size (in.)**	**rate/A (fl oz)**	**grass size (in.)**	**rate/A (lb ae/A)**	**grass size (in.)**	**rate/A[6] —(fl oz)—**	
										3	29													
Panicum, fall	2–6	7	8	2–6	12	12	26	8	10	3	22	<4	18	–	–	–*	–*	2–6	5	4–8	0.75	1–4	4–5	–
										5	29	<8	4	24	24					2–8	0.19	8–10	2–8	8–10
												<12[8]	36											
Panicum, Texas	2-4	8		2-8	12		2-8	8	8-12	4	22	8		16	–	–	–	–	–			2-6	6	
										6	29													
Shattercane	6–12	5	5	6–12	6	12	6–12	6	8	6	22	<18	–	24	–	1–8	4	2–8	5	4–8	0.75	4–10	4	–
										3	29											6–18	6	8–10
Signalgrass, broadleaf	2-6	10		2-4	12		2-4	8-10	10-12	3	22	8		16	–	1-8	4	2-5	5			2-6	6	
										5	29													
Volunteer corn	6–18	5	5	12–24	6	12	12–24	6	8	10	22	<12	18	–	–	–	–	2–8	5	4–8	0.75	4–12	4	–
										12	29	<20	12	24	24							12–24	6	8–10

Table 5.56 - Weed Sizes for Postemergence Soybean Herbicides (cont.)

Herbicides	*Assure II/Targa*[1]			*Fusillade DX*[1,2]			*Fusion*[1,2]			*Liberty*		*Poast*[1]				*Pursuit DG*		*Raptor*		**Glyphosate**		**Select/Clethodim**[4,5]		
		alone	**w/BH**		**alone**	**w/BH**		**alone**	**w/BH**			**alone**	**w/BH**	**alone**	**w/BH**								**alone**	**w/BH**
GRASSES Perennials	**grass size (in.)**	**rate/A —(fl oz)—**		**grass size (in.)**	**rate/A[6] —(fl oz)—**		**grass size (in.)**	**rate/A[6] —(fl oz)—**		**grass size (in.)**	**rate/A (fl oz)**	**gr. size[6] —(in)—**		**rate/A[6] —(fl oz)—**		**grass size (in.)**	**rate/A (oz)**	**grass size (in.)**	**rate/A (fl oz)**	**grass size (in.)**	**rate/A (lb ae/A)**	**grass size (in.)**	**rate/A[6] —(fl oz)—**	
Bermudagrass																								
1st applic.	≤6	10		4-8	12		4-8	12			22	6 stolon		24		–	–	–	–			3	8	
2nd applic.	≤6	7		4-8	8		4-8	8			22	4 stolon		16		–	–	–	–			3	8	
Johnsongrass (rhizome)																								
1st applic.	10–24	10	10	8–18	12	12	8–18	12		–*	–*	20–25		24		6–12*	4	6–12*	5	<18	0.75–1.5	12–24	8	16
2nd applic.	6–10	7	–	6–12	8	–	6–12	8				6–12		24						<24		6–18	6	–
Quackgrass																								
1st applic.	6–8	10		S[7]	6–10	12	12	6–10	12	–*	–*	6–8		36	–	–	–	4–8*	5	6–8	0.75–1.5	4–8	8	16
2nd applic.	4–8	7			<10	8	–	10	8			6–8		36				4–8*	8	–				
Wirestem muhly																								
1st applic.	4–8*		8	S[7]	4–12	12	12	4–12	8	–*	–*	<6		36	–	–	–	–	–	<8	0.75–1.5	4–8+	8	16
2nd applic.	4–8*		7	–	4–12	12	–	4–12	8			<6		36								4–8	8	–

* Suppression only; provides <75% control. ≤ means less than or equal to. > means greater than.

[1] May be tank-mixed with certain broadleaf herbicides only, refer to herbicide labels.

[2] Special reduced rates may be possible if applied early and under certain conditions; refer to label.

[3] For use on Roundup Ready soybean varieties only. Split applications may be necessary if new weed flushes occur.

[4] Select/Clethodim can be applied at a special high rate of 8 oz/A for annual grasses and 16 oz/A for perennials. These high rates should be used only for heavy grass pressure or when grasses are at maximum height.

[5] Select/Clethodim application rates vary when tank-mixed with certain broadleaf herbicides. Average rate ranges are shown above. Refer to label for additional information.

[6] Refers to rate per acre of herbicide if applied alone or if tank-mixed with broadleaf herbicides ("w/BH"). For Poast, target grass sizes are smaller if tank-mixed with broadleaf herbicides.

[7] Split applications may be necessary. May not provide adequate control of this species if tank-mixed with a broadleaf herbicide.

[8] Rescue application only, better control will result if applied alone. (Do not tank-mix Fusion with broadleaf herbicides for rescue treatments).

Table 5.56 - Weed sizes for postemergence soybean herbicides (cont.)

Broadleaves	Burcucumber	Cocklebur	Jimsonweed	Lambsquarters	Morningglory, Annual	Nightshade, Eastern Black	Palmer Amaranth Waterhemp	Pigweed	Ragweed, Common	Ragweed, Giant	Sida Prickly	Smartweed	Spurred Anoda	Velvetleaf
Herbicide (rate/A)	---------- height range (inches) at application ----------													
Basagran (2 pt)	–	≤10	≤10	≤2*	–	–	–	–	≤3	≤6	3	≤10	4	≤6
Cadet (0.9 fl oz)	≤3	–	≤2	≤3*	≤3	≤2	≤4	≤4	–	–	–	≤2	–	≤36
Classic (0.5 oz)	–	2–6	2–4	–	1–2	–	1–2	1–2	–	–	–	1–2	–	–
Classic (0.66 oz)	2–3*	2–8	2–5	–	1–3	–	1–3	1–3	2–3	2–4*	–	1–3	–	2–4
Classic (0.75 oz)	2–6*	2–12	2–6	–	1–4	–	1–4	1–4	2–4	2–6	–	1–4	–	2–6
Cobra (12.5 oz)[1]	4 lvs	6 lvs	4 lvs	–	<4 lvs	6 lvs	6 lvs	6 lvs	6 lvs	4 lvs	3	4 lvs*	2*	4 lvs
Engenia (12.8 oz)/ XtendiMax (22 oz)[2]	≤4	≤4	≤4	≤4	≤4	≤4	≤4	≤4	≤4	≤4	≤4	6	≤4	2
FirstRate (0.3 oz)	–	<10	<4	–	<6	–	–	–	<10	<10	–	<6	–	<6
Flexstar GT (3.5 pt)	–	≤4	≤4	≤4	≤3	≤4	≤4	≤4	≤4	≤4	2	≤4	4	≤4
Glyphosate (0.75 lb ae)[3]	4–8	4–8	4–8	3–6	3–6	4–8	4–8	4–8	4–8	4–8	2	3–6	2	4–8
Harmony SG (0.125 oz)	–	2–6*	2–4*	2–4	–	–	2–8	2–8	–	–	–	2–6	–	2–6
Liberty (22 oz)	6	6	6	4	6	6	3	3	6	6	4	6	3	3
Liberty (29 oz)	10	14	10	6	8	8	4	4	10	12	5	14	5	4
Permit Plus (0.75 oz)	≤3	≤9	≤4	≤4	≤3	–	≤6	≤6	≤9	≤3	–	≤6	–	≤9
Pursuit 2L (1.44 oz)	–	1–8	1–3	1–2*	1–2*	1–3	1–8	1–8	1–3*	1–3*	–	1–3	1-2	1–3
Raptor (5 fl oz)	–	2–8	2–6	2–5	2–4	2–5	2–8	2–8	2–5*	2–5	4*	2–5	–	2–8
Reflex (1.25 pt)[1]	–	2 lvs	6 lvs	2 lvs	2 lvs	4 lvs	2–6 lvs	2–6 lvs	4 lvs	4 lvs	–*	4 lvs	2 lvs	2 lvs
Resource (6 oz)[1]	–	–	–	2–3 lvs*	–	–	≤3 lvs[3]	≤3 lvs[4]	≤4 lvs	–	3	–	–	≤8 lvs
Storm (1.5 pt)	–	≤6	≤6	≤2*	≤2	≤2	2–3	2–3	≤3	≤6	2	≤6	2	≤2*
Synchrony[5]	2–3*	2–8	2–5	2–4	1–3*	–	2–8	2–8	2–4	2–4*	–	2–8	3*	2–8
Ultra Blazer (1.5 pt)	–	≤2	≤6	≤2	≤2	≤2	≤4	≤4	≤3	≤3	–	≤6	–	–

Note: See Table 5.4 (generics table) for additional herbicides that contain these active ingredients and Table 5.2 (glyphosate table) for information on glyphosate formulations.

* Suppression only, additional control measures may be necessary.

[1] Labels refer to weed size by number of leaves (lvs).

[2] For use on dicamba-resistant (Xtend) soybean varieties only.

[3] For use on glyphosate-resistant soybean varieties only.

[4] Smooth pigweed control only.

[5] For use on STS, Bolt, or non-STS varieties; use lower rate on non-STS soybeans.

The following herbicides can be added with postemergence herbicides to improve residual weed control. They will not provide control of emerged weeds, so they should be applied to weed-free soil surface, or apply with products that will provide postemergence control of weeds present at time of application. Consult labels when tankmixing with any herbicide. Some pesticides or adjuvants used in combination with the following herbicides could increase the chance of soybean injury.

Residual Herbicides Labeled for Postemergence Use

Table 5.57 - Comments on Postemergence Herbicides for Soybeans

Trade Name	Herbicide Common Name	Site of Action Number	Application (timing on soybean growth stage)	Product/A	lb ai/A
Anthem Maxx 4.3SC	**pyroxasulfone + fluthiacet**	**15 14**	**preemergence up to third trifoliate**	**2–5.7 fl oz**	**0.033–0.186 0.002–0.006**

- Do not exceed a seasonal total of 3.4 fl oz on coarse soils or 5.7 fl oz on all other soils.
- Contains fluthiacet (Cadet); see Cadet for more information.
- Make applications at least 60 days before harvest.

Dual Magnum 7.62EC	**S-metolachlor**	**15**	**postemergence**	**1–1.33 pt**	**0.95–1.27**

- Application timing is not specified on label.
- Do not exceed a seasonal total of 2.6 pt/A.
- Make applications at least 90 days before harvest.
- A prepackaged mixture with glyphosate is available as Sequence; application timing is cracking through 3PrdP leaf stage.
- A prepackaged mixture with fomesafen (Reflex) is available as Prefix; label mentions early postemergence application timing. Ratio of fomesafen (Reflex) is too low for consistent postemergence control of emerged weeds.

Outlook 6EC	**dimethenamid**	**15**	**cracking stage to 5th trifoliate**	**12–21 fl oz**	**0.56–0.98**

- Rates vary with soil type, refer to label.
- Limited residual control when applied to coarse-textured soils.
- Do not exceed a seasonal total of 24 fl oz.

Warrant 3CS	**acetochlor**	**15**	**emergence to R2**	**1.25–2 qts**	**0.94–2.0**

- Rates vary with soil type and organic matter, refer to label.
- Do not exceed 4 qts/A/yr.
- Label recommends application at V2 to V3 stage.
- A prepackaged mixture with fomesafen (Reflex) is available as Warrant Ultra; ratio of fomesafen (Reflex) is too low for consistent postemergence control of emerged weeds.

Zidua 85WDG Zidua SC 4.17SC	**pyroxasulfone**	**15**	**emergence to 3rd trifoliate**	**1–3.5 oz wt 1.75–5.75 fl oz**	**0.053–0.186 0.057–0.187**

- Rates vary with soil type, refer to label.
- Can be applied from emergence to the third trifoliate stage.
- Do no exceed 2.1 oz wt and 3.5 fl oz per acre per season on coarse-textured soils, 3.0 oz wt and 5.0 fl oz on medium-textured soils, and 3.5 oz wt and 5.75 fl oz on fine-textured soils of Zidua 85WDG and Zidua SC 4.17SC, respectively.

The following herbicides are commonly applied postemergence to control emerged weeds. Most of these herbicides require an adjuvant to improve control; refer to proper tables to assist with adjuvant selection.

Postemergence Herbicides

Table 5.57 - Comments on Postemergence Herbicides for Soybean (cont.)

Trade Name	Herbicide Common Name	Site of Action Number	Application	Product/A	Active Ingredient (ai) lb/A
Assure II 0.88E/ Targa	**quizalofop**	**1**	**Postemergence**	**5–10 fl oz**	**0.03–0.06**

- Do not use crop oils manufactured from vegetable oils.
- When tank-mixing with a broadleaf herbicide, always read both labels to make sure the right surfactant and concentration are used.
- Apply when grasses are within the recommended growth stage specified on the label
- Perennial grasses may require a second application for complete control.
- Apply to actively growing grasses in 10 to 40 gallons of water per acre using flat fan or hollow cone nozzles.
- To avoid antagonism (reduced grass control) from broadleaf herbicides, spray 2-3 days before the broadleaf herbicide or wait 7 days after the broadleaf herbicide application.
- Assure II/Targa must be applied at least 80 days before harvest.

Basagran 4S	**bentazon**	**6**	**Postemergence**	**1.5–2.0 pt**	**0.75–1.0**

- Application should be made while weeds are small and actively growing and before weeds reach maximum size listed on product label. Basagran will not control pigweed species.
- Add crop oil concentrate or nitrogen solution to spray mixture as directed.
- Apply in a minimum of 20 gal of water/A and at minimum pressure of 40 psi.
- Tank-mixing with Ultra Blazer improves pigweed control.
- Apply at least 30 days prior to harvest as forage.
- *Water quality advisory.*

Butyrac 200 2L	**2,4-DB**	**4**	**Postemergence**	**0.7–0.9 pt**	**0.175–0.22**

- 2,4-DB is not recommended for use by itself due to limited control and potential for crop injury. Rather 2 oz of 2,4-DB can improve morningglory, cocklebur, and jimsonweed control when tank-mixed with other postemergence herbicides.
- Potential for crop injury is increased under hot, dry growing conditions.
- If more than 2 oz/A rate is used, apply as directed spray into rows when soybeans are 8 to 12 inches high and cocklebur, morningglory, jimsonweed and pigweed have not exceeded a height of 3 inches.
- Top of weed seedling must be sprayed. Use precision directed spray application equipment. Apply with sprayer nozzles mounted on skids or gauge wheels. Do not spray more than one-third of the base of soybean as severe injury may occur.
- Apply at least 60 days prior to harvest (forage or grain).

Table 5.57 - Comments on Postemergence Herbicides for Soybean (cont.)

Trade Name	Herbicide Common Name	Site of Action Number	Application	Product/A	Active Ingredient (ai) lb/A
Cadet 0.91EC	**fluthiacet**	**14**	**emergence to full flowering**	**0.4–0.9 fl oz**	**0.0028–0.006**

- Apply 0.4 to 0.6 fl oz/A with glyphosate (RR-soybean) or glufosinate (LL-soybean); or 0.6 to 0.9 fl oz when applied alone.
- Include the necessary spray additives (NIS or COC plus AMS or nitrogen solution). Applications should be made when susceptible broadleaf weeds are small. Cadet is very effective on velvetleaf, but other broadleaf weeds must be small (less than 3 inches) to achieve control/suppression. Tank-mixing with other herbicides will usually be necessary to provide broad-spectrum weed control.
- Cadet does not provide residual weed control.
- Cadet can cause bronzing or browning of the soybean leaves.
- Marvel is prepackaged mixture with Reflex and Cadet; but rate of Reflex is below what is typically recommended and needed for effective weed control.
- Apply at least 60 days prior to grain harvest.

Classic 25DF	**chlorimuron**	**2**	**after 1PstP trifoliate**	**0.5–-0.75 oz wt**	**0.008–0.012**

- Application should be made while weeds are small and actively growing.
- Always read the label to determine the proper adjuvants.
- Observe labeled rotational crop restrictions for all products containing Classic (see Table 5-5).
- If the soil pH is greater than 7.0, at Classic rates of 0.5 oz/A or greater, do not plant corn for at least 9 months after application. Use of STS and Bolt varieties will reduce the risk of injury.
- Classic plus Harmony SG is available as a prepackaged mixture called Synchrony XP. Synchrony XP can be applied to non-STS soybean varieties at 0.375 oz/A use rate or to STS and Bolt varieties at rates up to 1.125 oz/A.
- There is widespread resistance to Classic and other Group 2 herbicides in the region.
- Apply at least 60 days prior to harvesting for grain.

Cobra 2E	**lactofen**	**14**	**Postemergence**	**6.0–12.5 fl oz**	**0.09–0.19**

- Soybeans should have one to two trifoliate leaves.
- Applications should be made while weeds are small and actively growing.
- Use surfactant or crop oil concentrate as directed.
- Cobra often causes foliar injury to soybeans.
- Use 6–8 fl oz/A for control of four- to six-leaf common ragweed or pigweed.
- Apply at least 45 days prior to harvesting for grain.

Table 5.57 - Comments on Postemergence Herbicides for Soybean (cont.)

Trade Name	Herbicide Common Name	Site of Action Number	Application	Product/A	Active Ingredient (ai) lb/A
Engenia	**dicamba BAMPA Salt**	**4**	**emergence through R1**	**12.8 fl oz**	**0.5 (ae)**
XtendiMax/FeXapan	**dicamba DGA Salt with VaporGrip**			**22 fl oz**	**0.5 (ae)**

- Apply over the top to dicamba-tolerant (Xtend) soybean varieties only.
- These are the only brands of dicamba registered for this use.
- Applications should be made while weeds are small (4 inches) and actively growing.
- The risk of injuring sensitive plants via off-target movement is much less when these products are used early burndown or prior to planting full-season soybean in the spring compared to postemergence applications or applications prior to planting double-crop soybean during the summer months.
- Spray droplet size plays an important role in minimizing off-target movement. Nozzles that produce extremely coarse or ultra coarse droplets while limiting the amount of driftable fine droplets are necessary to limit spray drift. Consult labels for approved nozzles.
- Dicamba can be difficult to completely remove from spray equipment and residue is capable of injuring sensitive plants. Follow label instructions concerning sprayer cleanout.
- Cotton, grapes, lima bean, pea, pepper, snap bean, soybean, sweetpotato, tobacco, tomato, watermelon, and many other crops are very sensitive to dicamba. Follow application instructions on label to avoid injuring neighboring plants.
- See **Engeniatankmix.com, xtendimaxapplicationrequirements.com**, and **www.fexapanapplicationrequirements.dupont.com** for approved adjuvants, drift reduction agents, and other tank mixes.
- See federal and supplemental labels for use in dicamba-tolerant soybean for details on drift management, including recommended nozzles and pressures, wind speed, boom height, temperature inversions, buffers, susceptible plants, and spray equipment cleanout.
- Can be applied multiple times postemergence; do not exceed a total of 25.6 fl oz of Engenia or 44 fl oz of XtendiMax/FeXapan postemergence; do not exceed a combined total for the season of 51.2 fl oz of Engenia or 88 fl oz of XtendiMax/FeXapan.
- *Water quality advisory.*

Extreme	**glyphosate + imazethapyr**	**9 + 2**	**Postemergence**	**1.5 qt**	**0.56 (ae) + 0.06**

- Prepackaged mixture of glyphosate plus Pursuit. Amount of glyphosate is lower compared to amount applied with alone; additional glyphosate maybe recommended for some species.
- Pursuit is a Group 2 herbicide, and there is wide-spread resistance in the region to this family of herbicides.
- Apply at least 85 days prior to harvesting for grain.
- Refer to comments in sections for individual herbicides for more information.

Table 5.57 - Comments on Postemergence Herbicides for Soybean (cont.)

Trade Name	Herbicide Common Name	Site of Action Number	Application	Product/A	Active Ingredient (ai) lb/A
FirstRate 84WDG	**cloransulam**	**2**	**1st trifoliate to 50% flowering**	**0.3–0.6 oz**	**0.016–0.031**

- Tank-mix to broaden weed spectrum.
- FirstRate may be applied up to 0.6 oz for heavy weed infestations or added residual control.
- FirstRate water-dispersible packets are not soluble in liquid fertilizer solutions; premixing in water is required. UAN will improve velvetleaf control.
- Two applications of 0.3 oz/A are allowed. Do not exceed 1.05 oz/A per season.
- FirstRate is a Group 2 herbicide, and there is wide-spread resistance in the region to this family of herbicides.
- Apply at least 65 days prior to harvesting for grain and 14 days prior to harvesting for forage.
- *Water quality advisory.*

Flexstar GT 3.5	**glyphosate + fomesafen**	**9 + 14**	**Postemergence**	**3–4.5 pt**	**1.0–1.47 (ae) + 0.24–0.35**

- Prepackaged mixture of glyphosate plus Reflex; refer to comments in those sections for more information.

Fusilade DX 2E	**fluazifop**	**1**	**Postemergence**	**6–12 fl oz**	**0.09–0.18**
Fusion 2.56EC	**fluazifop + fenoxaprop**	**1 + 1**	**Postemergence**	**6–12 fl oz**	**0.094–0.188 0.031–0.062**

- See label for rate and size of weed to be controlled.
- Most annual grasses should be treated when 2–4 inches in height. Perennial grasses may require second application to achieve complete control.
- To avoid antagonism (reduced grass control) from broadleaf herbicides, spray 2-3 days before the broadleaf herbicide or wait 7 days after the broadleaf herbicide application.
- Apply before soybeans begin to bloom.

Glyphosate	**glyphosate**	**9**	**Postemergence**	**vary by formulation and acid equivalent[1]**	**0.75–1.5 (ae)**

- Apply over-the-top to glyphosate-resistant (Roundup Ready) soybean varieties only.
- There are many formulations available, but sure to read the label for rates, adjuvants etc.
- Treat in-crop from soybean emergence through full flowering of soybeans.
- If additional weed emergence is anticipated, consider including a herbicide that provides residual control.
- Perennial weeds may require higher rates and repeat applications. Best control may be obtained when perennial weeds are treated in the bud to bloom growth stage.
- Include ammonium sulfate in the tank to improve control of weeds and be sure to read the label to determine if additional adjuvants are required or recommended.
- Observe maximum rates per application and per crop.
- If glyphosate-resistant weeds are present or Palmer amaranth is in the vicinity, include a second, highly effective herbicide to control these species.
- Avoid drift to adjacent crops or other desirable vegetation.

[1]Consult specific product label for active ingredient concentration and application rate; various formulations of this herbicide are available (e.g., 1 qt/A glyphosate = 22 fl oz/A WeatherMax).

Table 5.57 - Comments on Postemergence Herbicides for Soybean (cont.)

Trade Name	Herbicide Common Name	Site of Action Number	Application	Product/A	Active Ingredient (ai) lb/A
Harmony SG 50DF	**thifensulfuron**	**2**	**at least 1PstP trifoliate**	**0.125 oz wt (1/8 oz)**	**0.004**

- Harmony SG is a very concentrated formulation. Be sure to use proper application rate otherwise soybean injury may occur.
- Various formulations of Harmony 50SG and generic 75DF thifensulfuron are available, be sure proper rate is applied.
- Apply when weeds are actively growing and before they reach maximum size listed on product label.
- Any crop may be planted within 45 days following Harmony SG application.
- For adequate velvetleaf control, add 1 gallon of liquid nitrogen solution per acre.
- Use of STS or Bolt varieties will reduce the risk of injury.
- Harmony SG plus Classic is available as a pre-packaged mixture called Synchrony XP.
- Harmony SG plus Sandea/Permit is available as a pre-packaged mixture called Permit Plus.
- Synchrony XP can be applied to non-STS soybean varieties at 0.375 oz/A use rate or to STS or Bolt varieties at rates up to 1.125 oz/A rate.
- Harmony SG, generic thifensulfuron products, Permit Plus, and Synchrony XP labels state that the first trifoliate leaf of the soybean is fully expanded before the application is made.
- Apply Harmony 7 days before harvesting forage green; 30 days before harvesting dried forage; and 60 days before harvesting for grain.
- Harmony is a Group 2 herbicide, and there is wide-spread resistance in the region to this family of herbicides.

Liberty 280 2.34L	**glufosinate**	**10**	**emergence to bloom stage**	**32–43 fl oz**	**0.59–0.79**

- Apply over-the-top to glufosinate-resistant soybean varieties (e.g., LibertyLink) only.
- For best results, plant in narrow rows and apply up to 43 fl oz Liberty about 4 weeks after residual herbicides were applied, when weeds are 2–4 inches tall, and before soybean canopy begins to interfere with spray coverage.
- If using sequential applications, apply 10–14 days apart and do not apply more than 87 fl oz/A/season and before soybean bloom stage.
- A residual soil-applied product or a sequential POST application may be necessary depending on weed species and severity.
- Liberty provides no soil residual activity.
- Tank-mixing Liberty with other herbicides including residual products (e.g., Outlook, Warrant) is allowed. Local university research has not observed increased injury with most herbicide combinations; some stunting and leaf burn was observed when Liberty was tank-mixed with Prefix.
- Liberty 280 must be applied with ammonium sulfate at the rate of 3 lb/A.
- Use of surfactants or crop oils may increase risk of crop response.
- Uniform, thorough spray coverage is necessary to achieve consistent weed control; do not use nozzles that produce large droplets; use at least 15 gal/A, 20 gal/A if dense vegetation is present.
- Applications should be made between 2 hours after sunrise and 1 hour before sunset to avoid the possibility of reduced weed control.
- Liberty 280 has been observed to antagonize grass control with postemergence grass herbicides.
- Apply 45 days before harvesting for grain or forage.

Table 5.57 - Comments on Postemergence Herbicides for Soybean (cont.)

Trade Name	Herbicide Common Name	Site of Action Number	Application	Product/A	Active Ingredient (ai) lb/A
Permit Plus 74WDG	**halosulfuron + thifensulfuron**	**2 2**	**1st trifoliate to R2 stage**	**0.75 oz wt**	**0.031 0.004**

- Permit Plus is labeled only for STS or Bolt varieties.
- Permit Plus can be applied from V1 stage up till 88 days before harvest.
- Permit Plus is excellent for yellow nutsedge control.
- Can be tank-mixed with glyphosate.
- See Harmony entry for more information.
- Permit Plus contains two Group 2 herbicides, and there is wide-spread resistance in the region to this family of herbicides.

Poast 1.5E	**sethoxydim**	**1**	**Postemergence**	**0.75–1.5 pt**	**0.14–0.28**

- Application should be made when grasses are actively growing and within the recommended stage of growth on the Poast label. Perennial grasses may require a second application to achieve complete control.
- Nitrogen fertilizer additives may improve control of some species.
- To avoid antagonism (reduced grass control) from broadleaf herbicides, spray 2-3 days before the broadleaf herbicide or wait 7 days after the broadleaf herbicide application.
- Poast must be applied at least 75 days before harvest.

Pursuit 2S	**imazethapyr**	**2**	**before bloom**	**4 fl oz**	**0.063**

- A prepackaged mixture with glyphosate is available as Extreme. The amount of glyphosate is lower than the rate commonly used with glyphosate is applied alone.
- Only one application of Pursuit can be made per soybean growing season.
- Extreme can only be applied to soybean varieties designated Roundup Ready.
- Observe rotational restrictions for products containing imazethapyr.
- Pursuit is a Group 2 herbicide, and there is wide-spread resistance in the region to this family of herbicides.
- Apply at least 85 days prior to grain harvest.
- *Water quality advisory.*

Raptor 1S	**imazamox**	**2**	**before bloom**	**4–5 fl oz**	**0.031–0.039**

- Occasionally, internode shortening and/or temporary yellowing of soybeans may occur, especially if under environmental stress.
- When adequate soil moisture is present, Raptor will provide residual activity of susceptible germinating weeds.
- Apply when weeds are actively growing and before they reach the maximum size listed on product label. Add a nonionic surfactant and fertilizer solution as directed).
- Less persistent than Pursuit, but follow labeled rotational crop restrictions
- Raptor is a Group 2 herbicide, and there is wide-spread resistance in the region to this family of herbicides.
- Apply at least 85 days prior to grain harvest.

Table 5.57 - Comments on Postemergence Herbicides for Soybean (cont.)

Trade Name	Herbicide Common Name	Site of Action Number	Application	Product/A	Active Ingredient (ai) lb/A
Reflex 2E or Flexstar 1.88E	**fomesafen**	**14**	**Postemergence**	**1.0–1.5 pt**	**0.25–0.375 or 0.235–0.35**

- Do not apply Reflex or Flexstar or other fomesafen containing products more than once every 2 years.
- Follow labeled rotation restrictions (see Table 5-4).
- Flexstar can cause more soybean injury than Reflex.
- Prefix is a premix of Reflex and Dual and must be applied at least 90 days before grain harvest.
- Tankmixing Reflex with glyphosate formulated as a potassium salt can cause compatibility issues; glyphosate formulations as isopropyl or diammonium salts do not have this issue.
- Flexstar GT contains glyphosate plus fomesafen and should be applied only to glyphosate-resistant soybeans.
- Marvel is prepackaged mixture with Reflex and Cadet; but rate of Reflex is below what is typically recommended and needed for effective weed control.
- Prefix is a premix of Reflex and Dual and must be applied at least 90 days before grain harvest; Warrant Ultra is a premix of Reflex with Warrrant and must be applied at least 45 days before grain harvest. Both have low ratio of Reflex and is below what is typically recommended for effective control.
- Apply Reflex prior to soybean bloom.
- Do not apply within 14 days of an application of saflufenacil (Kixor or Sharpen).
- *Water quality advisory.*

Resource 0.86EC	**flumiclorac**	**14**	**Postemergence**	**4–12 fl oz**	**0.027–0.08**

- Apply to actively growing weeds at growth stages recommended on the label.
- Tank-mixing broadens the weed-control spectrum use higher rates for larger velvetleaf. Resource has activity against several other weeds when they are in the two- to three-leaf stage, including cocklebur, lambsquarters, common ragweed, jimsonweed, pigweed species, and prickly sida, but control declines on larger weeds.
- Apply in a minimum of 10 gal of water/A and a minimum pressure of 30 psi.
- In most cases, use a crop oil concentrate or other additive according to produce label.
- Apply at least 60 days prior to grain harvest.

Select 2E or Select Max 0.97EC	**clethodim**	**1**	**Postemergence**	**6–16 fl oz or 6–32 fl oz**	**0.094–0.25 or 0.05–0.25**

- Clethodim is also available as Select Max, which contains a specialized adjuvant system, thus nonionic surfactant plus ammonium sulfate (AMS) is the standard adjuvant recommendation. Also, Select Max does not require additional adjuvants (other than AMS) when tank-mixed with a “loaded” glyphosate product and provides greater flexibility in additive selection when tank-mixed with other products.
- Select 2E should always include crop oil concentrate at 1 qt/A. Add ammonium sulfate at 2.5 lb/A to improve quackgrass control.
- To avoid antagonism (reduced grass control) from broadleaf herbicides, spray 2-3 days before the broadleaf herbicide or wait 7 days after the broadleaf herbicide application.
- Apply at least 60 days prior to grain harvest.

Table 5.57 - Comments on Postemergence Herbicides for Soybean (cont.)

Trade Name	Herbicide Common Name	Site of Action Number	Application	Product/A	Active Ingredient (ai) lb/A
Storm	**bentazon + aciflourfen**	**6 + 14**	**Postemergence**	**1–1.5 pt**	**0.33–0.5 0.167–0.25**

- Prepackaged mixture of Basagran plus Ultra Blazer; refer to comments in those sections for more information.
- Apply at least 50 days prior to grain harvest.

Synchrony XP 28.4XP	**chlorimuron + thifensulfuron**	**2 + 2**	**fully expanded 1st trifoliate**	**0.375–1.125 oz**	**0.005–0.015 + 0.0016–0.0045**

- Synchrony XP may be applied postemergence to STS or Bolt soybeans at a use rate of 0.375–1.125 oz/A; and to non-STS soybeans at 0.375 oz/A.
- Synchrony XP may be tank-mixed to improve weed control spectrum.
- Carefully observe crop rotation intervals, and note that extended crop rotation intervals apply when Synchrony XP is applied following preemergence applications of other sulfonylurea or imidazolinone herbicides.
- Synchrony contains two Group 2 herbicides, and there is wide-spread resistance in the region to this family of herbicides.
- Apply at least 60 days before harvest.

Ultra Blazer 2S	**acifluorfen**	**14**	**at least 1 trifoliate**	**0.5–1.5 pt**	**0.125–0.38**

- Apply in a minimum of 20 gal of water/A and at a minimum pressure of 40 psi.
- Do not apply when weeds or crop are under stress; applications made under these conditions generally will be less satisfactory than those made under optimum conditions.
- Tank-mixing with Basagran improves velvetleaf and common lambsquarters control.
- Apply at least 50 days prior to grain harvest.
- *Water quality advisory.*

[1] Various glyphosate formulations exist; see Table 5.2 (glyphosate formulations for more information).

Table 5.58 - Spray Additives and Rainfastness for "Burndown" or Postemergence Soybean Herbicides

Spray additives, or adjuvants, are products included in the spray tank to improve the performance of herbicides. These include non-ionic surfactants (NIS), crop oil concentrate (COC), methylated or ethylated seed oil (MSO or ESO), or nitrogen solutions. In general, NIS should contain at least 80% active ingredient and COC should contain at least 15% emulsifier. Nitrogen solutions can be 28, 30, or 32% ammonium-based fertilizer solutions; ammonium sulfate (AMS) should be spray-grade dry ammonium sulfate (21-0-0).

Trade Names	Adjuvant(s)	Rate	Rainfastness (hours)
2,4-D (burndown)	none recommended or		1
	non-ionic surfactant or	1 qt/100 gal	
	crop oil concentrate	1–2 qt/A	

Table 5.58 - Spray Additives and Rainfastness for "Burndown" or Postemergence Soybean Herbicides (cont.)

Spray additives, or adjuvants, are products included in the spray tank to improve the performance of herbicides. These include non-ionic surfactants (NIS), crop oil concentrate (COC), methylated or ethylated seed oil (MSO or ESO), or nitrogen solutions. In general, NIS should contain at least 80% active ingredient and COC should contain at least 15% emulsifier. Nitrogen solutions can be 28, 30, or 32% ammonium-based fertilizer solutions; ammonium sulfate (AMS) should be spray-grade dry ammonium sulfate (21-0-0).

Herbicide	Adjuvant(s)	Rate	Rainfastness (hours)
Aim, Cadet, Marvel	nonionic surfactant or	2 pt/100 gal	1
	crop oil concentrate plus	1 gal/100 gal	
	ammonium sulfate or	2–4 lb/A	
	nitrogen solution (optional)	2–4 gal/100 gal	
Assure II/Targa	nonionic surfactant	1 qt/100 gal	1
	or crop oil concentrate	4 qt/100 gal	
Basagran	crop or vegetable oil concentrate	5 qt/100 gal (2 pt/A maximum)	8
	or nitrogen solution	2–4 qt/A	
	or ammonium sulfate (for velvetleaf)	2.5 lb/A	
Classic	nonionic surfactant	1 qt/100 gal	1
	or crop oil concentrate	1 gal/100 gal	
	plus nitrogen solution	2–4 pt/A	
	or ammonium sulfate (for velvetleaf)	2–4 lb/A	
Cobra[1]	nonionic surfactant	1 qt/100 gal	0.5
	or crop oil concentrate	1–2 pt/100 gal	
	plus/or nitrogen solution	4 qt/A	
	or ammonium sulfate	2.5 lb/A	
Durango DMA/Duramax	no NIS/COC recommended		1
	ammonium sulfate (optional)	8.5–17 lb/A	
Elevore (burndown)	crop oil concentrate or	4–8 pt/100 gal	1
	methylated seed oil	4–8 pt/100 gal	
Enlist One (burndown)	consult enlisttankmix.com		1
Engenia	consult www.engeinatankmix.com		4
Envive (burndown)	crop oil/modified seed oil	1 gal/100 gal	1
	or nonionic surfactant	1 qt/100 gal	
Extreme	nonionic surfactant	1 pt/100 gal	1
	plus ammonium sulfate	2.5 lb/A	
FirstRate	nonionic surfactant	1–2 pt/100 gal	2
	plus nitrogen solution	2.5 gal/100 gal	
	or ammonium sulfate	2 lb/A	
	or crop oil concentrate	1.2 gal/100 gal	
	plus nitrogen solution (optional)	2.5 gal/100 gal	

Table 5.58 - Spray Additives and Rainfastness for "Burndown" or Postemergence Soybean Herbicides (cont.)

Spray additives, or adjuvants, are products included in the spray tank to improve the performance of herbicides. These include non-ionic surfactants (NIS), crop oil concentrate (COC), methylated or ethylated seed oil (MSO or ESO), or nitrogen solutions. In general, NIS should contain at least 80% active ingredient and COC should contain at least 15% emulsifier. Nitrogen solutions can be 28, 30, or 32% ammonium-based fertilizer solutions; ammonium sulfate (AMS) should be spray-grade dry ammonium sulfate (21-0-0).

Herbicide	Adjuvant(s)	Rate	Rainfastness (hours)
Flexstar	nonionic surfactant	1–2 qt/100 gal	1
	or crop oil concentrate	2–4 qt/100 gal	
	plus nitrogen solution	1 gal/100 gal (minimum)	
	or ammonium sulfate	4 lb/100 gal (minimum)	
Flexstar GT	ammonium sulfate	8.5–17 lb/100 gal	1
Fusilade	nonionic surfactant	1–2 qt/100 gal	1
	or crop oil concentrate	2–4 qt/100 gal	
	plus nitrogen solution	1 gal/A	
	or 10–34–0 (optional)	2 pt/A	
Fusion	nonionic surfactant	1–2 qt/100 gal	1
	or crop oil concentrate	2–4 qt/100 gal	
	plus nitrogen solution (optional)	4 gal/100 gal	
Glyphosate	nonionic surfactant	2 qt/100 gal	1–6
	plus ammonium sulfate (optional)	8.5–17 lb/100 gal	
Gramoxone SL	nonionic surfactant	1 pt/100 gal	0.5
	or crop oil concentrate	1 gal/100 gal	
Harmony SG[2]	nonionic surfactant	1–2 pt/100 gal	1
	or crop oil concentrate	2 qt/100 gal	
	plus nitrogen solution	4 gal/100 gal	
	or ammonium sulfate (for velvetleaf)	2–4 lb/A	
Liberty 280	ammonium sulfate	3 lb/A	4
Permit Plus	nonionic surfactant	1–2 pt/100 gal	4
	or crop oil concentrate	2 qt/100 gal	
	plus nitrogen solution	4 gal/100 gal	
	or ammonium sulfate (for velvetleaf)	2–4 lb/A	
Poast	crop or vegetable oil concentrate	2 pt/A	1
	or Dash HC	1 pt/A	
	plus nitrogen solution	2–4 qt/A	
	or ammonium sulfate (certain species)	2.5 lb/A	
Prefix	non-ionic surfactant	1 qt/100 gal	1
	DO NOT use crop oil concentrate	–	

Table 5.58 - Spray Additives and Rainfastness for "Burndown" or Postemergence Soybean Herbicides (cont.)

Spray additives, or adjuvants, are products included in the spray tank to improve the performance of herbicides. These include non-ionic surfactants (NIS), crop oil concentrate (COC), methylated or ethylated seed oil (MSO or ESO), or nitrogen solutions. In general, NIS should contain at least 80% active ingredient and COC should contain at least 15% emulsifier. Nitrogen solutions can be 28, 30, or 32% ammonium-based fertilizer solutions; ammonium sulfate (AMS) should be spray-grade dry ammonium sulfate (21-0-0).

Herbicide	Adjuvant(s)	Rate	Rainfastness (hours)
Pursuit	nonionic surfactant	1 qt/100 gal	1
	or crop oil concentrate	2 pt/A	
	or vegetable oil concentrate	1.5–2 pt/A	
	plus nitrogen solution	1–2 qt/A	
	or ammonium sulfate	2.5 lb/A	
Raptor	crop oil concentrate	2 pt/A	1
	or vegetable seed oil	1.5–2 pt/A	
	or nonionic surfactant	1 qt/100 gal	
	plus nitrogen solution	1–2 qt/A	
	or ammonium sulfate	2.5 lb/A	
Reflex	nonionic surfactant	1–2 qt/100 gal	1
	or crop oil concentrate	2–4 qt/100 gal	
	plus nitrogen solution (optional)	4 qt/A	
Resource	crop oil concentrate	2–4 qt/100 gal	1
	plus nitrogen solution (optional)	2–4 qt/A	
Roundup WeatherMax/ PowerMax	no NIS/COC required	8.5–17 lb/100 gal	<1
	ammonium sulfate (optional)		
Select	crop oil concentrate	2–4 qt/100 gal	1
	plus nitrogen solution (optional)	1–2 qt/A	
Sharpen (burndown)	methylated seed oil (MSO)	1 gal/100 gal	1
	plus ammonium sulfate	8.5-17 lb/100 gal	
	or nitrogen solution	1.25-2.5 gals/100 gal	
Storm	nonionic surfactant	1–2 pt/100 gal	8
	or crop oil concentrate	1–2 pt/A	
	or nitrogen solution	2 qt/A	
	or ammonium sulfate (for velvetleaf or pigweed)	2 lb/A	
Synchrony XP	crop oil concentrate	1 gal/100 gal	1
	plus nitrogen solution	2–4 qt/A	
	or 10-34-0	1–2 qt	
	or ammonium sulfate (for velvetleaf)	2–4 lb/A	
Touchdown HiTech	nonionic surfactant	1 qt/100 gal	1–6
	plus ammonium sulfate (optional)	8.5–17 lb/100 gal	
Touchdown Total	no NIS/COC required	—	1–6
	plus ammonium sulfate (optional)	8.5–17 lb/100 gal	

Table 5.58 - Spray Additives and Rainfastness for "Burndown" or Postemergence Soybean Herbicides (cont.)

Spray additives, or adjuvants, are products included in the spray tank to improve the performance of herbicides. These include non-ionic surfactants (NIS), crop oil concentrate (COC), methylated or ethylated seed oil (MSO or ESO), or nitrogen solutions. In general, NIS should contain at least 80% active ingredient and COC should contain at least 15% emulsifier. Nitrogen solutions can be 28, 30, or 32% ammonium-based fertilizer solutions; ammonium sulfate (AMS) should be spray-grade dry ammonium sulfate (21-0-0).

Herbicide	Adjuvant(s)	Rate	Rainfastness (hours)
Ultra Blazer	non-ionic surfactant	1–2 pt/100 gal	6
	or crop oil concentrate	1–2 pt/100 gal	
	or ammonium sulfate	2.5 lb/A	
	or nitrogen solution (for velvetleaf)	2–4 qt/A	
Valor XLT/Rowel FX (burndown)	crop oil concentrate	1–2 pt/A	1
	or nonionic surfactant	1 qt/100 gal	
	plus ammonium sulfate (optional)	8.5–17 lb/100 gal	
Warrant Ultra	non-ionic surfactant	1–2 qt/100 gal	1
	or crop oil concentrate	2–4 qt/100 gal	
XtendiMax/FeXapan	consult www.xtendimaxapplicationrequirements.com		4
	consult www.fexapanapplicationrequirements.dupont.com		

[1] Adjuvants for use with Cobra depend on relative humidity and weed species.

[2] Use crop oil concentrate (COC) under drought-stressed conditions.

Table 5.59 - Grain Harvesting Interval and Forage Restrictions for Soybean Herbicides

	Forage	Grain
Trade Name	**(ok to feed)**	**(days to harvest)**
2,4-D	no	–*
2,4-DB	60 days	60
Afforia	no	–
Aim, Cadet	no	60
Anthem	no	–
Anthem Maxx	no	60
Assure II/Targa	no	80
Authority Elite	30	–
Authority First/Sonic	no	65
Authority MTZ	no	–
Authority Supreme	–	–
Authority XL	no	–
Basagran	30 days	none
Boundary	40 days	–

Table 5.59 - Grain Harvesting Interval and Forage Restrictions for Soybean Herbicides (cont.)

	Forage	Grain
Herbicide	**(ok to feed)**	**(days to harvest)**
BroadAxe	30	–
Canopy DF/Blend	no	–
Classic	no	60
Cobra	no	45
Command	no	–
Dual Magnum	no	–
Elevore	–	–
Enlist One	56 days	–
Engenia	7 days (forage), 14 days (hay)	before full bloom
Envive	no	–
Extreme	no	85
Fierce, Fierce XLT	no	–
FirstRate	14 days	65
Flexstar GT	no	45
Fusilade	no	before bloom
Fusion	no	before bloom
Gangster	no	–
Glyphosate	no	14
Gramoxone (preharvest)	no	application restriction[1]
Harmony SG	7 days (green), 30 days (dried)	60
Liberty	45 days	45
Lorox	yes	–
Marvel	no	60
Metribuzin	40 days	–
OpTill	no	85
Outlook	no	–
Permit Plus	30	88
Poast	yes[3]	75
Prefix	no	90
Prowl	yes	–
Pursuit	no	85
Python	no	–
Raptor	no	85
Reflex, Flexstar	no	before bloom
Resource	no	60
Roundup (in-crop)[4]	14	14
Select	no	60

Table 5.59 - Grain Harvesting Interval and Forage Restrictions for Soybean Herbicides (cont.)

	Forage	Grain
Herbicide	**(ok to feed)**	**(days to harvest)**
Sharpen	65	—
Storm	no	50
Surveil	no	—
Synchrony XP	no	60
Touchdown	no	14
Treflan	yes	—
Trivence	no	—
Ultra Blazer	no	50
Valor/Rowel, Valor XLT/Rowel FX	no	—
Warrant	no	no
Warrant Ultra	no	45
XtendiMax/FeXapan	7 days (forage), 14 days (hay)	before full bloom
Zidua	yes	—
Zidua PRO	no	85

* — = not addressed on the label.

[1] When at least 65% of the seed pods have reached a mature brown, or when seed moisture is 30% or less.

[2] Do not feed if applied after crop emergence.

[3] Do not feed green forage.

[4] Allow 7 days between preharvest application and grain harvest.

Table 5.60 - Comments on Harvest Aids for Soybeans

Treatments are based on broadcast application, not wiper-bar or rope-wick applications.

Trade Name	Common Name	Site of Action Number	Timing	Product/A	lb ai/A
Aim 2EC	**carfentrazone**	**14**	**At least 3 days before harvest**	**1.5 fl oz**	**0.024**

- Use as a harvest aid to desiccate a limited number of broadleaf weed species.
- Use a non-ionic surfactant at 2 pt/100 gal spray solution or crop oil concentrate at 1 gal/100 gal spray solution plus ammonium sulfate at 2-4 lb/A or nitrogen solution at 2-4 gal/100 gal spray solution.
- Application shall be made when the crop is mature and the grain has begun to dry down. Do not apply within 3 days of harvest.
- Apply in 10 gal/A water.
- Do not feed treated soybean forage or hay to livestock.
- Include necessary adjuvants and make sure spray coverage is sufficient, otherwise poor control will result.

Table 5.60 - Comments on Harvest Aids for Soybeans (cont.)

Treatments are based on broadcast application, not wiper-bar or rope-wick applications.

Trade Name	Common Name	Site of Action Number	Timing	product/A	lb ai/A
Clarity 4S	**dicamba**	**4**	**At least 7 days before harvest**	**8-64 fl oz**	**0.25-2.0**

- Apply Clarity to actively growing weeds after soybean pods have reached mature brown color and at least 75% leaf drop has occurred.
- Use a non-ionic surfactant at 1 qt/100 gal spray solution or crop oil concentrate at 1 gal/100 gal spray solution plus nitrogen solution at 2-4 qt/A.
- Do not feed soybean fodder or hay following a pre-harvest application of Clarity.
- *Water quality advisory.*

Defol 5	**sodium chlorate**		**7 to 10 days before harvest**	**4.8 qts**	**6.0**

- Labeled to dry weeds in early maturing soybeans and to facilitate harvest.
- Apply to soybeans 7 to 10 days before anticipated harvest, when beans are mature and ready to harvest.
- No adjuvant recommended.
- Do not graze treated field or feed treated fodder.
- Apply in at least 5 gals of water by air, and 20 gals of water with ground application.

Glyphosate	**glyphosate**	**9**	**At least 7 days before harvest**	**varies with formulation**	**Up to 0.75**

- Refer to individual herbicide label to be sure the formulation used is labeled for this type of application.
- Apply glyphosate to soybeans after pods have set and lost all green color (80–90% drop of leaves has occurred).
- Use a non-ionic surfactant at 2 qt/100 gal spray solution plus ammonium sulfate (optional) at 8.5-17 lb/100 gal spray solution.
- Apply glyphosate in 10–20 gallons of water/A to control weeds that may interfere with harvest or to control perennials such as quackgrass or Canada thistle.
- Do not graze or harvest the treated crop for livestock feed within 25 days of application.
- Do not use on soybeans grown for seed.
- Will not control glyphosate-resistant weeds, nor dry down Roundup Ready varieties.
- See Table 5.2 (glyphosate table) for more information on glyphosate formulations.

Table 5.60 - Comments on Harvest Aids for Soybeans (cont.)

Treatments are based on broadcast application, not wiper-bar or rope-wick applications.

Trade Name	Common Name	Site of Action Number	Timing	product/A	lb ai/A
Gramoxone SL 2S	**paraquat**	**22**	**At least 15 days before grain harvest; at least 3 days before soybean grown for seed harvest**	**8–16 fl oz**	**0.125–0.25**

- Gramoxone may be used for drying certain weeds and quickening berry drop of Eastern black nightshade just before soybean harvest.
- Soybean plants must be mature (65% or more of the seed pods have reached mature brown color or seed moisture is 30% or less).
- Use a non-ionic surfactant at 1 pt/100 gal spray solution or crop oil concentrate at 1 gal/100 gal spray solution.
- Do not graze or harvest for forage or hay.

Sharpen	**saflufenacil**	**14**	**At least 3 days before harvest**	**1.0–2.0 fl oz**	**0.022–0.044**

- Apply after physiological maturity when greater than 50% leaf drop has occurred and remaining leaves are yellow.
- Include methylated seed oil (MSO) at 1 gal/100 gals (1% v/v) plus ammonium sulfate (AMS) at 8.5 to 17 lbs/100 gals or urea ammonium nitrate (UAN) at 1.25 to 2.5 gals/100 gals.
- Do not apply to soybeans grown for seed production.

Small Grains Weed Management

Integrated Weed Management

A well-planned weed management program for small grains involves using multiple strategies. These strategies include preventive techniques such as monitoring, cultural controls, mechanical or physical controls, biological controls, and chemical control tactics. Preventive techniques start with planting weed-free crop seed or choosing an alternative field or planting date. Regularly monitoring for pests is an important predictive tool. Rotating crops to disrupt weed life cycles and planting adapted varieties are good examples of cultural controls. Mechanical or physical controls may include tillage and mowing. Biological controls may include using insect or disease organisms or even grazing animals in pasture production systems. Finally, chemical controls are an important component of many IPM systems, but their use should be based on sound management decisions. See the introductory chapter of this guide for more information on an IPM system.

A good small-grain stand is highly competitive and may not require herbicides to control weeds. Planting an adapted variety at recommended populations into a weed-free field should serve as the foundation for weed control in small grains. Winter annuals such as chickweed and henbit are becoming more common in small-grain fields.

This guide provides chemical control suggestions based on university research and manufacturer recommendations. Management information for common small grain weed problems is outlined in the following pages. This publication strives for accuracy; however, omissions, inaccuracies, or dated information can occur because of the dynamics of pests and pest management. Seek out additional information from the manufacturer or other reliable sources when making important management decisions. Remember, this guide is not a substitute for the manufacturer's product label.

Fall-planted Small Grains

This chapter pertains to fall planted small grains for the Mid-Atlantic region. Herbicide application timing, expected control levels, and comments are based on fall planting. See below for spring oats.

Fields should be scouted in late fall or early spring to determine if weed populations warrant treatment. Early application while weeds are still small is the key to successful control of weeds in small grains. Apply herbicides only at recommended stages of crop growth in order to avoid crop injury. See Figure 5.1 and Tables 5.3 to 5.5.

Wheat and barley are sensitive to triazine residues; therefore, use a short residual herbicide program in crops preceding small grains. See the corn weed-control section for information on the effect of pH on triazine residues, and for weed-control programs that reduce triazine residues.

Specific Weed Issues:

Downy brome control is listed on Finesse, Finesse Grass and Broadleaf, Maverick, Olympus Flex, and PowerFlex labels. (Refer to label to determine if chess or cheat species will be controlled.) In most cases, Finesse Grass and Broadleaf provides only suppression of downy brome when applied in the fall. (Control may be obtained depending on rate and timing.) Maverick, PowerFlex, and Olympus Flex provide control of downy brome when applied in the fall and suppression when applied in the spring. Soybeans can be planted 3 months after PowerFlex application. However, be cautious of crop rotation intervals when using Maverick or Olympus Flex. Aside from STS soybeans and IR corn, most other rotational crops cannot be planted for at least 12 to 18 months or more after application depending on the herbicide used.

Group 2 (ALS) resistant common chickweed populations have been identified in the Mid-Atlantic region since group 2 herbicides such as Harmony Extra are routinely used in small grains. If group 2-resistant chickweed is suspected, contact your local county educator to report the incident. Starane Ultra (Dow AgroSciences) at 0.3–0.4 pt/A up to flag leaf growth stage on wheat, barley, and oats has resulted in good chickweed control in university trials. However, it will not control other key species such as wild garlic, mustards, and henbit. (It will, however, injure/kill underseeded legumes.) Starane Ultra can be tank-mixed with Harmony Extra to broaden the spectrum of control. Valor SX also provides very effective residual control of common chickweed and can be used in an early preplant burndown program before seeding wheat. Apply up to 2 oz/A Valor SX (plus other burndown herbicides) at least 7 days before planting wheat (see Table 5-8 for specific comments). Glory and TriCor (metribuzin) have a 24(c) use label and at 2 to 4 ounces per acre have provided excellent control of Group 2–resistant chickweed in university trials when applied in either fall or spring (see Table 5-8 for specific comments).

Herbicide-resistant annual ryegrass (or Italian ryegrass) in the region is resistant to Group 1 (ACCase) herbicides, which includes Axial and Hoelon. Other populations are resistant to Group 2 (ALS-herbicides) such as Osprey, PowerFlex, and Finesse. There is concern about developing populations resistant to both herbicide groups. Valor SX and Zidua (or Anthem Flex) have fair to good residual control of annual ryegrass but will not control it if emerged seedlings are present at time of application. POST applications of Osprey or PowerFlex or Axial XL will control susceptible populations. Do not rely on these herbicide groups to control annual ryegrass in rotational crops to reduce the risk of developing resistant populations.

Spring Oats: Oats are sensitive to triazine residues; therefore, use a short residual herbicide program when small grains follow in the crop rotation. Read the corn weed-control section for information on the effect of pH on triazine residues, and for weed-control programs that reduce triazine residues.

In addition to comments for other small grains, the following comments regarding herbicide use in small grains pertain:

2,4-D: Use only 0.5 pt/A for oats. Certain varieties, especially 'Pennuda,' are more sensitive to 2,4-D than other small grains.

Callisto: For use on to oats only (Callisto should not be applied to other small grains). If PRE, apply 6 fl oz/A Callisto prior to oat emergence. If POST, apply 3 fl oz/A Callisto after oat emergence but before weeds reach 5 inches tall. Callisto controls many broadleaf weeds. Callisto may cause temporary injury of the oat crop. Callisto has a 10-month rotation restriction to soybeans and an 18-month rotation restriction to most vegetables.

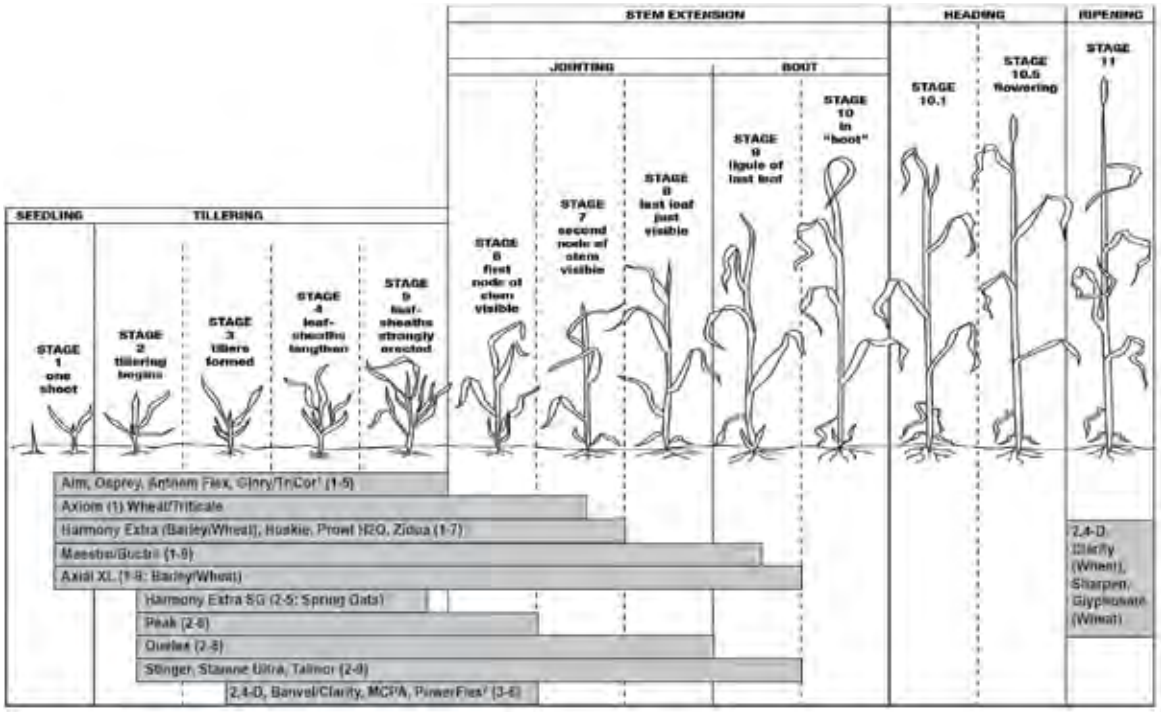
Clarity/Banvel: On spring-seeded oats, apply before five-leaf stage.

Harmony Extra: On spring-seeded oats, apply three-leaf to before jointing (growth stages 2–5). Apply at 0.45 oz to 0.6 oz/a. Do not use on Ogle, Porter, or Premier oat varieties.

Harmony SG: On spring-seeded oats, apply three-leaf to before jointing (growth stages 2–5). Apply at 0.45 oz to 0.6 oz/a. Do not use on Ogle, Porter, or Premier oat varieties.

MCPA amine or ester: Safer on oats underseeded with legumes than 2,4-D (amine formulation only) but use the lower rate (0.25–0.5 pt) and apply in 5–10 gal water/A; legumes should be 2–3 inches tall and cereal should be 8 inches tall to provide canopy to protect legume.

Fig. 5.61 - Growth stages in cereals when herbicides may be applied.



[1]Local research has demonstrated that Glory/TriCor should be applied during "greenup" period in early spring to reduce risk of crop injury.

[2]Local research has found fall applications of PowerFlex is best timing to reduce risk of crop injury.

Table 5.62 - Small Grain Herbicides and their Restrictions

Trade Name[1]	Common Name	Manufacturer	Site of Action Number	Restricted-Use Pesticide[2]	Water Quality Advisory[3]	Worker Reentry[4] (hours)
2,4-D 4 lb/gal	2,4-D	Several	4	—	—	12–48
Aim 2EC	carfentrazone	FMC	14	—	—	12
Anthem Flex 4SE	pyroxasulfone + carfentrazone	FMC	15, 14	—	yes	12
Axial Star 1.15L	pinoxaden + fluroxypyr	Syngenta	1, 4	—	—	48
Axial XL 0.42L	pinoxaden	Syngenta	1	—	—	48
Axiom 68DF	flufenacet + metribuzin	Bayer CropScience	15, 5	—	—	12
Callisto 4SC[6]	mesotrione	Syngenta	27	—	—	12
Clarity 4S/Banvel 4S	dicamba	BASF	4	—	—	24
Curtail 2.4L	clopyralid + 2,4-D	Corteva	4, 4	—	yes	48
Dimetric EXT[6]/TriCor 75DF	metribuzin	WinField/UPI	5	—	yes	12
Engenia 5S	dicamba BAMPA salt	BASF	4	—	yes	24
Express 50SG	tribenuron	FMC	2	—	—	12
Finesse Cereal and Fallow 75DF	chlorsulfuron + metsulfuron methyl	FMC	2, 2	—	—	4
Gramoxone SL 2S	paraquat	Syngenta	22	yes	—	12
Harmony SG 50DF	thifensulfuron	FMC	2	—	—	4
Harmony Extra 50DF	thifensulfuron + tribenuron	FMC	2	—	—	12
Huskie 2.06L	pyrasulfotole + bromoxynil	Bayer CropScience	27, 6	—	yes	12
Huskie Complete 2.4L	pyrasulfotole + bromoxynil + thiencarbazone	Bayer CropScience	27, 6, 2	—	yes	24
MCPA 4 lb/gal	MCPA	Several	4	—	—	12–48
Maestro	bromoxynil	Nufarm	6	—	—	12
Maverick 75DF	sulfosulfuron	Monsanto	2	—	yes	12
Osprey 4.5WDG	mesosulfuron	Bayer CropScience	2	—	—	4
Peak 57WDG	prosulfuron	Syngenta	2	—	—	12
PowerFlex HL 13WDG	pyroxsulam	Corteva	2	—	—	12
Prowl H_2O 3.8CS	pendimethalin	BASF	3	—	—	24
Pulsar 1.67L	fluroxypyr + dicamba	Syngenta	4, 4	—	—	24

Table 5.62 - Small Grain Herbicides and their Restrictions (cont.)

Trade Name[1]	Common Name	Manufacturer	Site of Action Number	Restricted-Use Pesticide[2]	Water Quality Advisory[3]	Worker Reentry[4] (hours)
Roundup Powermax 4.5S/Roundup Weather Max 4.5S/ other glyphosates	glyphosate	Monsanto/others	9	—	—	4–12
Quelex 20.4WDG	halauxifen + florasulam	Corteva	4, 2	—	yes	12
Sentrallas 1.55L	thifensulfuron + fluroxypyr	FMC	2, 4	—	—	24
Sharpen 2.85SC	saflufenacil	BASF	14	—	yes	12
Starane Ultra 2.8L	fluroxypyr	Corteva	4	—	—	12
Stinger 3S	clopyralid	Corteva	4	—	yes	12
Talinor 1.77EC	bicyclopyrone + bromoynil	Syngenta	27, 6	—	—	24
Valor 51WDG	flumioxazin	Valent	14	—	—	12
XtendiMax 2.9S/ FeXapan	dicamba DGA Salt withVaporGrip	Monsanto	4	—	yes	24
Zidua 85WDG / Zidua 4.17SC	pyroxasulfone	BASF	15	—	yes	12

[1] Generic alternatives to some of these products are available. See table in the introductory chapter of this guide.

[2] Only licensed applicators may purchase and apply restricted-use pesticides.

[3] These herbicides have an “Environmental Hazard Warning” on their label and have been detected in water supplies from normal agricultural use. Special precautions apply for their use on coarse-textured soils or where water tables are shallow. See the product label for specific restrictions.

[4] If soil-applied products are injected or incorporated at application time, under certain circumstances the Worker Protection Standard allows workers to enter the treated area if they will have no contact with anything that has been treated. Personal protective equipment is required for early entry to treated areas if contact with treated soil, plants, or water is involved.

[5] Callisto is only registered for use in spring oats.

[6] Dimetric EXT is approved for use under 24(c) labels in Maryland, Pennsylvania, and West Virginia. TriCor is approved for use under 24(c) label in Virginia.

Table 5.63 - Herbicides Labeled for Use in Small Grains by Small Grain Species

	Fall Seeded				
	Wheat	**Barley**	**Rye**	**Triticale**	**Spring Oats**
2,4-D[1]	X	X	X		X
Aim	X	X	X		X
Anthem Flex	X				
Axial Star	X	X			
Axial XL	X	X			
Axiom	X			X	
Callisto					X
Clarity/Banvel	X	X	X	X	X
Curtail	X	X			
Dimetric EXT/TriCor	X	X			
Finesse Cereal and Fallow	X	X		X	
Gramoxone	X	X	X	X	X
Harmony Extra, Express	X	X		X	X
Harmony SG	X	X		X	X
Huskie	X	X	X	X	
Huskie Complete	X				
Maverick	X				
MCPA	X	X	X		X
Maestro (Buctril)	X	X	X	X	X
Osprey	X			X	
Peak	X	X	X	X	X
Powerflex HL	X			X	
Prowl H2O	X			X	
Quelex	X	X		X	
Roundup	X	X	X	X	X
Sentrallas	X	X			
Sharpen	X	X	X	X	X
Starane Ultra	X	X		X	X
Stinger	X	X			X
Talinor	X	X			
Valor	X				
Zidua	X				

[1] 2,4-D is manufactured by various companies; labels may vary among manufacturers.

Table 5.64 - Small Grain Herbicide Prepackaged Mixes, or Co-packs, and Equivalents

Trade Name	Components (ai or ae/gal or lb)	Site of Action Number	If You Apply (per acre)	You Have Applied (ai or ae lb / A)	An Equivalent Tank-mix of
Anthem Flex 4SE	3.733 lb pyroxasulfone	15	2.75 fl oz	0.08 lb pyroxasulfone	2.46 fl oz Zidua 4.17SC
	0.267 lb carfentrazone	14		0.006 lb carfentrazone	0.4 fl oz Aim 2EC
Axial Star 1.15L	0.42 lb pinoxaden	1	16.4 fl oz	0.053 lb pinoxaden	16.4 fl oz Axial 0.42L
	0.73 fluroxypyr	4		0.094 lb fluroxypyr	4.3 fl oz Starane Ultra 2.8L
Axiom 68DF	0.544 lb flufenacet	15	6 oz wt	0.2 lb flufenacet	6.4 oz Define 4SC
	0.136 lb metribuzin	5		0.05 metribuzin	1.1 oz Metribuzin 75DF
Curtail 2.4L	0.38 lb clopyralid	4	1 qt	0.095 lb clopyralid	4.1 fl oz Stinger 3S
	2 lb 2,4-D	4		0.5 lb 2,4-D	16 fl oz 2,4-D amine 4L
Finesse Cereal and Fallow 75DF	0.625 chlorsulfuron	2	0.25 oz wt	0.001 chlorsulfuron	0.12 oz Glean XP 75DF
	0.125 metsulfuron	2		0.125 metsulfuron	1.2 oz Ally XP 60DF
Harmony Extra 50DF	0.333 thifensulfuron	2	0.75 oz wt	0.015 thifensulfuron	0.5 oz Harmony SG 50DF
	0.167 tribenuron	2		0.0078 tribenuron	0.25 oz Express 50DF
Huskie 2.06L	0.31 lb pyrasulfotole	27	13 fl oz	0.031 lb pyrasulfotole	0.5 oz ai pyrasulfotole
	1.75 bromoxynil	6		0.178 bromoxynil	11.4 fl oz Maestro 2EC (Buctril)
Huskie Complete 2.4L	0.26 lb pyrasulfotole	27	13.7 fl oz	0.027 lb pyrasulfotole	0.44 oz ai pyrasulfotole
	2.09 bromoxynil	6		0.224 lb bromoxynil	14.3 fl oz Maestro 2EC (Buctril)
	0.042 lb thiencarbazone	2		0.004 lb thiencarbazone	0.072 oz ai thiencarbazone
Quelex 20.4WDG	0.1 lb halauxifen	4	0.75 oz wt	0.005 lb halauxifen	1.1 fl oz Elevore 0.57L
	0.1 florasulam	2		0.005 lb florasulam	0.075 oz ai florasulam
Sentrallas 1.55L	0.25 lb thifensulfuron	2	12 fl oz	0.02 lb thifensulfuron	0.5 oz Harmony SG 50DF
	1.3 fluroxypyr	4		0.122l b fluroxypyr	5.6 fl oz Starane Ultra 2.8L
Talinor 1.77EC	0.31 lb bicyclopyrone	27	13.7 fl oz	0.03 lb bicyclopyrone	0.53 oz ai bicyclopyrone
	1.46 lb bromoxynil	6		0.16 lb bromoxynil	10.2 fl oz Maestro 2E

Table 5.65 - Relative Effectiveness of "Burndown" Treatments for No-Till Small Grains

Table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size (young weeds) or growth stage. Treatments are rated only for control of vegetation existing at the time of application.

Weed control rating

10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65%

N = less than 55% or no control L = Labeled but no university data - = no information available

	Trade Name					
Weed	**Clarity/ Banvel**	**Gramoxone**	**Harmony Extra (Fall-Applied)**	**Roundup/ Glyphosate (Fall-Applied)**	**Roundup/ Glyphosate (Spring-Applied)**	**Sharpen**
Site of Action Number	4	22	2	9	9	14
Chickweed, common	7	**8+**	**9**	**9**	9	L
Clover, Red	**9**	8	6	**8+**	7	--
Dandelion	7	N	6	**8+**	6	--
Dogbane, Hemp; Dewberry; Milkweed; etc.	6	6	N	**8+**	6	N
Foxtail spp.	N	**9**	N	**9**	**9**	N
Lambsquarters, Common	**9**	8	9	9	9	L
Marestail	8	7	7	**9**	**9**	**9+**
Mustard spp.	**9**	8	**9**	**9**	**9**	L
Ragweed, Common	**9**	8	6	**9**	**9**	L
Rye Cover, Volunteer Small Grains	N	**9**	N	**10**	**10**	N
Smartweed	**9**	7	**9**	7	7	L
Sod, Alfalfa	8	N	N	**8+**	7	--
Sod, Bromegrass or Quackgrass	N	6	N	**9**	7	N
Sod, Orchardgrass or Fescue	N	N	N	**9**	7	N
Thistle, Canada	8	6	7	**9**	7	--
Timothy or Bluegrass	N	7	N	**10**	**10**	N
Vetch, Hairy	**9**	7	7	8	6	--

Table 5.66 - Comments on "Burndown" Herbicides for No-Till Small Grains

See specific product label to determine correct rate for soil type and weed species found in each field.

These treatments may be used in conventional, reduced-till, and no-till systems.

Tables 5.62 and 5.65 list characteristics and efficacy of "burndown" herbicides.

Trade Name[1]	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Banvel 4S	**dicamba DMA Salt**	**4**	**Preplant or preemergence to postemergence**	**2-4 fl oz**	**0.06-0.125**
Clarity 4S	**dicamba DGA Salt**			**2-4 fl oz**	
Engenia 5S	**dicamba BAPMA Salt**			**1.6-3.2**	
XtendiMax 2.9S/ FeXapan	**dicamba DGA Salt with VaporGrip**			**2.75-5.5 fl oz**	

- The 4 fl oz rate controls small annual broadleaf weeds and there is no waiting period prior to planting at this rate.
- Clarity/Banvel may be used at greater than 4 fl oz prior to planting wheat; however, for each pt/A of Banvel applied, delay crop planting for 20 days.

Gramoxone SL 2S	**paraquat**	**22**	**Preplant, Preemergence,**	**2-4 pt**	**0.5-1.0**

- Apply in 20–60 gal/A for control of emerged annual weeds.
- Add 8–32 oz nonionic surfactant/100 gal of spray.
- Phosphate-containing liquid fertilizer solutions diminish paraquat activity if used as a carrier.
- Use appropriate precautions when handling paraquat to minimize exposure to the herbicide.
- Do not use flood jet tips larger than size 20 or spacing greater than 40 inches.
- *Restricted-use pesticide.*

Harmony Extra SG 50DF	**thifensulfuron + tribenuron**	**2 2**	**Preplant or preemergence to postemergence**	**0.45-0.9 oz**	**0.014-0.028**

- For use on wheat, barley, and oats only.
- Apply burndown treatment before or shortly after planting but before small grain emergence.

Roundup 3S/ glyphosate[2]	**glyphosate**	**9**	**Preplant or preemergence**	**1-3 qt**	**1.0-3.0 lb ae/A**

- Apply before, during, or after planting but before crop emergence.
- Use the low rate for annual weeds up to 6 inches tall and higher rates for weeds taller than 6 inches.

Sharpen 2.85SC	**saflufenacil**	**14**	**Preplant or preemergence**	**1-2 fl oz**	**0.022-0.044**

- Apply preplant surface, preplant incorporated, or preemergence for broadleaf weed control.
- For optimum burndown activity, include methylated seed oil (MSO) plus ammonium sulfate (AMS) at 8.5 to 17 lbs/100 gallons.
- Apply 1 to 2 oz/A for burndown activity. Sequential applications are allowed prior to crop emergence but do not apply more than 4 fl oz/A total per cropping season.

[1] The legitimate use of 2,4–D for burndown in wheat is uncertain. None of the 2,4–D ester or amine labels specify application just prior to wheat seeding or emergence. Some research suggests a minimum delay of 7–10 days after application at rates up to 1 pt/A 2,4–D ester. However, use of 2,4–D burndown in wheat is ambiguous at best and, if injury occurs, liability rests with the consultant or applicator.

[2] Various formulations of this product are available. See table in the introductory chapter of this guide. Refer to current product label for active ingredient concentration, application rate, and other restrictions.

Table 5.67 - Relative Effectiveness of Fall Planted Small Grain Herbicides for Winter Annuals

Table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size or growth stage. Results may differ with variations in weed size, temperature, rainfall, and soil moisture. Crop injury rating of VG or E is rarely significant.

Weed control rating

10 = 95–100%

9 = 85–95%

8 = 75–85%

7 = 65–75%

6 = 55–65%

N = less than 55% or no control

L = labeled but no university data

-- = not applicable or no information available

+ = upper end of rating range

Crop tolerance

E = excellent; almost never any crop injury observed

VG = very good; on rare occasion is crop injury observed

G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., seedling depth, seed slit closure, herbicide rate and application timing, adjuvants)

FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often due to herbicide interactions with environmental conditions

F = fair; some crop injury is commonly observed

	Grasses						Broadleaves															
	Site of Action Number	Bluegrass, Annual[1]	Bluegrass, Roughstalk	Brome, spp.[2]	Oatgrass, Bulbous[7]	Ryegrass, Annual[2]	Buckwheat, Wild	Catchweed Bedstraw	Chickweed, Common[2]	Corn, Chamomile	Field Pansy	Groundsel, Common	Henbit/purple Dead Nettle	Horseweed/Marestail	Knawel	Lettuce, Prickly	Mustard spp.	Pennycress, Field	Shepherdspurse	Speedwell spp.[3]	Vetch, Hairy/Annual	Crop Tolerance
Preplant																						
Sharpen	14	N	N	N	N	N	N	N	L	N	N	8	–	L	N	L	L	L	L	–	–	E
Valor	14	6	–	6	N	**9**	6	–	8	–	N	L	8	**9**	N	L	7	8	8	–	–	FG
Delayed Preemergence																						
Axiom	5/15	**8+**	N	7	–	**8+**	–	–	**8+**	**8+**	N	–	**9**	8	**9**	–	**8+**	8	6	–	–	FG
Prowl	3	6	–	–	–	8	–	–	7+	–	N	–	**8+**	N	N	–	7+	–	7+	N	N	VG
Zidua /Anthem Flex	15	**9**	–	8	–	**8+**	–	–	7	–	N	–	8	8	6	–	–	–	–	–	N	VG
Delayed Preemergence to Early Postemergence																						
Axial	1	N	N	N	N	**9**[4]	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	G
Osprey	2	**8+**	**8+**	**8**	**–**	**9**	N	N	7	7	6	N	7	N	8	N	8	N	N	N	8+	G
Postemergence																						
2,4-D[5]	4	N	N	N	N	N	6	7	6	–	N	6	6	**8+**	N	**9**	**9**	**9**	**9**	6	8[7]	F
Aim	14	N	N	N	N	N	6	**8**	N	–	–	N	6	N	6	6	6	8	6	6	6	VG
Clarity/Banvel	4	N	N	N	N	N	8+	N	7	–	N	7	7	8	7	8	7	7	8	6	**9**	F
Dimetric/TriCor	5	**8+**	6	6+	8	N	–	--	**9+**	–	N	--	**9**	N	**8+**	–	7	L	N	8	6	FG[6]
Harmony SG	2	N	N	N	N	N	8	N	7	–	–	**9**	7	N	–	7	**9**	**9**	**9**	N	6	VG
Harmony Extra	2/2	N	N	N	N	N	8	N	8[3]	–	7	**9**	**9**	7	**8+**	8	**9**	**9**	**9**	N	7	VG

Table 5.67 - Relative Effectiveness of Fall Planted Small Grain Herbicides for Winter Annuals (cont.)

	Grasses							Broadleaves															
	Site of Action Number	Bluegrass, Annual[1]	Bluegrass, Roughstalk	Brome, spp.[2]	Oatgrass, Bulbous[7]	Ryegrass, Annual[2]	Buckwheat, Wild	Catchweed Bedstraw	Chickweed, Common[2]	Corn Chamomile	Field Pansy	Groundsel, Common	Henbit/Purple Dead Nettle	Horseweed (Marestail)	Knawel	Lettuce, Prickly	Mustard spp.	Pennycress, Field	Shepherdspurse	Speedwell spp.[3]	Vetch, Hairy/Annual	Crop Tolerance
Huskie	6/27	N	N	N	N	N	L	L	7	N	N	–	**8+**	**8+**	N	–	L	L	L	N	–	VG
MCPA	4	N	N	N	N	N	8	N	6	–	N	6	6	**8+**	–	**9**	**9**	**9**	**8+**	6	7	FG
Maestro (Buctril)	6	N	N	N	N	N	**9**	N	6	–	–	**9**	6	7	N	6	**9**	8	8	N	6	VG
Peak	2	N	N	N	N	N	8	N	7	–	–	N	6+	8	–	**8+**	**9**	**9**	8	N	**9**	G
Powerflex	2	N	**8+**	8	–	**9**	6	7	8	**9+**	**7**	N	7	6	**9**	6	**9**	**9**	8	8	**9**	FG
Quelex	2/4	N	N	N	N	N	L	L	**9**	L	N	–	7	L	**8+**	6	L	L	L	N	L	VG
Starane Ultra	4	N	N	N	N	N	–	L	7+	–	N	–	8	L	6	–	L	L	–	N	**8+**	G
Stinger	4	N	N	N	N	N	**9**	N	N	–	N	**9**	N	**9+**	–	**9**	N	N	N	N	**9**	FG
Talinor	6/27	N	N	N	N	N	L	L	L	–	N	**–**	**8+**	L	–	L	L	–	L	–	**–**	VG

[1] Annual bluegrass control is listed on Osprey Flex label. Fall applications are best.

[2] See the introduction of this chapter for more detailed information on these weeds.

[3] There are several speedwell (Veronica) species, including corn, common, ivy leaf, and others. Depending on the species, their life cycle is either annual or perennial. Many of the commonly used small grain herbicides provide little or no control of speedwell. Finesse has a few annual and perennial speedwells listed on its label and usually provides 80–90 percent control of them. PowerFlex has provided control of certain speedwell species in some university trials. Be cautious of crop rotation intervals if using Finesse. If speedwell is small, Aim provides some control/suppression.

[4] Will not control group 1 (ACCase) resistant annual ryegrass biotypes.

[5] 2,4-D ester provides better control of hairy vetch than 2,4-D amine.

[6] Crop tolerance with Dimetric/TriCor is dependent on weather at time of application and variety. Crop tolerance is improved if applications are made in the early spring rather than in the fall or late spring.

[7] Maverick provides fair to good control (8) of bulbous oatgrass.

Table 5.68 - Relative Effectiveness of Fall Planted Small Grain Herbicides for Postemergent Perennial Weed Control

Table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size or growth stage. Results may differ with variations in weed size, temperature, rainfall, and soil moisture. Crop injury rating of VG or E is rarely significant.

Weed control rating	**Crop tolerance**
10 = 95–100%	E = excellent; almost never any crop injury observed
9 = 85–95%	VG = very good; on rare occasion is crop injury observed
8 = 75–85%	G = good; seldom is crop injury observed as long as proper management practices are followed (e.g., seedling depth, seed slit closure, herbicide rate and application timing, adjuvants)
7 = 65–75%	
6 = 55–65%	FG = fair to good; occasionally crop injury is observed even with proper management practices; injury is often due to herbicide interactions with environmental conditions
N = less than 55% or no control	
L = labeled but no university data	F = fair; some crop injury is commonly observed
-- = no information available	
+ = upper end of rating range	

	Site of Action Number	Cockle, White	Dandelion	Dock spp.	Garlic or Onion, Wild	Smooth Bedstraw	Thistle, Canada	Crop Tolerance
Postemergence								
2,4-D	4	7+	7+	6+	7	6	7	FG
Aim	14	N	N	N	N	6	N	VG
Clarity/Banvel	4	8	6	7	6	N	7	F
Dimetric/TriCor	5	–	L	N	N	–	N	FG[1]
Harmony SG	2	–	6	7	**9**	N	N	VG
Harmony Extra	2/2	–	6	8	**9**	N	7	VG
Huskie	6/27	L	L-s	L-s	**–**	L-s	–	VG
MCPA	4	N	8	6+	6	6	7	FG
Maestro (Buctril)	6	6	6	6	N	N	6	G
Peak	2	–	6	8	**9**	N	6+	VG
Powerflex	2	N	N	N	N	N	N	FG
Quelex	2/4	–	L-s	–	–	L	L-s	VG
Starane Ultra	4	–	7	–	–	L	N	VG
Stinger	4	7+	7+	7	N	N	8	FG
Talinor	6/27	–	L-s	–	–	L	L-s	VG

[1] Crop safety with Dimetric/TriCor is dependent on weather at time of application and variety. Crop safety is improved if applications are made in the spring rather than in the fall.

Table 5.69 - Comments on Herbicides for Small Grains

See specific product label to determine correct rate for soil type and weed species found in each field.

- Tables 5.66, 5.67, and 5.68 list characteristics and efficacy of herbicides.
- A good small grain stand is very competitive and normally does not require a herbicide treatment.
- It is important to control all existing vegetation at planting time, prior to no-till production.

Trade Name	Common Name	Site of Action Number	Application	Product/A	lb ai/A
2,4-D amine 4S	**2,4-D**	**4**	**Full tiller to prejointing (growth stages 3–6)**	**0.5–2.0 pt**	**0.25–1.0**

- For use on wheat, barley, rye, and oats.
- Use lower rates for small annual weeds.
- Use lower rate (0.25–0.5 pt/A) if underseeded with legume (alfalfa, red or white clover are labeled; vetch and sweet clover will be severely injured).
- Spraying small grains too young or after jointing can result in reduced yields or uneven ripening.
- In general, apply when small grain is 4 to 8 inches tall.
- May be tank-mixed with Harmony Extra SG, Banvel, or Maestro (Buctril).
- No rotation restriction to soybeans; 3 month rotation restriction to vegetables; see Table 5.6.

2,4-D LVE 4E	**2,4-D**	**4**	**Full tiller to prejointing (growth stages 3–6)**	**0.5–2.0 pt**	**0.25–1.0**

- For use on wheat, barley, rye, and oats.
- Use lower rates for annual weeds.
- For wild garlic or onion control, apply 1.5–2.0 pt.
- Avoid use if temperatures are expected to exceed 75°F.
- No rotation restriction to soybeans; 3 month rotation restriction to vegetables; see Table 5.6.

Aim 2EC	**carfentrazone**	**14**	**Up to the jointing stage (growth stages 1–5)**	**0.5–2 fl oz**	**0.008–0.016**

- For use on wheat, barley, and oats to control certain broadleaves.
- Apply before weeds are 4 inches tall.
- May be tank-mixed with 2,4-D, MCPA, or other common small grain herbicides to improve control and increase weed spectrum. Some research has shown that Aim provides suppression of Star-of-Bethlehem and speedwell.
- No rotational restrictions to soybeans or vegetables; see Table 5.6.

Table 5.69 - Comments on Herbicides for Small Grains (cont.)

See specific product label to determine correct rate for soil type and weed species found in each field.

- Tables 5.66, 5.67, and 5.68 list characteristics and efficacy of herbicides.
- A good small grain stand is very competitive and normally does not require a herbicide treatment.
- It is important to control all existing vegetation at planting time, prior to no-till production.

Trade Name	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Axial XL 0.42L	**pinoxaden**	**1**	**Two-leaf to preboot (growth stages 2–8)**	**16.4 fl oz**	**0.053**

- For use on wheat or barley only.
- Controls certain grassy weeds such as annual ryegrass, foxtails, barnyardgrass, and wild oat. (Apply Axial XL before weeds have more than 5 leaves on the main stem.)
- Axial XL does not control downy brome or ACCase-resistant grasses.
- Tank-mix with other labeled herbicides to enhance weed control spectrum.
- Axial TBC is a premix of pinoxaden (Axial) + florasulam (in Orion) and Axial Star is a combination of pinoxaden (Axial) + fluroxypyr (Starane); both products control annual grasses and broadleaves.
- No rotation restriction to soybeans; 30 days for leafy and root crops, all other vegetables after 90 days; see Table 5.6.

Axiom 68 DF	**flufenacet + metribuzin**	**5/15**	**Spiking to 2 leaf (growth stage 1)**	**4–10 oz**	**0.133–0333 0.033–0.083**

- For use on fall-seeded wheat and triticale.
- Plant seeds 1 to 2 inches deep to improve crop safety; do not use on broadcast-seeded wheat.
- Apply when crop is between full germination and 2-leaf stage and when weeds have not germinated (preemergence) and 1 leaf stage. Apply prior to weed emergence to 1 leaf stage weeds.
- Use rate depends on soil texture; see product label.
- Some crop varieties are more sensitive; see product label.
- No rotation restriction to soybeans. 12 month rotation restriction to vegetables; see Table 5.6.
- *Water Quality Advisory.*

Banvel 4S	**dicamba DMA Salt**	**4**	**Full tiller to jointing (growth stages 3–6)**	**2–4 fl oz**	**0.06–0.12**
Clarity 4S	**dicamba DGA Salt**			**2–4 fl oz**	
Engenia 5S	**dicamba BAPMA Salt**			**1.6–3.2 fl oz**	
XtendiMax 2.9S/ FeXapan	**dicamba DGA Salt with VaporGrip**			**2.75–5.5 fl oz**	

- For use on fall-seeded barley and wheat only.
- Crop safety and weed control will be similar for all dicamba formulations.
- May be tank-mixed with Maestro (Buctril) or 2,4-D to broaden spectrum of control.
- Do not use if legumes are underseeded.
- No rotation restrictions.

Table 5.69 - Comments on Herbicides for Small Grains (cont.)

See specific product label to determine correct rate for soil type and weed species found in each field.

- Tables 5.66, 5.67, and 5.68 list characteristics and efficacy of herbicides.
- A good small grain stand is very competitive and normally does not require a herbicide treatment.
- It is important to control all existing vegetation at planting time, prior to no-till production.

Trade Name	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Dimetric EXT 75WG/ TriCor 75DF	**metribuzin**	**5**	**2-leaf to 4-tiller growth stage (1–4)**	**2–4 oz**	**0.047–0.19**

- For use on wheat and barley only.
- For control of Group 2 (ALS) resistant common chickweed: Dimetric EXT is approved for use under 24(c) labels in Maryland, Pennsylvania, and West Virginia (expires Dec. 2020). and TriCor has a section 24(c) label in Virginia (expires Dec. 2020).
- The typical use rate is 2–4 oz/A (3 oz/A is recommended) either in the fall or spring when the crop is in the 2-leaf to 4-tiller growth stage.
- Rate depends on soil texture; see product label.
- Local research has shown wheat safety is best with an early-spring application (at green-up). Potential for injury increases with late spring applications or fall applications.
- Plant wheat at least 1 inch deep.
- Glory can be tank-mixed with other small grain herbicides to broaden control spectrum.
- Certain wheat and barley varieties are sensitive to metribuzin. Refer to the respective label for additional details on varieties and other use restrictions.
- In general, fall-applied herbicide generally provided more consistent common chickweed control, but spring metribuzin treatments were adequate as well.
- For best results, apply metribuzin when chickweed is small (4–6 inches in diameter).
- No rotation restriction to soybeans; 4 to 18 months for vegetables; see Table 5.6.

Harmony Extra SG	**Thifensulfuron**	**2**	**Two-leaf to before visible flag leaf**		**0.009–0.018**
50DF	**+ tribenuron**	**2**	**(growth stages 1– 7)**	**0.45–0.9 oz**	**0.005–0.009**

- For use on wheat,barley, and oats.
- Controls wild garlic and broadleaf weeds. Tank-mix with Express 50SG for improved wild carrot control. Not recommended for cornflower.
- Rates depend on type of weeds and severity.
- For garlic control use higher rates of Harmony Extra SG plus 2,4-D when garlic is less than 12 inches tall.
- Always premix Harmony Extra SG in water before adding to the spray tank.
- Tank-mixing with Banvel or Maestro (Buctril) may result in reduced control of certain broadleaf weeds.
- Do not tank-mix with Malathion.
- Any crop may be planted 45 days after application; see Table 5.6.

Table 5.69 - Comments on Herbicides for Small Grains (cont.)

See specific product label to determine correct rate for soil type and weed species found in each field.

- Tables 5.66, 5.67, and 5.68 list characteristics and efficacy of herbicides.
- A good small grain stand is very competitive and normally does not require a herbicide treatment.
- It is important to control all existing vegetation at planting time, prior to no-till production.

Trade Name	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Harmony SG 50DF	**Thifensulfuron**	**2**	**Two-leaf to before visible flag leaf (growth stages 1– 7)**	**0.45–0.9 oz**	**0.014–0.028**

- Harmony SG can be used on fall-seeded wheat, barley, triticale, and oats.
- Harmony SG controls wild garlic and broadleaf weeds. Not recommended for cornflower.
- The common rate is 0.75 oz/A, but higher or lower rates may be used.
- Tank-mix with other herbicides to increase weed control spectrum.
- Harmony SG also may be used as a preplant burndown application before small grain emergence.
- Any crop may be planted 45 days after application; Table 5.6.

Huskie 2.06L	**pyrasulfotole + bromoxynil**	**6 27**	**First-leaf to flag-leaf emergence (growth stage 1–7)**	**11–15 oz**	**0.026–0.036 0.151–0.205**

- For use on wheat, barley, and triticale only.
- Huskie controls many annual broadleaf weeds.
- In some university trials, Huskie provided control of marestail at the rosette stage when applied in the spring.
- 4 month rotation restriction to soybean; >9 months for vegetables; see Table 5.6.

MCPA amine or ester 4L	**MCPA**	**4**	**Full tiller to prejoint stage (growth stages 3–6)**	**0.5–1.0 pt**	**0.25–0.5**

- For use on wheat, barley, rye, and oats.
- Safer on small grains underseeded with legumes than 2,4-D (amine formulation only) but use the lower rate (0.25–0.5 pt) and apply in 5–10 gal water/A; legumes should be 2–3 inches tall and cereal should be 8 inches tall to provide canopy to protect legume.
- For best results, apply while weeds are small, typically when cereal is 4–8 inches tall.
- No rotation restrictions are indicated.

Table 5.69 - Comments on Herbicides for Small Grains (cont.)

See specific product label to determine correct rate for soil type and weed species found in each field.

- Tables 5.66, 5.67, and 5.68 list characteristics and efficacy of herbicides.
- A good small grain stand is very competitive and normally does not require a herbicide treatment.
- It is important to control all existing vegetation at planting time, prior to no-till production.

Trade Name	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Maestro (Buctril)	**bromoxynil**	**6**	**Emergence to boot stage (growth stages 1-9)**	**1–2 pt**	**0.25–0.5**

- For use on fall-seeded wheat, barley, rye and oats.
- May be applied to a small-grain/alfalfa under- seeding.
- Apply before weeds have more than four leaves or are 2 inches tall, or rosettes exceed 1 inch in diameter.
- Use flat fan nozzles and a minimum of 10 gal/A for best results.
- Weak on chickweed and henbit.
- May be tank-mixed with Harmony Extra SG, MCPA, 2,4-D, or Banvel/Clarity.
- 30 day rotation restriction for all crops; see Table 5.6.

Osprey 4.5 WDG	**mesosulfuron**	**2**	**Emergence to jointing stage (growth stages 1-5)**	**4.75 oz**	**0.013**

- For use in winter wheat and triticale.
- In our region, Osprey will be primarily targeted for control of annual ryegrass, including ACCase-resistant biotypes and downy brome.
- Applications should be made when weeds are young and actively growing at the one-leaf to two-tiller stage.
- To broaden weed control spectrum, Osprey may be tank-mixed with other herbicides including Harmony Extra SG, Harmony SG, MCPA, Maestro (Buctril), and Stinger.
- Do not topdress with nitrogen fertilizer within 14 days following an Osprey application.
- Certain insecticides and fungicides may be tank-mixed.
- Soybeans can be planted after 90 days of application; corn after 12 months; vegetables after 10 months, and alfalfa after 10 months; see Table 5.6.

Peak 57WDG	**prosulfuron**	**2**	**Three-leaf to before visible second node (growth stages 2-6)**	**0.25–0.5 oz (1 pack/6-12 A)**	**0.009–0.018 oz**

- For use on wheat, barley, oats, rye, and triticale
- Peak controls wild garlic and broadleaf weeds.
- For best results apply when weeds are small and use the 0.5 oz/A rate if used alone.
- May be tank-mixed with Banvel/Clarity, 2,4-D, MCPA, or Maestro (Buctril) to broaden weed spectrum; however, certain application timing restrictions may apply.
- Do not apply organophosphate (op) insecticide 15 days before or 10 days after Peak application.
- Be cautious of crop rotation restrictions (10 mo. for soybeans and 22 mo. for alfalfa; see label for other cropping restrictions); see Table 5.6.

Table 5.69 - Comments on Herbicides for Small Grains (cont.)

See specific product label to determine correct rate for soil type and weed species found in each field.

- Tables 5.66, 5.67, and 5.68 list characteristics and efficacy of herbicides.
- A good small grain stand is very competitive and normally does not require a herbicide treatment.
- It is important to control all existing vegetation at planting time, prior to no-till production.

Trade Name	Common Name	Site of Action Number	Application	Product/A	lb ai/A
PowerFlex HL 13WDG	**pyroxsulam**	**2**	**Three-leaf to jointing (growth stage 6)**	**2.0 oz**	**0.016**

- For use on wheat and triticale only.
- Crop stunting and chlorosis is commonly observed with spring applications; and stunted wheat can be observed for weeks after application. Stunting and chlorosis has not been observed with fall applications.
- The PowerFlex activity on certain grass and broadleaf weeds, including annual ryegrass, downy brome and annual bluegrass is improved with fall applications.
- Soybeans can be planted 3 months after application. Vegetables can be planted after 9 to 12 months; see Table 5.6.

Prowl H_2O 3.8SC	**pendimethalin**	**3**	**First-leaf to before the flag leaf is visible (growth stages 1-7)**	**1.5–3 pt**	**0.7–1.4**

- For use on wheat or triticale only.
- Wheat or triticale must be planted 0.5–1 inch deep to avoid crop injury.
- Must be applied prior before weed emergence. Any emerged weeds will not be controlled, so use a tank mix to control them.
- For best results, apply Prowl H_2O once the wheat rows are visible and before weeds have emerged.
- Prowl controls many annual grass and broadleaf weeds.
- No rotation restriction to soybeans or vegetables; see Table 5.6.

	halauxifen	**4**	**2-leaf to flag leaf emergence (growth**		**0.005**
Quelex 20.4WDG	**florasulam**	**2**	**stages 2-8)**	**0.75 oz**	**0.005**

- For use on wheat, barley, or triticale only.
- Best to apply to small, actively growing weeds (2 to 4-leaf stage).
- Quelex is a slow-acting herbicide.
- Do not apply within 60 days of crop harvest.
- Rotation to soybeans is 3 months and 15 months to most vegetables; see Table 5.6.

Sharpen 2.85SC	**saflufenacil**	**14**	**Preplant or preemergence**	**1–4 fl oz**	**0.022–0.088**

- For use on wheat, barley, oats, rye, and tricicale.
- Be sure seed row is sufficiently covered with soil to avoid washing and concentrating the herbicide in the seed zone.
- Apply Sharpen for burndown (see Table 5-4) and/or limited residual control of certain annual broadleaf weeds.
- Sharpen does not control grass weeds.
- Do not apply Sharpen if crop has emerged.
- No rotation restriction to soybeans; 1 to 5 months for vegetables, depending on species; see Table 5.6.

Table 5.69 - Comments on Herbicides for Small Grains (cont.)

See specific product label to determine correct rate for soil type and weed species found in each field.

- Tables 5.66, 5.67, and 5.68 list characteristics and efficacy of herbicides.
- A good small grain stand is very competitive and normally does not require a herbicide treatment.
- It is important to control all existing vegetation at planting time, prior to no-till production.

Trade Name	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Starane Ultra 2.8L	**fluroxypyr**	**4**	**Two-leaf to early boot (growth stages 2-9)**	**4.8–6.4 fl oz**	**0.09–0.13**

- For use on wheat, barley, triticale, and oats.
- The Starane label claims to control bedstraw, chickweed, hemp dogbane, prickly lettuce, ragweed, and velvetleaf and to suppress bindweed, wild buckwheat, mustard species, and others.
- Starane provides good control of group 2 (ALS) resistant common chickweed.
- Premixes with Starane (fluroxypyr) include Starane Flex (fluroxypyr + florasulam [in Orion]) and Pulsar (fluroxypyr + dicamba).
- 120 rotation restriction to crops not listed, which includes soybeans. 24(c) labels in Delaware and Virginia permits 90 day rotation to soybeans.

Stinger 3S	**clopyralid**	**4**	**Three-leaf to early boot (growth stages 2-9)**	**0.25–0.33 pt**	**0.1–0.125**

- For use on wheat, barley, and oats only.
- For best results, apply while weeds are actively growing.
- For Canada thistle, apply when thistle is 1–2 feet tall.
- May be tank-mixed with any other small-grain herbicide to increase weed spectrum. (Curtail is a premix of clopyrid and 2,4-D. See product label for details.)
- Do not use plant residues or manure from animals that consumed forage from treated areas for compost or mulch where susceptible plants may be grown the following season.
- 10.5 month rotation restriction to soybeans for soils >2% organic matter; 18 month restriction for soils <2% organic matter. See label as vegetable rotation varies greatly by species; see Table 5.6.
- *Water quality advisory.*

Talinor 1.77EC	**bicyclopyrone + bromoxynil**	**27 6**	**2 leaf-stage to pre-boot (growth stage 2-9)**	**13.7–18.2 fl oz**	**0.03–0.04 0.16–0.212**

- For use on wheat or barley.
- Always add the directed rate of CoAct+™, plus crop oil concentrate (preferred) or non-ionic surfactant.
- Best to apply to small, actively growing weeds.
- Rotation to soybeans is 10 months and 9 to 18 months to most vegetables; see Table 5.6.

Table 5.69 - Comments on Herbicides for Small Grains (cont.)

See specific product label to determine correct rate for soil type and weed species found in each field.

- Tables 5.66, 5.67, and 5.68 list characteristics and efficacy of herbicides.
- A good small grain stand is very competitive and normally does not require a herbicide treatment.
- It is important to control all existing vegetation at planting time, prior to no-till production.

Trade Name	Common Name	Site of Action Number	Application	Product/A	lb ai/A
Valor SX 51WDG or Valor EZ 4L	**flumioxazin**	**14**	**Early-preplant**	**1.0–2 oz**	**0.032–0.064**

- For use in wheat only in DE, MD, NJ, PA, and VA.
- Must be applied 7 days prior to planting in no-till or minimum till wheat; 30 days preplant restriction from conventionally tilled wheat.
- When using as a burndown, apply 2 oz/A.
- Wheat must be planted a minimum of 1 inch deep.
- Valor improves control of horseweed and other broadleaf weeds when tank-mixed with other herbicides that broaden control spectrum.
- With sandy soils, stunting and stand loss can occur if seed is not planted at least 1 inch deep and heavy rain occurs shortly after application.
- No rotation restriction to soybeans; more than 4 months for vegetables; see Table 5.6.

Zidua 85WDG or Zidua 4.17SC	**pyroxasulfone**	**15**	**Delayed pre- to early postemergence (4th tiller)**	**0.7–2.5 oz or 1.25–4 fl oz**	**0.04–0.13**
Anthem Flex 4SE	**pyroxasulfone + carfentrazone**	**15 14**	**(stages 1-3)**	**2–4.5 fl oz**	**0.004–0.01**

- For use in wheat only.
- All products can be applied as a delayed preemergence (80% germination with 0.5-inch-long shoot to spiking) to control annual grasses and small-seeded broadleaf weeds.
- Do not use on broadcast seeded wheat; do not plant wheat deeper than 1.5 inches (but at least 1 one inch deep).
- Do not apply if more than 0.25 inches of rain is expected within 48 hours.
- Crop injury may result under prolonged wet soil conditions.
- Consult label as soil texture influences rate.
- If applied as an early postemergence (spike to 4 tillers) Zidua may be tank-mixed with Clarity, Prowl H_2O, metribuzin, or Axial XL; consult label as soil texture influences rate.
- Zidua alone will not control emerged weeds; Anthem Flex contains carfentrazone (Aim) which will provide control of certain weed species if they are very small at time of application.
- No rotation restriction to soybeans; 18 months for vegetables; see Table 5.6.
- *Water quality advisory.*

Table 5.70 - Spray Additives and Rainfastness for "Burndown" or Postemergence Herbicides in Small Grains

Trade Name	Adjuvant(s)[1]	Rate	Apply in N-carrier (50:50)	Rainfastness (hours)
2,4-D amine 4S/	nonionic surfactant or	1 qt/100 gal	Yes	1
2,4-D LVE 4E	crop oil concentrate	4 qt/100 gal		
Aim	nonionic surfactant or	1 qt/100 gal	Yes	6 to 8
	crop oil concentrate plus	1 gal/100 gal		
	ammonium sulfate or	2-4 lb/A		
	nitrogen solution (optional)	2-4 gal/100 gal		
Anthem Flex[2]	non-ionic surfactant	1 qt/100 gal	N/A	1
	or crop oil concentrate	1-2 pt/A		
	or methylated seed oil	1-2 pt/A		
	plus nitrogen solution (optional)	1-2 pt/A		
	or ammonium sulfate (optional)	8.5 lb/100 gal		
Axial XL	none required		Yes	0.5
Axiom	Do not add crop oil concentrate, vegetable, or petroleum oils		No	N/A
Callisto	nonionic surfactant or	1 qt/100 gal	Yes	No information
	crop oil concentrate	1 gal/100 gal		
	ammonium sulfate	8.5 lbs/100 gal		
Clarity/Banvel	nonionic surfactant or	1 qt/100 gal	Yes	4
	crop oil concentrate plus	1 gal/100 gal		
	nitrogen solution	2-4 qt/A		
Dimetric/TriCor	Not recommended		Not recommended	N/A
Harmony Extra	nonionic surfactant	See table below	Yes	several
	nitrogen solution (optional)	2 qt/A		
Harmony SG	nonionic surfactant	See table below	Yes	several
	nitrogen solution (optional)	2 qt/A		
Huskie	ammonium sulfate or	0.5-1 lb/A	Yes	1
	Urea ammonium nitrate	1-2 qt/A		
MCPA	No information		Yes	No information
Maestro (Buctril)	nonionic surfactant or	1 qt/100 gal	Yes	No information
	crop oil concentrate or	1 gal/100 gal		
	nitrogen solution	2-4 gal/100 gal		
Osprey	methylated seed oil (MSO) or	2 gal/100 gal	Yes, but no more than 15% of solution	4
	Nonionic surfactant plus	2 pt/100 gal		
	Nitrogen solution	1-2 qt/A		

Table 5.70 - Spray Additives and Rainfastness for "Burndown" or Postemergence Herbicides in Small Grains (cont.)

Trade Name	Adjuvant(s)[1]	Rate	Apply in N-carrier (50:50)	Rainfastness (hours)
Peak	nonionic surfactant or	1-2 qt/100 gal	yes	4
	crop oil concentrate	1-4 qt/A	Do not use crop oil with N-carrier	
	nitrogen solution (optional)	2-4 qt/A		
Powerflex	nonionic surfactant plus	1-2 qt/100 gal	Yes	4
	nitrogen solutions (optional) or	1-2 qt/A		
	crop oil concentrate (nitrogen solutions is not recommended with COC)	1 gal/100 gal		
Quelex	non-ionic surfactant	0.8-2 qt/100 gal	yes[3]	4
	or crop oil concentrate	2-4 qt/100 gal		
	or methylated seed oil	2-4 qt/100 gal		
Sharpen	methylated seed oil	1 gal/100 gal	No information	1
	Nitrogen solution	1.25-2.5 gal/100 gals		
Starane Ultra	None recommended		No information	1
Stinger	None recommended		Yes	6
Talinor	CoAct+™	see label for rate	No	1
	plus crop oil concentrate (recommended)	1 gal/100 gal		
	or nonionic surfactant	1 qt/100 gal		
Valor	methylated seed oil	1 qt/A	No information	1
	nitrogen solution	1-2 qt/A		
Zidua	None recommended		No information	N/A

[1] In general, nonionic surfactants should contain at least 80% surface active agent; crop or vegetable oil concentrates should be nonphytotoxic containing at least 15% approved emulsifier; nitrogen solution is ammonium-based fertilizer such as 28%, 30%, or 32% N; and ammonium sulfate should be spray-grade dry ammonium sulfate (21-0-0). You also may use 10-34-0 with some products.

[2] Anthem Flex label recommends an adjuvant if emerged weeds are present (and are susceptible to carfentrazone [Aim]) at time of application.

[3] When applied with liquid nitrogen fertilizer use non-ionic surfactant at no more than 1 qt/100 gal instead of crop oil or methylated seed oil.

Adjuvant recommendations for Harmony SG and Harmony Extra SG.

Carrier	Situation	Rate of NIS/100 gallons
Water	Normal	1 qt
Nitrogen diluted with water (>50% nitrogen)	Normal	0.5-1 pt
Liquid nitrogen fertilizer	Garlic over 8 inches	0.5 pt
Liquid nitrogen fertilizer	Garlic less than 8 inches	None
Liquid nitrogen fertilizer	With 8 fl oz of 2,4-D	None
Water	With 8 fl oz of 2,4-D	1 pt

Table 5.71 - Comments on Herbicides for Harvest Aid in Small Grains

Paraquat/Gramoxone is not labeled as a harvest aid in small grains.

Trade Name	Common Name	Site of Action Number	Product/A	lb ai/A
2,4-D LVE 4E	**2,4-D**	**4**	**1.0–2.0 pt**	**0.5–1.0**

- For use on wheat, barley, rye, and oats. (Only certain 2,4-D products have all of these small grains listed.)
- Apply when grains are in the hard dough stage.
- 2,4-D is generally not recommended as a harvest aid due to its volatility, and potential damage to the crop during application.
- Avoid use if temperatures are expected to exceed 75°F.
- No adjuvants are recommended.
- 14 day preharvest interval.

Aim 2EC	**carfentrazone**	**14**	**2 fl oz**	**0.26 oz**

- Use as a harvest aid to desiccate a limited number of broadleaf weed species
- Application shall be made when the crop is mature and the grain has begun to dry down.
- Ensure spray coverage is sufficient, otherwise poor control will result.
- Methylated seed oil or crop oil concentrate at 1 to 2 gal/100 gal is required; liquid nitrogen fertilizer at 2 to 4 gal/100 gal or ammonium sulfate at 2 to 4 lb/A can be added to the methylated seed oil or crop oil.
- Allow at least 7 days between application and harvest.

Banvel 4S	**dicamba DMA Salt**	**4**	**8 fl oz**	**0.25**
Clarity 4S	**dicamba DGA Salt**		**8 fl oz**	
Engenia 5S	**dicamba BAPMA Salt**		**6.4 fl oz**	
XtendiMax 2.9S/ FeXapan	**dicamba DGA Salt with VaporGrip**		**11 fl oz**	

- For use on fall-seeded barley and wheat.
- Do not apply to grain grown for seed.
- Apply when grains are in the hard dough stage.
- Apply with a nonionic surfactant (1 qt/100 gal) or crop oil concentrate or methylated seed oil (1 to 2 qt/100 gal)
- Apply 7 days before harvest.

Table 5.71 - Comments on Herbicides for Harvest Aid in Small Grains (cont.)

Paraquat/Gramoxone is not labeled as a harvest aid in small grains.

Trade Name	Common Name	Site of Action Number	Product/A	lb ai/A
Roundup Powermax 4.5S[1]/ Glyphosate[1]	**glyphosate**	**9**	**1–2 pt**	**0.5–1.0**

- Do not apply to wheat grown for seed; and feed barley is only barley type labeled.
- Apply to feed barley after the hard dough stage when grain moisture is 20% or less; apply to wheat after the hard dough stage when grain moisture is 30% or less.
- Be cautious of drift.
- See specific glyphosate formulations for adjuvant recommendations.
- Apply at least 7 days before harvest.

Sharpen 2.85SC	**saflufenacil**	**14**	**1–2 fl oz**	**0.022–0.044**

- For use on wheat, barley (feed only), and tricicale.
- Apply after hard dough stage and grain is less than 30% moisture.
- Ground applications require 10 gallons spray volume per acre; aerial requires 5 gallons.
- No rotation restriction to soybeans; 1 to 5 months for vegetables.
- Apply with methylated seed oil (1 gal/100 gal) plus ammonium sulfate (8.5 lb/100 gal) or urea ammonium nitrate (UAN) (1.25 to 2.5 gal/A).
- Apply at least 3 days before harvest; label recommends 10 days for optimum desiccation effect.

[1] Various formulations of this product are available; see table in the introductory chapter of this guide for various glyphosate products and rates. Refer to current product label for active ingredient concentration, application rate, and other restrictions. Adjust application rate if using Roundup WeatherMax 4.5S (e.g., 1 qt Roundup 4S = 22 fl oz WeatherMAX 4.5S).

Table 5.72 - Grazing and Feeding Restrictions for Small Grain Herbicides and Livestock Use

	Days After Treatment Before:				
	Grazing		Feeding Straw	Withdraw for Meat	Silage
Herbicide	Beef	Dairy			
2,4-D[1]	0	14	0	14	—[2]
2,4-D[1] (late)	no	no	no	—	—
Aim	7	7	7	—	7
Anthem Flex	7	7	—	—	
Axial XL	30	30	60	—	30
Axiom	30	30	—	—	—
Callisto[3]	30	30	30	—	30
Clarity/Banvel/Engenia/ Xtendimax	0	7	37	30	37
Dimetric/TriCor	14	14	no	—	21
Harmony SG	7	7	yes	—	7/30
Harmony Extra	7	7	yes	—	7/30
Huskie	25	25	60	—	25
MCPA[1]	0	7	0	7	—
Maestro (Buctril)	30	30	30	30	30
Osprey	30	30	60	—	30
Peak	30	30	30	—	40
PowerFlex	7	7	28	—	28
Prowl H_2O	11	11	60	—	11
Quelex	7	7	21	—	—
Sharpen	30	30	30	—	30
Starane Ultra	7	7	40	—	14
Stinger	0	7	no	7	—
Talinor	30	30	60	—	—
Valor	5 inches in height	5 inches in height	—	—	—
Zidua	7	7	—	—	—

[1] 2,4-D and MCPA labels may vary depending on brand name. Consult label for restrictions.

[2] — = no information available.

[3] Callisto is only labeled for use in spring oats only.

Forages, CRP, and Farmstead Weed Management

Integrated Weed Management

Managing weeds in forages requires a different approach from managing weeds in row crops. Proper management to establish and maintain a dense stand of forage will render it competitive to most common weeds. Managing soil pH, nutrients, grazing or cutting, and insects, as well as using disease-resistant varieties and selective herbicides when necessary, will help the forage stand be competitive. A well-planned pest management program for forage crops involves using multiple strategies. These should include prevention, monitoring, cultural control, mechanical or physical control, biological control, and chemical control tactics. Preventive techniques may start with planting weed-free crop seed or choosing an alternative field or planting date. Regularly monitoring for pests is an important predictive tool. Mechanical or physical controls may include tillage and mowing to disrupt certain pests. Mixed grazing by including small ruminants into the livestock community will help manage brushy weeds in a pasture. Finally, chemical controls are an important component of many integrated pest management (IPM) systems, but their use should be based on sound management decisions. See Chapter 1 of this guide for more information about designing an IPM program.

This guide provides chemical control recommendations based on university research and manufacturer recommendations. Table 5.73 contains general information about herbicides available for use in legume or grass forages including pastures and hayfields.

This publication strives for accuracy; however, omissions, inaccuracies, or outdated information can occur because of the dynamics of pests and pest management. Seek out additional information from the manufacturer or other reliable sources when making important management decisions. Remember, this guide is not a substitute for the manufacturer's product label.

Legumes

If weeds become a problem, they can compete for or interfere with light, nutrients, water, and space, directly influencing yield and forage stand. For instance, winter annuals and perennials such as common or mouseear chickweed, henbit, and purple deadnettle have been reported to reduce alfalfa stands by more than 30 percent. They emerge in the fall and winter, and develop a thick, lush mat early in the spring that can compete with the first forage cutting. Once they complete their life cycle in early summer, summer annuals, such as foxtails, lambsquarters, and pigweeds, or perennial weeds such as dandelion or dock species can fill in the bare spots and continue to reduce forage yield and quality.

Unlike most grain or fiber crops from which weeds are separated at harvest, weeds often are harvested along with the forage crop, potentially reducing hay quality. Reductions in quality often are in the form of low protein content and feed digestibility. Forage value of weeds may vary from species to species. For example, dandelion is comparable to alfalfa in protein and total digestible nutrients (TDN). Dandelion control may not necessarily improve the quality of hay, but it may be of some value in reducing the time necessary to dry the hay since dandelion dries more slowly than alfalfa. Increased drying time may mean greater harvest losses due to untimely rainfall.

Quality of monocot weeds (grasses) can also be similar to that of the forage. In general, weedy grasses have about 75 percent of the quality of alfalfa. Controlling quackgrass in alfalfa can increase forage protein levels 4 to 7 percent. Weeds with woody stems or flower stalks, such as yellow rocket, white cockle, rough fleabane, curly dock, and broadleaf dock, have lower protein levels (about 50 percent of the quality of alfalfa), so controlling them is even more important.

When weeds are present or persist in spite of good management, herbicides can help improve yield and quality. Weed control at establishment or in the seedling year is most critical for maintaining a healthy forage stand. When weeds are controlled during the seedling year, the forage crop seldom requires additional herbicide treatments for at least the first two years of the stand.

Weed management in legume forages can be divided into two phases: control in the establishment or seedling year and control in an established stand.

Control Before and During Establishment

Managing weeds in forages begins long before crop establishment. Certain types of weeds are potentially serious problems for forages, so it is important to eliminate them in advance. In particular, perennial broadleaf and grass weeds such as dandelion, curly dock, Canada thistle, horsenettle, and quackgrass are much easier to manage prior to planting a forage crop. While combating such weeds in the establishment year, prudent use of a genetically modified glyphosate tolerant (Roundup-Ready) alfalfa seed could be of value. Biennial weeds including musk thistle and burdock should be eliminated before establishing forage. If these weeds are not removed before the seeding is made, they commonly persist throughout the life of the forage. The cost of controlling weeds before or at the time of seeding should be considered an investment that will be returned for the life of the stand.

Below are some general rules for managing weeds at establishment or in the seedling year:

- Weeds that emerge with the crop are generally more destructive.
- Maintain the forage relatively weed-free for the first 60 days.
- Weeds that emerge beyond 60 days will not influence that year's forage yield.
- Later-emerging weeds may still influence forage quality.
- Winter-annual weed competition in early spring is most damaging to forage.
- Broadleaf weeds are generally more competitive against legumes than grassy weeds.

Herbicides are needed most often during establishment, and several options exist for managing weeds in pure legume seedings. Weed control is also very important while the forage is young and prone to competition from invading species. In no-till seedings, adequately controlling the existing vegetation, especially perennials, is very important. Burndown herbicides available for use in legume forage seedings are listed in Tables 5.71 and 5.72. Herbicides available for use in legumes are listed in Table 5.73. The effectiveness of various herbicides at or during establishment is included in Table 5.74. Herbicides available for use during the establishment year are included in Table 5.75.

Control in an Established Stand

The best weed control in an established forage stand is achieved by maintaining a dense healthy stand through proper fertilization, cutting management, and insect control. Controlling weeds in established forages is normally of greatest benefit in the first cutting. Weeds generally contribute much less to yield in the second and succeeding harvests. Before using an herbicide in established stands, evaluate the forage to ensure it is worth the cost of the herbicide.

Below are some general rules to follow before using an herbicide in established forage stands:

- Thin or irregular stands do not thicken once weeds are removed. Be sure there are sufficient desirable species to fill in the gaps. A minimum of five alfalfa plants per square foot should be present.
- Weeds tolerant of the herbicide may invade the space left by susceptible species, ultimately creating a new or more severe weed problem.
- Treat only well-established, vigorous stands with herbicides.
- If the forage stand is at least two years old and 25 percent to 30 percent of the plants are weeds, removing them with an herbicide application is of questionable value. Renovation is likely more economical.
- If 50 percent or more of the plants are weeds, it is time to rotate to a different crop, or renovate the existing crop.

If weeds become a problem in established forages, several herbicide options are available (Table 5.75). Chemical control in established forage legumes is often limited to late fall or early spring applications. Many herbicides require the addition of adjuvants for effective control (Table 5.76). Also, many products have harvesting, feeding, or grazing restrictions on their use (Table 5.77).

Grass Forages Including Pastures and Hayfields

Without proper management, broadleaf weeds can directly compete with forage grasses to reduce their nutritional value and longevity. Weeds can replace desirable grass species, filling in gaps or voids and reducing yield and overall quality of the hay or pasture. In addition, certain plants such as poison hemlock, white snakeroot, or black locust have toxic properties that can cause livestock injury or loss under certain circumstances (see poisonous weeds below).

Biennial and perennial weeds are considered especially troublesome by grass hay and pasture producers. Both biennials and perennials produce seed each year, potentially starting new infestations. In addition, perennial weeds such as hemp dogbane, Canada thistle, and multiflora rose reproduce from underground roots or rhizomes. Perennial rooting structures can survive for several years in the soil and are often unaffected by occasional mowing or livestock grazing.

Good cultural practices such as maintaining optimum soil fertility, using a competitive cutting schedule for forages, rotationally grazing pastures, and periodic clipping and/or coring pastures, can help keep the crop competitive with weeds. The most critical time for weed control is during the establishment year. If a no-till seeding is desired, be sure the preplant vegetation is adequately controlled. See Tables 5.68 and 5.69 for the information on burndown herbicides in controlling vegetation prior to planting.

In general, use preplant tillage or herbicides, companion seedings, mowing, and/or a postemergence herbicide to ensure that weeds are not a problem in the seeding year. To reduce weed shading, mow at a height above the grass seedlings when weeds are 8 to 10 inches tall. For warm-season grasses, do not mow after early August.

Certain application methods used in forage crops, including spot spraying and wiper applications, are not commonplace in row crops. With spot spraying, the herbicide is applied to weed-infested areas of the field, typically less than one-tenth of the total area. Spot applications are accomplished using a hand-held sprayer or a spray gun. Refer to the spot treatment section of the herbicide label and apply the recommended concentration on a spray-to-wet basis avoiding spray dripping or runoff (1 gal/1000 ft^2) to provide thorough coverage. Most backpack sprayers hold only 1 to 3 gallons of spray solution. Specialized equipment capable of measuring a small volume or weight (i.e.: syringes, gram scales, etc.), are recommended to accurately dispense the desired quantity of herbicide product into small volumes of spray solutions (see Table 5.86). Apply all herbicides at least seven days before crop harvest, or harvest around weed patches, leaving them standing to be treated later. Apply all herbicides at least seven days before a killing frost. Spot treatment may kill desirable vegetation that is contacted by the herbicide. Select an herbicide based on its effectiveness on the target weed, safety to existing desirable vegetation, and grazing, overseeding, or rotational crop intervals.

Wiper applicators (weed wipers) are devices that physically wipe a concentrated solution of herbicide directly onto weeds by taking advantage of sufficient height difference between the weeds and crop canopy. The height difference in pasture can be increased by grazing the forage prior to wiper application and allowing some days for trampled weeds to recover. Sufficient contact from the wiper applicator while preventing contact with the crop controls weeds selectively is the goal. Since only the top several inches of the weeds are contacted with herbicide solution, a translocated herbicide such as dicamba or glyphosate is usually required for effective control. Repeat applications may be required to manage certain perennial weeds. A healthy actively growing crop that can develop a canopy over suppressed weeds is important to the success of wiper applications. There are several types of wiper applicators on the market. Wiper applicators must be designed and operated so that the rope, roller, sponge, or panel remains moist enough to transfer a sufficient amount of herbicide to the weed while not allowing drips to contact the crop. The two most common types are wick and roller applicators. Wick applicators use short braided ropes or appropriate fabric to “wick” the herbicide solution from inside a pipe to the plants that are wiped. With roller applicators, herbicide is manually sprayed intermittently onto a carpet covered roller that is rotated with a motor or a ground-driven shaft. The main advantage of the roller applicator is that more herbicide solution can be maintained on the roller because the centripetal force from the rotation inhibits dripping. Compared to wick applicators, roller applicators provide consistent weed control. Bidirectional application is recommended to provide thorough control. Herbicides labeled for wiper application will usually provide specific application instructions on the label. In addition, research trials have indicated that a 5% solution applied in a wiper applicator is somewhat comparable to a broadcast application rate of 1 qt/A.

Controlling woody perennial species (brush) or vines can be very difficult with standard broadcast herbicide applications. Achieving acceptable weed control can require multiple years of intensive and persistent management. Product labels often have specific recommendations concerning herbicide rate, spray volume, seasonal application, retreatment, and growth stage. Recommendations are often species specific, and tank-mixes with other herbicides or alternative application methods may be required. Application methods may include basal bark, cut stump, dormant stem, oil-water emulsions, or high volume foliar applications. Carefully read and follow all herbicide label recommendations.

Several herbicides are labeled for broadleaf weed control in grass pasture, hay, and CRP grassland. Table 5.78 lists herbicides that can be used in grass pasture, hay, and CRP grassland and labeled application timings. See Tables 5.79 through 5.81 for specific information about effectiveness of herbicides used in grass pasture, hay, and CRP grassland, use, adjuvant requirements, rainfastness, and grazing and haying restrictions. Table 5.83 lists herbicides labeled for use in conservation reserve program

(CRP) acres. Table 5.84 lists herbicides labeled for summer annual grass crops, and Table 5.85 shows the optimum time of year to treat selected weeds. Table 5.87 lists herbicides labeled for farmstead use.

Management of Autumn Olive

Autumn olive (*Elaeagnus umbellata*) is most easily managed through a proactive approach. Once plants become large, they are less easily and affordably controlled. Efficacy of broadcast applications is unknown; individual plant treatment is highly effective. For stems less than one inch in diameter at the base, apply a high volume foliar treatment of Remedy Ultra at 2 QT per 100 gallons of water after autumn olive leaves are fully expanded until prior to fall color. Apply to all foliage until wet but avoid dripping or runoff. For stems 1 to 6 inches in diameter, a basal bark treatment is most effective. Apply Remedy Ultra in bark oil in a 25% herbicide, 75% oil mixture to all sides every stem and exposed roots from the soil line up 12 to 18 inches on the stem. Apply any time of year except during spring. For stems greater than 6 inches in diameter, a cut-stump treatment is most effective. Cut the plant with a chain-saw and apply Remedy Ultra in bark oil in a 25% herbicide, 75% oil mixture less than 10 minutes after cutting. Cut-stump treatment is effective any time of year except during spring. For all treatment types, autumn olive wood is very brittle after death, making removal from fences much easier. Similarly, animals can trample small stems once dead. See Table 5.85 for additional information on timing of application. Mowing does not control autumn olive.

Management of Brambles and Multiflora Rose

Brambles (*Rubus spp.*) and multiflora rose (*Rosa multiflora*) can be very difficult and generally requires an herbicide application in two consecutive years for eradication. Goats are an effective option to graze out brambles, but be prepared to graze for 2 to 3 years for complete control. Mowing is a waste of time and money and can lead to decreased herbicide efficacy when conducted up to 1 year preceding application as well as 6 months following application. Triclopyr containing herbicides (Remedy Ultra, PastureGard, and Crossbow) and metsulfuron containing herbicides (metulfuron, Chaparral, and Cimarron) are most effective and a combination of triclopyr and metsulfuron are recommended. Apply a high volume foliar treatment of Remedy Ultra at 2 QT and metsulfuron 60DF at 1 oz per 100 gallons of water in mid- to late-September. Apply to all foliage until wet but avoid dripping or runoff. See Table 5.85 for additional information on timing of application. A second application is generally required for complete control of brambles. Application of metsulfuron in two consecutive years is not recommended due to tall fescue injury and stand thinning. In the second year, replace metsulfuron with GrazonNext at 7 fl oz/100 gallons of water.

Management of Weedy Grasses in Pasture and Hay

There are no selective postemergence grass herbicides labelled for use in cool-season grass pastures or hayfields. Therefore management practices that provide optimal growing conditions for desirable forages or minimizing bare spots that provide opportunities for weedy grasses could prevent their incidence and invasion. Some of these practices are discussed in earlier sections of this chapter. Scouting pastures to detect aggressive grasses such as Johnsongrass, Japanese stiltgrass, joint-head grass, etc., and taking appropriate steps is recommended to prevent their spread. Perennial grasses such as Johnsongrass may be controlled by applying a glyphosate product as a spot application (to provide 2 lb ae/A) or by applying glyphosate using a weed-wiper (solution strength vary with equipment; ~ 5% strength is required for rotary weed wiper and 1:3 ratio with water required for rope and other types of wipers). Late summer is a good time to apply so that the treated parts of the field can be reseeded in fall. For controlling annual grasses such as Japanese stiltgrass, joint-head grass, foxtails, barnyard grass etc., application of a preemergence herbicide may be considered. In established pastures and hayfields, pendimethalin (Prowl H2O) is effective to control most annual weedy grasses when applied prior to weed germination. Split application is recommended in hayfields (spring application followed by application after first-cut). Quinclorac (Facet L) is also effective to control certain annual grasses such as foxtails.

Find more information here: https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/spes/spes-28/SPES-28.pdf.

Poisonous Weeds

Health effects ranging from none to sickness or occasional death can occur when grazing animals contact or consume toxic plants. To protect animals, it is important to be aware of how toxic plant poisoning occurs commonly. Toxicity is usually derived from certain compounds synthesized by the plant to deter pests, to tolerate extreme soil or other environmental conditions, etc. The toxic potential (the ability to cause detrimental effects) of a given weed on a given day is dependent upon many factors including; the species, age, reproductive status, size, or health of animal consuming it; the plant part, growth stage,

condition, and amount of the plant consumed; and the season or environmental conditions when consumed. Discrepancies on poisonous attributes of weeds noted by different sources may be attributed to these variables. Since most of the poisonous substances emit a repulsive odor or are inherently distasteful, the animals typically stay away from plants or plant parts that are poisonous. This is especially true if other more desirable forage species are available. Occasional cases of poisoning, however, do occur when the stand of desirable species is significantly lower than the harmful plants, when extreme weather conditions such as drought occur, with excessive soil fertility, when livestock are contained for extended periods where poisonous plants are prevalent, or when accidental ingestion is followed by lactation and subsequent poisoning of the offspring. Lastly, poisonous weeds are known to affect forage and hay quality as noted above.

With some weeds the toxic compound remains in harvested hay or silage (poison hemlock) while in others it is reduced (hairy vetch) or eliminated (buttercup). Some tree leaves are more toxic after wilting (red maple, wild cherry). Some toxic compounds occur naturally in plants, while others are released by fungi (fungal endophytes) growing in association with a living host forage plant (tall fescue toxicosis, ryegrass staggers, red clover slobbers); by fungi in molded hay or clippings (aflatoxin, botulism, sweet clover poisoning); or by undesirable bacteria in silage (listeriosis). Applications of some herbicides may increase the palatability of certain poisonous plants. Blister beetle poisoning in horses results from consuming a toxin in dead beetles that are bailed into alfalfa hay. Certain weeds such as wild garlic or wild onion, while not toxic, may impart a disagreeable flavor to the milk of lactating animals.

About 200 to 300 plant species have been listed as poisonous to animals. While a complete list of poisonous plants is beyond the scope of this publication, a sampling of plant families and species with toxic potential are included here.

- Beech family – oak species
- Boxwood family (**highly toxic**) – boxwood, pachysandra
- Buckwheat family – buckwheat, dock species, rhubarb
- Buttercup family – buttercup species, baneberry, larkspur species
- Heath Family (**highly toxic**) – azalea, rhododendron, mountain laurel
- Legume family – black locust, crown or hairy vetch, golden chain tree, lupine species, pea species, alsike clover, sweet clover, red and white clover
- Lily family – autumn crocus, lily-of-the-valley, star-of-Bethlehem, hyacinth species, skunk cabbage, onion and garlic (both wild and cultivated), tulip, asparagus
- Maple family – red maple
- Nightshade family – nightshade species, jimsonweed, ground cherry, horsenettle, tomato, potato
- Rose family – wild black cherry, chokecherry
- Yew family (**highly toxic**) – English or American Yew
- Other species – black walnut (shavings used as bedding), bleeding heart, bouncing bet, bracken fern, burning bush, cocklebur, dogbane species, foxglove, ground-ivy, horse chestnut species, horsetail, johnsongrass, milkweed species, hemp dogbane. oleander, pigweed (amaranthus species), poison hemlock, pokeweed, privet, ryegrass species, shattercane, St. John's wort, tall fescue, water hemlock species, white snakeroot, and others.

Toxic weed consumption most often occurs when animals are undernourished, when they are introduced to new grazing areas, when toxic plants are fed directly to them, or when they escape enclosures and feed on toxic plants. It can also occur when the forage provided is not suitable for the species, or is grazed at the wrong growth stage (prussic acid poisoning), while experiencing environmental stress (nitrate poisoning), or during rapid growth with imbalanced fertility (grass tetany). In addition, otherwise suitable feed, hay, or forage can have toxic effects when animals are transitioned to the new source too quickly.

Provide grazing animals with adequate pasture to meet their nutrient and energy requirements, or supplement their diets with a balanced ration, to reduce the chance that they will consume toxic plants. Make gradual transitions to new food sources. Be aware of environmental, seasonal, and fertility conditions that may cause forages to accumulate toxic compounds and test if necessary. Scout for toxic plants (inside and outside the fence), implement good forage and weed management practices, spray for weed control when needed, wait after herbicide treatment until plants are no longer palatable, and remove dangerous plants from your property. Minimize the potential for accidental introductions of toxic plants via downed tree limbs, yard cuttings (especially ornamentals), or others feeding your animals. Provide animals with safe bedding materials.

If you suspect plant poisoning has occurred, call a veterinarian immediately. Remove all animals from the area. Identify the suspected plants. Remove accidentally introduced plant material, or eradicate toxic plant species by hand-weeding, herbicide applications, pasture renovation, or other recommended practices. Monitor the grazing area over time to assure the toxic species has been eradicated. Remove animals from herbicide treated infestations of toxic plant species until dead and unpalatable, as herbicide treatment may increase palatability.

Discussion of toxic ingredients within plants, their specific effects on grazing animals, or toxic dosages (amount required to cause toxicity symptoms) is beyond the scope of this publication. More information can be found in the following sources:

- Burrows, G. E., and R. J. Tyrl, *Handbook of Toxic Plants of North America* (Oxford: Blackwell Publishing, 2006)
- Colorado State University – Veterinary Internal Medicine. http://southcampus.colostate.edu/poisonous_plants/index.cfm
- Cornell University - Animal Science. www.ansci.cornell.edu/plants/index.html
- University of Pennsylvania – Veterinary Medicine. http://research.vet.upenn.edu/Home/tabid/5849/Default.aspx
- Nova Scotia Museum – The Poisonous Patch. http://museum.gov.ns.ca/poison/?section=species&id=111
- Knight, A.P., and RG. Walter. 2001. A Guide to Plant Poisoning of Animals in North America. Teton NewMedia, Wyoming, USA.

Table 5.73 - Forage and Pasture Herbicides and their Restrictions

Trade Name[1]	Common Name	Manufacturer	Crop	Group # (site of action)	Restricted-Use Pesticide[2]	Water Quality Advisory[3]	Worker Reentry[4] (hours)
2,4-D amine or ester (3.8 lb ae/gal)	2,4-D	Several	grass	4	—	yes	48 or 12
Aim 2EC	carfentrazone	FMC	grass and legume	14	—	—	12
Balan 60DF	benefin	Loveland	legume	3	—	—	12
Butyrac 200 2E	2,4-DB	several	legume	4	—	yes	48
Chaparral 71.6WG	aminopyralid + metsulfuron	Corteva	grass	4, 2	—	yes	48
Chateau 51WDG	flumioxazin	Valent	alfalfa	14	—	—	12
Cimarron Max (co-pack)	metsulfuron + 2,4-D + dicamba	Bayer	grass	2, 4, 4	—	—	48
Cimarron Plus 63WDG	metsulfuron + chlorsulfuron	Bayer	grass	2, 2	—	—	4
Clarity/Banvel 4S	dicamba (DGA/DMA)	BASF/Arista LifeScience	grass	4	—	yes	24
Crossbow 3L	2,4-D + triclopyr	several	grass	4, 4	—	yes	until dry
Curtail 2.38L	clopyralid + 2,4-D	Corteva	grass	4, 4	—	yes	48
Engenia	dicamba (BAPMA)	BASF	grass	4	yes	yes	24
Eptam 7E/20G	EPTC	Gowan	legume	8	—	—	12
Escort XP 60DF	metsulfuron	Bayer	grass	2	—	—	4
Facet 1.5L	quinclorac	BASF	grass	4	—	yes	12

Table 5.73 - Forage and Pasture Herbicides, their Characteristics, and their Restrictions (cont.)

Trade Name[1]	Common Name	Manufacturer	Crop	Group # (site of action)	Restricted-Use Pesticide[2]	Water Quality Advisory[3]	Worker Reentry[4] (hours)
FeXapan	dicamba (DGA plus VaporGrip)	DuPont	grass	4	—	yes	24
Freelexx 3.7 SL	2,4-D (Choline)	Corteva	grass	4	—	yes	48
Gramoxone SL 2S	paraquat	Syngenta	legume	22	yes	—	12
GrazonNext HL 3.74E	aminopyralid + 2,4-D	Corteva	grass	4, 4	—	yes	48
Grazon P+D 2.54SL	picloram +2,4-D	Corteva	grass	4, 4	yes	yes	48
Huskie 2.06EC[5]	pyrasulfotole + bromoxonyl	Bayer	grass	27, 6	—	yes	24
Kerb 50W	pronamide	Corteva	legume	3	yes	—	24
Maestro 2E (Buctril)	bromoxynil	Nufarm	legume	6	—	—	24
MCPA amine or ester (3.7 lb ae/gal)	MCPA	Several	grass and legume	4	—	yes	48 or 12
Metribuzin 75DF/4L	metribuzin	Several	legume	5	—	yes	12
Metsulfuron 60WG	metsulfuron	Several	grass	2	—	—	4
Milestone 2L	aminopyralid	Corteva	grass	4	—	yes	48
Overdrive 70WDG	dicamba + diflufenzopyr	BASF	grass	4, 4	—	yes	12
PastureGard HL 4SL	triclopyr + fluroxypyr	Corteva	grass	4, 4	—	yes	12
Poast 1.5E	sethoxydim	BASF	legume	15	—	—	12
Prowl H_2O 3.8CS	pendimethalin	BASF	alfalfa and grass	3	—	—	24
Pursuit 2AS	imazethapyr	BASF	alfalfa/ and grass mix	2	—	yes	4
Raptor 1AS	imazamox	BASF	legume	2	—	—	4
Remedy Ultra 4L	triclopyr	Corteva	grass	4	—	yes	until dry
Roundup 3S/ Roundup WeatherMax 4.5S/ glyphosate[6]	glyphosate	Bayer/others	grass and legume	9	—	—	4-12
Sandea 75DF	halosulfuron	Gowan	grass	2	—	yes	12
Satellite HydroCap 3.8CS	pendimethalin	United Phosphorus, Inc.	alfalfa	3	—	—	24
Select Max 1E/ Select 2E	clethodim	Valent	legume	15	—	—	24

Table 5.73 - Forage and Pasture Herbicides, their Characteristics, and their Restrictions (cont.)

Trade Name[1]	Common Name	Manufacturer	Crop	Group # (site of action)	Restricted-Use Pesticide[2]	Water Quality Advisory[3]	Worker Reentry[4] (hours)
Sharpen 2.85SC[7]	saflufenacil	BASF	grass and alfalfa	14	—	yes	12
Sinbar 80W	terbacil	NovaSource	legume	5	—	yes	12
Spike 20P/80DF	tebuthiuron	Corteva	grass	7	—	yes	—
Starane Ultra 2.8L	fluroxypyr	Corteva	grass	4	—	—	12
Stinger 3S	clopyralid	Corteva	grass	4	—	yes	12
Surmount 1.34E	picloram + fluroxypyr	Corteva	grass	4, 4	yes	yes	12
Tordon 22K 2SL	picloram	Corteva	grass	4	yes	yes	48
Touchdown Total 4S[6]	glyphosate	Syngenta	legume	9	—	—	12
Vastlan 4SL	triclopyr	Corteva	grass	4	—	yes	24
Velpar AlfaMax 77.7WG	hexazinone + diuron	Bayer	alfalfa	5, 7	—	yes	24
Velpar 2L/90DF	hexazinone	Bayer	legume	5	—	yes	24
Weedmaster 3.87L	dicamba + 2,4-D	Nufarm	grass	4	—	yes	48
Xtendimax	dicamba (DGA+ VaporGrip)	Bayer	grass	4	yes	yes	24
Yukon 67.5WG	halosulfuron + dicamba	Gowan	grass	2, 4	—	—	24

[1] Generic or post-patent alternatives to some of these products are available.

[2] Only licensed applicators may purchase and apply restricted-use pesticides. To become licensed, contact your state's Department of Agriculture.

[3] These herbicides have properties that may result in ground or surface water contamination. Do not apply them in areas where soils are permeable or coarse and groundwater is near the surface. Practices should be followed to minimize the potential for dissolved runoff and/or runoff erosion. See the herbicide label for specific restrictions.

[4] If soil-applied products are injected or incorporated at application time, under certain circumstances the Worker Protection Standard allows workers to enter the treated area if they will have no contact with anything that has been treated. Personal protective equipment is required for early entry to treated areas if contact with treated soil, plants, or water is involved.

[5] Huskie is recently registered on grass forage; there is little local experience for this use.

[6] Various formulations available. Refer to product label application rates and other restrictions.

[7] This use is listed on a supplemental label for use in dormant alfalfa.

Table 5.74 - Relative Effectiveness of "Burndown" Treatments for No-Till Forages (cont.)

Table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size or growth stage. Treatments are rated only for control of vegetation existing at the time of application.

Weed control rating

10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65% N = less than 55% or no control

		Roundup/glyphosate	
Species	**Gramoxone**	**(Fall-applied)**	**(Spring-applied)**
Alfalfa sod	N	**8+**	7
Bromegrass or Quackgrass Sod	6	**9**	**9**
Chickweed	**8+**	**9**	**9**
Clover, Red	8	**8+**	7
Dandelion	N	**8+**	6
Foxtail spp.	**9**	**9**	**9**
Hemp Dogbane, Dewberry, Milkweed, etc.	6	**8+**	6
Horseweed (Marestail)	7	**9**	**9**
Lambsquarters	8	**9**	**9**
Mustard spp.	8	**9**	**9**
Orchardgrass or Fescue Sod	N	**9**	7
Ragweed, Common	8	**9**	**9**
Rye Cover, Volunteer Small Grains	**9**	**10**	**10**
Smartweed, Annual	7	7	7
Thistle, Canada	6	**9**	8
Timothy, Bluegrass	7	**10**	**10**
Vetch, Hairy	7	8	6

Table 5.75 - Comments on Burndown Herbicides for No-Till Legume Forages

See specific product label to determine correct rate for the weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Product/A	lb ai/A
Gramoxone SL 2S	**paraquat**	**Alfalfa**	**2–4 pt**	**0.5–1.0**

- Gramoxone SL controls emerged weeds only (no residual activity).
- Apply in a minimum of 10 gal/A (ground, 20-60 gal/A preferred) or 5 gal/A (aerial) of water.
- Apply before, during, or after planting but before crop emerges.
- Phosphate-containing liquid fertilizer carrier solutions diminish Gramoxone activity if used as a carrier.
- Gramoxone SL is effective on small annual weeds.
- Improved activity on perennial grass sods can be achieved when two applications are made. Graze or mow sod to a height of 3 inches or less and apply 2 pt/A followed in 10 to 14 days by 1.5 pt/A.
- Use appropriate precautions when handling Gramoxone to minimize exposure to the herbicide.
- Do not use flood jet tips larger than size 20 or spacing greater than 40 inches.
- See Table "Adjuvants and rainfast intervals for postemergence herbicides in grass pasture or hay".
- See Table "Grazing, harvest, haying, and slaughter restrictions for grass forage and pasture herbicides".
- *Restricted Use Pesticide.*

Table 5.75 - Burndown Herbicides for No-Till Legume Forages (cont.)

See specific product label to determine correct rate for the weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Product/A	lb ai/A
Roundup 3S[2] or Roundup WeatherMax 4.5S[2]	**glyphosate**	**Alfalfa, clover, and alfalfa or clover-grass mixtures**	**1.5–4 qt or 1–3 qt**	**1.0–3.0**

- Glyphosate controls emerged weeds only (no residual activity).
- Make ground applications in 10 to 40 gal/A of water. Increase the spray volume within this range as the weed density increases.
- Glyphosate may be applied in clear liquid nitrogen fertilizers and clear liquid complete-analysis fertilizers. Do not use Roundup/glyphosate with suspension-type liquid fertilizers.
- Preplant applications can be made before, during, or after planting but before the crop emerges.
- Glyphosate is effective on annual, biennial, and perennial weeds as well as small grain cover crops.
- Repeated applications may be needed for effective perennial weed control.
- Fall applications are better than spring applications for control of orchardgrass sods and quackgrass.
- Spring applications may be used for control of annual weeds.
- Existing perennial grass stands can be renovated by applying 0.7 to 3.3 qt/A (consult the label for rates for specific species). The existing crop can be grazed or harvested for feed after applications totaling 2 qt/A or less. For applications greater than 2 qt/A, remove livestock before application and wait 8 weeks before grazing or harvest.
- See Table “Adjuvants and rainfast intervals for postemergence herbicides in grass pasture or hay”.
- See Table “Grazing, harvest, haying, and slaughter restrictions for grass forage and pasture herbicides”.

[1] See Table 5.70 for additional formulations or trade names containing these same active ingredients.

[2] Various formulations of this product are available. Refer to current product label for active ingredient concentration, application rate, and other restrictions.

Table 5.76 - Application Timings for Herbicides Used in Legume Forages

Establishment: Herbicide is applied preplant in no-till establishment to control existing weeds, preplant in existing stands of alfalfa or clover to kill the existing crop and plant a new one (renovation), or preplant incorporated (PPI) or preemergence (PRE) in conventional tillage for residual weed control.

Seedling stand POST: Herbicide is applied postemergence (POST) to seedling alfalfa or clover that has reached a specific growth stage and is actively growing.

Established stand POST: Herbicide is applied POST to alfalfa or clover that has been established for a minimum length of time and is actively growing.

Fall/spring dormant: Herbicide is applied POST to dormant alfalfa or clover legume; may be for seedling legume at a specific growth stage, for legume established for a minimum length of time, or for either. Herbicide rate may be different for seedling or established stands.

Post-cutting: Herbicide is applied to alfalfa or clover between forage or hay cuttings, but within a certain time period after cutting or before the legume achieves a specified level of regrowth.

Spot-spray application: Herbicide is applied only to weed-infested areas of the field; usually with hand-held equipment.

Herbicide	Crop[8](s)	Establishment	Seedling Stand POST	Established Stand POST	Fall/Spring Dormant (seedling)	Fall/Spring Dormant (established)	Post-Cutting	Spot-Spray or Wiper Applicator
2,4-DB	alfalfa/ clovers		NR[5]	NR[5]				
Balan	alfalfa / clovers	PPI						

Table 5.76 - Application Timings for Herbicides Used in Legume Forages (cont.)

Herbicide	Crop[8](s)	Establishment	Seedling Stand POST	Established Stand POST	Fall/Spring Dormant (seedling)	Fall/Spring Dormant (established)	Post-Cutting	Spot-Spray or Wiper Applicator
Chateau	alfalfa					<6"regrowth	< 6" regrowth	
Eptam	alfalfa / clovers	PPI						
Glyphosate	alfalfa / clovers	preplant renovation						spot spray and wiper
Gramoxone SL	alfalfa / clovers	preplant			< 1 yr	> 1 yr	within 5 days of cut[6]	spot spray
Kerb	alfalfa / clovers				1-trif[1,3]	> 1 season[4]		
Maestro (Buctril)	alfalfa		4-trif[1]					
MCPA	alfalfa / clovers		2-trif[1,7]			> 1 season[6]		
Metribuzin	alfalfa					> 1 yr		
Poast	alfalfa / clovers		NR[5]	NR[5]				spot spray
Prowl H_2O/ Satellite HydroCap	alfalfa		2-trif[1] to 6"		2-trif[1]	after 1 cut	< 6" regrowth	
Pursuit	alfalfa / clovers		2-trif[1]	fall	2-trif[1]	> 1 season	< 3" regrowth	
Raptor	alfalfa		2-trif[1]		2-trif[1]	> 1 season	< 3" regrowth	
Roundup PowerMax/ WeatherMax	Round -up ready alfalfa	preplant renovation	emergence to first cut[2]	after first cut; 1 appl/cut[2]				spot spray and wiper
Select Max	alfalfa		NR[5]	NR[5]				spot spray
Sinbar	alfalfa					> 1 yr	< 2" regrowth	
Velpar	alfalfa					> 1 yr[3]	< 2" regrowth	

[1] #-trif = alfalfa trifoliate leaf stage that must be reached before herbicide application.

[2] For use on Roundup-Ready alfalfa only; up to 5 days before cutting.

[3] Spring application.

[4] Fall application before soil freeze-up.

[5] NR = no alfalfa size restriction on label; application based on weed stage.

[6] Application labeled for alfalfa only, not clover.

[7] Application labeled for clover only, not alfalfa.

[8] See herbicide comments table or herbicide label to determine for which clovers herbicide application is labeled.

Table 5.77 - Relative Effectiveness of Herbicides on Weeds and Crop Tolerance in Legume Forages

Table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size or growth stage. Results may differ with variations in weed size, temperature, rainfall, soil moisture, soil type, and soil pH. Crop tolerance rating of VG or less is rarely significant.

Weed control rating

10 = 95–100%

9 = 85–95%

8 = 75–85%

7 = 65–75%

6 = 55–65%

N = Less than 55% or no control

	Preemergence								Postemergence										
Trade Name	**Chateau**	**Balan**	**Eptam**	**Kerb**	**Metribuzin**	**Prowl H20**	**Sinbar**	**Velpar**	**Aim**	**Balan**	**Butyrac / 2,4-DB / MCPA**	**Eptam**	**Gramoxone**	**Maestro (Buctril)**	**Poast**	**Pursuit**	**Raptor**	**Roundup/ glyphosate**	**Select**
Crop Tolerance[1]	F	VG	FG	VG	F	FG	FG	FG	G	VG	G	FG	FG	F	E	G	G	G	E
Site of Action Number	14	3	8	3	5	3	5	5	14	3	4	8	22	6	1	2	2	9	1
Winter Annuals																			
Bluegrass, Annual	7+	**8+**	**8+**	**8+**	8	6+	7+	8	N	**8+**	N	**8+**	**8+**	N	6	6	6	**9**	7+
Brome, Downy	N	**9**	**9**	**9**	**9**	6	**9**	**9**	N	**9**	N	**9**	**9**	N	**9**	6	N	**9**	**9**
Chickweed, Common	**8+**	8	7	8	**9**	7	**9**	**9**	**8+**	8	6	7	**9**	6	N	**8+**	**8+**	**9+**	N
Henbit/Deadnettle	**8+**	6	**9**	8	**9**	8	**9**	**9**	7+	6	6	**9**	**9**	8	N	7	7	8	N
Horseweed/Marestail	**8+**	**N**	**N**	N	6	N	7	7	N	N	8	N	6	6	N	N	N	**9**	N
Mustard, Wild	7	N	6	6	**9**	6	**9**	**9**	8	N	**10**	6	**9**	8	N	**9**	**9**	**9**	N
Pennycress, Field	6	N	6	6	**9**	**6**	**9**	**9**	**9**	N	**9**	6	**9**	**9**	N	**9**	**9**	**9**	N
Pepperweed spp.	7	N	6	6	**9**	6	**9**	**9**	8	N	**10**	6	**9**	8	N	**9**	**9**	**9**	N
Radish, Wild	7	N	N	N	7	6	7	7	8	N	7	N	7	6	N	**8+**	**8+**	**9**	N
Rocket, Yellow	6	N	N	N	**9**	6	**9**	**9**	**8+**	N	8	N	8	7	N	**8+**	**8+**	**9**	N
Ryegrass, Annual	N	**8+**	**9**	**8+**	7	8	N	7	N	**8+**	N	**9**	8	N	**9**	6	6	8	**9**
Shepherds Purse	6	N	7	6	**9**	6+	**9**	**9**	**9**	N	**9**	7	**9**	**9**	N	**8+**	**9**	**9**	N
Summer Annuals																			
Amaranth, Spiny	**9**	**9**	**9**	6	**9**	**9**	**8+**	**9**	8	**9**	**8+**	**9**	**9**	8	N	**9**	**9+**	**9**	N
Barnyardgrass	6	**9**	**9**	8	6	**8+**	6	7	N	**9**	N	**9**	8	N	**9**	8	8	**9+**	**9**
Crabgrass	6	**9**	**9**	8	6	**9**	7	7	N	**9**	N	**9**	6	N	**9**	8	8	**9**	**9**
Foxtails (annual spp.)	6	**9**	**9**	8	6	**9**	7	7	N	**9**	N	**9**	**9**	N	**9**	**8+**	**8+**	**9+**	**9+**
Goosegrass	6	**9**	**9**	8	6	**9**	7	7	N	**9**	N	**9**	**9**	N	**9**	8	6	**9+**	**9+**
Lambsquarters	**9**	**9**	**9**	6	**9**	**9**	**9**	**9**	**9**	**9**	**8+**	**9**	8	10	N	7	**8+**	**9**	N

Table 5.77 - Relative Effectiveness of Herbicides on Weeds and Crop Tolerance in Legume Forages (cont.)

	Preemergence								Postemergence										
	Chateau	**Balan**	**Eptam**	**Kerb**	**Metribuzin**	**Prowl H20**	**Sinbar**	**Velpar**	**Aim**	**Balan**	**Butyrac / 2,4-DB / MCPA**	**Eptam**	**Gramoxone**	**Maestro (Buctril)**	**Poast**	**Pursuit**	**Raptor**	**Roundup/ glyphosate**	**Select**
Nightshade, Eastern Black	**8+**	6	**9**	N	6	N	**8+**	7	8	6	**8+**	**9**	**9**	9	N	7+	7+	**9**	N
Panicum, Fall	6	**9**	**9**	6	6+	**9**	6+	6+	N	**9**	N	**9**	**9**	N	**9**	8	**8+**	**9+**	**9**
Pigweed spp.	**9**	**9**	**9**	6	**9**[2]	**9**	**8+**	**9**	8	**9**	**8+**	**9**	**9**	8	N	**9+**	**9+**	**9**	N
Ragweed, Common	7	N	N	N	8	N	8	**8+**	7	N	**9**	N	**9**	9	N	7	8	**9**	N
Smartweed spp.	7	N	N	N	**8+**	8	**8+**	**8+**	8	N	6	N	**9**	9	N	**8+**	8	**9**	N
Velvetleaf	7	N	N	N	8	**8+**	8	**8+**	**9**	N	**9**	N	**9**	8	N	**9**	**9**	**9**	N
Biennials																			
Carrot, Wild	N	N	N	N	6	N	N	L	N	N	6	N	8	6	N	6	7	7	N
Perennials																			
Aster spp.	N	N	N	N	6	N	6	6	N	N	6	N	6	N	N	7	7	**8+**	N
Bedstraw, Smooth	N	N	N	N	N	N	N	N	6	N	N	N	6	N	N	7	7	8	N
Bermudagrass	N	N	7	N	N	N	6	N	N	N	N	7	6	N	8	N	N	8	8
Cockle, White	N	N	N	N	7	N	7	7	6	N	7	N	6	N	N	6	6	**9**	N
Dandelion	7+	N	N	N	7	N	6	8	6	N	7+	N	N	N	N	7	6	8	N
Dock spp.	N	N	N	N	6	N	6	7	6	N	6	N	N	N	N	7	7+	8	N
Dogbane, Hemp	N	N	N	N	N	N	6	6	N	N	N	N	6	N	N	N	N	**8+**	N
Fescue, Tall	N	N	N	8	N	N	7	7	N	N	N	N	6	N	6	N	N	**9**	**7**
Horsenettle	N	N	N	N	6	N	6	6	N	N	N	N	6	N	N	N	N	7	N
Johnsongrass	N	6	7	N	N	N	N	N	N	6	N	7	6	N	8	8	8	**9**	**9**
Milkweed, Common	N	N	N	N	N	N	6	6	N	N	N	N	N	N	N	N	N	7	N
Nutsedge, Yellow	N	N	8	N	N	6	N	N	N	N	N	8	N	N	N	7	6	7	N
Orchardgrass	N	N	6	7	N	N	6	7	N	N	N	6	6	N	6	N	N	8	7+
Plantain spp.	N	N	N	N	7	N	7	7	6	N	7	N	N	N	N	6	6	8	N
Quackgrass	N	N	8	8	N	N	6	6	N	N	N	8	6	N	7	6	N	**9**	8
Thistle, Canada	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	6	6	**9**	N

[1] Crop tolerance ratings are for forage crops listed under each herbicide in Table 5.78.

[2] Triazine-resistant biotypes exist in the region and are not controlled by metribuzin.

Table 5.78 - Comments on Herbicides for Legume Forages

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
Preplant					
Balan 60DF	**benefin**	**Alfalfa, birdsfoot trefoil, red clover, ladino clover, alsike clover**	**Preplant incorporated**	**2 lb**	**1.2**

- Balan provides approximately one month of soil residual control of many annual grass weeds and some annual broadleaf weeds.
- Apply in 5 to 40 gal/A of water or liquid fertilizer to clean, dry soil within three weeks of planting.
- Soil incorporation must occur within 8 hours after application. Uniformly incorporate into the top 2 to 3 inches of soil; see product label.
- Do not use with companion seedings of small grains or forage grasses.
- Forage grasses, small grains, sorghum, and corn can be planted 10 months after application.

Eptam 7E	**EPTC**	**Alfalfa, birdsfoot trefoil, clovers, lespedeza; not white Dutch clover**	**Preplant incorporated**	**3.5–4.5 pt**	**3.0–4.0**

- Eptam provides approximately one month of soil residual control of many annual grass weeds, some annual broadleaf weeds, and yellow nutsedge.
- Apply in 10 to 50 gal/A of water or liquid fertilizer to clean, dry soil just before planting and incorporate immediately. Operate equipment to uniformly incorporate into the top 2 to 3 inches of soil. Refer to the product label for specific instructions on soil incorporation equipment and methods.
- Do not use if atrazine was applied within 12 months of planting.
- Do not use on white Dutch clover.
- Do not use on soils with greater than 10% organic matter.
- Forage grasses, small grains, sorghum, and corn can be planted after normal harvest of the legume forage.

Postemergence					
Aim 2EC	**carfentrazone**	**Alfalfa, clover, and alfalfa or clover-grass mixtures**	**Seedling-POST Established-POST**	**1–2 fl oz**	**0.016–0.032**

- Aim only controls emerged weeds (no residual activity).
- Apply in spring or summer immediately after cutting but before 6 inches of new growth.
- Apply when weeds are actively growing and no more than 3 inches in height or rosettes are less than 2 inches across.
- Aim may be applied when crop is in dormancy such as alfalfa fall application through breaking dormancy but before 6 inches of new growth.
- There are no rotational crop or overseeding restrictions for labeled crops; see label.
- *Water quality advisory.*

Table 5.78 - Comments on Herbicides for Legume Forages (cont.)

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
Butyrac 200 2E (2,4-DB)	**2,4-DB**	**Alfalfa, birdsfoot trefoil, CRP**	**Seedling-POST Established-POST**	**1–3 qt**	**0.5–1.5**

- Butyrac 200 controls a relatively narrow spectrum of emerged broadleaf weeds, and is particularly effective on morningglory species.
- Apply in spring or summer when seedling legumes have two to four trifoliate leaves.
- Apply by ground in a minimum of 10 gal/A or by air in 5 to 40 gal/A of water.
- Apply when weeds are actively growing and no more than 3 inches in height, or rosettes are less than 2 inches across.
- Do not apply if temperatures above 90°F or below 40°F are expected during or shortly after application.
- 2,4-DB labels vary concerning overseeding or rotational crop restrictions or do not mention them. Unless specified on the label, most crops can be safely planted 3 months after application under normal environmental conditions.
- *Water quality advisory.*

Chateau 51WDG	**flumioxazin**	**Alfalfa**	**Established-dormant Between cuttings**	**2–4 oz**	**0.064–0.128**

- Chateau provides 1 to 2 months of residual control of many annual broadleaf weeds and suppression of some annual grasses as they germinate.
- It will not control weeds that have already emerged at the time of application.
- Apply by ground in 10 to 30 gal/A or by air in 5 to 10 gal/A of water.
- Dormant applications can be made in the fall after the last cutting, during winter dormancy, or anytime in the spring prior to 6 inches of alfalfa regrowth.
- Postcutting applications should be made prior to 6 inches of regrowth or unacceptable crop injury may occur.
- Wait a minimum of 60 days between applications.
- Do not apply with any adjuvant or tank-mix with any products formulated as an emulsifiable concentrate (EC) unless the application follows the last cutting of the season.
- Application with paraquat can be used to burndown winter annuals prior to the winter dormant period.
- Do not apply to mixed alfalfa-grass stands.
- When applied at the 3 to 4 oz/A rate, forage grasses can be planted 6 months after application if soil is tilled or 12 months after application if planted no-tillage; at the 2 oz/A rate it is 4 months (tilled) and 8 months (no-till); see label for more details.

Table 5.78 - Comments on Herbicides for Legume Forages (cont.)

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
Extreme 2.17L	**imazethapyr + glyphosate**	**Roundup Ready alfalfa**	**Seedling-POST Established-dormant Established-POST**	**2.2–4.4 pt/A**	**0.41–0.81(ae) 0.05–0.1**

- Extreme controls or suppresses many annual and some perennial broadleaf and grass weeds.
- Extreme also provides 1 to 2 months of residual control of many emerging weeds.
- Apply over the top to Roundup Ready alfalfa varieties only.
- Apply to seedling Roundup Ready alfalfa at the second trifoliate stage or larger.
- Apply to established Roundup Ready alfalfa in the fall, spring, or between cuttings before alfalfa regrowth reaches 3 inches.
- Apply when the majority of weeds are 1 to 3 inches (height or rosette diameter).
- Typical application rate is 3 pt/A.
- Due to breeding constraints, some alfalfa plants may not contain the glyphosate-resistant gene; thus, some seedlings may not survive the application.
- Do not apply more than 3 pt/A Extreme during the last year of the stand, or crop rotation options will be very limited.
- Forage grasses are not listed on the Extreme label in rotational crops section; small grains can be planted 4 months after application; see label.
- If replanting is necessary, do not plant alfalfa for 4 months following an Extreme application.

Gramoxone SL 2S	**paraquat**	**Alfalfa, clover, or trefoil**	**Seedling-dormant Established-dormant Between cuttings Spot treatment**	**1–2 pt 2–3 pt 1 pt 0.2-0.7 fl oz/gal**	**0.25–0.5 0.5–0.75 0.25 0.15%–0.5% solution**

- Gramoxone SL controls emerged weeds only (no residual activity).
- Dormant applications provide control of many winter annual weeds, and some seedling biennial and perennial weeds.
- Apply only one dormant application per year by ground in a minimum of 10 gal/A or by air in a minimum of 5 gal/A of water.
- To avoid injury, use only on seedling alfalfa or clover stands that are completely dormant, established clover stands with less than 2 inches of remaining fall regrowth that are completely dormant, or established alfalfa stands with less than 6 inches of remaining fall regrowth or 2 inches of new spring regrowth.
- On seedling alfalfa (first year), 2 between-cutting applications may be made. First-year alfalfa stands and yields may be reduced if alfalfa is allowed to regrow more than 2 inches after cutting and before application.
- On established alfalfa, 3 between-cutting applications may be made. Do not make between-cutting applications more than 5 days after cutting.
- Between-cutting applications are not allowed on other legumes or alfalfa-grass mixtures.
- There are no rotational crop restrictions when applying Gramoxone in legume forages.
- Spot spraying with Gramoxone SL is recommended when only small areas are to be sprayed with labeled applications. Refer to weed rate tables of the herbicide label for the recommended herbicide concentration and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft2) to provide thorough coverage. Do not spray to the point of runoff.
- Always add a nonionic surfactant at 0.5 fl oz/gal (15 ml/gal).
- *Restricted-use pesticide.*

Table 5.78 - Comments on Herbicides for Legume Forages (cont.)

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
Kerb 50W	**pronamide**	**Alfalfa, birdsfoot trefoil, crown vetch, clovers**	**Seedling-dormant Established-dormant**	**1–3 lb**	**0.5–1.5**

- Kerb provides 1 to 2 months of residual control or suppression of several annual grass and some broadleaf weeds, and also has postemergence activity on several small annual grass weeds.
- Apply by ground in 20 to 50 gal/A of water. Make applications in fall or winter when temperatures fall below 55F but before soil freeze-up.
- Kerb may be applied to fall-seeded legumes after they reach the trifoliate leaf stage.
- Do not apply to spring-seeded legumes until the following fall or early winter.
- Do not use on alfalfa-grass mixtures.
- Rainfall or overhead irrigation is required after application to activate the herbicide.
- Do not use on soils with greater than 4% organic matter.
- Forage grasses, as well as most other crops, can be planted 12 months after application; see label.
- *Restricted-use pesticide.*

Maestro 2EC (Buctril)	**bromoxynil**	**Alfalfa and alfalfa/ small grain companion seedings, CRP**	**Seedling-POST**	**1.0–1.5 pt**	**0.25–0.375**

- Maestro controls emerged weeds only (no residual activity).
- Apply in spring or fall to seedling alfalfa with at least 4 trifoliate leaves.
- May be applied to a small grain companion seeding up to the boot stage.
- Apply by ground in 10 to 20 gal/A or by air in a minimum of 5 gal/A of water or liquid fertilizer. Applications in liquid fertilizer may increase leaf burn to alfalfa.
- Weeds should not exceed the four-leaf stage, 2 inches in height, or 1 inch in diameter (whichever comes first).
- Maestro application where temperatures are expected to exceed 70°F at or 3 days following application can result in unacceptable crop injury.
- Any crop can be planted 30 days after application.
- Do not use an adjuvant unless a tank-mix partner requires it. See table 5.79.

MCPA amine 4S	**MCPA**	**Alfalfa, clovers, or trefoil with small grain companion seeding, CRP**	**Seedling-POST**	**0.25 pt 0.5 pt**	**0.125 0.25**

- MCPA controls or aids in control of some emerged annual, biennial, or perennial weeds.
- Treat after the grain is tillered and legumes are 2–3 inches tall.
- Do not use more than 5-10 gal/A of water; higher volumes may result in injury to legumes.
- Do not spray when grain is in the boot to dough stage.
- Do not use on sweet clover or vetch.
- Follow all label recommendations to reduce the potential for spray drift.
- MCPA labels vary concerning overseeding or rotational crop restrictions or do not mention them. Unless specified on the label, most crops can be safely planted 3 months after application under normal environmental conditions.
- See Tables 5.79 and 5.80.
- *Water Quality Advisory.*

Table 5.78 - Comments on Herbicides for Legume Forages (cont.)

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
Metribuzin 75DF	**metribuzin**	**Alfalfa and alfalfa-grass mixtures**	**Established-dormant**	**0.5–1.3 lb**	**0.38–1.0**

- Metribuzin provides both postemergence and 1 to 2 months of residual control of several annual broadleaf weeds and a few grasses (Brome species, annual bluegrass, green foxtail, and barnyardgrass).
- Apply by ground in 10 to 40 gal/A or by air in a minimum of 2 to 10 gal/A of water or liquid fertilizer.
- Apply in fall after alfalfa goes dormant or in the spring before new growth starts. Alfalfa may be severely injured if new growth is present at spring application.
- May be applied after dormancy is broken, but before 3 inches of new growth, if impregnated on dry fertilizer.
- Apply the appropriate rate from the label when weeds are less than two inches tall or two inches in diameter.
- May be used on alfalfa-grass mixtures. Orchardgrass in mixed stands will generally tolerate Metribuzin at rates of up to 0.67 lb/A. Rates of 0.67 to 1.0 lb/A can be used in mixed stands of alfalfa and grass to reduce grass stands and prevent crowding out of alfalfa.
- Do not use Metribuzin on sandy soils or serious crop injury can occur. Crop injury can also occur on loamy sand soils.
- Forage grasses and corn can be planted 4 months, small grains 8 months, and sorghum 12 months after application.
- *Water quality advisory.*

			Seedling-POST	**1.0–2.5 pt**	**0.19–0.47**
			Established-POST	**1.0–2.5 pt**	**0.19–0.47**
Poast 1.5E	**sethoxydim**	**Alfalfa, clovers, and birdsfoot trefoil**	**Spot treatment**	**1.3–1.9 fl oz/gal**	**1%–1.5% v/v solution**

- Poast controls many annual and perennial grass weeds (emerged weeds only).
- Apply to actively growing grasses by ground in 5 to 20 gal/A or by air in a minimum of 5 gal/A of water.
- Refer to the herbicide label for the recommended herbicide concentration based on grass species and size (generally less than 8 inches tall) and apply the recommended concentration on a spray-to-wet basis (1 gal/1000 ft^2) to provide thorough coverage.
- Repeated applications may be needed for complete control of perennial species.
- Any crop can be planted 30 days after application.
- Spot applications are allowed, but do not make spot treatments in addition to broadcast treatments. Apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft2) to provide thorough coverage. Do not spray to the point of runoff.
- Always add a crop oil concentrate at 1.3 fl.oz./gal (38 ml/gal).

Table 5.78 - Comments on Herbicides for Legume Forages (cont.)

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
			Seedling-POST	**0.5–1 qt**	**0.5–0.95**
Prowl H_2O /			**Seedling-dormant**	**0.5–1 qt**	**0.5–0.95**
Satellite HydroCap			**Established-dormant**	**1.1–4.2 qt**	**1.0–4.0**
3.8AS	**pendimethalin**	**Alfalfa**	**Between cuttings**	**1.1–4.2 qt**	**1.0–4.0**

- Prowl H_2O provides 1 to 2 months of residual control of most annual grasses and some annual broadleaf weeds as they germinate. It will not control any weeds that have already emerged at the time of application.
- Apply by ground in a minimum of 10 gal/A or by air in a minimum of 5 gal/A of water.
- Adequate rainfall or overhead irrigation is required after application to activate Prowl H_2O.
- Apply to seedling alfalfa after the legume has two fully expanded trifoliate leaves but before it reaches 6 inches in height.
- Established alfalfa is defined by the label as alfalfa planted in the fall or spring which has gone through a first cutting/ mowing.
- Apply to established alfalfa before weed emergence. Applications can be made in the fall after the last cutting, during winter dormancy, in the spring, or between cuttings. Applications should be made prior to the alfalfa reaching 6 inches in regrowth.
- Some stunting and yellowing of the alfalfa may occur with postemergence applications.
- Rotational restrictions are based on Prowl rate used, rainfall received, and time of year applied; see label.

			Seedling-POST		
			Seedling-dormant		
		Alfalfa and alfalfa-grass	**Established-POST**		
		mixtures, birdsfoot trefoil,	**Established-dormant**		
Pursuit 2S	**imazethapyr**	**clover, CRP**	**Between cuttings**	**3–6 fl oz**	**0.047–0.094**

- Pursuit controls or suppresses many annual and some perennial broadleaf weeds, as well as several grasses when they are small.
- Pursuit also provides 1 to 2 months of residual control of many emerging weeds.
- Apply by ground in a minimum of 10 gal/A or by air in a minimum of 5 gal/A of water.
- Seedling applications are for pure seeded alfalfa or clover only. Apply when legume has 2 fully expanded trifoliate leaves or larger.
- Dormant applications can be made in the fall after the last cutting or anytime in the spring prior to 3 inches of alfalfa or clover regrowth.
- Between cutting applications should also be made prior to 3 inches of regrowth.
- Apply when weeds are 1 to 3 inches in height or in the rosette growth stage.
- Do not apply Pursuit to alfalfa-grass mixtures during the establishment year.
- Do not apply more than 4 oz/A to alfalfa or clover in the last year of the stand (crop rotation considerations).
- Forage grasses are not listed on the Pursuit label in rotational crops section; small grains can be planted 4 months after application; see label.
- *Water Quality Advisory.*

Table 5.78 - Comments on Herbicides for Legume Forages (cont.)

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
Raptor 1AS	**imazamox**	**Alfalfa**	**Seedling-POST Seedling-dormant Established-dormant Between cuttings**	**4–6 fl oz**	**0.031–0.047**

- Raptor controls or suppresses many annual and some perennial broadleaf weeds, as well as several grasses when they are small.
- Raptor also provides approximately one month of residual control of many emerging weeds.
- Apply by ground in a minimum of 10 gal/A or by air in a minimum of 5 gal/A of water.
- Do not apply Raptor in liquid fertilizer as a carrier.
- Apply when seedling alfalfa has 2 fully expanded trifoliate leaves or larger.
- Seedling alfalfa may experience a temporary reduction in growth.
- Apply when weeds are 1–3 inches in height or rosette width.
- Apply to established alfalfa in the fall, winter, or spring to dormant or semi-dormant alfalfa or between cuttings.
- Any application should be made before significant alfalfa growth or regrowth (3 inches).
- Forage grasses can be planted 18 months, small grains 3-18 months (see label), and sorghum 9 months after application.

Roundup PowerMax or WeatherMax 5.5L	**glyphosate**	**Roundup Ready alfalfa only**	**Seedling-POST Established-POST**	**22–44 fl oz**	**0.77–1.9**

- Roundup provides broad-spectrum control of existing grass and broadleaf weeds, but has no effect on weeds emerging after application.
- Some species of weeds may require retreatment for complete control, as will species with multiple germination flushes.
- Apply by ground in 3 to 40 gal/A or by air in 3 to 15 gal/A of water.
- Two applications may be made to seedling stands prior to the first cutting. The first application is from emergence up to the 4-trifoliate leaf stage and is necessary to remove the small percentage of glyphosate-susceptible alfalfa plants that are present in the new seeding. The second application is from the 5-trifoliate leaf stage to 5 days before the first cutting.
- After the first cutting, a single application per cutting may be made up to 5 days before cutting.
- In established stands, a single application per cutting may be made up to 5 days before cutting.
- The highest level of control is achieved when annual weeds are less than 4 inches tall.
- For perennial weed problems, glyphosate should be applied during early fall.
- Sequential applications of glyphosate should be at least 7 days apart.
- The combined total for all in-crop applications can not exceed 4.1 qt/A per year. The combined total for all applications (in-crop and establishment) can not exceed 5.3 qt/A per year.
- There are no rotational crop restrictions when applying glyphosate in legume forages.
- The Roundup Ready system in alfalfa is easy to use and very effective on most weeds common to alfalfa plantings. However, herbicide-resistant weeds are selected for by repeated use of the same or similar herbicide over a period of time. Weed species with a very high amount of seed production and a variable genetic pool are more likely to develop resistant populations—for example, horseweed, common lambsquarters, ragweed species, and pigweed species. Therefore, it is recommended that the Roundup Ready system be used during the establishment year when the most benefit can be recognized, and then rotate between Roundup and other herbicides with different modes of action through subsequent seasons.

Table 5.78 - Comments on Herbicides for Legume Forages (cont.)

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
Roundup 3S[2] or Roundup WeatherMax 4.5S[2]	**glyphosate**	**Alfalfa, clover, and alfalfa or clover-grass mixtures**	**Spot treatment or Wiper applicator**	**2% solution or 33–77% solution**	

- Make applications with hand-held equipment or wiper applicator.
- Apply only to weed-infested areas of the field, and do not treat more than one tenth of the total area at any one time.
- Refer to weed rate tables of the herbicide label for the recommended herbicide concentration and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft2) to provide thorough coverage. Do not spray to the point of runoff.
- Apply to actively growing susceptible weeds.
- Avoid contact with desirable species as severe injury or death can occur.
- Further application may be made at 30-day intervals if necessary.
- Consult the herbicide label for specific wiper applicator recommendations.
- For best results, do not graze or harvest forage for seven days after application, and make applications at least seven days before a killing frost.
- There are no rotational crop restrictions when applying glyphosate in legume forages.

Roundup 3S or Roundup WeatherMax 4.5S[2]	**glyphosate**	**Alfalfa or alfalfa-grass mixtures**	**Preharvest**	**32–63 fl oz or 22–44 fl oz**	**0.77–1.5**

- For use on declining alfalfa stands prior to crop rotation.
- Apply before last cutting in fall or spring to control certain perennials such as quackgrass.
- Can be grazed or harvested in 36 hours. However, harvest should be delayed for 7 to 10 days after application to allow herbicide to have full effect.
- Deep tillage after harvest improves control.
- Fall applications are more effective on perennial grasses relative to spring applications.
- Refer to herbicide label for additional application information and use restrictions.
- There are no rotational crop restrictions when applying glyphosate in legume forages.

Table 5.78 - Comments on Herbicides for Legume Forages (cont.)

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
Select 2EC or Select Max 1EC	**clethodim**	**Alfalfa, birdsfoot trefoil**	**Seedling-POST or Established-POST 0.33–0.65 fl oz/gal or Spot treatment**	**6–16 fl oz or 12–32 fl oz or 0.44–0.85 fl oz/gal**	**0.09–0.25 or 0.09–0.25 or 0.25%–0.5% v/v solution or 0.34%–0.67% v/v solution**

- Select Max controls many annual and perennial grass weeds (emerged weeds only).
- Apply to actively growing grasses by ground in 10 to 40 gal/A or by air in a minimum of 10 gal/A of water.
- Apply to grasses at the size recommended on herbicide label (generally less than 6 inches tall).
- Repeated applications are required for complete control of perennial grasses. Allow a minimum interval of 14 days between repeat applications.
- For annual bluegrass control, apply 6–16 fl oz Select or 12-32 fl oz Select Max before the 4-leaf stage of bluegrass.
- Any crop can be planted 30 days after application.
- Select 2EC and Select Max 1EC require different adjuvants. See table 5.79.
- Spot treatments are allowed but do not exceed a total of 32 fl oz/A per season for Select or 64 fl oz/A per season for Select Max for spot treatments and broadcast treatments combined. Refer to weed rate tables of the herbicide label for the recommended herbicide concentration and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- Always add a crop oil concentrate at 1.3 fl.oz./gal (38 ml/gal).

Sinbar 80WG	**terbacil**	**Alfalfa**	**Established-dormant Between cuttings**	**0.75–1.5 lb**	**0.6–1.2**

- Sinbar provides postemergence control (small weeds) and 1 to 2 months of soil residual control of many annual weeds and some biennial and perennial weeds.
- Use only on alfalfa established for 1 year or more.
- Apply by ground in water with sufficient spray volume for uniform coverage.
- Dormant applications can be made in the fall through winter to dormant alfalfa or in the spring prior to 2 inches of alfalfa regrowth. Spring between cutting applications should also be made prior to 2 inches of regrowth.
- Two applications per year are allowed, but they must be separated by 60 days, and the total amount of Sinbar can not exceed 1.5 lb/A per year.
- Apply before weeds germinate or before they exceed 2 inches in height or width.
- Do not use on alfalfa-grass mixtures.
- Do not use on sand, loamy sand, or gravel soils, or on soils with less than 1% organic matter or serious crop injury can occur.
- No other crops can be planted for two years following an application of Sinbar.
- Do not use any spray adjuvants. See table “Adjuvants and Rainfast Intervals for Postemergence Herbicides in Alfalfa and Clover”.
- See Table 5.79.
- *Water Quality Advisory.*

Table 5.78 - Comments on Herbicides for Legume Forages (cont.)

See specific product label to determine correct rate for the soil type and weed species found in individual fields.

Trade Name[1]	Common Name	Crop(s)	Application Timings	Product/A	lb ai/A
Velpar 2L or 75DF	**hexazinone**	**Alfalfa**	**Established-dormant Between cuttings**	**2–6 pt or 0.67–2 lb**	**0.5–1.5**

- Velpar provides postemergence control (small weeds) and 1 to 2 months of soil residual control of many annual, biennial, and perennial weeds as well as suppression of some woody species.
- Use only on alfalfa established for 1 year or more.
- Apply by ground in a minimum of 20 gal/A or by air in a minimum of 5 gal/A of water.
- Make a single application after alfalfa becomes dormant and before new growth begins in the spring. Where weeds have emerged, include a surfactant. Weeds should be less than two inches tall or two inches in diameter.
- If no dormant application is made, a between cuttings treatment may be made; apply before 2 inches of alfalfa regrowth. Severe injury may result with between cutting applications if significant alfalfa foliage is present at application or air temperature exceeds 90°F.
- Do not use an adjuvant with between cutting applications.
- Do not use on gravelly or rocky soils, exposed subsoils, or hardpan, sand, or poorly drained soils or serious crop injury can occur.
- Unacceptable weed control may occur on soils with greater than 5% organic matter.
- When applied at 3 pt/A or less, corn can be planted 12 months after application.
- Other crops may be planted 24 months after application.
- See Tables 5.79 and 5.80.
- *Water Quality Advisory*

[1] See Table 5.73 for additional formulations or trade names containing these same active ingredients.

[2] Various formulations of this product are available. Refer to current product label for active ingredient concentration, application rate, and other restrictions. Adjust application rate if using Roundup.

Table 5.79 - Adjuvants and Rainfastness for Postemergence Herbicides in Legume Forages

Adjuvants are products included in the spray tank to improve the performance of herbicides. These include non-ionic surfactant (NIS), crop oil concentrate (COC), methylated seed oil (MSO) or nitrogen solutions. In general, NIS should contain at least 80% active ingredient, and COC should contain at least 15% emulsifier. Nitrogen solutions can be 28%, 30% or 32% ammonium based fertilizer solutions; ammonium sulfate should be spray grade dry ammonium sulfate (21-0-0). Crop injury can occur with the use of adjuvants. Adding additional adjuvants other than what is labeled can increase the chance or severity of crop injury. Following are recommended adjuvants for broadcast postemergence applications; refer to herbicide labels for adjuvant recommendations with other application types.

Rainfastness is number of hours needed between time of application and rainfall or irrigation to ensure sufficient absorption in the plant.

Trade Name	Adjuvant(s)	Rate	Rainfastness (hours)
Aim 2EC	nonionic surfactant or crop oil concentrate	1 qt/100 gal 0.5-1 gal/100 gal	not specified
Butyrac 200 2L / 2,4-DB 2L	none		not specified
Glyphosate preplant or spot treatment	varies by product, check label ammonium sulfate (optional)	see label 8.5–17 lb/100gal	1–6

Table 5.79 - Adjuvants and Rainfastness for Postemergence Herbicides in Legume Forages (cont.)

Trade Name	Adjuvant(s)	Rate	Rainfastness (hours)
	nonionic surfactant or	1 qt/100 gal	
Gramoxone 2SL	crop oil concentrate	1 gal/100 gal	0.5
Kerb 50W	none		not specified
Maestro 2EC (Buctril)	not recommended (see label for instructions when tank-mixing)		1
MCPA 3.7L	none		not specified
Metribuzin 75DF	none		not specified
	crop oil concentrate or	2 pt/A	
	methylated seed oil	1.5 pt/A	
	plus nitrogen solution or	2–4 qt/A or	
Poast 1.5EC	ammonium sulfate (optional)	2.5 lb/A	1
	nonionic surfactant or	1 qt/100 gal	
		1 gal/100 gal	
	crop oil concentrate or	1.25 gal/100 gal	
	methylated seed oil	1.25–2.5 gal/100 gal	
	plus nitrogen solution or		
Pursuit 2AS	ammonium sulfate (required)	12-15 lb/100 gal	1
	nonionic surfactant or	1 qt/100 gal	
	crop oil concentrate or	1–2 gal/100 gal	
	methylated seed oil	1–2 gal/100 gal	
	plus nitrogen solution or	2.5 gal/100 gal	
Raptor 1AS	ammonium sulfate (required)	12–15 lb/100 gal	1
Roundup PowerMax or WeatherMax 5.5L in RR alfalfa	ammonium sulfate (optional)	8.5–17 lb/100 gal	not specified
	crop oil concentrate	1 gal/100 gal	
	plus nitrogen solution or	1–2 qt/A	
Select 2EC	ammonium sulfate (optional)	2.5–4 lb/A	1
	nonionic surfactant or	1 qt/100 gal	
	crop oil concentrate or	1 gal/100 gal	
Select Max 1EC	methylated seed oil	1 gal/100 gal	1
Sinbar 80WP	do not use		not specified
	nonionic surfactant on dormant alfalfa		
Velpar 2L	none on non-dormant alfalfa	1 qt/100 gal	not specified

Table 5.80 - Grazing, Harvest, Haying, and Slaughter Restrictions for Herbicides in Legume Forages

Trade Name	Type	Length	Comments
Aim (carfentrazone)	Grazing (forage) and haying (harvest)	21 days	May be used in established, mixed grass-clover stands as well as established pure forage legume stands
Butyrac (2,4-DB)	Grazing or feeding	60 days	Seedling alfalfa
		30 days	Established alfalfa
Chateau (flumioxazin)	Grazing or harvest	25 days	Established alfalfa; less than 6 inches of regrowth
Gramoxone (paraquat)	Grazing or harvest	60 days	Fall or spring dormant application alfalfa or clover
	Grazing or harvest	30 days	Between-cutting application alfalfa only
Kerb (pronamide)	Grazing or harvest	120 days	Fall or dormant application alfalfa or clover
Maestro (bromoxynil)	Grazing or harvest	30 days	After spring application
		60 days	After fall or winter application
MCPA	Forage or grazing	7 days	Do not forage or graze meat animals within 7 days of slaughter or dairy animals within 7 days of treatment, alfalfa or clover
Metribuzin	Grazing or harvest	28 days	Dormant application
Poast (sethoxydim)	Forage (grazing)	7/20 days	On the label, forage refers to green, undried alfalfa. Poast has 20-day restriction for clover hay only.
	Hay (harvest)	14/20 days	Hay is dried alfalfa. Poast has 20-day restriction for clover hay only.
Prowl H_2O (pendimethalin)	Forage or hay harvest	28 days	Apply before 6 inches of alfalfa regrowth. Has a 28-day restriction for 2.1 qt/A or less; 50-day restriction for >2.1 qt/A.
Pursuit (imazethapyr)	Feeding, grazing, or harvest	30 days	Alfalfa or clover, be cautious of rotational crop restrictions.
Raptor (imazamox)	Feeding, grazing, or harvest	NA	Not specified on the label.
Roundup/glyphosate	Grazing or harvest (preplant)	0 days	Alfalfa or clover may be grazed or cut for hay immediately following preplant application.
	RR alfalfa only	5 days	In Roundup Ready alfalfa varieties, apply glyphosate up to 5 days before cutting.
	Grazing or harvest (spot treatment)	3–14 days	Spot treatment on alfalfa or clover depends on glyphosate product used.
Select (clethodim)	Feeding, grazing, or harvest	15 days	Increases when tankmix with 2,4-DB (60 days).
Velpar (hexazinone)	Grazing or feeding	30 days	Plant only corn for 12 months following application of Velpar.

Table 5.81 - Application Timings for Herbicides Used in Grass Pasture, Hay, and CRP Grassland

Use only in these states: If left blank these products are available in Delaware, Maryland, New Jersey, Pennsylvania, Virginia, and West Virginia.

Establishment: Herbicide is applied preplant in no-till establishment to control existing weeds. There are currently no herbicides registered for preplant incorporated (PPI) or preemergence (PRE) applications in grass forage for residual weed control.

Seedling stand POST: Herbicide is applied postemergence (POST) to seedling grass that has reached a specific growth stage and is actively growing, or at a maximum allowable rate.

Established stand POST: Herbicide is applied POST to grass that has been established for a minimum length of time and is actively growing.

Spot-spray application: Herbicide is applied only to weed-infested areas of the field; usually with hand-held equipment. If the herbicide is labeled for seedling or established stands postemergence, then herbicide use rates, application timing, and minimum establishment periods should be observed unless otherwise stated on the label. Grazing, harvest, slaughter, and transfer restrictions still apply for all spot-spray applications.

Grazed Fencerows: Herbicide is applied along a grazed fencerow to control emerged weeds and/or prevent seedling emergence. Use postemergence broadcast rates and timings unless grazed fencerows are specifically mentioned on the label. If the herbicide is labeled for spot applications, and the total area of the fencerows being treated is less than 10% of the total area inside the fencerows, spot application recommendations can be used. Grazing, harvest, slaughter, and transfer restrictions still apply for all applications to grazed fencerows.

Trade Name	Use Only in These States	Establishment	Seedling Stand POST	Established Stand POST	Spot-Spray or Wiper Applicator	Grazed Fencerows
2,4-D amine [1]				L[2]	--[3]	yes
2,4-D ester[1]				L	--[3]	yes
Aim			L	L		yes
Arsenal						yes
Banvel			1 pt/A max[4]	L	spot	yes
Chaparral (aminopyralid + metsulfuron)	PA, VA, WV			after tillering[5]	spot	yes
Clarity			1 pt/A max[4]	L	spot and wiper	yes
2,4-D + dicamba tank-mix				L		yes
Crossbow (triclopyr + 2,4-D)				after tillering[5]	spot	yes
Engenia				L	spot and wiper	yes
Facet L				L	spot	yes
FeXapan			22 fl oz/A max[4]	L	spot	yes
Freelexx				L	spot	yes
Glyphosate		preplant renovation			spot and wiper	yes
Gramoxone SL		preplant				no
GrazonNext HL (aminopyralid + 2,4-D)	PA, VA, WV			after tillering[5]	spot	yes
Grazon P+D (picloram + 2,4-D)	VA, WV			after tillering[5]		yes

Table 5.81 - Application Timings for Herbicides Used in Grass Pasture or Hay (cont.)

Herbicide	Use Only in These States	Establishment	Seedling Stand POST	Established Stand POST	Spot-Spray or Wiper Applicator	Grazed Fencerows
MCPA			½ pint/A max[6]	L		yes
Metsulfuron				6-24 months[7]	spot	yes
Milestone				after tillering[5]	spot	yes
Overdrive (dicamba + diflufenzopyr)				L	spot	yes
PastureGard HL (triclopyr + fluroxypyr)				after tillering[5]	spot	yes
Prowl H2O				6 or more tillers		yes
Remedy Ultra				after tillering[5]		yes
Sandea				L	spot and wiper	yes
Sharpen				L		yes
Spike 20P (pelleted)[8]				L	spot	yes
Stinger				L	spot	yes
Surmount (picloram +fluroxypyr)	VA, WV			after tillering[5]	spot	yes
Tordon				L	spot	yes
Vastlan				after tillering[5]	spot	yes
Weedmaster (dicamba + 2,4-D)			2 pt/A max[4]	L	spot	yes
Xtendimax			22 fl oz/A max[4]	L	spot	yes
Yukon			L	L	spot	yes

[1] 2,4-D is manufactured by various companies; labels may vary among manufacturers.

[2] L = allowed on herbicide label with no specific grass size or establishment period restrictions.

[3] Most 2,4-D labels do not include spot-spray applications, while some do.

[4] Labels state that “newly seeded areas” may be severely injured if rates greater than 1 pt/A (Banvel or Clarity), 2 pt/A (Weedmaster), or 22 fl oz/A (FeXapan and XtendiMax) is applied, but no minimum size or growth stage is given. In practice, these products should not be applied until seedling grasses have attained the 3- to 4-leaf stage, have reached a minimum height of 6 inches, and are healthy and actively growing.

[5] Grasses should be tillering and have developed a good secondary root system.

[6] This is labeled for mixed clover/grass stands after 2-trifoliate clover.

[7] Six months after establishment for bluegrass, bromegrass, and orchardgrass; 12 months for Timothy; 24 months for fescue.

[8] Spike is labeled for broadcast applications, but because it can persist for several years in the soil, it is generally only recommended for hand treatment of single plants, multistem clumps, or small stands of woody vegetation in land (including fencerows) dedicated to long-term grass pasture.

Table 5.82 - Herbicides Used in Grass Pasture, Hay, and CRP Grassland, Prepackaged Mixes, or Co-packs, and Equivalents

Trade Name	Components (lb ai/gal or lb ae/gal)	If you apply (per acre)	You have applied (ai or ae)	Site of Action Number	An equivalent tank mixture of
Chaparral 71.6WG	0.6213 lb aminopyralid 0.0945 lb metsulfuron	2.5 oz	0.098 lb aminopyralid 0.015 lb metsulfuron	4 2	6.25 fl oz Milestone 2L 0.4 oz Metsulfuron 60DF
Cimarron Max (co-pack 60DF and 2.87L)	dry: 0.6 lb metsulfuron liquid: 1.87 lb 2,4-D + 1 lb dicamba	dry: 0.4 oz liquid: 1.6 pt	0.015 lb metsulfuron 0.57 lb 2,4-D 0.2 lb dicamba	2 4 4	0.4 oz Metsulfuron 60DF 1.2 pt 2,4-D amine 3.8L 6.4 fl oz Banvel 4S
Cimarron Plus 63WDG	0.48 lb metsulfuron 0.15 lb chlorsulfuron	0.5 oz	0.015 lb metsulfuron 0.0047 chlorsulfuron	2 2	0.4 oz Metsulfuron 60DF 0.1 oz Telar 75DF
Crossbow 3L	2 lb 2,4-D 1 lb triclopyr	4 qt	2 lb 2,4-D 1 lb triclopyr	4 4	2 qt 2,4-D ester 2 pt Remedy Ultra 4L
Curtail 2.38L	0.38 lb clopyralid 2 lb 2,4-D	3 qt	0.285 lb clopyralid 1.5 lb 2,4-D	4 4	12 fl oz Stinger 3L 1.5 qt 2,4-D amine 3.8L
GrazonNext HL 3.74E	0.41 lb aminopyralid 3.33 lb 2,4-D	2.1 pt	0.108 lb aminopyralid 0.9 lb 2,4-D	4 4	6.9 fl oz Milestone 2L 1 qt 2,4-D amine 3.8L
Grazon P+D 2.54SL	0.54 lb picloram 2 lb 2,4-D	4 pt	0.27 lb picloram 1 lb 2,4-D	4 4	1 qt Tordon 2L 1 qt 2,4-D amine 3.8L
Huskie 2.06 EC	0.31 lb pyrasulfotole 1.75 lb bromoxynil	15 fl oz	0.036 lb pyrasulfotole 0.2 lb bromoxynil	27 6	0.31 lb pyrasulfotole 13 fl oz Maestro 2EC
Overdrive 70WDG	0.2 lb diflufenzopyr 0.5 lb dicamba	8 oz	0.1 lb diflufenzopyr 0.25 lb dicamba	19 4	0.1 lb diflufenzopyr 8 fl oz Clarity 4L
PastureGard HL 4SL	3 lb triclopyr 1 lb fluroxypyr	1.5 pt	0.75 lb triclopyr 0.25 lb fluroxypyr	4 4	1.5 pt Remedy Ultra 4L 11 fl oz Vista XRT 2.8L
Surmount 1.34E	0.67 lb picloram 0.67 lb fluroxypyr	3 pt	0.34 lb picloram 0.34 lb fluroxypyr	4 4	1.4 pt Tordon 2L 1 pt Vista XRT 2.8L
Weedmaster 3.87L	1 lb dicamba 2.87 lb 2,4-D	4 pt	0.5 lb dicamba 1.44 lb 2,4-D	4 4	1 pt Banvel 4S 3 pt 2,4-D amine 3.8L
Yukon 67.5WDG	0.125 lb halosulfuron 0.55 lb dicamba	6 oz	0.047 lb halosulfuron 0.206 lb dicamba	2 4	1 oz Permit 75WG 6.6 fl oz Clarity 4S

Table 5.83 - Relative Effectiveness of Herbicides Used in Grass Pasture, Hay, and CRP Grassland

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates, weed size or growth stage, and proper timing of application (see Table 5.86). Results may differ with variations in weed size, temperature, rainfall, soil moisture, soil type, and soil pH. Spike 20P also is available for control of problem woody perennials as well as some herbaceous perennials. See a Spike label for additional information. Some products show for which states they are registered under the rate. These products should only be used in the listed states.

Weed control rating

10 = 95–100% 9 = 85–95% 8 = 75–85% 7 = 65–75% 6 = 55–65%

L = Weed is listed as control on herbicide label but local data is limited. N = Less than 55% or no control

- = not applicable or no local data available

Species	2,4-D[1] 2–3 pt	2,4-D + dicamba[1] 1 qt + 1 pt	Aim 1–2 oz	Chaparral[1] 2–3 oz (PA,VA,WV)	dicamba[1] 1 pt	Crossbow[1] 2–4 qt	GrazonNext[1] HL1.5–2.6 pt (PA,VA,WV)	Grazon P+D[1] 3-4 pt (VA,WV)	Metsulfuron 60DF 0.1–0.3oz	Milestone 5-7 oz (PA,VA,WV)	Overdrive 4–6 oz	Pasture-Gard HL[1] 1-1.5 pt	Remedy Ultra 2-4 pt	Roundup/glyphosate 1–2 qt (spot treatment)	Stinger 0.66–1.33 pt	Surmount[1] 1.5-3 pt (VA, WV)
Site of Action Number	4	4	14	4/2	4	4/4	4/4	4/4	2	4	4/19	4/4	4	9	4	4/4
Winter Annuals																
Chamomile, Cayweed	7	**10**	6	L	**8+**	8	7+	–	**10**	–	**8+**	–	–	**9**	**9**	–
Chickweed, Common	7	8	**8+**	**10**	7	**9**	**9**	8	**10**	7	8	8	7+	**10**	6	**9**
Cockle, Corn	8	**10**	**9**	L	**10**	**8+**	–	–	L	–	**10**	–	–	**10**	N	–
Cockle, Cow	8	**10**	**9**	**9+**	**10**	**8+**	–	–	**9**	–	**10**	–	–	**10**	N	–
Fleabane spp.	**9**	**10**	7	**9**	8	**9+**	8	**9**	**9**	L	8	–	–	**8+**	**9**	–
Henbit/ Deadnettle	6	**8+**	N	**9**	7+	**9+**	8	**9+**	**9**	**8+**	7+	**8+**	7+	**9+**	–	**9**
Horseweed (marestail)	**9**	**9**	N	**9**	**9**	**10**	**9**	**10**	**9**	**9+**	**9**	6	6	**9+**	**9+**	**9**
Mustard, Garlic	N	8	7	8	7	8	–	–	8	–	7	–	8	8	N	–
Mustard spp.	**9**	**10**	**8+**	8	8	**10**	7+	7	**8+**	N	8	8	8	**10**	N	–
Pennycress, Field	**9**	**10**	**8+**	**10**	8	**9+**	8	**10**	**9**	–	**8+**	L	–	**10**	N	**9+**
Pepper Weed spp.	**9**	**10**	**8+**	8	8	**9+**	8	7	**10**	N	**8+**	8	8	**10**	N	–
Shepherdspurse	**8+**	**10**	**9**	**10**	8	**9**	8	–	**10**	–	8	–	–	**10**	N	–
Yellow Rocket	**9**	**10**	**9**	**8+**	**9**	**10**	8	–	**9**	–	**9**	–	–	**9**	6	–
Summer Annuals																
Amaranth, Spiny	**9**	**10**	**9**	**8+**	**9**	**9**	8	7+	8	8	**9**	N	N	**9**	6	**9**
Cocklebur, Common	**9**	**10**	8	**10**	**10**	**10**	**9**	**10**	**8+**	L	**10**	**8+**	**8+**	**9**	**9**	**9**

Table 5.83 -Relative Effectiveness of Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Species	2,4-D[1] 2–3 pt	2,4-D + dicamba[1] 1 qt + 1 pt	Aim 1–2 oz	Chaparral[1] 2–3 oz (PA,VA,WV)	dicamba[1] 1 pt	Crossbow[1] 2–4 qt	GrazonNext HL[1] 1.5–2.6 pt (PA,VA,WV)	Grazon P+D[1] 3-4 pt (VA,WV)	Metsulfuron 60DF 0.1–0.3oz	Milestone 5-7 oz (PA,VA,WV)	Overdrive 4–6 oz	Pasture-Gard HL[1] 1-1.5 pt	Remedy Ultra 2-4 pt	Roundup/glyphosate 1–2 qt (spot treatment)	Stinger 0.66–1.33 pt	Surmount[1] 1.5-3 pt (VA, WV)
Groundsel, Common	7	7	8	**9**	6	8	7	–	**9+**	–	7	–	–	**9**	**9**	L
Jimsonweed	8	**10**	**9**	**8+**	**10**	**9**	**9**	7	**9**	**8+**	**10**	–	–	**9**	8	7+
Lambsquarters, Common	**10**	**10**	**9**	**9+**	**10**	**10**	**9**	**9+**	**9**	**9+**	**10**	**9**	**9**	**9**	6	**10**
Lettuce, Wild/ Prickly	**9+**	**10**	**9**	**10**	**8+**	**9**	**9**	**10**	**9**	**9+**	**8+**	**9**	–	**9**	**9**	**9**
Nightshade, Black	7+	**8+**	**9**	**8+**	**8+**	**8+**	7	6	8	9	**8+**	6	–	**9**	8	L
Pigweed spp.	**9**	**10**	**9**	**9**	**9**	**9**	8	7	**10**	**9**	**9**	**9**	8	**9**	6	**9+**
Ragweed, Common	**9**	**10**	7	**9**	**9**	**10**	**9**	**9+**	N	**9**	**9**	**9**	**8+**	**10**	**9+**	**9**
Ragweed, Giant	**8+**	**10**	N	**9**	**9**	**10**	**9**	**9+**	N	**9**	**9**	**9**	**8+**	**10**	**9+**	**9**
Smartweed spp.	7	**9**	N	**9**	8	**9**	**9**	**9**	7	**8+**	8	N	–	**9**	**8+**	**9+**
Velvetleaf	**8+**	**10**	**9**	8	**10**	**9**	8	**8+**	8	–	**10**	**9**	–	**9**	6	**9**
Biennials																
Burdock, Common	**9**	**10**	N	**8+**	8	**9**	8	**9+**	7	**9**	8	**9**	**9**	**9**	**9**	8
Carrot, Wild	**9**	**10**	N	**10**	8	**9+**	8	**9+**	**9**	N	**8+**	7	7	**9**	6	**8+**
Evening Primrose, cCommon	**9**	**10**	7+	**9**	8	**9+**	**9**	–	–	**9**	**8+**	–	–	**10**	–	–
Evening Primrose, Cutleaf	**9**	**10**	N	**8+**	7	8	**9**	**9**	7+	**9**	7	8	8	6	–	–
Hemlock, Poison	7+	**9**	7+	N	8	**9**	8	**8+**	N	N	8	N	N	**9**	N	8
Mullein, Common	N	6	N	**9+**	N	N	–	7+	8	–	N	N	N	**–**	N	7+
Parsnip, Wild	**9**	**10**	N	**9**	**9**	**10**	**8+**	**8+**	7	7	**9**	–	–	**9**	N	–
Teasel	7+	**10**	8	**9**	**9**	**8+**	**8+**	**8+**	6	**9**	**9**	–	–	**9**	**9**	–
Stiltgrass, Japanese	N	N	N	8	N	N	7	–	N	7	**–**	–	N	**10**	N	N
Thistle, Bull	**9+**	**10**	N	**9+**	**9**	**9+**	**9**	**9**	6	**9**	**9**	6	7	**9**	**9+**	**9**
Thistle, Musk	**8+**	**10**	N	**9+**	**9**	**9+**	**9**	**9**	8	**9+**	**9**	6	7	**9**	**9+**	**8+**
Thistle, Plumeless	**8+**	**10**	N	**9+**	**9**	**9+**	**9**	**9**	8	**9+**	**9**	6	7	**9**	**9+**	**8+**

Table 5.83 -Relative Effectiveness of Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Species	2,4-D[1] 2–3 pt	2,4-D + dicamba[1] 1 qt + 1 pt	Aim 1–2 oz	Chaparral[1] 2–3 oz (PA,VA,WV)	dicamba[1] 1 pt	Crossbow[1] 2–4 qt	GrazonNext HL[1] 1.5–2.6 pt (PA,VA,WV)	Grazon P+D[1] 3–4 pt (VA,WV)	Metsulfuron 60DF 0.1–0.3oz	Milestone 5-7 oz (PA,VA,WV)	Overdrive 4–6 oz	Pasture-Gard HL[1] 1-1.5 pt	Remedy Ultra 2-4 pt	Roundup/glyphosate 1–2 qt (spot treatment)	Stinger 0.66–1.33 pt	Surmount[1] 1.5-3 pt (VA, WV)
Herbaceous Perennials																
Aster spp.	**9**	**10**	N	**9**	**8+**	9	7	8	7	–	**8+**	–	–	**9**	**9+**	—
Bedstraw, Smooth	7	7	6	**9**	N	8	**9**	7	N	**9**	N	L	–	**9**	7	L
Bindweed, Field	8	**8+**	6	–	**8+**	8	7	6	N	–	**8+**	7	7	8	N	8
Bindweed, Hedge	**9**	**10**	N	–	**9**	9	8	**8+**	N	–	**9**	7+	8	8	N	**8+**
Brackenfern	7	7	N	7	N	7+	7	–	7	–	N	–	–	6	–	–
Buttercup spp.	**8+**	**9**	7	**8+**	8	**10**	**9**	**10**	**9**	**8+**	8	8	8	**9**	8	**8+**
Catsear, Common	**7**	**9**	N	**9**	7+	**–**	**9**	–	**–**	**9**	**7+**	–	–	**8+**	–	–
Chickweed, Mouseear	6	8	6	**10**	7+	**8+**	7	**9**	**10**	8	7+	8	**8+**	**9**	6	**9**
Chicory	**9**	**10**	7	**9**	8	**9**	**9**	**9+**	7+	**9**	8	**9**	**8+**	**9**	**9**	**8+**
Clover spp.	7	**8+**	N	**10**	**8+**	**8+**	**9+**	**10**	**8+**	**9+**	**8+**	**8+**	**9**	**10**	**9**	**10**
Cockle, White	7	**9**	6	8	**8+**	**9**	N	–	8	–	**8+**	L	–	**9+**	**9**	L
Daisy spp.	**9**	**10**	N	**9**	**8+**	**9+**	**9**	8	6	**9**	**8+**	–	–	**8+**	**8+**	–
Dandelion	**9+**	**10**	6	**8+**	7	**9+**	**9**	**9**	7+	**9**	**9**	8	7+	**7**	7	**9**
Dock spp.	8	**10**	7	**9**	8	**9**	**9**	**9**	**8+**	**9**	**8+**	8	8	**9**	7+	**9**
Dogbane, Hemp	6	7	N	N	7	8	6	7	N	N	7	7	7	8	6	**8+**
Dogfennel	7	7+	N	N	7	7	7	7+	6	N	7	**9**	8	8	6	**9**
Garlic or Onion, Wild	8	**8+**	N	**9**	7	8	6	N	**9+**	N	7	N	N	**9**	N	N
Goldenrod spp.	8	**8+**	N	8	7	8	8	**9**	8	6	7	7	7+	**9**	6	**9**
Groundcherry spp.	7	7+	7	**9**	7	**8+**	7	–	–	**9**	8	–	–	8	N	–
Hawkweed spp.	8	**9**	6	L	7+	**9**	8	6	7	L	7+	–	–	**9**	8	–
Horsenettle	6	7+	N	**9**	7	8	**8+**	**9**	7	**9**	7	6	6	8	N	**8+**
Ironweed, Tall	8	**9**	N	**8+**	**8+**	**9**	**9**	**9+**	N	8	**8+**	7	6	**9**	6	**8+**
Knapweed, Spotted	7	8	N	**8+**	7	7	**9**	**9**	6	**8+**	7	6	6	**9**	**9**	**8+**
Knotweed, Japanese	7	7+	6	7+	7+	7	7	N	–	7+	7+	N	–	8	8	L

Table 5.83 -Relative Effectiveness of Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Species	2,4-D[1] 2–3 pt	2,4-D + dicamba[1] 1 qt + 1 pt	Aim 1–2 oz	Chaparral[1] 2–3 oz (PA,VA,WV)	dicamba[1] 1 pt	Crossbow[1] 2–4 qt	GrazonNext HL[1] 1.5–2.6 pt (PA,VA,WV)	Grazon P+D[1] 3-4 pt (VA,WV)	Metsulfuron 60DF 0.1–0.3oz	Milestone 5-7 oz (PA,VA,WV)	Overdrive 4–6 oz	Pasture-Gard HL[1] 1-1.5 pt	Remedy Ultra 2-4 pt	Roundup/glyphosate 1–2 qt (spot treatment)	Stinger 0.66–1.33 pt	Surmount[1] 1.5-3 pt (VA, WV)
Lespedeza, Sericea	N	N	N	6	N	7+	N	6	6	N	N	8	8	7	N	**7**
Milkweed, Common	6	7	N	N	6	7	6	7	N	N	6	6	6+	7+	N	**8+**
Mugwort	6	7	6	8	7	8	8	7	7	8	7	–	–	7	**8+**	–
Nettle, Stinging	8	**9**	6	8	8	**9**	**9**	**9**	6	**9**	8	**9**	**9**	**9**	7	**9**
Nightshade, Bitter	7	**8+**	6	–	7	––	7	7	–	–	7	–	–	**9**	8	–
Plantain spp.	8	**10**	7	**9**	8	**9**	7+	**9**	**9**	N	**8+**	**9**	8	**9**	N	**8+**
Pokeweed, Common	7	7	N	6	7	**9**	8	7+	N	7+	8	N	N	8	N	**8+**
Snakeroot, White	8	**9**	7	–	**9**	**9**	8	8	N	–	**9**	–	–	**8**	N	–
Sorrel, Red	6	**10**	**8+**	8	**8+**	–	–	**9**	**8+**	–	**8+**	6	–	**9**	8	–
Sowthistle, Perennial	7	**9**	N	**8+**	8	8	**9**	**9+**	7	**9**	8	8	8	**9**	8	–
Star-of-Bethlehem	N	N	**8+**	–	N	–	–	–	–	–	N	–	–	8	–	–
Thistle, Canada	7	7+	N	**9+**	7	8	**9**	**9**	7	**9**	7+	N	6	**8**	**9**	7
Toadflax, Yellow	7	8	**8+**	–	7+	–	7	–	–	–	7+	–	–	8	N	–
Waterhemlock, Spotted	7+	**9**	N	–	8	**9**	7	–	N	–	8	–	–	**9**	N	–
Wingstem	8+	8+	N	**9**	6	7+	**9**	**9**	N	**9**	6	6	7+	–	6	**8+**
Woodsorrel, Yellow	7	7+	7	L	7	8	**8+**	–	**9**	–	7	–	––	**9**	8	–
Yarrow, Common	7	**9**	N	L	**9**	**8+**	7	–	8	L	**9**	L	L	**9**	7	L
Woody Perennials[1]																
Blackberry spp.	6	6+	N	L	6	8	N	7+	7	N	6	L	7+	8	7	8
Dewberry spp.	6	7	N	L	6	7+	N	––	**8+**	–	6	–	––	7	7	7
Grape, Wild	8	**9**	N	–	8	**9**	8	–	–	–	8	L	–	8	N	L
Honeysuckle spp.	7	7+	N	L	N	**8+**	7	8	**10**	––	N	L	–	8	N	L
Kudzu	N	6	N	8	6	6	8	**9**	N	8	6	7	7	–	–	–
Locust, Black	7	**8+**	N	L	8	8	L	–	7	L	8	L	L	8	N	**9+**
Olive, Autumn	7	8	N	–	7+	8	7	–	–	–	7+	–	**9**	8	N	–
Poison-ivy, Oak	7	**8+**	N	6	7+	**8+**	7	**8+**	6	–	7+	L	L	8	N	7

Table 5.83 -Relative Effectiveness of Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Species	2,4-D[1] 2–3 pt	2,4-D + dicamba[1] 1 qt + 1 pt	Aim 1–2 oz	Chaparral[1] 2–3 oz (PA,VA,WV)	dicamba[1] 1 pt	Crossbow[1] 2–4 qt	GrazonNext HL[1] 1.5–2.6 pt (PA,VA,WV)	Grazon P+D[1] 3–4 pt (VA,WV)	Metsulfuron 60DF 0.1–0.3oz	Milestone 5-7 oz (PA,VA,WV)	Overdrive 4–6 oz	Pasture-Gard HL[1] 1-1.5 pt	Remedy Ultra 2-4 pt	Roundup/glyphosate 1–2 qt (spot treatment)	Stinger 0.66–1.33 pt	Surmount[1] 1.5-3 pt (VA, WV)
Rose, Multiflora	6	7+	N	8	6	**8+**	-	**8+**	**8+**	–	6	6	**8+**	8	N	7
Sumac spp.	6	7+	N	–	7	**8+**	L	7	N	–	7+	L	L	8	7	8
Trumpet Creeper	6	7+	N	–	6	8	–	7	N	–	7	–	L	7+	N	7
Virginia Creeper	7	**9**	N	–	8	**8+**	7	–	––	–	8	L	L	8	N	–

[1] Herbicide contains multiple active ingredients. See Table 5.82 for prepackaged mixture or co-packs and their constituents.

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland

The following comments apply to all herbicides, unless otherwise noted below:

- Apply postemergence to actively growing broadleaf weeds. Treat biennials in the rosette stage of growth.
- Higher rates or repeat treatments may be required for less susceptible species, perennial weeds, and woody plants.
- For maximum efficacy, do not mow, graze, hay, or disturb the treated area for 7 days after application. Make applications at least 7 days before a killing frost.
- These herbicides will severely injure alfalfa, clover, and other legumes. Do not use if loss of desirable legume species cannot be tolerated.
- Follow label recommendations to reduce the potential for spray drift or volatility to sensitive plants.

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier
2,4-D LVE 3.8L or 2,4-D amine 3.8L	**2,4-D**	**Established-POST**	**1.5-3 qt or 1-2 qt**	**1.4-2.8 or 0.95-1.9**	**yes**

- 2,4-D is marketed by various companies with various trade names. Refer to the label provided with the product for specific recommendations and restrictions.
- Make application when grasses are well established, usually 4–5 inches tall with a good root system and tiller development.
- Make applications by ground in a minimum of 10 gal/A or by air in a minimum of 2 gal/A of water or liquid fertilizer.
- Do not make applications when the temperature is expected to exceed 80 degrees that day as drift is more likely to occur.
- Treat susceptible woody perennials in the spring after leaves are fully expanded.
- Ester formulations are slightly more effective (more leaf-absorbed) than amine formulations, but also slightly more volatile.
- 2,4-D labels vary concerning overseeding or rotational crop restrictions. Unless specified on the label, most crops can be safely planted 3 months after application under normal environmental conditions.
- *Water Quality Advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
Aim 2EC	**carfentrazone**	**Seedling-POST Established-POST**	**1-2 fl oz**	**0.016-0.032**	**yes**

- For new seedings apply to grasses that have at least 3-4 leaves.
- Aim is safe to legumes and clovers, but temporary injury may occur.
- Significant crop response may occur, but is temporary.
- Apply in a minimum of 10 gal/A of water or liquid fertilizer. Applying Aim in liquid fertilizer may increase the level of crop response.
- Applications made within 8 hours of rainfall or irrigation or when heavy dew is present may cause significant crop response.
- Aim has a relatively narrow spectrum of weed control and is primarily used for control of winter or summer annual broadleaf weeds up to 4 inches tall (emerged weeds only).
- Aim has activity on Star-of-Bethlehem, dayflower species, and speedwell species. Star-of-Bethlehem may require additional application at least 10 days after the first.
- Three applications per season are allowed, but do not make applications less than 7 days apart.
- There are no rotational crop or overseeding restrictions for labeled crops; see label.

Arsenal 2AS	**imazapyr**	**Grazed fencerows**	**1-3 pt or 0.4-1.2 fl oz/gal**	**0.25-0.75 or 0.3%-0.9% v/v solution**	**no**

- Arsenal is labeled for spot treatment in grass pasture. However, due to its length of residual activity on cool-season grass species, bare spots in the pasture could persist for several months. Therefore, it is only recommended for use along permanent or long-term fencerows.
- This use falls under the spot treatment part of the label, so grazed fencerows can be treated so long as the total area to be treated is no more than 10% of the total pasture and fencerow areas combined.
- Arsenal provides postemergence and 3 to 6 months of soil residual control of many annual, biennial, and perennial grass and broadleaf weeds as well as several vine and brush species.
- Make applications with hand-held equipment.
- Refer to weed rate tables of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- Rotational crops can be planted 12 months after application and completion of a successful field bioassay.

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
		Established-POST	**2-3.3 oz**	**0.078-0.128 + 0.012-0.019**	
		Seed head suppression	**2-2.5 oz**	**0.078-0.098 + 0.012-0.015**	
Chaparral 71.6WG PA, VA, WV only	**aminopyralid + metsulfuron**	**Spot treatment**	**0.025-0.033 oz/ gal**	**0.02%-0.026% w/v solution**	**yes**

- Chaparral provides postemergence control and 2 to 3 months of soil residual control of on many annual, biennial, and perennial weed species and suppression of blackberry and multiflora rose **in permanent grass pasture**.
- Apply by ground in a minimum of 10 gal/A or by air in a minimum of 2 gal/A of water or liquid fertilizer.
- High-volume foliar applications for brush control (volume not specified) are allowed; consult herbicide label for details.
- In general, Chaparral may be applied in the spring or early summer, depending on the target weed species, as a broadcast application over grass that was planted at least 4 months prior to the application and growing under favorable conditions for establishment. Grasses should have well-established root systems and be tillering.
- Smooth bromegrass may be more sensitive to applications of Chaparral than other perennial grasses, and temporary growth suppression may occur.
- Special precautions are provided on the label for applications to tall fescue to minimize injury and stunting. Make application later in spring after new growth is 5–6 inches tall or in the fall. Do not use more than 2 oz/A of Chaparral and tank-mix with 2,4-D. Use only a non-ionic surfactant (0.5–1 pt/100 gal) when mixing with water; do not use any adjuvant when mixing with liquid fertilizer. Adhere strictly to these precautions, or severe injury may occur. Even when these precautions are followed, some stunting, yellowing, or seed head suppression of fescue may occur.
- Do not use Chaparral on timothy, annual (Italian) ryegrass, or perennial ryegrass, or severe injury will occur.
- With fall applications, do not plant grasses the following spring; do not overseed ryegrass for 4 months after application.
- Do not rotate to any crop within 1 year following treatment, or to any broadleaf crop until an adequately sensitive field bioassay shows that the aminopyralid level in soil will not adversely affect that broadleaf crop. Cereals and corn can be planted 1 year after treatment; most broadleaf crops require at least a 2-year wait until planting.
- The Chaparral label has restrictions concerning the use and management of plant residues (hay, straw, mulch, compost) and manure that may contain aminopyralid residues. These include important restrictions concerning the movement and sale of hay products treated with aminopyralid. Be certain you understand and are able to follow these label restrictions before using this product.
- For tall fescue seed head suppression and broadleaf weed control: Chaparral may be used to reduce the number of seed heads of tall fescue when applied prior to flower emergence. For best results apply 2–2.5 oz/A after initial green-up when grass height is approximately 6 inches. Later applications may still be effective; however, the seed head suppression will be less effective and the number of seed heads could be noticeably higher. Many weed species can be controlled with this application timing in addition to the suppression of seed head development.
- Make spot applications with hand-held equipment. Refer to weed rate tables of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- Spot treatments may be applied at equivalent broadcast rates of up to 6.6 oz/A (0.066 oz/gal), but no more than 50% of the acreage may be treated, and the total amount of Chaparral applied from all applications must not exceed 3.3 oz per acre per year.
- A non-ionic surfactant should be added.
- Repeat treatments may be made, but the total amount of Chaparral applied from all applications must not exceed 3.3 oz per acre per year.
- *Water quality advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
Clarity 4S or Banvel 4S	**dicamba**	**Seedling-POST Established-POST Spot treatment**	**0.5-1 pt 0.5-2 pt 0.2-1.6 fl oz/gal**	**0.25-0.5 0.25-1.0 0.16%-1.25% v/v solution**	**yes**

- Application to seedling grasses should not exceed 1 pt/A, and grasses should be actively growing, unstressed, and have attained the 3- to 4-leaf stage and 6 inches tall. For higher rates delay application until grasses are well established, usually 4–5 inches tall with a good root system and tiller development.
- Apply in a minimum of 10 gal/A of water or liquid fertilizer, or by air in 2 to 40 gal/A of water.
- High-volume foliar applications for brush control (up to 600 gal/A) are allowed; consult herbicide label for details.
- Do not make applications when the temperature is expected to exceed 80 degrees that day as drift is more likely to occur.
- Forage grasses or small grains can be overseeded after 30 days per pint of dicamba applied.
- Legumes and other broadleaf crops may be planted 4 months after application.
- Make spot applications with hand-held equipment. Do not treat more than one-tenth of the total area at any one time.
- Refer to weed rate tables of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- Clarity is also labeled for wiper applications. Consult the herbicide label for specific recommendations.
- *Water quality advisory.*

Crossbow 3E	**triclopyr + 2,4-D**	**Established-POST Spot treatment**	**1–6 qt 1.5-2 fl oz/gal**	**0.25-1.5 + 0.5–3.0 1.2%-1.6% v/v solution**	**yes**

- The label states **"This product may not be applied to forage that is to be cut and sold for commercial purposes"**.
- Crossbow provides postemergence control and 1 to 2 months of soil residual control of many annual, biennial, and perennial weeds as well as many woody plants.
- Apply only to grasses with well-established root systems that are tillering.
- Apply to actively growing weeds or brush by ground or air (helicopter only) in 10 to 30 gal/A of water or liquid fertilizer.
- Some hard-to-control perennial weeds and woody species may require retreatment. Use higher rates for less susceptible species.
- High-volume foliar applications for brush control (100–200 gal/A) are allowed; consult herbicide label for details.
- Forage grasses may be overseeded 21 days after application. Other crops can be planted the next growing season.
- Make spot applications with hand-held equipment. Refer to weed rate tables of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff
- *Water quality advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
Facet L 1.5SL	**quinclorac**	**Established-POST Spot treatment**	**12-64 fl oz 0.55-1.6 fl oz/ gal**	**0.14-0.75 0.4%-1.25% v/v solution**	**no**

- Facet L (formerly Paramount 75WDG) provides postemergence control and 1 to 2 months of soil residual control or suppression of several annual grass weeds, a few annual broadleaf weeds, and field or hedge bindweed.
- Facet L is the only herbicide labeled for postemergence control of grass weeds in grass forage crops. Labeled grass weeds are barnyardgrass, large crabgrass, giant, green, and yellow foxtails, junglerice, and broadleaf signalgrass.
- Rates greater than 32 fl oz/A and less than 22 fl oz/A are for leafy spurge control and bindweed maintenance, respectively. For broadleaf control apply 22–32 fl oz/A. For grass control apply at 32 fl oz/A with MSO at 1 % v/v.
- Use only on labeled established grasses (timothy and reed canarygrass not included) that have developed a good root system and are tillering.
- Local experience indicates that Facet may cause more injury to orchardgrass than to the other labeled cool-season grasses.
- Apply to actively growing plants by ground in a minimum of 5 gal/A of water. Aerial applications are not allowed in the Northeast region.
- For best results apply to labeled grass and broadleaf weeds up to 2 inches tall and prior to grass tiller development.
- Do not apply Facet when air temperature is more than 90°F.
- Forage grasses can be overseeded 10 months after application.
- Legume crops can be planted 24 months after application and completion of a successful field bioassay.
- For spot applications, do not exceed the maximum per-area rates for broadcast application. Refer to weed rate tables of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- *Water quality advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
		Established-POST	**1.2-2.1 pt**	**0.062-0.108 + 0.5-0.9**	
GrazonNext HL 3.74E (PA, VA, WV only)	**aminopyralid + 2,4-D**	**Spot treatment**	**0.5-0.9 fl oz/gal**	**0.4%-0.7% v/v solution**	**yes**

- GrazonNext provides postemergence control and 2 to 3 months of soil residual control of many annual, biennial, and perennial weed species **in permanent grass pasture**.
- In general, it is best to wait 45–60 days after grass planting before applying GrazonNext.
- Smooth bromegrass may be more sensitive to applications of GrazonNext than other perennial grasses, and temporary growth suppression may occur.
- Apply by ground in a minimum of 10 gal/A or by air in a minimum of 2 gal/A of water or liquid fertilizer.
- High-volume foliar applications for brush control (volume not specified) are allowed; consult herbicide label for details.
- Grass can be overseeded in the fall after a spring or early summer application.
- Do not rotate to any crop within 1 year following treatment or to any broadleaf crop until an adequately sensitive field bioassay shows that the aminopyralid level in soil will not adversely affect that broadleaf crop. Cereals and corn can be planted 1 year after treatment; most broadleaf crops require at least a 2-year wait until planting.
- The GrazonNext label has restrictions concerning the use and management of plant residues (hay, straw, mulch, compost) and manure that may contain aminopyralid residues. These include important restrictions concerning the movement and sale of hay products treated with aminopyralid. Be certain you understand and are able to follow these label restrictions before using this product.
- Make spot applications with hand-held equipment. Refer to weed rate tables of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- Spot treatments may be applied at equivalent broadcast rates of up to 4.2 pt/A (1.7 fl oz/gal), but no more than 50% of the acreage may be treated, and the total amount of GrazonNext applied from all applications must not exceed 2.1 pints per acre per year.
- A non-ionic surfactant should be added.
- Repeat treatments may be made, but the total amount of GrazonNext applied from all applications must not exceed 2.1 pints per acre per year.
- *Water quality advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
Grazon P+D 2.54SL (VA, WV only)	**picloram + 2,4-D**	**Established-POST**	**2-8 pt**	**0.14-0.54 + 0.5-2.0**	**yes**

- Grazon P+D provides postemergence control and 2 to 3 months of soil residual control of many annual, biennial, and perennial weed species **in permanent grass pasture**.
- The distribution of Grazon P+D may be further restricted within Virginia and West Virginia due to the picloram content of the product and sensitivity of certain broadleaf crops.
- Apply to grasses that are well established as indicated by tillering, development of secondary root system, and vigorous growth.
- Smooth bromegrass may be more sensitive to applications of Grazon P+D than other perennial grasses, and temporary growth suppression may occur.
- Apply by ground in 10–40 gal/A or by air in a minimum of 2 gal/A of water, an oil-water emulsion, or liquid fertilizer.
- High-volume foliar applications for brush control (100 gal/A) are allowed; consult herbicide label for details.
- Cool season grasses can be seeded a minimum of 21 days after application (60 days for smooth bromegrass).
- Do not rotate to food or feed crops on treated land if they are not registered for use with picloram until an adequately sensitive field bioassay or chemical test shows that no detectable picloram is present in soil.
- The Grazon P+D label has restrictions concerning the use and management of plant residues (hay, straw, mulch, compost) and manure that may contain picloram residues. Be certain you understand and are able to follow these label restrictions before using this product.
- *Water quality advisory.*
- *Restricted-use pesticide.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
		Established-POST	**0.1-0.4 oz**	**0.004-0.015**	
		Seed head suppression	**0.3-0.4 oz**	**0.011-0.015**	
				0.008% w/v	
Metsulfuron 60DF	**metsulfuron**	**Spot treatment**	**0.01 oz/gal**	**solution**	**yes**

- Metsulfuron provides both postemergence control and 2 to 3 months of soil residual control of many annual, biennial, and perennial weed species, and suppression of blackberry and multiflora rose **in permanent grass pasture**.
- Apply by ground in a minimum of 10 gal/A or by air in 2 to 5 gal/A of water or liquid fertilizer.
- Postemergence applications are rainfast in 4 hours, after which rainfall or overhead irrigation is required to activate the herbicide in the soil.
- Applications up to 0.4 oz/A may be made to grasses that have been established for a minimum amount of time as follows: bermudagrass (2 months); bluegrass, bromegrass, and orchardgrass (6 months); timothy (12 months); and fescue (24 months).
- Special precautions are provided on the label for applications to fescue or timothy. Apply to fescue in late spring or fall or to timothy in late summer or fall. Either species should be at least 6 inches tall and actively growing. Use the lowest recommended rate of metsulfuron (up to 0.4 oz/A) for the target weeds and tank-mix with 2,4-D for added safety. Use only a non-ionic surfactant at 0.5 pt/100 gal when mixing with water; do not use any adjuvant when mixing with liquid fertilizer. Adhere strictly to these precautions, or severe injury may occur. Even when these precautions are followed, some stunting or yellowing of timothy or fescue may occur.
- Do not use metsulfuron on annual (Italian) or perennial ryegrass, or severe injury will occur.
- Overseeding intervals for grasses are specific to region, soil pH, metsulfuron rate, and grass species. In our region with soils of pH 7.5 or less, the interval range is from 6 to 34 months (see label).
- Metsulfuron is persistent in soil; rotation to most broadleaf crops is 34 months or completion of a successful field bioassay.
- Cimarron Max is a co-pack that contains the active ingredients of metsulfuron and 2,4-D plus dicamba.
- Cimarron Plus is a premix with the active ingredients metsulfuron and chlorsulfuron (Glean or Telar).
- For tall fescue seed head suppression and broadleaf weed control: Metsulfuron may be used to reduce the number of seed heads of tall fescue when applied prior to flower emergence. For best results apply 0.3–0.4 oz/A after initial green-up when grass height is approximately 6 inches. Later applications may still be effective; however, the seed head suppression will be less effective and the number of seed heads could be noticeably higher.
- Spot treatment with metsulfuron is effective for suppression or control of multiflora rose, blackberry, and Canada thistle. Make applications with hand-held equipment. Apply 1 oz/100 gal (0.28 gr/gal) on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff, but dense stands of brush may need to be treated form both sides to achieve adequate coverage.
- A non-ionic surfactant at 2–4 pt/100 gal should be added.
- Make applications after plants are fully leafed in the spring up through late summer.

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
Milestone 2E (PA, VA, WV only)	**aminopyralid**	**Established-POST Spot treatment**	**3-7 fl oz 0.13-0.36 fl oz/ gal**	**0.047-0.109 0.1%-0.3% v/v solution**	**yes**

- Milestone provides postemergence control and 2 to 3 months of soil residual control of on many annual, biennial, and perennial weed species **in permanent grass pasture**.
- In general, it is best to wait 45–60 days after grass planting before applying Milestone.
- Smooth bromegrass may be more sensitive to applications of Milestone than other perennial grasses, and temporary growth suppression may occur.
- Apply by ground in a minimum of 10 gal/A or by air in a minimum of 2 gal/A of water or liquid fertilizer.
- High-volume foliar applications for brush control (volume not specified) are allowed; consult herbicide label for details.
- Grass can be overseeded the fall after a spring treatment.
- Do not rotate to any crop within 1 year following treatment or to any broadleaf crop until an adequately sensitive field bioassay shows that the aminopyralid level in soil will not adversely affect that broadleaf crop. Cereals and corn can be planted 1 year after treatment; most broadleaf crops require at least a 2-year wait until planting.
- The Milestone label has restrictions concerning the use and management of plant residues (hay, straw, mulch, compost) and manure that may contain aminopyralid residues. Follow the label restrictions carefully.
- Make spot applications with hand-held equipment. Refer to weed rate tables of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- Spot treatments may be applied at equivalent broadcast rates of up to 14 fl oz/A (0.32 fl oz/gal), but no more than 50% of the acreage may be treated, and the total amount of Milestone applied from all applications must not exceed 7 fl oz per acre per year.
- A non-ionic surfactant should be added.
- Repeat treatments may be made, but the total amount of Milestone applied from all applications must not exceed 7 fl oz per acre per year.
- *Water quality advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
		Established-POST	**4-8 oz**	**0.125-0.25**	
				0.05-0.1	
	dicamba+	**Spot treatment**	**0.1-0.2 oz/gal**	**0.08%-0.16%**	
Overdrive 70WDG	**diflufenzopyr**			**w/v solution**	**no**

- Use only on established grasses that have developed a good root system and are tillering.
- Some leaf burn may occur on certain forage grasses (orchardgrass, timothy), especially with spring applications.
- Apply to actively growing plants by ground in a minimum of 10 gal/A of water. Do not apply by air.
- Multiple applications are allowed as long as all treatments do not exceed 8 oz/A during a growing season.
- Grass or broadleaf crops can be planted 30 days after application.
- Make spot applications with hand-held equipment. Refer to weed rate tables of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- *Water quality advisory.*

		Established-POST	**0.75-4 pt**	**0.28-1.5 +**	
				0.094-0.5	
	triclopyr +	**Spot treatment**	**0.2-1.5 fl oz/gal**	**0.16%-1.2% v/v**	
PastureGard HL 4L	**fluroxypyr**			**solution**	**not recommended**

- PastureGard provides postemergence control and 1 to 2 months of soil residual control of many annual, biennial, and perennial weeds as well as many woody plants.
- Apply to actively growing weeds or brush by ground in a minimum of 5 gal/A or by air in a minimum of 3 gal/A (non-woody broadleaf weeds) or 4 gal/A (woody plants) of water.
- For brush control, high-volume foliar applications (50–100 gal/A), basal methods, and cut stump methods are allowed; consult herbicide label for details.
- For best results treat blackberry either before first flower or after fruit drop.
- Some hard-to-control woody species may require retreatment.
- Apply only to grasses with well-established root systems that are tillering.
- Forage grasses or small grains can be overseeded 21 days after application.
- Other crops can be planted 4 months after application.
- For spot treatments apply at rates equivalent to broadcast application rates. Refer to weed rate tables of the herbicide label and apply the recommended per gallon concentration above on a spray-to-wet basis (1 gal/1,000 ft2) to provide thorough coverage. Do not spray to the point of runoff.
- *Water quality advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
Prowl H2O 3.8AS	**pendimethalin**	**established POST (fall, winter, spring) between cuttings**	**1.1-4.2 qt**	**1-4**	**yes**

- Prowl H2O has a supplemental label (expires April 30, 2019) for use in cool-season forage grasses (forage, green chop, silage, hay, or pasture).
- Prowl H2O will not control any weeds that have already emerged at the time of application.
- Provides 1 to 2 months of residual control of most annual grass weeds and a few broadleaf weeds as they germinate (refer to label for weeds controlled).
- An early April application may be required to control annual grasses such as foxtails (annual species only), jointhead arthraxon, crabgrass, and others as well as suppression of Japanese stiltgrass
- Applications may be made in fall after last cutting/grazing, in winter, spring, or between cuttings (but before weed emergence).
- Apply to solid (established) stands of perennial forage grasses with a minimum of 6 tillers.
- Apply by ground in a minimum of 10 gal/A or by air in a minimum of 5 gal/A of water or liquid fertilizer.
- Adequate rainfall or overhead irrigation is required to activate Prowl H2O.
- Multiple applications are allowed, however maximum use rate of Prowl H2O is 4.2 qt/A/year with 30 days between sequential applications.
- Adverse environmental conditions or weak stands of grass may cause temporarily injury.
- Do not apply to mixed stands with forage legumes other than alfalfa.
- Rotational restrictions are based on Prowl rate used, precipitation, and application timing; see label.

Remedy Ultra 4L	**triclopyr**	**Established-POST**	**0.5-4 pt**	**0.25-2.0**	**yes**

- Remedy Ultra provides postemergence control and 1 to 2 months of soil residual control of many annual, biennial, and perennial weeds as well as many woody plants.
- Apply to actively growing weeds or brush by ground in a minimum of 10 gal/A or by air in a minimum of 2 gal/A (non-woody broadleaf weeds) or 4 gal/A (woody plants) of water or liquid fertilizer.
- Do not use liquid fertilizer as the carrier when treating woody plants (brush).
- For brush control, high-volume foliar applications (100–200 gal/A), basal methods, and cut stump methods are allowed; consult herbicide label for details.
- Biennial or winter annual weeds are most susceptible while in the rosette stage.
- For best results treat blackberry during or after bloom.
- Some hard-to-control woody species may require retreatment.
- Apply only to grasses with well-established root systems that are tillering.
- Forage grasses can be overseeded 21 days after application.
- Other crops can be planted the next season after application.
- *Water Quality Advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
Roundup 3S or Roundup WeatherMax 4.5S	**glyphosate**	**Spot treatment**	**2.5 fl oz/gal**	**2% v/v solution**	**no**

- Glyphosate controls emerged weeds only (no residual activity).
- Make applications with hand-held equipment or wiper applicators. Avoid contact with desirable vegetation. Consult the herbicide label for specific wiper applicator recommendations.
- At rates up to 2 qt/A, any portion up to the entire field may be treated. For rates above 2 qt/A, apply only to weed-infested areas of the field, and do not treat more than one-tenth of the total area at any one time.
- Subsequent applications to the same areas can be made at 30-day intervals.
- Refer to weed rate tables of the herbicide label for the recommended herbicide concentration.
- For spot treatment, apply on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- There are no overseeding restrictions for spot treatment with glyphosate.

Sandea 75WDG	**halosulfuron**	**Established-POST Spot treatment**	**0.67-1.3 oz 0.019 oz/gal**	**0.031-0.063 0.016% w/v solution**	**no**

- Sandea provides excellent postemergence control of yellow nutsedge and has both preemergence (3 to 4 weeks soil residual) and/or postemergence activity on several annual broadleaf weeds.
- Apply by ground in a minimum of 10 gal/A water or by air in 3–15 gal/A water.
- For best results, spray actively growing nutsedge plants at the 3- to 5-leaf stage and susceptible broadleaf plants that are 1 to 3 inches tall.
- Heavy nutsedge infestations may require additional applications.
- Wait at least 48 hours after application before irrigation.
- Yukon is a premix of Sandea and dicamba.
- Forage grasses, small grains, sorghum, and corn can be overseeded 2 months after application.
- Legume forages can be planted 9 months after application; see label for other broadleaf crops.
- Apply Sandea as a postemergence spot treatment only to those areas of emerged nutsedge. Do not exceed a rate of 0.75 oz/A (0.019 oz/gal). Apply on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff. A second postemergence spot application at 0.75 oz/A is allowed where nutsedge has emerged or regrown. Follow the same procedures as first application. The potential for injury to desirable broadleaf and grass plants is increased with a second application.
- *Water Quality Advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
Sharpen 2.85SC	**saflufenacil**	**Established-dormant Established-POST**	**1-2 fl oz**	**0.022-0.044**	**yes**

- Sharpen has a relatively narrow spectrum of weed control and is primarily used for control of winter or summer annuatl broadleaf weeds up to 6 inches tall. It primarily controls emerged weeds but has some very short (1-2 weeks at the labeled rates) residual activity.
- Apply by ground in a minimum of 5 gal/A water or 20 gal/A liquid fertilizer, or by air in a minimum of 3 gal/A water.
- Make dormant applications in the fall, during the winter, or in early spring before green-up.
- Make in-season applications before weeds reach the maximum size (usually 3-6 inches) listed on the weed table of the label.
- Sharpen may cause transitory injury to forage grasses.
- There are no replant restrictions for forage grasses, small grains, or sorghum at the 2 fl oz/A rate.
- For other crops, rotation restrictions are up to 5 months at the 2 fl oz/A rate; see label.
- *Water Quality Advisory*

Spike 20P	**tebuthiuron**	**Established-POST Individual plant**	**10-20 lb 0.4-0.7 oz/100 sq ft**	**2-4 2-4**	**n/a**

- Spike 20P is a pelleted formulation for control of woody plants (trees, shrubs, etc) and vines.
- Apply by hand evenly over the area occupied by individual plants, multistem clumps, or small stands of woody vegetation.
- For multiflora rose control, apply Spike in early spring after ground thaw and before multiflora rose growth.
- Requires rainfall to move herbicide to root zone.
- Make only one application per year.
- Desirable grasses or legumes in the treated area may be injured or killed. Dormant season application is recommended to minimize herbicidal activity on forage grasses.
- For best results, do not disturb treated plants by wood cutting or removal for 2 years after application.
- Poor or erratic results are likely to occur in soils containing more than 5% organic matter or more than 30% clay, and in areas where woody plants are rooted directly in a shallow water table.
- Spike can persist in the soil for several years, and should therefore only be used on land dedicated to long-term grass forage production unless severe herbicide injury to legumes, row crops, shrubs, or trees can be tolerated in treated areas for several years. A field bioassay is required before planting sensitive crops.
- Do not apply Spike 20P in the vicinity of desirable plants. Exposure of even a small part of a plant root system to Spike may cause severe plant injury or death. Treatment setback distance from desirable plants should be one to two times the height or width of adjacent non-target vegetation, whichever is greater. Avoid applications on slopes where surface or ground water flow toward desirable vegetation.
- Do not apply more than 10 lb/A on “vulnerable sites” as described on the herbicide label under “Use Restrictions for Groundwater Protection.” Do not apply in areas where the water table is predominately shallow (5 feet or less), to interior ditch banks, or to ditches used to transport irrigation water or potable water. Do not apply within areas identified by state or local authorities as protected groundwater recharge zones.
- *Water quality advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
Stinger 3S	**clopyralid**	**Established-POST Spot treatment**	**0.66-1.3 pt 0.13-0.5 fl oz/ gal**	**0.25-0.50 0.1%-0.4% v/v solution**	**no**

- Stinger provides postemergence control and 1 to 3 months of soil residual control of some annual, biennial, and perennial broadleaf weeds, but is primarily used for Canada thistle control.
- Apply to actively growing weeds by ground in a minimum of 10 gal/A of water. Do not apply by aircraft.
- For Canada thistle, apply in rosette stage or after thistle is at least 4 inches tall, but before the bud stage.
- Multiple treatments are allowed as long as all treatments do not exceed 1.33 pt/A during a growing season.
- Apply only to actively growing well-established grasses that are tillering and have developed secondary roots.
- The Stinger label has restrictions concerning the use and management of plant residues (hay, straw, mulch, compost) and manure that may contain herbicide residues. Follow the label recommendations carefully.
- There are no overseeding restrictions for forage grasses, small grains, or field corn.
- Most broadleaf crops can be planted 10.5–18 months after application; see label.
- Spot treatment with Stinger is primarily for Canada thistle control. Refer to weed rate table of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft2) to provide thorough coverage. Do not spray to the point of runoff.
- *Water quality advisory.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
		Established-POST	**3-6 pt**	**0.25-0.5 +**	
Surmount 1.33L (VA, WV only)	**picloram + fluroxypyr**	**Spot treatment**	**0.6-1.1 fl oz/gal**	**0.25-0.5 0.5%-0.85% v/v solution**	**yes**

- Surmount provides postemergence control and 2 to 3 months of soil residual control of many annual, biennial, and perennial weed species **in permanent grass pasture**. It may provide improved control of hemp dogbane, milkweed, dewberry, or sumac species over Grazon P+D.
- The distribution of Surmount may be further restricted within Virginia and West Virginia due to the picloram content of the product and sensitivity of certain broadleaf crops.
- Apply to grasses that are well established as indicated by tillering, development of secondary root system, and vigorous growth.
- Apply by ground in a minimum of 10 gal/A or by air in a minimum of 5 gal/A of water, an oil-water emulsion, or liquid fertilizer.
- High-volume foliar applications for brush control (100 gal/A) are allowed; consult herbicide label for details.
- Cool-season grasses can be seeded a minimum of 21 days after application.
- Do not rotate to any crop within 1 year following treatment other than range or pasture grasses, grasses for hay or silage, barley, oats, rye, or grain sorghum. Thereafter, other crops may be planted after an adequately sensitive field bioassay shows that the risk of crop injury is within acceptable limits.
- The Surmount label has restrictions concerning the use and management of plant residues (hay, straw, mulch, compost) and manure that may contain picloram residues. Be certain you understand and are able to follow these label restrictions before using this product.
- Spot treatment with hand-held sprayers should be applied at a rate equivalent to a broadcast application. Refer to weed rate table of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff.
- Make applications at least 7 days before a killing frost.
- *Water quality advisory.*
- *Restricted-use pesticide.*

Table 5.84 - Comments on Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Common Name	Application Timing	Product/A	lb ai/A	Apply in Liquid Fertilizer as a Carrier (yes/no)
		Seedling-POST	**0.5-2 pt**	**0.06-0.25 + 0.18-0.72**	
		Established-POST	**1-4 pt**	**0.125-0.5 + 0.36-1.4**	
Weedmaster 3.87L	**dicamba + 2,4-D**	**Spot treatment**	**0.4-1.6 fl oz/gal**	**0.3%-1.25% v/v solution**	**yes**

- For broadcast applications, apply by ground in 5–40 gal/A of water or liquid fertilizer or by air in 3–10 gal/A of water.
- For brush control, foliar and basal applications in oil and water emulsions and cut surface applications are allowed; consult herbicide label for details.
- Applications to newly seeded areas should not exceed 2 pt/A and should only be applied to actively growing unstressed grasses that have attained the 3- to 4-leaf stage and have reached a minimum height of 6 inches.
- Multiple applications are allowed on established grasses as long as all treatments do not exceed 8 pt/A during a growing season.
- Do not make applications when the temperature is expected to exceed 80°F that day, as drift is more likely to occur.
- Forage grasses and small grains can be overseeded after 10 days per pint of Weedmaster applied.
- Legumes and other broadleaf crops may be planted 4 months after application.
- Make spot applications with hand-held equipment. Refer to weed rate tables of the herbicide label and apply the recommended concentration on a spray-to-wet basis (1 gal/1,000 ft^2) to provide thorough coverage. Do not spray to the point of runoff. Do not make spot treatments in addition to broadcast treatments.
- Weedmaster is effective on many woody species as a spot spray at the higher rates.
- Add a surfactant at 0.5% v/v for improved control.
- *Water quality advisory.*

Table 5.85 - Adjuvants and Rainfastness for Postemergence Herbicides Used in Grass Pasture, Hay, and CRP Grassland

Adjuvants are products included in the spray tank to improve the performance of herbicides. These include non-ionic surfactant (NIS), crop oil concentrate (COC), methylated seed oil (MSO), or nitrogen solutions. In general, NIS should contain at least 80% active ingredient, and COC should contain at least 15% emulsifier. Nitrogen solutions can be 28, 30, or 32% ammonium-based fertilizer solutions; ammonium sulfate should be spray-grade dry ammonium sulfate (21-0-0). Crop injury can occur with the use of adjuvants. Adding additional adjuvants than what is labeled can increase the chance or severity of crop injury. Following are recommended adjuvants for broadcast postemergence applications; refer to herbicide labels for adjuvant recommendations with other application types.

Rainfastness is number of hours needed between time of application and rainfall or irrigation to ensure sufficient absorption in the plant.

Trade Name	Adjuvant(s)	Rate	Apply in Liquid Fertilizer as a Carrier	Rainfastness (hours)
2,4-D amine 3.8L	none recommended[2] or nonionic surfactant[3] or crop oil concentrate[3]	1 qt/100 gal 1-2 qt/A	yes	1

Table 5.85 - Adjuvants and Rainfastness for Postemergence Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Adjuvant(s)	Rate	Apply in Liquid Fertilizer as a Carrier	Rainfastness (hours)
2,4-D ester 3.8L	none recommended[2] or nonionic surfactant[3] or crop oil concentrate[3]	1 qt/100 gal 1-2 qt/A	yes	1
Aim 2EC	nonionic surfactant or crop oil concentrate or methylated seed oil plus nitrogen solution or ammonium sulfate (optional)	1 qt/100 gal 1 gal/100 gal 1 gal/100 gal 2-4 gal/100 gal 2-4 lb/A	yes	not specified
Arsenal 2AS	nonionic surfactant or methylated seed oil	1 qt/100 gal 1.5-2 pt/A	N/A	1
Chaparral 71.6WG[1]	crop oil concentrate or methylated seed oil or nonionic surfactant plus nitrogen solution or ammonium sulfate (optional)	1 gal/100 gal 0.5-1 gal/100 gal 1 qt/100 gal 2 qt/A 2 lb/A	yes	not specified
Clarity/Banvel 4L	nonionic surfactant or crop oil concentrate plus nitrogen solution or ammonium sulfate (optional)	1-2 pt/100 gal 1 qt/A 2-4 qt/A 2.5 lb/A	yes	4
Crossbow 3L	none recommended		yes	not specified
Facet 1.5L	crop oil concentrate or methylated seed oil plus nitrogen solution or ammonium sulfate (optional)	2 pt/A 1-2 pt/A 2-4 qt/A 8.5 lb/100 gal	no	6
Glyphosate preplant or spot treatment	varies by product, check label ammonium sulfate (optional)	see label 8.5 – 17 lb/100gal	no	1-6
Gramoxone 2SL	nonionic surfactant or crop oil concentrate	1 qt/100 gal 1 gal/100 gal	no	0.5
GrazonNext HL 3.74E	nonionic surfactant	1-2 qt/100 gal	yes	not specified
Grazon P+D 2.54SL	nonionic surfactant[2]	1 qt/100 gal	yes	not specified
MCPA 3.7L	none recommended		yes	not specified
Metsulfuron 60DF	nonionic surfactant or nonionic surfactant (on fescue) nonionic surfactant (on timothy)	1-2 qt/100 gal 0.5-1 pt/100 gal 0.5 pt/100 gal	yes	4

Table 5.85 - Adjuvants and Rainfastness for Postemergence Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

Trade Name	Adjuvant(s)	Rate	Apply in Liquid Fertilizer as a Carrier	Rainfastness (hours)
Milestone 2L	nonionic surfactant	1-2 qt/100 gal	yes	not specified
Overdrive 70WG	nonionic surfactant or methylated seed oil	1 qt/100 gal 1.5 to 2 pt/A	no	4
PastureGard HL 4L	nonionic surfactant[4] or nitrogen solution[4]	1-2 qt/100 gal 1-2 qt/100 gal	not recommended	not specified
Prowl H2O 3.8AS	none recommended		yes	not applicable
Remedy Ultra 4L	nonionic surfactant[2]	1 qt/100 gal	yes	not specified
Sandea 75DF	nonionic surfactant	1-2 qt/100 gal	no	4
Sharpen 2.85SC	methylated seed oil plus ammonium sulfate (dormant only)	1 gal/100 gal 8.5-17 lb/100 gal	yes	1
Stinger 3S	not recommended[5]		no	6
Surmount 1.33L	nonionic surfactant[3] or nitrogen solution[3]	1-2 qt/100 gal 1-2 qt/100 gal	yes	not specified
Weedmaster 3.87L	nonionic surfactant plus nitrogen solution (optional)	2-4 pt/100 gal 2-4 qt/A	yes	4

[1] See fescue precautions on herbicide label for specific adjuvant recommendations.

[2] An adjuvant is allowed in water dilutions to provide improved wetting of the foliage, but not required.

[3] An adjuvant is recommended for control of woody plants only.

[4] An adjuvant is allowed for improved weed or woody plant control, especially when plants are drought-stressed.

[5] The label states that the addition of adjuvants is not usually necessary and that "adding a surfactant to the spray mixture may increase effectiveness on weeds but may reduce selectivity to the crop, particularly under situations of plant stress.

Table 5.86 - Grazing, Harvest, Haying, and Slaughter Restrictions for Herbicides Used in Grass Pasture, Hay, and CRP Grassland

A – (dash) means interval not specified on the label.

Trade Name	Type of Animal	Interval between Application and Grazing	Interval between Application and Green Harvest[1]	Interval between Application and Haying	Comments
2,4-D amine or 2,4-D LVE	Lactating dairy Other livestock	7 days 0	–[2] –	7 days 7 days	Remove meat animals from treated area 3 days before slaughter. 2,4-D labels vary. See specific label of product used.
Aim (carfentrazone)	All	0	0	0	Slaughter restrictions are not mentioned on label.

Table 5.86 - Grazing, Harvest, Haying, and Slaughter Restrictions for Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

A – (dash) means interval not specified on the label.

Trade Name	Type of Animal	Interval between Application and Grazing	Interval between Application and Green Harvest1	Interval between Application and Haying	Comments
Chaparral (aminopyralid + metsulfuron)	All	0	-	0	No slaughter restrictions.
Cimarron Plus (metsulfuron + chlorsulfuron)	All	0	0	0	Be cautious of crop rotation restrictions. See label for details.
Clarity/Banvel (dicamba)	Lactating dairy	7 days if < 1 pt	-	37 days if < 1 pt	Remove meat animals from treated areas 30 days prior to slaughter.
		21 days if 1-2 pt		51 days if 1-2 pt	
	Other livestock	40 days if 2-4 pt	-	70 days if 2-4 pt	
		0		7	
Crossbow (2,4-D + triclopyr)	Lactating dairy	Do not graze until next season	-	14 days	Remove meat animals from treated areas or dried hay 3 days prior to slaughter.
	Other livestock	0	-	14 days	
Facet L (quinclorac)	All	0	-	7 days	No slaughter restrictions on the label
GrazonNext HL (aminopyralid + 2,4-D)	All	0	-	7	Do not transfer grazing animals for 3 days from treated areas to areas with Milestone sensitive-species. Do not spread manure to areas where sensitive-species are or will be grown.
Grazon P+D (picloram + 2,4-D)	Lactating dairy	7 days	-	30 days	Remove meat animals from treated area 3 days before slaughter.
	Other livestock	0	-	30 days	
Metsulfuron	All	0	0	0	Do not seed to other crops for 1 or more years. See label for restrictions.
Milestone (aminopyralid)	All	0	0	0	Do not transfer grazing animals for 3 days from treated areas to areas with Milestone-sensitive species. Do not spread manure to areas where sensitive-species are or will be grown.
Overdrive (dicamba + diflufenzopyr)	All	0	0	0	Do not apply more than 8 oz/A per season.

Table 5.86 - Grazing, Harvest, Haying, and Slaughter Restrictions for Herbicides Used in Grass Pasture, Hay, and CRP Grassland (cont.)

A – (dash) means interval not specified on the label.

Trade Name	Type of Animal	Interval between Application and Grazing	Interval between Application and Green Harvest1	Interval between Application and Haying	Comments
PastureGard HL (triclopyr + fluroxypyr)	Lactating dairy[3]	0	0	14 days	Remove meat animals from treated areas at least 3 days before slaughter.
	Other livestock	0	0		
Prowl H2O (pendimethalin)	All	0	0	0	Mixed stand alfalfa/cool-season forage grasses may be grazed or harvested for forage or hay 14 or more days after applying Prowl H2O.
Remedy Ultra (triclopyr)	Lactating dairy	next season	next season	14 days	Remove meat animals from treated areas at least 3 days before slaughter.
	Other livestock	0	0		
Roundup/ glyphosate	All	Spot-7 days Renovate-56 days	Spot-7 days Renovate-56 days	Spot—7 days Renovate-56 days	Use as spot treatment. Do not treat more than one-tenth of any acre. Leaves no soil residue.
Sandea (halosulfuron)	All	0	37	37	0-day pre-slaughter interval.
Sharpen (saflufenacil)	All	0	0	0	No slaughter restrictions on the label.
Spike (tebuthiuron)	All	< 20 lb/A-0	-	One year	Leaves soil residue up to 2 years.
Stinger (clopyralid)	All	0	0	0	Do not use hay or straw from treated areas for compost or mulch on susceptible broadleaved crops.
Surmount (picloram + fluroxypyr)	Lactating dairy	14	14	14	Remove meat animals from treated areas at least 3 days before slaughter.
	Other livestock	0	0	0	
Weedmaster (dicamba + 2,4-D)	Lactating Dairy	7	37	37	Remove meat animals from treated areas 30 days prior to slaughter.
	Other livestock	0	37	37	

[1] Green harvest includes harvest for silage, green-chop, or haylage.

[2] — = interval not specified on the label.

[3] Consult product supplemental label for restrictions on lactating dairy animals.

Table 5.87 - Herbicides Labeled for Use in Conservation Reserve Program (CRP) acres

This table contains a list of herbicides that are available for use on Conservation Reserve Program (CRP) acres seeded to grasses or legumes. Many products labeled for use on grass forage have the same label requirements for CRP grasses. These uses are listed in the first column of the table, and the grass forage section of this guide also applies to use on CRP acres. Some products labeled for use on grass or legume forage can be used on CRP acres but have specific label recommendations or supplemental labels for CRP acres (columns 2 & 4). Other products are not labeled for use on forages grown in Delaware, but allow their use on CRP acres (columns 3 & 5). When choosing products for CRP acres, it is very important to consult the herbicide labels to determine non-target plant, environmental, and human risks, grass or legume species tolerance, weed species susceptibility, use rates, rotational crop or overseeding restrictions, and adjuvant requirements.

Trade Name	CRP Grass Same as Forage (use guide)	Specific CRP Grass Section (see label)	Labeled for CRP Grass, not Forage (see label)	Specific CRP Legume Section (see label)	Labeled for CRP Legume, not Forage (see label)
2,4-D amine/ester	POST				
2,4-DB / Butyrac 200			POST	POST	
Aim	POST				
Buctril			POST	POST	
Chaparral[3]	POST				
Cimarron Max		POST			
Cimarron Plus		POST			
Clarity / Banvel		POST			
Crossbow	POST				
Facet	POST				
Glyphosate		preplant, renovation, or dormant POST		preplant or renovation	
Gramoxone SL		preplant		preplant	
GrazonNext HL[3]	POST				
Grazon P+D[4]	POST				
Huskie	POST				
Journey			preplant[1]		preplant
Kerb			POST		
MCPA		POST		POST	
Metsulfuron	POST[2]				
Milestone[3]	POST				
PastureGard		POST			
Plateau			PRE[1] or POST[1]		PRE or POST
Poast				POST	
Prowl EC / pendimethalin					PPI or PRE
Pursuit			POST	POST	
Remedy Ultra	POST				
Sandea	POST				

Table 5.87 - Herbicides labeled for use in Conservation Reserve Program (CRP) acres (cont.)

Herbicide	CRP Grass Same as Forage (use guide)	Specific CRP Grass Section (see label)	Labeled for CRP Grass, not Forage (see label)	Specific CRP Legume Section (see label)	Labeled for CRP Legume, not Forage (see label)
Starane Ultra			POST		
Stinger		POST			
Telar XP			POST		
Weedmaster		POST			

[1] primarily for use on warm-season grasses.

[2] not on all metsulfuron labels.

[3] for Pennsylvania, Virginia, and West Virginia only.

[4] for Virginia and West Virginia only.

Table 5.88 - Herbicides Labeled for Summer Annual Grass Crops

Weed management in summer annual grasses begins with a clean seedbed obtained by either tillage close to planting or preplant herbicides such as glyphosate. Use fields with fewer perennial and annual grass weeds. Successful establishment begins with properly amended soils (pH and fertility) and appropriate seeding rate, depth, and equipment. When moisture is adequate, annual forage grasses emerge and grow quickly and compete well with weeds. There is often no need for additional weed control. Chemical weed control may be warranted when establishment is slow, weed populations are high, potentially toxic weeds are present, or high-quality (weed-free) hay or forage is desired. Herbicide options are limited. 2,4-D and dicamba herbicides are labeled for use in annual grass forages. However, **2,4-D and dicamba herbicides are not recommended in many areas during the hot summer months** due to potential injury to sensitive plants with physical or vapor drift.. Pay particular attention to rotational crop restrictions; consult labels for crops not listed. Check labels for weeds controlled. The listed postemergence herbicides typically control only small annual broadleaf weeds, so check labels for maximum weed size or growth stage.

Herbicide	Labeled Annual Grasses	Timing[1]/ Weed Type	Use Rate per Acre	Crop Stage	Season Maximum Rate	Grazing/ Harvest Interval	Rotation to Grasses (months)	Rotation to Small Grains (months)	Rotation to Alfalfa/ Clover (months)
2,4-D	forage sorghum, sorghum-sudan hybrid	POST/ broadleaf	0.5-2.1 pt	At least 6 leaves and 5 to 10 inches tall	2.1 pt (1 appl.)	30 days	1	After harvest	After harvest
Aim[2]	teff, crabgrass	POST / broadleaf	0.5-2.0 fl oz	any	5.9 fl oz (3 appls.)	0	0	0	12/12
Aim[2]	millets	POST / broadleaf	0.5-2.0 fl oz	up to jointing	2.0 fl oz	7 days	0	0	12/12
Aim[2]	forage sorghum	POST / broadleaf	0.5-1.0 fl oz	up to 6 leaf	1 fl oz	after 6 leaf	0	0	12/12
Atrazine[2] 4L	forage sorghum, sor-sudan hybrid	PPI, Pre, POST / broadleaf	3.2-4.0 pt (see label for details)	up to 12 inches	5 pt	PPI/Pre =60 day POST = 45 days	second year	next year to second year[2]	second year

Table 5.88 - Herbicides labeled for summer annual grass crops (cont.)

Herbicide	Labeled Annual Grasses	Timing[1]/ Weed Type	Use Rate per Acre	Crop Stage	Season Maximum Rate	Grazing/ Harvest Interval	Rotation to Grasses (months)	Rotation to Small Grains (months)	Rotation to Alfalfa/ Clover (months)
Basagran[2]	forage sorghum	POST / broadleaf	1.0-2.0 pt	before heading	2 pt	12 days	0	0	0
Callisto[2]	pearl millet	Pre / broadleaf	up to 6.0 fl oz	n/a	6.0 fl oz (1 appl.)	n/a	18	4	10/18
dicamba	forage sorghum, sudan-grass	POST/ broadleaf	8-32 fl oz	At least 3 leaves	64 fl oz	7 days	1	0.5-1.5 (see label)	4
Dual II Magnum[4,5]	forage sorghum	Pre / grass	1.0 to 1.67 pt[5]	n/a	1 applic.	n/a	next spring	4.5	4/9
Huskie[2]	forage sorghum	POST / broadleaf	12.8-16 fl oz	3-lf but prior to flag leaf or 30 inches.	32 fl oz	7/ 7	1 (9 for timothy)	1 week	4/bioassay
Maestro 2EC (Buctril) (for 4EC formulation reduce rates by half)[4]	forage sorghum, sudan-grass, sor-sudan hybrid	POST / broadleaf	1 pt/ 1.5 pt	3-lf but prior to pre-boot/ 4-lf but prior to pre-boot	2 pt	45 days	1	1	1
Sandea[2]	pearl millet	POST / broadleaf & nutsedge	0.5-0.67 oz	2 lf but prior to head	0.67 oz	0/ 0 forage 37 hay	2	2	9
Sandea[2]	sorghum	POST / broadleaf & nutsedge	0.67-1.0 oz	2 lf but prior to head	1.0 oz	30/30	2	2	9
Yukon	sorghum, proso millet	POST/ broadleaf and nutsedge	3-6 oz	3- to 5-leaf	6 oz (1 appl.)	0/0; 30/30	2	2	9

[1] Abbreviations: appl, application; POST, postemergence; PPI, preplant incorporated, PRE, preemergence.

[2] Check label for adjuvant recommendations.

[3] Next year if applied before June 10; second year if applied after June 10.

[4] No adjuvant recommended.

[5] Requires the use of Concep-treated seed.

[6] Coarse soils 1.0 to 1.33 pt; medium soils 1.33 to 1.5 pt; fine soils 1.33 to 1.67 pt.

Table 5.89 - Optimum Time of Year for Foliar Application of Systemic Herbicides to Selected Weeds

These timings are based on adequate soil moisture and climate of the Eastern Shore area. Across the Mid-Atlantic region (north to south or east to west) these timings could vary by 1 to 3 weeks either way. Consult this table for general guidelines but herbicide labels for specific application information.

Winter annual weeds should be treated in late fall to spring. Summer annual weeds should be treated in early to late summer soon after emergence. Biennial weeds should be treated in the fall or early-spring while in the seedling or rosette stages or in the early spring prior to bolting. Herbaceous and woody perennial weeds can vary significantly by species for when best to apply herbicides. In general, apply systemic herbicides to perennials is when the source/sink movement of sugars is towards the underground structures, typically optimized when the perennial is in early bloom stage or in the fall when temperature begin to cool. Applications of these herbicides made in earlier growth stages, when movement is upward from underground structures to shoots and foliage, provides only control of top growth, with essentially no effect on the perennial structures. The addition of mechanical weed control techniques can substantially improve herbicide efficacy on perennials. Mowing or clipping the weed one or more times causes significant reductions in underground food reserves because the plant is forces to produce new top growth. When the weed reaches the early bloom stage following clipping, relatively less of the systemic herbicide is required to produce a lethal concentration in the depleted perennial structure.

	Do not apply
	Less than optimal but potentially effective depending on your specific geography and weather
	Optimal timing of application

Weeds	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Winter annual weeds (chickweed, henbit, etc.)									
Summer annual weeds (pigweed, ragweed, etc.)									
Biennial weeds (wild carrot, bull thistle, etc.)									
Herbacious Perennials									
Buttercup, ssp.									
Dandelion									
Dock spp.									
Dogfennel									
Garlic, Wild									
Horsenettle, Carolina									
Milkweed, common									
Pokeweed									
Star-of-Bethlehem									
Thistle, Canada									
Woody Perennials									
Barberry, Japanese									
Brambles (*Rubus* spp.)									
Olive, Autumn									
Rose, Multiflora									

Table 5.90 - Accurate Herbicide Volume and Weight Measurements for Small Volume Applications

Common conversion factors

Liquid Products	Quart (qt)	Pint (pt)	Cup	Fluid Ounces (fl oz)	Tablespoon (Tblspn)	Teaspoon (tsp)	Milliliter (ml)
1 gallon	4	8	16	128	256	768	3785
1 quart	–	2	4	32	64	192	946
1 pint	–	–	2	16	32	96	473
1 cup	–	–	–	8	16	48	237
1 fl oz	–	–	–	–	2	6	29.57
1 tbsp	–	–	–	–	–	3	14.8
1 tsp	–	–	–	–	–	–	4.9
Dry Products:							
1 pound (lb) = 16 oz-wt = 453.6 grams (gr)							
1 oz wt = 28.35 grams (gr)							

Spot-spray, wiper bar, or other small-area applications often require preparation of a small volume of spray solution. Backpack sprayers usually have a 1- to 3-gallon capacity. Spray concentrations for liquid herbicide formulations can be as low as 0.05 fl oz (1.5 ml) per gallon, and concentrations for dry herbicide formulations as low as 0.01 oz wt (0.28 gr) per gallon. Inaccurate measurement of these very small concentrations can cause large deviations above or below the intended application rate, resulting in possible crop damage, carryover, or poor weed control. For example, when measuring a pint of liquid herbicide, a deviation of 0.5 ml, which is equivalent to 6 drops from a dropper, would result in a negligible increase or decrease of 0.1% from the intended rate. However, the same 6 drop deviation when measuring 1.5 ml of a liquid herbicide would result in an unacceptable rate increase or decrease of 33%.

Most liquid measuring devices intended for use with agricultural products are good for measuring large volumes (pints, quarts, gallons), but they are usually not accurate below a volume of 10 fl oz (296 ml). Two types of measuring devices are available for low volumes that are accurate and easy to use. Graduated cylinders are tall, narrow cylinders with milliliter graduations along the outside of the tube. They are available in durable polypropylene material that can be washed and reused. They are available in sizes ranging from 10 ml (0.34 fl oz) with 0.2-ml increments to 4,000 ml (1.06 gal) with 50-ml increments. Pouring liquid herbicides into small graduated cylinders from large containers can be difficult. Disposable syringes are probably the cleanest and most accurate way to measure small volumes of liquid herbicide. Although they are termed disposable, they can be easily dismantled, washed, and reused several times. Buy syringes without the needles if possible, or remove and dispose of needles before use to avoid possible injury or exposure to the herbicide through a skin puncture. A syringe is essential for measuring volumes of less than 0.17 fl oz (5 ml) and can be purchased in sizes ranging from 3 ml with 0.1-ml increments up to 60 ml with 1-ml increments. A good arrangement of measuring devices to have for medium- to small-volume measurements includes a 250-ml graduated cylinder with 2-ml graduations, and 3-ml, 10-ml, and 60-ml syringes.

For dry products, postal scales measuring to 0.1 oz wt are adequate for weights above 1 oz wt (28.4 gr). A gram scale accurate to 1/100 of a gram (0.01 gr) should be used for measuring weights of less than 1 oz wt. Converting products measured by mass (oz wt or grams) into volume (teaspoons, tablespoons, or milliliters) is not practical because of the variability in the density (weight per given volume) of individual products. If sufficiently accurate weighing devices are not available, dry products requiring low concentrations should not be used for small-volume applications.

Table 5.91 - Herbicides Labeled for Farmstead Use

This table lists several herbicides available for use in farmstead areas. Farmstead areas may include areas around buildings (storage buildings, poultry houses, greenhouses, etc.), non-grazed fencerows, non-irrigation ditch banks, unpaved lanes, or other non-cropped agricultural areas where selective weed control or bare ground is desired. Some herbicide labels allow grazing or haying of treated areas within or around these sites, others do not. Many of these herbicides are toxic to desirable plants when spray particles contact either above-ground plant parts, bare roots, and/or the soil where plant roots have penetrated. Most of these products should not be used on impervious surfaces such as paved or highly compacted areas. Runoff from treated impervious surfaces or transport of treated soils by erosion can severely injure or kill susceptible non-target plants. Do not apply these products directly to water, and exercise caution when using these products near irrigation or domestic water supplies. Many of these products are not recommended for use on highly permeable soils and/or soils with groundwater near the soil surface. Read herbicide labels carefully to determine allowed uses, environmental risks, human risks, desirable plant species tolerance, weed species susceptibility, application types, use rates, adjuvant requirements, and specific grazing or haying restrictions.

Trade Name	Components (ai or ae/gal or lb)	Soil Residual[1] (yes/no)	Grass Control	Broadleaf Control	Woody Plant and Vine Control	Grazing Restriction (days)	Haying Restriction (days)
2,4-D (various formulations)	(varies) 2,4-D	no	no	yes	few	0-7	7
Arsenal 2AS	2 lb imazapyr	yes	yes	yes	yes	0	7
Cimarron Max CoPack	Part A (dry) 0.6 lb metsulfuron Part B (liquid) 1 lb dicamba 2.87 lb 2,4-D	yes	no	yes	several	0-7	37
Cimarron Plus 63WG	0.48 lb metsulfuron 0.15 lb chlorsulfuron	yes	no	yes	several	0	0
Crossbow 3L	2 lb 2,4-D 1 lb triclopyr	limited	no	yes	several	0-NS[2]	14
dicamba	4 lb dicamba	no	no	yes	several	0-40	0-70
Escort / Metsulfuron[3] 60WG	0.6 lb metsulfuron	yes	no	yes	few	0	0
EsplAnade 200SC	1.67 lb indaziflam	yes	yes	yes	no	do not	do not
Glyphosate (various formulations)	(varies) glyphosate	no	yes	yes	several	0-56	0-56
Karmex80DF / Direx 4L	0.8 lb diuron	yes	yes	yes	no	not specified	not specified
PastureGard HL 4L	3 lb triclopyr 1 lb fluroxypyr	limited	no	yes	several	0-NS[2]	14
Payload 51WG	0.51 lb flumioxazin	yes	yes	yes	no	do not	do not
Pramitol 25E	2 lb prometon	yes	yes	yes	no	not specified	not specified
Prowl3.3EC	3.3 lb pendimethalin	yes	yes	yes	no	do not	do not
Prowl H2O	3.87 lb pendimethalin	yes	yes	yes	no	see label	see label

Table 5.91 - Herbicides Labeled for Farmstead Use (cont.)

Trade Name	Components (ai or ae/gal or lb)	Soil Residual[1] (yes/no)	Grass Control	Broadleaf Control	Woody Plant and Vine Control	Grazing Restriction (days)	Haying Restriction (days)
Sahara 70DG	0.078 lb imazapyr 0.62 lb diuron	yes	yes	yes	many	not specified	not specified
Solicam 78.6DF	0.79 lb norflurazon	yes	yes	yes	no	do not	do not
Spike 20P	0.2 lb tebuthiuron	yes	no	yes	many	0	365
Starane Ultra / Vista 2.8L	2.8 lb fluroxypyr	limited	no	yes	no	7	14
Stinger 3L	3 lb clopyralid	limited	no	yes	no	0	0
Velpar 2L or 75DF	2 lb hexazinone	yes	yes	yes	several	60-365	60-365
Weedmaster 3.87L	2.87 lb 2,4-D 1 lb dicamba	no	no	yes	several	0-7	37

[1] Herbicides listed as having limited soil residual activity may, for a short time, provide residual control or suppression of some species, and can injure or kill susceptible desirable plants through soil activity.

[2] NS=next season after application

[3] Not on all metsulfuron labels.

Problem Weeds

Amaranth (Palmer) and Waterhemp

Palmer Amaranth
Scientific name: *Amaranthus palmeri*
Other names: Palmer pigweed or careless weed

Waterhemp
Scientific name: *Amaranthus tuberculatus* or *A. rudis*
Other names: tall waterhemp, common waterhemp

Palmer amaranth and waterhemp are both summer annual weeds from the Amaranthaceae family (pigweed). These two species can look very similar and have similar biological characteristics. They have leaves that are longer and narrower than those of redroot or smooth pigweed (Palmer amaranth leaves are often diamond shaped and waterhemp are lance shaped). Palmer amaranth petioles are long (often as long as the leaf blade), which causes the leaves to droop, while waterhemp's petioles are shorter than the leaf blade. The stems, petioles, and leaves of both species are hairless, while redroot and smooth pigweed have short hairs on the leaf and stem. Both are dioecious, meaning they have separate male and female plants. Both have long seed heads, unlike redroot or smooth pigweed, which have shorter and more compact seed heads. Hybridizations between Palmer amaranth and other pigweeds have been reported, complicating positive identification.

Palmer amaranth and waterhemp have a prolonged germination pattern that allows them to emerge throughout the summer and into the early fall. However, germination is suppressed by a dense crop canopy.

Herbicide Resistance:

Both species are prone to developing resistance. Since they are dioecious, they are well adapted for resistance genes carried in the pollen to spread long distances (>3,000 feet). Palmer amaranth populations in the Mid-Atlantic region have been confirmed to have resistance to ALS-inhibiting herbicides (Group 2) and glyphosate (Group 9). In other regions of the United States, Palmer amaranth has developed resistance to dinitroanilines (Group 3), triazines (Group 5), HPPD inhibitors (Group 27), and PPO inhibitors (Group 14) including in North Carolina.

Waterhemp populations in the Mid-Atlantic region have been confirmed to have resistance to ALS-inhibiting herbicides (Group 2) and glyphosate (Group 9). In other regions of the United States, waterhemp has developed resistance to triazines (Group 5), HPPD inhibitors (Group 27), PPO inhibitors (Group 14), and plant growth regulators (Group 4).

Management:

Already well known as the most troublesome weed in cropping systems in the Midwest and southern states, Palmer amaranth has become established in the Delmarva region and waterhemp has been identified in Pennsylvania, Virginia, New Jersey, and Delaware. These species can be controlled when treated with an effective herbicide applied to plants at a susceptible stage (usually 3 inches or less). However, because these species have a higher growth rate than most species, they quickly become too tall for effective control, and there are no herbicide controls that will serve as a "rescue treatment." These species deserve to be met with a "zero-tolerance" attitude concerning their control. These species have a high drought tolerance and can withstand periods of water stress better than many other weeds.

Due to the prolonged germination period of these two species, the use of residual herbicides is important. Furthermore, residual herbicides need to be applied as close to planting as possible to ensure that they provide effective control for 3 to 4 weeks after planting. Postemergence herbicides need to be applied to plants no taller than 3 inches, and postemergence treatments often need to include an herbicide that will provide effective residual control. Both species are suppressed by a dense crop canopy, which also reduces late season seed germination.

Controlling plants before they produce viable seed is important for long-term management. The seeds of both species decline rapidly after 2 to 3 years in the soil, so stopping the influx of new seeds will reduce seedling density.

Corn: The herbicide options for control of Palmer amaranth and waterhemp in corn are better than for soybean production; however, most fields will require both a preemergence and a postemergence treatment. Be aware that control programs relying on atrazine (Group 5) or HPPD (Group 27) herbicides could be problematic since populations with resistance to atrazine and HPPD herbicides have been reported.

Corn should be planted into a weed-free field that relies on conventional tillage or an effective burndown program. Preemergence herbicides should be applied within 7 to 10 days of planting to maximize residual control during the early stages of corn growth. A range of preemergence herbicides that contain both a Group 15 herbicide and atrazine can provide effective control, including Anthem ATZ, Bicep II Magnum, Cinch ATZ, Degree Xtra, Harness Xtra, FulTime NXT, and Keystone NXT. Balance Flexx, Lexar, and Lumax are herbicide premixes with HPPD inhibitors (Group 27) that have been applied for successful preemergence control of these species. However, do not rely on Group 27 herbicides for both preemergence *and* postemergence control.

Effective postemergence treatments include 2,4-D/dicamba, atrazine, and HPPD inhibitors (Armezon, Callisto, Impact, or Laudis). If additional residual control is needed, products such as Outlook, Dual, or Harness can be applied early postemergence.

Due to heavy reliance on Group 14 herbicides in soybean, avoid using Kixor or Valor products in corn, except in situations of continuous corn.

Sorghum: Palmer amaranth and waterhemp control in sorghum will often require a preemergence and a postemergence application. Start "clean," with all existing weeds dead at the time of planting. Be aware that sorghum is not as tolerant to atrazine as corn, and that there are use restrictions with Lumax or Lexar (refer to labels). Use a preemergence application of Bicep II Magnum, Cinch ATZ, Degree Xtra, FulTime NXT, Warrant plus atrazine, Lexar, or Lumax. Follow up with a timely postemergence application of 2,4-D, Clarity, Huskie, Marksman, or Yukon.

Soybean: Start with a clean field using tillage or an effective burndown treatment. No-till fields with horseweed or other hard-to-control winter annuals may need to be treated early (3 to 5 weeks prior to planting). Residual herbicides applied this early will have limited effectiveness for controlling Palmer amaranth or waterhemp beyond soybean planting. Fields infested with hard-to-control winter annuals and waterhemp or Palmer amaranth should be treated early (for winter annual weeds) and with an application of a residual herbicide at planting (for Palmer amaranth or waterhemp control).

Do not expect effective control of emerged waterhemp and Palmer amaranth plants with glyphosate or a Group 2 herbicide (chlorimuron, imazethapyr, thifensulfuron, etc.) due to widespread resistance. 2,4-D or paraquat plus metribuzin have been used as effective burndown treatments for control of these two species. Liberty can also be effective if applied under conditions of full sunlight, with good spray coverage, and to plants less than 4 inches tall. Residual herbicides are important for Palmer amaranth and waterhemp control since the seeds continue to germinate during the growing season. Residual herbicides need to be applied as close to the planting date as possible to ensure maximum weed control. Herbicides and herbicide mixes containing flumioxazin (Envive, Fierce, Gangster, Valor XLT) and sulfentrazone (Authority Assist/XL/First/Maxx/MTZ and Sonic) provide the highest level of control. However, even using these herbicides will only provide short-term control. Postemergence control of Palmer amaranth or waterhemp in soybean is achieved by using fomesafen-containing herbicides (Flexstar, Flexstar GT, Prefix, Reflex), lactofen (Cobra, Phoenix), or glufosinate (Liberty) in cases of LibertyLink soybean. Fomsafen-containing herbicides will provide residual control; otherwise, consider combining postemergence herbicides with residual herbicides to help control later emerging seedlings. S-metolachlor (Dual II Magnum, Sequence), acetochlor (Warrant), pyroxasulfone (Zidua), and dimethenamid (Outlook) can be used here. All postemergence treatments must be made before Palmer amaranth or waterhemp plants are taller than 3 inches.

Double-cropped soybeans need an effective burndown treatment if Palmer amaranth or waterhemp seedlings are present at the time of small grain harvest. Burndown programs based on paraquat or Liberty (glufosinate) have been effective, but they may require additional herbicides if grasses or other species are present.

Heavy reliance on Group 14 herbicides require long-term planning to limit their use to crops where they are needed. Fields with continuous soybean should not use Group 14 herbicides every year.

Perennial Forages: Applications of 2,4-D and/or dicamba or triclopyr-containing herbicides will control emerged Palmer amaranth or waterhemp in grass hay or pasture. Alfalfa could be treated with Chateau after cutting, or rely on 2,4-DB (Butyrac).

Burcucumber

Scientific name: *Sicyos angulatus*
Other names: wild pickle, pickle, wild cucumber

Burcucumber (*Sicyos angulatus*) is a summer annual broadleaf weed that is a serious problem in agronomic crops in some regions of the Northeast. Because of its prolonged seedling emergence and aggressive growth habit, burcucumber is not easily controlled using conventional weed management strategies. Like most weeds, burcucumber cannot be eradicated; however, an integrated control approach can reduce the size of burcucumber infestations and slow or stop the weed's further spread.

Burcucumber can be identified by its pentagon-shaped leaves, long vines, and spiny seed clusters. The individual seeds are flattened, have a hard seed coat about the size of a watermelon seed, and are enclosed in a prickly, fleshy shell, or pericarp. The hard seed coat contributes to the burcumber's prolonged seed dormancy, which means that fields currently infested with burcucumber will have a lasting seed reservoir in the soil and the potential for a burcucumber problem for many years.

Herbicide Resistance:

None reported.

Management:

The first step is to prevent burcucumber seed spread by thoroughly cleaning tillage and harvesting equipment before leaving infested fields. Encourage aggressive crop growth through good cultural practices such as maintaining adequate soil fertility, choosing appropriate high-yielding crop varieties, and regularly scouting for and managing pests. Include in the rotation crops that provide early competition such as alfalfa or small grains. Include no-till in fields that are infested with burcucumber. Research suggests that no-till allows burcucumber seed to remain near the soil surface, thus allowing germination to occur over a shorter time period and reducing the number of germination flushes. This also improves herbicide effectiveness and performance. Harvest burcucumber-infested fields for silage to prevent viable seed production.

Corn: Herbicides are essential in a burcucumber management program, but use them in combination with other control methods. Several corn herbicides provide good control of burcucumber and they are most effective on young seedlings rather than larger plants. Include herbicides that have residual activity to control new burcucumber flushes. POST (foliar-applied) herbicides provide the best burcucumber control. In corn, if possible, include at least 1.5 pounds of atrazine in the herbicide program for residual control. Other effective herbicides include prosulfuron plus primisulfuron (Peak), mesotrione (Callisto), and glyphosate. In addition, other Group 6 herbicides such as bromoxynil are effective for controlling emerged plants.

Sorghum: Management of burcucumber in sorghum should be similar to corn and relies on POST herbicides. Some of the same herbicides, except glyphosate, can be used in sorghum.

Soybean: Burcucumber may be easier to manage in soybean than in corn simply because you can better monitor control and apply herbicides later in soybean than in corn. The most effective herbicides for control in soybean are glyphosate plus a residual product like chlorimuron. More than one foliar application may be necessary.

Small Grains: Burcucumber is only an issue in spring-seeded small grains and generally not winter grains, so it could be problematic in oats or other spring-seeded cereals. Seed spring grains as early as possible to get a head-start on the burcucumber. Some suppression can be obtained from the Group 2 or ALS herbicides or Group 6 or 14 contact-type herbicides.

Perennial Forages: Perennial forages are an excellent crop for managing burcucumber. In particular, established alfalfa that can be mowed four or more times per season will suppress burcucumber seedlings and it is rarely a problem in these crops. Establish alfalfa in late summer to avoid burcucumber problems at establishment. Burcucumber is rarely a problem in perennial grass hay or pasture.

Fallow or Spot Treatment: Spot spray with glyphosate, paraquat, or use a group 4 growth regulator herbicides.

Dock (Broadleaf and Curly)

Broadleaf Dock
Scientific name: *Rumex obtusifolius*
Other names: bitter dock

Curly Dock
Scientific name: *Rumex crispus*
Other names: sour dock, yellow dock, narrowleaf dock, or curled dock

Broadleaf dock and curly dock are introduced taprooted perennials that are found throughout North America and common in the Mid-Atlantic region. Both species initially form basal rosettes of lanceolate leaves; the plant later bolts and produces an erect flower stalk that is typically 3 feet in height but can be up to 5 feet. Curly dock can produce more than 60,000 seeds per plant, some of which readily germinate, while others remain viable for over 10 years. Approximately 50 percent of seeds remain viable after 3 years. Seeds readily disperse via wind or float on water. To distinguish between species, leaf width and margins are most readily used; curly dock has narrower leaves with wavy margins, while broadleaf dock has wider leaves with smooth or finely undulate margins. Additionally, curly dock's leaf base tapers to the leaf stalk as opposed to broadleaf dock whose leaf base joins the leaf stalk abruptly, without taper. However, control measures are similar between these species.

Herbicide Resistance:

None reported.

Management:

Broadleaf dock and curly dock are generally weeds of no-till and perennial systems. Tillage is an effective option for control. Continual mowing will reduce seed production and can deplete the energy reserves in the taproot, but it is not an effective management strategy on its own. Heavy grazing should be avoided, as these plants are rarely grazed (but can be poisonous to livestock); docks thrive in open canopies, thus heavy grazing can lead to increased infestations. Conversely, docks are not competitive in aggressive, vigorous competition. Seedlings are best controlled in early spring, but once the perennial structures are established, fall applications may be more effective. Contact herbicides readily control top growth, but regrowth from taproots will occur.

Corn: In corn, it is best to control dock species prior to planting through burndown herbicides or tillage. Glyphosate (Roundup, others) plus higher rates of 2,4-D or dicamba (Banvel, Clarity, others) is most effective, but regrowth from taproots can occur. Observe all rotation restrictions. Atrazine will help control dock species and is similarly effective when applied PRE or POST. Clopyralid-containing products (Stinger, Curtail) are most effective POST, but growers should be aware of long rotation restrictions for many crops. Other effective POST options include 2,4-D, dicamba, and glyphosate (in glyphosate-resistant hybrids only).

Sorghum: Management of broadleaf dock and curly dock in sorghum is similar to corn except that clopyralid and glyphosate cannot be used after sorghum emerges.

Soybean: Dock control in soybean is more challenging due to fewer herbicide options. Similar to corn, management should focus on control prior to planting through tillage or burndown herbicides. Harmony Extra (thifensulfuron plus tribenuron) and chlorimuron-ethyl-containing products (Authority XL, Classic, Canopy, Envive, Valor XLT, others) applied with glyphosate are effective. Glyphosate plus 2,4-D is another good option, but it is not as effective as others mentioned. Observe all rotation restrictions. The best POST option is glyphosate (to glyphosate resistant varieties only), but imazethapyr (Pursuit), imazamox (Raptor), and bentazon (Basagran) are options for suppression.

Small Grains: Broadleaf dock and curly dock are not as problematic in small grains. Burndown options include glyphosate plus dicamba and Harmony Extra. POST herbicide options include Harmony Extra and clopyralid-containing products (Stinger). Again, producers should be aware of long rotation restrictions with clopyralid.

Perennial Forages: A vigorous, competitive forage is the best tool for managing dock infestations. Proper grazing or haying management and optimizing soil fertility and pH will help prevent infestation or spread. In established alfalfa and other legume forages, herbicide options are limited; imazethapyr (Pursuit) and imazamox (Raptor) will suppress dock species. Control prior to establishment is critical. In grass forages, several very effective herbicide options exists as well; 2,4-D plus dicamba is perhaps the most economical option and results in excellent control. Crossbow (2,4-D plus triclopyr) and aminopyralid-containing products (GrazonNext HL; Milestone; Pennsylvania, Virginia, and West Virginia only) are also very effective. Apply in March through early April.

Fallow or Spot Treatments: Spot treat with 2,4-D plus dicamba. Glyphosate spot treatment is also a good option.

Henbit

Scientific name: *Lamium amplexicaule*
Other names: n/a
Similar species: purple or red deadnettle, *Lamium purpureum*

Henbit is a winter annual species from the Lamiaceae family (mint). New plants emerge from seeds primarily in the fall, with some early spring germination. Stems are square, green to purple, and nearly hairless. Henbit is a short plant, seldom more than 5 inches tall, but can develop a low-growing (prostrate) growth with plants of over 5 inches in diameter. Lower leaves are round to heart-shaped and have petioles (petoliate); upper leaves do not have petioles (sessile), with leaves encircling the stem at the base. Henbit is one of the first species to flower in the spring, developing showy pink to purple flowers. Henbit is effectively controlled with most spring burndown applications for corn or soybean, but these applications are often made after viable seeds are produced. It competes primarily with winter forage and grain crops.

Herbicide Resistance:

Resistance to Group 2 (ALS herbicides chlorsulfuron and propoxycarbazone) was reported in Kansas in 2014. No known resistance has been reported in the Mid-Atlantic region.

Management:

Plants are easier to control in the fall. Plants can be controlled with full rates of thifensulfuron plus tribenuron, 2,4-D plus dicamba, or aminopyralid. For burndown, fall applications of glyphosate or paraquat, or spring applications of glyphosate plus atrazine, paraquat plus atrazine, or glyphosate plus metribuzin are effective. When considering long-term management of henbit, apply burndown treatments in the fall or early spring shortly after henbit begins flowering to stop the production of viable seed.

Plants emerging with fall-seeded forage grasses are difficult to control. Treatments with the low labeled rates of dicamba plus 2,4-D on seedling grasses are somewhat effective when applied early in the fall. However, these early applications sometimes result in significant crop injury and have little to no residual activity to control later emerging winter annual weeds.

Corn and Sorghum: Typically only present in no-till fields. Glyphosate plus triazine or paraquat plus triazine applied preplant burndown are effective.

Soybean: Typically only present in no-till fields. Plants are often senescing (ending their life cycle) during the period soybean burndown applications are made. Effective preplant burndown with glyphosate or glyphosate plus metribuzin.

Small Grains: Thifensulfuron plus tribenuron applied during the fall or spring or metribuzin applied during the spring are effective (in states with 24[c] registrations). Thifensulfuron and tribenuron are both Group 2 (ALS inhibitor) herbicides, to which henbit has developed resistance in Kansas. This approach should be rotated with other herbicides with different modes of action such as dicamba, Group 4 (synthetic auxins) or bromoxynil, or Group 6 (PSII inhibitor), which are slightly less effective but adequate.

Perennial Forages: For alfalfa establishment (conventional tillage), preplant-incorporated application of Eptam. For fall no-tillage establishment, glyphosate. For seedling alfalfa, applications of bromoxynil, Roundup (Roundup Ready alfalfa only), or paraquat (dormant application).

For newly seeded grasses, 2,4-D plus dicamba applied early postemergence are marginally effective, but injury can be significant. For established grasses, 2,4-D plus dicamba (higher rates than newly seeded), triclopyr plus 2,4-D, triclopyr plus fluroxypyr, or products containing metsulfuron or aminopyralid (where available) applied during the fall or early spring are effective.

Fallow or Spot Treatment: Fall application of glyphosate or paraquat.

Horsenettle

Scientific name: *Solanum carolinense*
Other names: wild potato, sand brier

Horsenettle is a perennial species from the Solanaceae family (nightshade). New plants emerge readily from seeds as well as creeping rootstocks. Stems and leaves have short stiff spines. In addition to weed competition, horsenettle affects crop production since its berries are harvested with soybeans and processing vegetables and are difficult to separate, and plants can be poisonous to animals at high concentrations.

Herbicide Resistance:

None reported.

Management:

Plants emerging from seeds are controlled with most triazine herbicides (simazine, atrazine, and metribuzin) applied at planting. Plants emerging from overwintering rootstocks are difficult to control. Postemergence applications of glyphosate, Liberty, atrazine, dicamba, or aminopyralid are effective to varying degrees. Burndown treatments of glyphosate or paraquat in the spring will control the emerged portion of the plant, but additional shoots are likely to emerge. The best time to treat it is in the late summer or with glyphosate or dicamba. This species is sensitive to frost, so applications should be made about 2 weeks before a killing frost. Plants damaged by harvest should be allowed time to recover before treatment. Due to the extensive horsenettle root system, 2 to 3 years of consistent management is needed to significantly reduce horsenettle shoots.

Corn: Soil application of atrazine or simazine at planting are effective for plants emerging from seed. Postemergence applications of glyphosate (in RR corn), glufosinate (Liberty; in LL corn), dicamba, or dicamba plus a Group 2 herbicide (halosulfuron, nicosulfuron, primisulfuron) in early June will provide fair to good control for that cropping season but have minimal impact on long-term management of this species. Fields should be treated after harvest and when horsenettle plants are actively growing. Plants damaged by harvest should be allowed time to recover before treating; thus, keeping the combine header as high as possible will result in quicker horsenettle plant recovery. Wait 7 to 10 days after herbicide application before the field is tilled or mowed.

Sorghum: Soil application of atrazine at planting is effective for seedling control, and a postemergence application of dicamba or dicamba plus halosulfuron is effective for suppression of emerged plants. Fields should be treated after harvest and while the horsenettle plants are actively growing. Plants damaged by harvest should be allowed time to recover before treating; thus, keeping the combine header as high has possible will result in quicker horsenettle plant recovery. Wait 7 to 10 days after herbicide application before the field is tilled or mowed.

Soybean: Soil application of metribuzin at planting is effective for plants emerging from seed. Postemergence applications of glyphosate (RR corn) or glufosinate (Liberty; in LibertyLink soybean) are effective to control emerged plants. Classic, Pursuit, and Synchrony can provide some suppression. Since soybeans are harvested late in the fall and all of the horsenettle leaves are

removed during harvest, postharvest applications are not practical. Glyphosate applications as part of a harvest aid approach may be beneficial.

Small Grains: Horsenettle typically does not interfere with small grain.

Perennial Forages: Grass hay crops should be treated after the last cutting of the year, after allowing horsenettle to recover, but before the forages interfere with spray coverage. Dicamba, aminopyralid, and picloram, in labeled crops and states, provide the most consistent control. Roundup Ready alfalfa can be treated with glyphosate. Spot treatments of glyphosate is the best option for conventional alfalfa, or dicamba in a mixed stand to allow the forage grasses to survive.

Horseweed

Scientific name: *Conyza canadensis*
Other names: marestail, Canada fleabane, stickweed

Horseweed is a winter or summer annual and a member of the Asteraceae family. In the winter annual cycle, horseweed germinates in the fall and overwinters as a basal rosette. The following spring, the rosette bolts, reaching 1.5 to 6 feet in height. While most populations of horseweed in the region emerge in the fall, significant spring emergence can occur under certain conditions. Leaves are alternate, simple, linear to oblanceolate in shape, and lack petioles. Leaf margins are either entire or toothed. Flowers consist of numerous small heads arranged in a panicle with many white ray flowers and 20 to 40 yellow disk flowers. Seed are small and have a pappus of tan to white bristles (resemble dandelion seed). Seeds are easily dispersed by the wind, allowing it to quickly spread to nearby fields and within fields.

Herbicide Resistance:

In the United States, biotypes of horseweed resistant to Group 9 (glyphosate), Group 2 (acetolactate synthase [ALS] inhibiting), Group 22 (photosystem [PS] I inhibiting), and Group 5 (photosystem II inhibiting) herbicides exist. Regionally, glyphosate- and ALS-resistant horseweed are widespread. Resistance to paraquat (PS I inhibitor) has been reported in Delaware.

Management:

Horseweed is more prevalent in no-till fields compared to fields prepared conventionally. Tillage can be useful in the long-term management of horseweed. Chemical control of horseweed is more consistent when the weed is in the seedling or rosette stage compared to bolting plants. Traditionally, glyphosate and ALS-inhibiting herbicides effectively controlled horseweed; however, biotypes resistant to these herbicides are widespread. Chemical control of glyphosate- and ALS-resistant horseweed requires a postemergence herbicide to control emerged horseweed and, depending on application timing, a residual herbicide for horseweed yet to emerge. Due to the prolonged germination period, horseweed seedlings can emerge 5 to 6 weeks after residual herbicide application; thus, fall applications of residual herbicides often have limited effectiveness for spring emergence.

Herbicides used for emerged plants include 2,4-D (1 pint in the fall or 1 quart in the spring), dicamba, glufosinate, saflufenacil, or paraquat plus a triazine herbicide. Herbicides providing residual control include flumioxazin, triazine herbicides (atrazine, simazine, and metribuzin), or an ALS-inhibiting herbicide (if horseweed is not ALS resistant).

Horseweed seedlings do not tolerate shade. Thus, a well-established cover crop or dense crop canopy can be very effective to manage horseweed-infested fields.

Corn: In no-till corn, paraquat plus a triazine herbicide, glyphosate plus atrazine plus 2,4-D or dicamba, and glufosinate plus atrazine applied burndown for control of emerged seedlings and residual control of glyphosate- and ALS-resistant horseweed. Consult labels for waiting interval prior to planting corn. Atrazine alone will provide good residual control of horseweed. Dicamba and 2,4-D are the most effective postemergence herbicides. For small emerged horseweed, foliar-applied HPPD inhibitors or glufosinate plus atrazine are effective.

Sorghum: Glyphosate plus saflufenacil or paraquat plus a triazine applied burndown. Atrazine alone or in combination with paraquat applied preemergence for residual control and control of small emerged horseweed. Atrazine can be used postemergence for control of small horseweed. However, similar to corn, 2,4-D and dicamba are the most effective postemergence options.

Soybeans: Horseweed management is challenging in soybeans because of the later planting date and horseweed plants need to be controlled before they begin to bolt (grow upright); this may require an application weeks prior to planting. Glyphosate plus 2,4-D (1 quart per acre) or glyphosate plus saflufenacil will effectively control glyphosate- and ALS-resistant horseweed when they are small. If horseweed is susceptible to the ALS-inhibiting herbicides, chlorimuron-containing herbicides (e.g., Canopy, Valor XLT, Envive, Surveil) are effective. If applications are made early preplant, herbicides containing flumioxazin, metribuzin, or sulfentrazone can be included to provide residual control, or a second application of a non-selective herbicide may be needed at planting. Glufosinate or paraquat also control small horseweed and can be used as a part of the burndown application. If horseweed is present at planting, paraquat plus a residual product containing flumioxazin, sulfentrazone, or metribuzin or saflufenacil is suggested in regions with later emerging horseweed. Foliar- applied PPO-inhibiting herbicides (acifluorfen, fomesafen, flumiclorac, and lactofen) do not control emerged horseweed. For LibertyLink varieties, glufosinate applied postemergence controls small horseweed. Chlorimuron and cloransulam are postemergence options where horseweed is susceptible to the ALS-inhibiting herbicides and small. (Note: Many prepackaged herbicides are available for soybean; consult the premix equivalent table in the soybean section for active ingredients and rates. Use of residual herbicides as part of an early plant application may not provide acceptable control of summer annual weeds that may emerge shortly after planting. See comments in the soybean section on precautions with the use of saflufenacil.)

Small Grains: 2,4-D, dicamba, or Huskie will provide effective postemergence control of horseweed in small grains. Thifensfulfuron plus tribenuron (Harmony Extra) is also very effective on small horseweed that is Group 2 susceptible.

Perennial Forages: For grass hay crops, most of the auxin herbicides effectively control horseweed. For alfalfa, small horseweed can be controlled with 2,4-DB. Also, for Roundup Ready alfalfa and where glyphosate-susceptible horseweed exists, horseweed control by glyphosate is excellent.

Fallow or Spot Treatment: In fields with a history of horseweed, fall-applied herbicides can be helpful in managing the weed. However, a fall herbicide application will not substitute for a spring burndown application. Target applications for emerged horseweed plants in the late fall after one to two killing frosts. 2,4-D or dicamba should serve as the base for these applications. Glyphosate is often suggested in combination with 2,4-D and dicamba to control other winter annual weeds.

Johnsongrass and Shattercane

Scientific name: *Sorghum halepense* (Johnsongrass); *Sorghum bicolor* (shattercane)
Other names: wild cane (shattercane)

Both species are extremely competitive grasses that commonly reach heights of 7 to 9 feet and form thick, dense patches in fields and roadsides. Johnsongrass is a perennial species that reproduces by seed and its scaly, jointed rhizomes. Shattercane is an annual weed that does not have rhizomes. Leaves of shattercane can be as wide as 3 inches, while Johnsongrass leaves are seldom more than 1 inch wide. The seed head of shattercane is a loose or open panicle that tends to droop and shatters easily, spreading seeds and causing future weed problems. Shattercane seed is larger and more rounded than Johnsongrass seed. The seed remains attached to the base of the young seedling and can be seen by carefully removing young seedlings from the soil.

Herbicide Resistance:

In the United States, biotypes of Johnsongrass are resistant to glyphosate (Group 9), ALS-inhibiting herbicides (Group 2), ACCase-inhibiting herbicides (Group 1), and dinitroanilines (Group 3). Regionally, biotypes resistant to Groups 1 and 2 have been reported. Biotypes of shattercane resistant to Group 2 exist in the United States and within the region.

Management:

Preventing the introduction of either species is important to their management. The perennial habit of Johnsongrass allows it to become established in many settings and to spread. Tillage can break and spread Johnsongrass rhizomes and allow infestations to expand, thus plants along fencerows or field edges can continuously infest fields. Shattercane, on the other hand, is an annual species, thus timely cultivation and mowing are effective strategies for control.

Johnsongrass management requires more than removal of top growth and eliminating seed production; the rhizomes must be depleted. Depleting rhizomes requires consistent control over a few years, and then growers must ensure that new plants do not emerge from seeds in the soil. A fall glyphosate application can help control Johnsongrass rhizomes. Johnsongrass emerging from seeds will develop rhizomes within 3 to 4 weeks, after which it needs to be treated as a perennial plant.

Both species have large seeds that allow them to emerge from over 1 inch deep in the soil. Herbicide concentrations from soil depths of more than 1 to 1.5 inches are often below the levels needed to control seedlings. Therefore, control of these species with soil-applied herbicides is difficult.

Corn: Pendimethalin (Prowl) will suppress seedling Johnsongrass and shattercane, but it will need a postemergence herbicide application. Postemergence control of both species is very good to excellent with nicosulfuron (Accent Q) or glyphosate.

Sorghum: Johnsongrass, shattercane, and sorghum are closely related, and there are no satisfactory broadcast treatments currently available for controlling either species in grain sorghum. The only alternative available for rhizome Johnsongrass control is spot spraying glyphosate. Grain sorghum should not be planted in fields infested with Johnsongrass or shattercane.

Soybeans: Both species are suppressed with pendimethalin (Prowl) or trifluralin (Treflan) if incorporated prior to planting, but they will not provide full-season control and will need to be treated with a postemergence herbicide application. Group 1 herbicides (clethodim [Select], fluazifop [Fusilade], quizalofop [Assure II], sethoxydim [Poast]) and glyphosate will provide excellent control of shattercane and Johnsongrass emerging from weeds, and good control of rhizome Johnsongrass. Sequential applications may be needed for control of rhizome Johnsongrass.

Small Grains: These species are sensitive to frost and emerge in late spring; therefore, they are not problem weeds in small grains.

Perennial Forages: Johnsongrass is rarely a problem in pastures as cattle selectively graze it. Johnsongrass can be toxic when under stress, so active management is needed to graze safely. For grass hay crops, there are no selective postemergence herbicides to control either species. Glyphosate applied with a rope-wick or wiper can be used to selectively treat Johnsongrass. Pendimethalin (Prowl H2O) applied prior to seedling emergence will suppress shattercane and seedling Johnsongrass, but not rhizome Johnsongrass. In alfalfa, Group 1 herbicides and glyphosate will provide excellent control of shattercane and Johnsongrass emerging from weeds, and good control of rhizome Johnsongrass. Sequential applications are usually required for control of rhizome Johnsongrass.

Fallow or Spot Treatment: Glyphosate applied in the fall will provide an opportunity to control Johnsongrass rhizomes.

Lambsquarters (Common)

Scientific name: *Chenopodium album* L.
Other names: goosefoot, fat-hen

Originally from Europe and Asia, common lambsquarters is a summer annual known worldwide as of one of the most important weeds in agriculture. Common lambsquarters is a member of the goosefoot family, which also includes the crops spinach and beets as well as several weedy *Chenopodium* species, including oakleaf goosefoot (*C. glaucum* L.), late flowering goosefoot (*C. strictum*), and narrow-leaved goosefoot (*C. pratericola*). A related genus, *Atriplex*, contains at least three species found in the north central and northeastern United States that can be confused with common lambsquarters, including spreading orach (*Atriplex patula* L.).

Common lambsquarters generally begins emergence in early spring but can emerge throughout the summer, with peak emer-

gence in mid- to late spring. As seedlings, common lambsquarters has two long, linear-shaped cotyledons, with the first ovate-shaped true leaves appearing opposite in arrangement. True leaves eventually become alternate and may be purplish on the underside with both surfaces covered with white granules or a mealy substance. This granular substance is responsible for part of its scientific name—album is Latin for white. More mature plants have broadly triangle-shaped leaves that are alternate with irregular, shallow-toothed margins. The stems can be green or reddish, are grooved, and can be smooth or hairless. Mature plants generally reach a height of 2 to 6 feet. At flowering, very small, green or gray-green flowers are tightly clustered at the tips of stems and branches, which turn into seeds with a thin, papery covering. An average-sized common lambsquarters plant can produce more than 70,000 seeds in a single season. Many of the seeds remain on the plant until early winter and these small, smooth seeds have no other apparent adaptation for dispersal other than their high density and ability to be spread from site to site by various means, including equipment transfer. The seeds can also survive well in the digestive tracts of cows, sheep, and horses, so manure is considered a possible source for introducing seed.

Seed dormancy in common lambsquarters contributes to its success as a weed. Under certain conditions, seeds can remain viable in the soil for a number of years and a portion of these seeds will only germinate when conditions are right. Some research suggests that only 10 to 30 percent of the current season's seed will germinate under favorable conditions the following season.

Herbicide Resistance:

Herbicide resistance in common lambsquarters was identified as early as the 1970s with the discovery of triazine (Group 5) resistance. Triazine resistance in common lambsquarters is almost universal in regions of the Mid-Atlantic, especially on dairy farms where corn is often grown for multiple years in the same field allowing annual application of triazine herbicides. More recently, common lambsquarters populations resistant to ALS inhibitors (Group 2) were identified in Michigan, Ohio, and Ontario. For many years, producers in several states have reported problems controlling common lambsquarters with postemergence glyphosate applications (Group 9). Common lambsquarters has become more prevalent in glyphosate-resistant soybean fields in the Midwest and Northeast, and anecdotal observations in several states suggest that common lambsquarters populations are not being controlled effectively with glyphosate in glyphosate-resistant soybean. Historically, common lambsquarters has been problematic for several POST-applied herbicides, and environmental conditions before, during, and after foliar application can influence performance. In addition, weed size at application also affects the response of common lambsquarters to glyphosate and other herbicides.

Management:

Historically, common lambsquarters has been a successful weed across tillage systems, being equally problematic in plowed and no-till fields. Cultural practices that help control common lambsquarters include anything that makes the crop more competitive and reduces the success of the weed. Such practices include selecting crops with quick emergence, altering planting dates relative to weed emergence, planting to narrow rows and using higher seeding rates for greater crop competition, placing fertilizer with the crop (not the weed), and implementing crop rotations that discourage summer annual weed success. In particular, late seeding can give some control because common lambsquarters tends to germinate early in the season and those seedlings are killed through soil preparation or with a burndown herbicide. Rotations that include a winter grain or perennial forage can help break summer annual weed life cycles. In addition, because seeds of common lambsquarters persist in the soil, removing escapes before seed set is useful for long-term management. Consider using tillage, mowing, or an effective herbicide application after cereal grain harvest to prevent seed production.

Corn: A number of PRE and POST herbicides can control common lambsquarters in corn effectively. In general, the chloroacetamides (Group 15) generally need to be tank-mixed with another effective PRE herbicide or followed with a POST herbicide application for complete control The principal PRE corn herbicides include flumetsulam (Python), isoxaflutole (Balance), mesotrione-chloroacetamide mixes (Acuron, Lumax/Lexar), pendimethalin (Prowl), and rimsulfuron (Resolve). Since triazine resistance is so prevalent, it is unlikely that atrazine or simazine will contribute much to control. Many POST corn herbicides are effective for common lambsquarters control in corn, but the plants should be less than 6 inches tall at the time of application for best results. Herbicides include 2,4-D, bromoxynil (Buctril), dicamba (Banvel/Clarity), glyphosate, glufosinate (Liberty), thifensulfuron (Harmony), and the Group 27 herbicides mesotrione (Callisto), tembotrione (Laudis), and topramezone (Armezon/Impact).

Sorghum: Management of common lambsquarters in sorghum is similar to that for corn, although with fewer herbicide options. Safened seed (Concept treated) allows for the use of Group 15 herbicides, including certain acetochlor formulations and mesotrione-chloroacetamide (Lumax, Lexar) premixes. POST herbicide options are fewer, with the Group 4 herbicides, bromoxynil, and several others being available.

Soybean: In soybean, using PRE herbicides or combining a PRE herbicide followed by a POST herbicide provides the most consistent control. Avoid total POST herbicide programs for common lambsquarters control in soybean. PRE herbicides include chlorimuron-containing products (Canopy, Valor XLT, etc.), clomazone (Command), cloransulam (FirstRate), flumioxazin (Valor), imazethapyr (Pursuit), pendimethalin (Prowl), and sulfentrazone (Authority). Apply soybean herbicides with POST activity to small common lambsquarters plants less than about 4 weeks old. POST herbicides include glyphosate, the Group 2 herbicides thifensulfuron (Harmony) and imazamox (Raptor). Thifensulfuron and imazamox must be applied to small lambsquarters 4 inches tall or less. When plants are less than 6 inches tall, apply glyphosate at a rate of 0.75 to 1.5 pounds acid equivalent per acre.

Small Grains: Common lambsquarters is less of a problem in winter small grains but can be a threat in spring-seeded cereals. In oats, thifensulfuron (Harmony) and the Group 4 herbicides are most effective, with 2,4-D or MCPA being most commonly used.

Perennial Forages: Perennial forages are an excellent crop for managing common lambsquarters. In particular, established alfalfa that can be mowed four or more times per season will suppress lambsquarters seedlings, and it is rarely a problem in this crop. Establish a new seeding in late summer to avoid lambsquarters problems at establishment. In new seedings, the use of the Group 4 growth regular 2,4-DB or Group 6 bromoxynil (Buctril) can be effective on seedling lambquarters plants. Common lambsquarters is rarely a problem in perennial grass hay or pasture.

Fallow or Spot Treatment: Spot spray with glyphosate, paraquat, glufosinate, or use a Group 4 growth regulator herbicide.

Milkweed (Common) and Hemp Dogbane

Common Milkweed
Scientific name: *Asclepias syriaca*
Other names: butterfly flower, silk flower

Hemp Dogbane
Scientific name: *Apocynum cannabinum*
Other names: Indian hemp, wild cotton

Common milkweed and hemp dogbane are persistent perennial broadleaf weeds in row crops, pastures, or hay fields. They can reproduce by seed, crown buds, rootstocks, or rhizomes capable of overwintering, thus making it difficult to control them once they are established. Seeds, contained by dehiscent pods, are attached to tufts of silky fibers, which aids in wind dispersal. The waxy cuticle found on the leaf surface affects the uptake of systemic herbicides. Both common milkweed and hemp dogbane are native to North America and considered to have certain beneficial attributes, such as habitat for monarch butterflies (milkweed) and a source of fiber (hemp dogbane).

Herbicide Resistance:

None reported.

Management:

The seedlings of common milkweed and hemp dogbane germinate initially from seeds, but once the plants are established, they can emerge from adventitious buds on creeping roots or rhizomes. Seedlings may be selectively controlled by certain PRE herbicides, but infestations in crops typically arise from regrowth of established vegetative propagules beneath the soil, which have been reported to form within a month after seedling emergence. Mechanical control by repeated removal of top growth is

possible where cultural practices allow; however, tillage is not a viable option due to fragmentation and resultant multiplication of vegetative propagules. Therefore, effective control is limited to applying selective or non-selective systemic herbicides. In general, late bud stage or early bloom stage is a good window to apply such herbicides as long as the label of the respective herbicide allows such an application timing in the particular crop. When possible, glyphosate may be spot applied between crops to manage these weeds. Adding a surfactant and liquid nitrogen or AMS can improve weed control.

Corn: The use of glyphosate in Roundup Ready corn is perhaps the most effective approach for control of milkweed and hemp dogbane in this crop. Glufosinate (Liberty) can suppress these weeds in LibertyLink crops. Selective broadleaf herbicides such as fluroxypyr (Starane) and dicamba (Banvel, Clarity) are somewhat effective in conventional corn. Tank mixtures such as diflufenzopyr plus dicamba (Distinct), primisulfuron (Beacon) plus 2,4-D or dicamba, and nicosulfuron (Accent) plus dicamba can also provide fair control of these weeds.

Sorghum: Herbicides such as dicamba and 2,4-D may provide fair selective control of milkweed and hemp dogbane. Herbicides such as fluroxypyr (Starane Ultra) and halosulfuron plus dicamba (Yukon) may also provide selective control of these weeds in sorghum.

Soybean: Chemical control is limited to the use of glyphosate in Roundup Ready hybrids since there are no selective herbicides to control this weed. Using a weed wiper to apply glyphosate by taking advantage of the height difference between the crop canopy and the weed is also an effective strategy to control this weed in conventional soybean.

Small Grains: Selective herbicides such as fluroxypyr (Starane), dicamba (Banvel/Clarity), and 2,4-D may control these weeds if applied at the proper stage. Otherwise, application of glyphosate or dicamba as a harvest aid or during the same fallow season may provide better control of milkweed and hemp dogbane.

Perennial Forages: In alfalfa, the use of glyphosate in a Roundup Ready variety is perhaps the most effective approach to control milkweed and hemp dogbane. Selective herbicides labeled for alfalfa do not provide satisfactory control of established plants.

In pasture and hay fields, the herbicides picloram plus fluroxypyr (Surmount) and fluroxypyr plus triclopyr (PastureGard) can provide selective control of these weeds; however, sequential applications may be necessary for successful control. Sequential applications of 2,4-D plus dicamba may also provide fair control of these weeds. A weed wiper may also be used to control these weeds in forage crops. In forages, hemp dogbane is considered toxic to animals in both the fresh and dry forms.

Morningglory (Annual Species)

Scientific name: *Ipomoea hederacea, Ipomoea lacunose, and Ipomoea purpurea*
Other names: ivyleaf morningglory, pitted morningglory, and tall morningglory

Morningglories (*Ipomoea* species) are summer annual broadleaf weeds with similar life-cycles, growth habits, and respond to management in a similar fashion. They are in the morningglory family, which includes perennial weeds such as bindweed and bigroot morningglory, dodder species, and ornamental species as well as sweet potato. Annual morningglory weeds are a serious problem in agronomic crops due to their vining growth habits that allow them to grow up crop plants, often pulling them down to the ground. The vining of the morningglory can interfere with harvesting. The prolonged germination period of morningglory species complicates management.

Morningglories are identified by its vining growth habit. Ivyleaf morningglory has leaves with three lobes (resembling common ivy), leaves are pubescent, and are purple to blue or white; pitted morningglory has heart-shaped leaves but have no hairs on the leaf and has white flowers; and tall morningglory has oval to heart-shaped leaves with dense short hairs and with purple to white flowers. Tall morningglory is slightly more aggressive in growth habit than the other two species. A seedpod (or fruit) develops containing 4 to 6 seeds. The seeds and seedpods can be difficult to separate from harvested grain.

Herbicide Resistance:

None reported.

Management:

Successful management of morningglory species starts with encouraging rapid crop growth through good cultural practices such as maintaining adequate soil fertility, choosing appropriate high-yielding crop varieties, and regularly scouting for and managing pests. Include in the rotation crops that provide early competition such as alfalfa or small grains. Using no-till in fields or using rye cover crops that are allowed to grow until heading before they are terminated will also help to improve management. These species have large seeds that allow them to emerge from deeper than 1 inch deep which often allow seeds deeper in the soil to be affected less by soil-applied herbicides. Futhermore, once these plants start to "vine" (often occurs ~6 leaf stage) the plants are less susceptible to postemergence herbicides.

Corn: Herbicides are essential in a morningglory management program, but use them in combination with other control methods. Atrazine or simazine are the most effective soil-applied corn herbicides, but they alone at planting will not provide full-season control. Moderate to heavily infested fields will need a POST (foliar-applied) herbicide application to provide the best control. 2,4-D, dicamba (Status, DiFlexx, etc), atrazine, Liberty or glyphosate are the most effective POST treatments when applied before morningglory have 5 to 6 leaves. Early POST treatments should include atrazine (at least 1.25 lbs) for additional residual control.

Sorghum: Management of morningglory in sorghum should be similar to corn and relies on POST herbicides. Some of the same herbicides, except Liberty or glyphosate, can be used in sorghum.

Soybean: Morningglory may be easier to manage in soybean than in corn simply because soybean canopy is often denser than corn and the later planting date means earlier emerging morningglory plants are control with tillage or burndown herbicide application. The most effective soil-applied herbicides for morningglory control in soybean are chlorimuron (in premixes like Canopy), cloransulam (in premixes like Surveil or Authority XL), flumioxazin (Valor) or sulfentrazone (Authority products). Effectiveness is very dependent on rate and many premixes have lower rates of these active ingredients, so refer to table 4-2 to select appropriate rates. The need for residual control with POST herbicide applications appears to be less critical for soybeans than has been in corn. Effectiveness of POST herbicides require a timely application (before 5 to 6 leaves). Liberty, FirstRate, Reflex, or Ultra Blazer have provided the most consistent control, while glyphosate needs to be applied to morningglory with 4 leaves or less for consistent control.

Small Grains: Morningglory is only an issue in spring-seeded small grains and generally not winter grains, so it could be problematic in oats or other spring-seeded cereals. Seed spring grains as early as possible to get a head start on the morningglory.

Perennial Forages: Perennial forages are an excellent crop for managing morningglory. In particular, established alfalfa that can be mowed four or more times per season will suppress seedlings and it is rarely a problem in these crops. Establish alfalfa in late summer to avoid morningglory problems at establishment. Morningglory is rarely a problem in perennial grass hay or pasture.

Fallow or Spot Treatment: Spot spray with glyphosate or paraquat, or use maximum rate of a Group 4 growth regulator herbicide.

Mustard and Radish (Wild)

Scientific name: *Sinapis arvensis* (wild mustard) and *Raphanus raphanisturm* (wild radish)
Other names (wild radish): jointed charlock, jointed radish, jointed wild radish

Both members of the Brassicaceae (mustard) family, wild mustard and wild radish are ubiquitous in the United States and the Mid-Atlantic region. Both are well-known winter annuals; however, wild mustard and wild radish are also capable of spring emergence. Typically, both species emerge during the fall and overwinter in the rosette stage. The following spring, stem regions between the leaves will begin to lengthen and a flower stalk will form at the top (a process known as bolting). Both species have a stout taproot, can reach 3 feet in height, and are capable of producing 800 to 1,200 seeds per plant. It can be difficult to distinguish between wild mustard and wild radish. Leaves of wild radish are much more deeply lobed (often reaching nearly back to the midvein) than those of wild mustard. Flowers of wild mustard are bright yellow. Comparatively, flowers of wild radish are a paler yellow and can become white with age. Wild mustard has straight, jointless seed pods, whereas seed pods of wild radish are jointed (constricted between seeds at maturity) and appear ribbed.

Herbicide resistance:

Regionally, herbicide-resistant biotypes of wild mustard and wild radish do not exist. In North Dakota, wild mustard has developed resistance to ALS-inhibiting (Group 2) herbicides. Herbicide-resistant wild radish has not been observed in the United States. Globally, biotypes of wild mustard and wild radish resistant to Group 2, synthetic auxins (Group 4), and triazine (Group 5) herbicides and Group 2, Group 4, Group 5, glyphosate (Group 9), and carotenoid biosynthesis-inhibiting (Group 12) herbicides exist, respectively.

Management:

Wild mustard and wild radish are more prevalent in no-till systems. Although tillage can control wild mustard and wild radish effectively, it can also stimulate seed germination. Wild mustard and wild radish can be difficult to control with herbicides. This is often attributed to plant size at the time of herbicide application. Many herbicides that control small (< 6 inches) wild mustard and wild radish are ineffective once these species begin to bolt. In a no-till system, timing burndown applications prior to bolting of wild mustard and wild radish is the key to successful control of both species. For preplant burndown applications in the Mid-Atlantic region, targeting wild mustard and wild radish in March or early April with 2,4-D is normally in order. Likewise, for winter small grains, wild mustard and wild radish treated in the fall are easier to control than plants treated during the spring.

Corn: Wild mustard and wild radish should be targeted prior to planting corn. Preplant burndown, 2,4-D is the most effective herbicide against small and more mature wild mustard and wild radish. Glyphosate or paraquat plus 2,4-D is a popular choice for both species. Dicamba is less effective than 2,4-D. For small wild mustard or wild radish preplant, thifensulfuron plus tribenuron [Harmony Extra] plus glyphosate or paraquat, saflufenacil [Sharpen] plus glyphosate, atrazine plus paraquat, and flumioxazin [Valor SX] plus glyphosate are effective. Consult labels for information regarding rotation restrictions. Postemergence in corn, 2,4-D and dicamba are most effective.

Sorghum: Wild mustard and wild radish should be targeted prior to planting sorghum. Similar to corn, 2,4-D and dicamba are the most effective preplant and postemergence options. Dicamba is not as effective as 2,4-D. Preplant burndown, glyphosate plus saflufenacil [Sharpen] and paraquat plus atrazine are effective against small wild mustard and wild radish. Consult labels for information regarding rotation restrictions.

Soybean: Wild mustard and wild radish should be targeted prior to planting soybean. Preplant burndown, 2,4-D is most effective followed by dicamba. Glyphosate or paraquat should be applied in combination with 2,4-D or dicamba to improve control. For small wild mustard or wild radish preplant burndown, tribenuron-containing products plus glyphosate or paraquat, rimsulfuron plus thifensulfuron (LeadOff) plus glyphosate or paraquat, saflufenacil (Sharpen) plus glyphosate, metribuzin plus paraquat, and flumioxazin (Valor SX) plus glyphosate are effective. Consult herbicide labels for information regarding rotation restrictions. Large wild mustard and wild radish are difficult to control postemergence in soybean. For very small (< 3 inches) wild mustard or wild radish postemergence, many of the Group 2 and PPO-inhibiting (Group 14) herbicides, bentazon (Basagran), and glufosinate (Liberty) (for LibertyLink cultivars only) provide suppression.

Small Grains: Wild mustard and wild radish should be targeted while still small during the fall. 2,4-D and MCPA control both species effectively. Dicamba is not as effective as 2,4-D or MCPA. For small wild mustard and wild radish, thifensulfuron plus tribenuron (Harmony Extra) and pyroxsulam (PowerFlex HL) offer good control and are the best alternatives to Group 4 herbicides (2,4-D, dicamba, and MCPA).

Perennial Forages: For grass hay crops, most Group 4 herbicides and metsulfuron control both species effectively. For legume forages, 2,4-DB is effective against small wild mustard and wild radish.

Fallow or Spot Treatment: 2,4-D and dicamba (less effective than 2,4-D) plus glyphosate or paraquat will provide good control of wild mustard and wild radish that have yet to bolt.

Pokeweed (Common)

Scientific name: *Phytolacca americana*
Other names: pokeberry, inkberry, poke

Common pokeweed is a herbaceous simple (not creeping) perennial weed that has become a problem in agronomic crops in the Mid-Atlantic region, especially in no-till. It is native to North America and can be found in most of the 50 states as well as Canada, Mexico, and Europe. Common pokeweed will grow in wooded areas and along ponds, ditches, roads and fencerows; but more recently it has invaded Northeast farm fields and continues to spread. Traditionally, plowing was used to keep common pokeweed at bay. However, the widespread adoption of no-till along with a decline in the use of soil residual herbicides, especially in soybean, has likely allowed pokeweed populations to explode in some areas. Birds are believed to be the main mechanism of seed dispersal and seedling plants are often observed under trees or power lines where birds roost. An often cited piece of information is that the seeds can remain viable for at least 40 years. The leaves, roots, and stems of pokeweed are poisonous to humans and livestock, although young pokeweed is edible if cooked. The toxin, called phytolaccatoxin, causes damage to the digestive, nervous, and respiratory systems and can result in death.

Herbicide Resistance:

None reported.

Management:

Common pokeweed is difficult to manage due to the large, persistent taproot and abundant seed production. Pokeweed is less of a problem in tilled systems. In addition, increasing the diversity of the crop rotation to include crops such as winter small grains and perennial forages will provide cultural and mechanical control options not available in corn and soybean.

Corn: Perennial pokeweed plants are difficult to control in corn, mostly due to limitations in herbicide application timing. POST or foliar herbicides are essential, as soil-applied herbicides are not effective on perennial plants. However, soil-applied residual herbicides can be important for seedling pokeweed control. Unfortunately, POST herbicides in corn are generally applied before pokeweed is most susceptible to control. Potentially effective herbicides in corn include the Group 4 growth regulator herbicides and Group 9 glyphosate. Some Group 2 or ALS inhibitors can potentially increase performance, but they must be tank-mixed with a Group 2 or 9 herbicide. In addition, the Group 27 herbicide mesotrione has fair pokeweed activity when applied POST and can help provide control, particularly when tank-mixed with atrazine. Glyphosate is good for control of pokeweed depending on application timing. With the concern for glyphosate-resistant weeds and overreliance on glyphosate in much of the corn and soybean growing areas of the Northeast, our suggestion is to preserve glyphosate for soybean where other effective alternatives for pokeweed control do not currently exist, and use alternative effective modes of action in corn.

Sorghum: Management of pokeweed in sorghum should be similar to corn and relies on POST systemic herbicides. Some of the same herbicides, except glyphosate, can be used in sorghum.

Soybean: The only effective soybean herbicide for control of common pokeweed is POST-applied glyphosate. Penn State tested a number of active ingredients primarily in the Group 2 or ALS inhibitor class along with some others, including glyphosate. Nothing other than glyphosate provided better than 60 percent control. Glyphosate application timing had the largest effect on pokeweed control, while nozzle selection, spray volume, and application rate were less important (full rates are still necessary). Application too early in the season is not effective. In Pennsylvania, glyphosate application after mid-June provided at least 90 percent control of pokeweed. This is possibly due to increased glyphosate translocation when pokeweed was flowering and starting produce fruit.

Small Grains: Pokeweed is only an issue in spring-seeded small grains and generally not winter grains, so it could be problematic in oats or other spring-seeded cereals. Some suppression can be obtained from the Group 4 or growth regulator herbicides, but these will generally need to be applied too early, before pokeweed is susceptible. Spring small grains are a good crop to manage pokeweed.

Perennial Forages: Perennial forages are an excellent crop for managing common pokeweed. In particular, established alfalfa

that can be mowed four or more times per season will suppress pokeweed, and it is rarely a problem in these crops. Establish alfalfa in late summer to avoid pokeweed problems at establishment. In addition, a number of effective herbicides can be used to control pokeweed in perennial grass hay or pasture.

Fallow or Spot Treatment: Spot spray with glyphosate or use a Group 4 growth regulator herbicide for effective control. For best results, apply herbicides from bud to bloom and before fruit set.

Ragweed (Common)

Scientific name: *Ambrosia artemisiifolia*
Other names: hay-fever weed, bitterweed, annual ragweed

Common ragweed is a native summer annual weed that is found throughout North America and quite common in parts of the Mid-Atlantic region. It generally is one of the first emerging species in spring with club-shaped cotyledons and opposite leaves that are compound with multiple lobes. Plants generally grow 3 to 6 feet in height and flower in late summer. Common ragweed produces male and female flowers in separate heads on the same plant. The males produce and release pollen in late summer, and it is reported that plants can produce in excess of 1 billon pollen grains per plant. Common ragweed pollen is very well known for being a key allergen during the fall of the year.

Common ragweed is generally considered a weed of tilled systems; it is less common in no-till because of its larger seed size. If is also often considered more problematic in soybean than in other crops, mostly because of the lack of effective herbicides.

Herbicide Resistance:

Herbicide resistance to glyphosate and the Group 2 herbicides (ALS inhibitors) is common in some populations but more prevalent in the states of Virginia, Ohio, and Indiana. Group 5 or triazine herbicide resistance or tolerance has been suspected for many years in parts of the Northeast, but tests have been inconclusive. Finally, PPO or Group 14 resistance has been documented in Delaware and North Carolina.

Management:

Common ragweed's early spring emergence characteristic can make it more difficult in some crops or easier to manage in others by altering cash crop planting date. It is a particular problem for early planted spring crops such as oats, while delaying planting will allow some control measures prior to crop establishment. No-till management will also reduce the potential success of this weed.

Corn: In corn, atrazine and simazine have traditionally been effective soil-applied herbicides, but as mentioned, herbicide tolerance has reduced their success and required higher application rates in order to achieve effective control. Other soil-applied corn herbicides that have good activity on common ragweed include isoxaflutole (Balance) and clopyralid (Hornet and SureStart). A number of soil-applied corn herbicides have fair activity on common ragweed. A number of POST products are also effective on common ragweed and include the Group 4 or growth regulator herbicides as well as atrazine and the Group 2 herbicide halosulfuron (Permit or Yukon). In general, most Group 2 corn herbicides are not very effective. Glyphosate is an effective POST herbicide for control of common ragweed, assuming they are not resistant, and Liberty or glufosinate can also be effective.

Sorghum: Management of common ragweed in sorghum is similar to corn relying on atrazine and the POST herbicides. Some of the same herbicides, except glyphosate, can be used in sorghum.

Soybean: Ragweed control in soybean is more challenging, particularly for full-season soybean. The most effective soil-applied herbicide is the Group 2 herbicide cloransulam, which is an active ingredient in FirstRate, Authority First/Sonic, Gangster, and others. Chlorimuron-containing herbicides will provide suppression but generally require additional control measures. ALS-resistant biotypes will survive these Group 2 herbicides. POST herbicides are the most effective approach to con-

trolling common ragweed in soybean. Again, cloransulam and glyphosate are effective, assuming it is not ALS or glyphosate resistant. Alternative POST herbicides include the Group 14 products such as lactofen (Cobra), fomesafen (Reflex), or acifluorfen (Ultra Blazer). Liberty or glufosinate can also be used in LibertyLink soybean.

Small Grains: Common ragweed is less of a problem in winter small grains but can be a severe threat in spring-seeded cereals. In oats, the Group 4 herbicides are most effective, with 2,4-D or MCPA being most commonly used.

Perennial Forages: Perennial forages are excellent crops for managing common ragweed. In particular, established alfalfa that can be mowed four or more times per season will suppress ragweed seedlings, and it is rarely a problem in these crops. Establish alfalfa in late summer to avoid ragweed problems at establishment. In new seedings, the use of the Group 4 growth regular 2,4-DB can be effective on young ragweed plants. Ragweed is rarely a problem in perennial grass hay or pasture.

Fallow or Spot Treatment: Spot spray with glyphosate or paraquat, or use a Group 4 growth regulator herbicide.

Ragweed (Giant)

Scientific name: *Ambrosia trifida*
Other names: great ragweed, tall ragweed, horseweed, others

Giant ragweed is the bigger cousin to common ragweed and tends to be less widespread in the Mid-Atlantic. It is also a North American native summer annual that is a particular weed problem in the states of Ohio, Indiana, and parts of Illinois. Giant ragweed can attain heights up to 10 feet tall and flowers in late summer. Like common, giant ragweed also produces male and female flowers in separate heads on the same plant, and giant ragweed pollen can also be a potent allergen during the fall of the year. There are at least two distinct giant ragweed biotypes based on emergence timing and preference for soil disturbance. In much of the Northeast, giant ragweed emerges in late March to late April and is a common plant growing along the margins of fields or in hedge rows, but it is seldom a weed of field crops. In parts of the eastern Corn Belt, the biotype has prolonged seedling emergence and is often found in tilled fields. Like common ragweed, this aggressive biotype is also considered a weed of tilled systems and is less common in no-till because of its large seed size. This Ohio-Indiana biotype is a very competitive weed in field crops and often the key driver for the need for weed management.

Herbicide Resistance:

Thirteen states have reported infestations of herbicide-resistant biotypes. Resistance has developed to ALS-inhibiting herbicides (Group 2) and glyphosate (Group 9). As with common ragweed, these resistant biotypes are more prevalent in Ohio and Indiana as well as Ontario, Canada. Currently, no herbicide-resistant biotypes have been reported in the Mid-Atlantic region.

Management:

Like common ragweed, giant ragweed's early spring emergence characteristic can make it more difficult in some crops or easier to manage in others by altering cash crop planting date. Again, it is a particular problem for early planted spring crops such as oats, while delaying planting will allow some control measures prior to crop establishment. The biotype that has prolonged germination is not easily managed with altered planting date. No-till management will also reduce the potential success of this weed.

Corn: In corn, atrazine and simazine have traditionally been effective soil-applied herbicides, but relatively high rates (more than 1.5 pounds per acre) are required to achieve effective control. Other soil-applied corn herbicides that have activity on giant ragweed include isoxaflutole (Balance), clopyralid (Hornet and SureStart), and mesotrione (Lumax/Lexar). A number of POST products are also effective on common ragweed and include the Group 4 or growth regulator herbicides, atrazine, and several Group 2 herbicides. Glyphosate is an effective POST herbicide for control of giant ragweed, assuming it is not resistant, and Liberty or glufosinate can also be effective.

Sorghum: Management of common ragweed in sorghum is similar to corn and relies on atrazine and the POST herbicides. Some of the same herbicides, except glyphosate, can be used in sorghum.

Soybean: Giant ragweed control in soybean is more challenging, particularly for full-season soybean. The most effective soil-applied herbicide is the Group 2 herbicide cloransulam, which is an active ingredient in FirstRate, Authority First/Sonic, Gangster, and others. Chlorimuron-containing herbicides will provide suppression but generally require additional control measures. None of these soil-applied herbicides provide season-long control, and ALS-resistant biotypes will survive these Group 2 herbicides. POST herbicides are the more effective approach to controlling giant ragweed in soybean. Again, cloransulam and glyphosate are effective, assuming the ragweed is not ALS or glyphosate resistant. Chlorimuron (Classic) can also provide some suppression. Alternative POST herbicides include the Group 14 products such as lactofen (Cobra), fomesafen (Reflex), or acifluorfen (Ultra Blazer). Liberty or glufosinate can also be used in LibertyLink soybean.

Small Grains: Giant ragweed is less of a problem in winter small grains but can be a severe threat in spring-seeded cereals. In oats, the Group 4 herbicides are most effective, with 2,4-D or MCPA being most commonly used.

Perennial Forages: Perennial forages are an excellent crop for managing giant ragweed. In particular, established alfalfa that can be mowed four or more times per season will suppress ragweed seedlings, and it is rarely a problem in these crops. Establish alfalfa in late summer to avoid ragweed problems at establishment. In new seedings, the use of the Group 4 growth regulator 2,4-DB can be effective on young ragweed plants. Ragweed is rarely a problem in perennial grass hay or pasture.

Fallow or Spot Treatment: Spot spray with glyphosate or paraquat, or use a Group 4 growth regulator herbicide.

Ryegrass (Annual)

Scientific name: *Lolium multiflorum*
Other names: Italian ryegrass, common ryegrass

Annual ryegrass, also known as Italian ryegrass, is a tufted winter annual or biennial bunchgrass growing 12 to 36 inches tall. Leaf blades are shiny light green, 2.5 to 8 inches in length, and rolled in the bud. The presence of conspicuous auricles (small clawlike appendages) and a lack of hairs around the leaf collar region help to distinguish this species from other grasses. Erect stems of this species will often exhibit a purple coloration at the base.

This weed is primarily a problem in fall-seeded crops such as winter wheat as well as grass seed crops, but it can also present problems to summer crop establishment if not properly managed.

Herbicide Resistance:

In the southern and Mid-Atlantic regions of the United States, annual ryegrass has been confirmed to be resistant to ACCase-inhibiting herbicides (Group 1), ALS-inhibiting herbicides (Group 2), or have multiple resistance to both modes of action. In addition, populations with glyphosate resistance have been reported in the southern United States.

Management:

Prevention is a key step in ryegrass management. This can be accomplished by ensuring that equipment, feed, and crop seed are free of ryegrass contaminants; managing ryegrass populations on field edges and in ditch banks; and preventing ryegrass plants from producing seeds. This requires burndown applications before ryegrass stems begin to elongate, which maybe earlier than most burndown applications are made.

Corn: Controlling annual ryegrass in the spring prior to planting corn or soybean is challenging due to vigorous growth resulting in larger plants the presence of herbicide-resistant biotypes, and potential antagonism when glyphosate is tank-mixed with other herbicides. Tillage or preplant burndown using glyphosate-based products will control emerged ryegrass prior to spring planting. Glyphosate plus rimsulfuron products (e.g., Basis) may improve control of populations susceptible to Group 2 her-

bicides. Applications of Bicep II Magnum, Lexar, or Lumax plus glyphosate may antagonize glyphosate control of ryegrass. Postmergence applications of glyphosate or nicosulfuron can further suppress susceptible populations.

Note: Growers should be cautious of using annual ryegrass blends as a cover crop due to the possibility of herbicide-resistant seed in the mix.

Sorghum: Tillage and/or glyphosate will provide an effective preplant burndown control. The addition of atrazine to the tank may antagonize the effectiveness of glyphosate. There are no highly effective herbicides to control annual ryegrass after sorghum emergence.

Soybean: Tillage and/or residual herbicides such as Boundary, Dual, Treflan, and Zidua may be applied from mid-October to mid-November and can provide residual control of ryegrass. Glyphosate or Gramoxone with surfactant can be used to control emerged ryegrass in the fall. For susceptible populations, Group 1 products such as Select with crop oil and ammonium sulfate will provide control when applied as a preplant burndown, provided ryegrass is less than 6 inches tall. Glyphosate is the preferred treatment for spring burndown of susceptible populations.

Note: Growers should be cautious of using annual ryegrass blends as a cover crop due to the possibility of herbicide-resistant seed in the mix.

Small Grains: Chemical control of annual ryegrass in small grains has often relied on Group 2 herbicides, such as Osprey and PowerFlex, or Group 1 herbicides, such as Axial and Hoelon, applied when the majority of ryegrass plants have emerged. However, larger ryegrass plants are more difficult to control, and with resistance to these two herbicide groups reported in the Mid-Atlantic, more emphasis has been placed on fall applications of soil-applied herbicides such as Tricor, Valor, and Zidua. Early postemergence applications of Axiom, Anthem Flex, or Zidua will provide good residual ryegrass control but will not control emerged ryegrass plants. Applications of Valor may also be made 7 days prior to planting wheat. POST applications of Group 2 herbicides, such as Osprey or PowerFlex, or the Group 1 herbicide Axial XL will control susceptible ryegrass populations.

Perennial Forages: Glyphosate-based products may be applied as spot treatments or as a broadcast application over dormant forage grasses. Wait 60 days after glyphosate application before the pasture is mowed or grazed. Gramoxone may also be applied as spot treatments or as a broadcast application over dormant forage grasses. Ryegrass that has tillered or entered a period of rapid growth is not sensitive to Gramoxone. Applications should be made when temperatures reach above 50°F using a high rate with a non-ionic surfactant at 0.125 to 0.25 percent v/v. Wait 40 days after Gramoxone application before the pasture is mowed or grazed.

Texas Panicum

Scientific name: *Urochloa texana*
Other names: Texas millet, buffalograss, Coloradograss

Texas panicum, sometimes referred to as Texas millet, is an extremely competitive summer annual grass commonly found in agronomic fields and along roadsides. It can grow close to the ground or form dense patches that reach heights of 2 to 3 feet. Leaf sheaths and both sides of the leaf blades are covered with soft hairs. Relative to other annual grasses, the first leaves of Texas panicum are broad. As the plant matures, leaves remain relatively wide and continue to be covered with short, soft hairs. Stems are also covered with soft hairs. Texas panicum has a short membranous ligule fringed with thick hairs and lacks auricles. The weed has a fibrous root system and is capable of rooting at lower nodes. Texas panicum seedheads are simple panicles ranging 3 to 10 inches in length and produce large seed compared to other summer annual grasses. The large seed allow Texas panicum to emerge from soil depths down to 3 inches.

Herbicide Resistance:

None reported.

Management:

As with all weeds, prevention is key to managing Texas panicum. Field equipment should be thoroughly cleaned to limit the spread of Texas panicum seed into un-infested areas. Ensure manure, mulch, straw, or seed are free of seed before introducing these amendments. Plants along field edges and ditchbanks must be controlled to prevent introduction into neighboring fields. Texas panicum can recover following early harvest of corn and other crops; post-harvest control with mowing, tillage, or herbicides is necessary to limit seed production. Cultivation in combination with herbicides can improve control. However, cultivation should not occur within 7 days of herbicide application. Care must be taken to ensure cultivation does not lift untreated soil to the surface, thereby stimulating Texas panicum seed to germinate. Texas panicum will germinate throughout the summer and since most residual herbicides do not provide effective, a second postemergence application maybe necessary.

Corn: Texas panicum control by residual herbicides is fair at best and none will provide season-long control. Pyroxasulfone (Zidua) and isoxaflutole + thiencarbazone (Corvus) may offer some suppression, but postemergence herbicides will almost always be necessary for full-season control. Products containing s-metolachlor (Dual II Magnum, Bicep II Magnum, etc), acetochlor (Warrant, Degree Xtra, Harness Xtra, etc), alachlor (Intrro, Bullet, Lariat, etc.), and dimethenamid (Outlook, Guardsman Max, etc) do not adequately control Texas panicum. Glyphosate and nicosulfuron containing products (Accent Q, Revulin Q, Steadfast Q) are the most effective postemergence options. Small Texas panicum (<¬ 2 inches tall) may be controlled or suppressed by foramsulfuron (Option), glufosinate (Liberty), rimsulfuron (component of Realm Q, Resolve Q, and Steadfast Q), tembotrione (Laudis, component of Capreno), and topramezone (Impact, Armezon). If Texas panicum seedlings emerge shortly after the postemergence application is applied, a second postemergence application maybe necessary for full season control.

Sorghum: Texas panicum is difficult to control in sorghum; therefore, sorghum should not be planted in heavily infested fields. Products containing s-metolachlor (Dual II Magnum, Bicep II Magnum, etc), acetochlor (Warrant, Degree Xtra, Harness Xtra, etc), alachlor (Intrro, Bullet, Lariat, etc.), and dimethenamid (Outlook, Guardsman Max, etc) are weak on Texas panicum. There are no satisfactory postemergence options currently available for controlling emerged Texas panicum in sorghum. Nicosulfuron (Zest) effectively controls Texas panicum and may be applied postemergence to grain sorghum containing the Inzen herbicide tolerance trait.

Soybean: Clomazone (Command 3ME), pendimethalin (Prowl H2O), and trifluralin (Treflan) are the most effective residual options. Pyroxasulfone (Zidua) preemergence offers some suppression. Similar to other crops, Texas panicum control relies on postemergence options. Postemergence, glyphosate and the graminicides are highly effective. The graminicides include clethodim (Select, Select Max), fluazifop (Fusilade, Fusion), quizalofop (Assure II, Targa) and sethoxydim (Poast). Glufosinate (Liberty) will control or suppress small (< 4 inches) Texas panicum.

Small Grains: Texas panicum is sensitive to frost and emerges late in the spring; therefore, it is not a problem weed in winter small grains.

Perennial Forages: Pendimethalin (Prowl H2O) has a supplemental label for use in established cool-season forage grasses (forage, green chop, silage, hay, or pasture) and offers some residual control. There are no satisfactory postemergence options currently available for controlling emerged Texas panicum in grass forage or hay. Mowing may be appropriate to limit seed production. For alfalfa and other legume forages, clethodim (Select, Select Max) and sethoxydim (Poast) can be used for postemergence control. For Roundup Ready alfalfa, glyphosate effectively controls emerged Texas panicum.

Fallow or Spot Treatment: Glyphosate is in order for most fallow or spot treatment situations. The graminicides, including clethodim (Select, Select Max), fluazifop (Fusilade, Fusion), quizalofop (Assure II, Targa) and sethoxydim (Poast) would also be effective.

Thistle (Canada)

Scientific name: *Cirsium arvense*
Other names: creeping thistle

Canada thistle is an upright perennial that is 24 to 59 inches tall. Plants are often found in patches due to an extensive rhizome system that extends up to 3.5 feet into the soil. Shoots begin to emerge in early May and plants start bolting 3 to 4 weeks later. Cotyledons are dull green, thick, and club shaped. Young leaves are covered with short hairs and leaf margins are wavy with spines. Stems are grooved, branching at the top, and become pubescent at maturity. Flowering occurs from mid-June to early July. A single plant produces an average of 1,500 wind-dispersed seeds. Although the majority of seeds germinate the following year, buried seed may remain viable for up to 20 years. Plants will also regenerate from root fragments as small as 1 inch. The lack of spines on flowers and stems helps distinguish this species from bull and musk thistles.

Herbicide Resistance:

No herbicide resistance has been reported for Canada thistle in the United States; however, resistance to 2,4-D and MCPA has been reported in Europe.

Management:

Canada thistle is a major problem in pastures and rangeland, but it is also a problem in row crops. The key to its control is to exhaust the root system's energy reserves. Successive mowing every 3 weeks can help deplete root reserves, and mowing should occur before seed set. Sheep, cattle, and goats will graze on young, tender plants, but they tend to avoid dense patches of older plants. Canada thistle shoots require high light levels to survive. Cover crops such as alfalfa and hairy vetch can provide a competitive edge over emerging plants. Planting crops in narrow rows can also exclude the amount of light reaching the soil surface. Canada thistle completes its life cycle in crops such a corn and soybean, and rotating with winter wheat can aid in control. Glyphosate may be applied as a burndown treatment to control emerged weeds in row crops. There are no preemergence herbicide programs that will provide adequate season-long control. Complete control of established populations of Canada thistle often require multiple applications within a single season for several seasons.

Corn: Stinger, Hornet/Stanza, Callisto, and glyphosate-containing products will provide effective postemergence control. Multiple or split applications may be required to control underground root systems.

Sorghum: Suppression of Canada thistle may be achieved with Basagran, Basagran plus atrazine, dicamba, Marksman, Peak plus dicamba, and Yukon. Spot treatments of 2,4-D, dicamba, glyphosate, or Stinger are an option for small, localized patches of Canada thistle. Always follow label instructions when using dicamba around sensitive crop species.

Soybean: Glyphosate-containing products are effective postemergence options, but multiple applications may be necessary for complete control. Basagran can help to remove aboveground vegetation, but a second application 7 to 10 days later may be necessary to kill the remainder of the top growth. Always use a crop oil with Basagran on soybean.

Small Grains: Earlier plantings can help establish a dense crop canopy to suppress growth. Spring applications of Harmony Extra plus surfactant can be effective in the spring when plants are 4 to 8 inches tall with 4 to 6 inches of new growth. Control can be improved with the addition of 2,4-D ester. 2,4-D application in small grains should be made between the tillering and jointing stages. Glyphosate may also be used as a preharvest treatment once small grains have reached the hard dough stage. A 7-day preharvest interval should be observed when using glyphosate.

Perennial Forages: The standard approach of 2,4-D and dicamba has been shown to be ineffective against established stands. Milestone will provide control of thistles and legumes while not harming established grasses. These products should not be used where desirable trees are present. Spot treatments of glyphosate-containing products will also provide control. Since Canada thistle is not tolerant of shade, proper maintenance of forage species will provide suppression.

Fallow or Spot Treatment: Spot treatments may be made using 2,4-D, Crossbow, glyphosate, metsulfuron, or Stinger. 2,4-D, Crossbow, and Stinger can volatize and drift, causing harm to sensitive crops. Always consult label instructions for proper application procedures.

Tobacco

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Soil Texture

Herbicide performance and safety are highly influenced by soil texture and organic matter content. Herbicide rates are usually higher for fine versus coarse soil textures and with increasing percentages of organic matter content. In general, high herbicide rates may be necessary for fine-textured soils with at least 1% to 2% organic matter. Use the low recommended herbicide rate when soil organic matter is less than 1%, regardless of soil texture. Soil textures are described in herbicide recommendations as:

Coarse - Sands; loamy sands; sandy loams

Medium - Sandy clay loams; loams; silt loams; silts

Fine - Clay loam; silty clay loams; clays

Soil Preparation

All weed growth and crop stubble must be thoroughly worked into the soil prior to application of most herbicides used in tobacco fields. The soil should be moist and loose with all clods broken down.

Spray Equipment

ALWAYS clean, check, and calibrate sprayers before use to ensure correct herbicide spray volume and uniform spray pattern. Apply liquid, wettable powder, and dry flowable herbicide formulations in 20 to 40 gallons of water per acre using a standard low-pressure (25 to 50 psi) boom sprayer. Poast must be applied in 5 to 20 gallons of water per acre at 40 to 60 psi using hollow-cone or flat-fan nozzles. Maintain continuous agitation, and never leave a spray mixture in the tank overnight.

Preplant Incorporated (PPI)

Apply herbicides in an even broadcast application before planting. **Avoid spray overlap**. Use boom sprayer equipped with fan-type (8004, etc.), flood-jet (TK4, etc.), or raindrop nozzles. Incorporate herbicide immediately after application (see label) with the following:

1. **Disc** (Combination, tandem, double-disc, disk harrow, or similar equipment) - Set to cut 4 to 6 inches deep and operate in two different directions (at right angles to each other) at 4 to 6 mph. A disc set to cut 4 to 6 inches will incorporate herbicide in the top 1 to 2 inches of soil.

   Precautions - Avoid use of a large field disc. Discs should be set no more than 8 inches apart and be no wider than 24 inches in diameter. **A single cultivation does not adequately incorporate herbicides, and may increase crop injury and decrease weed control.** Incorporation with implements set to cut less than 2 inches deep may result in erratic weed control. Using incorporation equipment and tractor speeds not listed on the label may result in poor or erratic weed control and/or crop injury.

2. **PTO-driven equipment** (tillers, cultivators, hoes) - Set to cut 3 to 4 inches deep and operate one time at 4 mph. This type of equipment performs best on coarse soil types. PTO-driven equipment should not be operated at a speed greater than 4 mph.

3. Other equipment can be used, but proper procedures should be followed. Read labels or manufacturer's directions.

Overtop after Transplanting

Herbicides labeled for this use can be sprayed, either in a band or broadcast, onto freshly prepared soil within 7 days of transplanting. Cultivation is required, immediately before or at time of application, if the application is made more than 2 days after transplanting or if significant rain has fallen since transplanting.

1. **Band application** - Apply herbicide in a 14- to 24-inch band over the row using fan-type, even-spray nozzles (8004E, etc.). Refer to label and product information on this type of application. The amount of herbicide required per crop acre is

reduced with band application and can be determined by the following formula: **Banded product rate/acre = Band width (inches)/Row spacing (inches) x Broadcast product rate.**

2. **Broadcast** - Apply herbicide in an even broadcast application with a sprayer equipped with fan-type nozzles (8004, etc.).

Layby

Labeled herbicides can be applied as a directed spray to weed-free row middles immediately after the last normal cultivation. Application should be made using commercially available drop nozzles equipped with flood-jet flat (TK2, TK4, etc.) or even flat-fan (8004E, etc.) nozzles in order to spray a 16- to 30-inch band between rows. In fields where the spray boom passes over the same row-middle twice, use nozzles which apply one-half the normal number of gallons per acre to prevent over-application. Use the following formula to determine the amount of product to use with band application: **Product/acre for band treatment = Band width (inches)/Row spacing (inches) x Broadcast rate of product/A**. One-half inch of water is usually necessary within 7 to 10 days after application for herbicide activation.

No-till

Aim (carfentrazone) or Spartan Charge (sulfentrazone + carfentrazone) may be used as a pretransplant burndown treatment. Command 3ME and Devrinol DF may be applied at transplanting. Irrigation or rainfall may be needed to wash Devrinol off mulch and onto the soil surface.

Weeds

A herbicide should be selected based on the most important weeds in each field. The majority of the herbicides used in tobacco will control grasses and a limited number of broadleaf weeds. Herbicide applications to heavier soils may be somewhat less effective than in sandier or "lighter" soils. These differences are indicated in Tables 5.92 and 5.93 below.

Relative Effectiveness of Herbicides for Tobacco

Table 5.92 - Grasses and Nutsedge[1]

	Barnyardgrass	Bermudagrass	Broadleaf Signalgrass	Crabgrass	Crowfoot grass	Fall Panicum	Foxtails	Goosegrass	Johnsongrass (seedling)	Johnsongrass (rhizome)	Nutsedge	Texas Panicum
Aim	N	N	N	N	N	N	N	N	N	–	N	N
Command & generics	E	P-F	G-E	G-E	E	G-E	G-E	E	F-G	P	P	G
Devrinol	G	P	F-G	G-E	E	G	G-E	E	F	P	N-P	–
Poast	G	G	E	G	F	G-E	G-E	G	G-E	F	N	E
Prowl & generics	G	P	G	G-E	E	G	G-E	E	G	P	N-P	G
Spartan & generics	F	P	F	F	F	F	F	F	P-F	P	G-E	F

[1]E = 90 to 100% control; G = 75 to 90%; F = 50 to 75%; P = Less than 50%; N = no control. This table gives general ratings of relative herbicidal activity. Activity varies with weather conditions, soil type, and application method. Under non-optimal conditions, activity may be less than indicated.

Table 5.93 - Broadleaf Weeds[1]

	Black Nightshade	Carpetweed	Cocklebur	Galinsoga	Jimsonweed	Lambsquarters	Morningglory	Pigweed	Purslane	Prickly sida	Ragweed, Common	Ragweed, Giant	Sicklepod	Smartweed	Velvetleaf
Aim	–	–	G	P	G	G	E	E	G	P	N	N	P	G	–
Command & generics	P	P	F	P-G	F-G	G	P	P	F-G	G-E	F-G	P-F	P	G	G
Devrinol	P	G	N-P	P-F	N-P	F-G	N-P	F-G	G-E	P	F	N-F	P	P	P
Poast	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Prowl & generics	N	G	N-P	P	N-P	G	P	G	P-G	P	P	N-P	P	P	F
Spartan & generics	G	G	F-G	F-G	G	G-E	G-E	G-E	G	G	P	P	P	G	F

[1]E = 90 to 100% control; G = 75 to 90%; F = 50 to 75%; P = Less than 50%; N = no control. This table gives general ratings of relative herbicidal activity. Activity varies with weather conditions, soil type, and application method. Under non-optimal conditions, activity may be less than indicated.

Effect of PPI Applications on Early-season Growth of Tobacco

Preplant herbicides may delay plant growth during the first month after transplanting, but under favorable growing conditions any delay should be minimal and should not effect yield. Herbicide application factors that can enhance root injury include: 1) improper incorporation; 2) incorrect rates for soil texture; 3) poor spray technique or equipment. Applying tobacco herbicides at transplanting and/or after the last cultivation will eliminate possible delays in plant growth from herbicide residues already present in soil prior to transplanting.

Effect of Herbicide on Small Grain Crops

Residues of some tobacco herbicides (Command and Devrinol applied PPI) may affect the growth of small grain crops following tobacco (as indicated on product labels). If the small grain is grown only as a cover crop, the problem may not be serious. The potential for carry-over can be reduced by: 1) using minimum labeled rates of the chemicals; 2) band applications of labeled products at transplanting and/or at layby; 3) early stalk and root destruction; 4) deep plowing before seeding of small grain.

Table 5.94 - Field-grown Tobacco

Weed problem	Soil[1] Texture	Chemical; lbs Active Ingredient/A	Product; Rate/A	Application[2] Method	Remarks
Pigweed, lambsquarters, nightshade, purslane, smartweed, velvetleaf, spurred anoda, carpetweed, cocklebur, cotton, groundcherry, morningglory, common ragweed		carfentrazone 0.012-0.024 0.013-0.023	Aim 0.5-1.0 oz Aim EC or Aim EW 0.8-1.5 fl oz.	Burndown, shielded, directed	HRAC Group E. Use a Crop Oil Concentrate (1% v/v). *Spray solution will cause extensive burn to broadleaf plants (and tobacco leaves) on contact.* Pre-transplant interval = 1 day; pre-harvest interval = 6 days. For directed sprays to flue-cured tobacco (only), direct nozzles toward the base of tobacco plants, at least 3 to 4 inches above the soil, to spray *beneath* the plant canopy. **Read precautionary statements.**
Barnyardgrass, broadleaf signalgrass, crabgrass, field sandbur (suppression), foxtails, seedling. johnsongrass, lambsquarters, fall panicum, velvetleaf, jimsonweed, prickly sida, purslane, spurred anoda, venice mallow, common ragweed, smartweed, cocklebur (suppression), shattercane	 Coarse Fine	clomazone 0.75 1.0	Command 3ME Willowood Clomazone 3ME Caravel 2.0 pt 2.7 pt	PPI, OT	HRAC Group F4. Use the higher rate for heavy weed pressure or heavy soils. Best results are obtained when the product is incorporated no more than 1 inch deep. Transplants should be planted so that roots are below the treated area. OT applications must be made within 7 days of transplanting. **Read precautionary statements.**
Barnyardgrass, carpetweed, crabgrass, fall panicum, foxtails, goosegrass, johnsongrass from seed, lambsquarters, pigweed, common purslane, ragweed (suppression),rye-grass. Check label for uncommon weeds.	 Coarse Medium Fine Coarse Medium Fine	napropamide 1.0 1.0-1.5 2.0 1.0 1.0-1.5 2.0	Devrinol 2EC or Devrinol 2-XT 2.0 qt 2.0-3.0 qt 4.0 qt Devrinol 50DF or Devrinol DF-XT 2.0 lb 2.0-3.0 lb 4.0 lb	PPI only PPI, OT, Layby	HRAC Group K3. Incorporate the same day as applied. Small grain injury may result from PPI application. Use high rate for burley in southwest Virginia. **Read precautionary statements.**

Table 5.94 - Field-grown Tobacco (cont.)

Weed problem	Soil[1] Texture	Chemical; lbs Active Ingredient/A	Product; Rate/A	Application[2] Method	Remarks
Grass weeds and Volunteer small grain	All types	sethoxydim	Poast	post-emergence	HRAC Group A. Apply to actively growing grasses at 40-60 psi in 5-20 gal/A through hollow cone or flat-fan nozzles. May be banded or applied broadcast. Do not apply more than 4 pt/A/season. **Read precautionary statements.**
	Single use:	0.28	1.5 pt + 2.0 pt oil concentrate		
	Sequential use:	0.19	1.0 pt + 2.0 pt oil concentrate		
Annual spurge, barnyardgrass, carpetweed, crabgrass, crowfootgrass, Florida pusley, foxtails, goosegrass, johnsongrass from seed, lambsquarters, panicums, pigweed, purslane, signalgrass. Check label for uncommon weeds.		pendimethalin	Prowl 3.3EC		HRAC Group K1. **Use on transplanted tobacco.** Apply up to 60 days prior to transplanting; incorporate within 7 days after application. Use highest rate of Acumen specified for each soil type. May also be applied in a **band** in row middles at layby. **Read precautionary statements.**
	Coarse	0.74-0.99	1.8-2.4 pt	PPI only	
	Medium	0.74-1.24	1.8-3.0 pt		
	Fine	0.99-1.24	2.4-3.0 pt		
	Coarse	0.50-0.74	1.2-1.8 pt	Layby only	
	Medium	0.74-0.99	1.8-2.4 pt		
	Fine	0.74-0.99	1.8-2.4 pt		
			Acumen		
			Satellite 3.3		
	Coarse		2.4 pt	PPI only	
	Medium		2.4 pt		
	Fine		3.0 pt		
	Coarse		1.8 pt	Layby only	
	Medium		2.4 pt		
	Fine		2.4 pt		
			Prowl H_20		
			Satellite		
			HydroCap		
	Coarse	0.95	2.0 pt	PPI only	
	Medium	0.95-1.19	2.0-2.5 pt		
	Fine	1.19	2.5 pt		
	Coarse	0.71	1.5 pt	Layby	
	Medium	0.95	2.0 pt		
	Fine	0.95	2.0 pt		

Table 5.94 - Field-grown Tobacco (cont.)

Weed problem	Soil[1] Texture	Chemical; lbs Active Ingredient/A	Product; Rate/A	Application[2] Method	Remarks
Hairy galinsoga, goosegrass, groundcherry, jimsonweed, lambsquarters, morning-glory (except pitted), wild mustard, nightshade, nutsedge, orchardgrass, fall panicum, pigweed, prickly sida, broadleaf signalgrass, Pennsylvania smartweed. Suppresses: most grasses, foxtail, cocklebur, spurges. Check label for uncommon weeds.		sulfentrazone	Spartan 4F Blanket 4F, Sulfentrazone 4F, Sulfentrazone 4SC, Shutdown	After bedding, before transplanting	HRAC Group 14. Apply to soil surface after field has been prepared for planting. Apply within 14 days of transplanting. Where raised beds are used, apply after beds are knocked down for planting. If soil must be worked after application, do not disturb soil below a 2 inch depth. Do not apply at or after transplanting. Maximum rates for Shutdown are 11.8 fl.oz./A for all soil textures. Read precautionary statements.
	Coarse				
	<1.5%OM	0.14–0.19	4.5-6.0 fl.oz.		
	1.5-3%OM	0.19-0.25	6.0-8.0 fl.oz.		
	>3%OM	0.25-0.32	8.0-10.1 fl.oz.		
	Medium				
	<1.5%OM	0.19-0.25	6.0-8.0 fl.oz.		
	1.5-3%OM	0.25-0.32	8.0-10.1 fl.oz.		
	>3%OM	0.32-0.38	10.1-12.0 fl.oz.		
	Fine				
	<1.5%OM	0.25	8.0 fl.oz.		
	1.5-3%OM	0.32	10.1 fl.oz.		
	>3%OM	0.38	12.0 fl.oz.		
Pre-Emergent: Same as Spartan 4F. Check label for uncommon weeds, as well as weed control spectrum for Post-Emergent, Pre-Plant Burndown applications.		sulfentrazone + carfentrazone	Spartan Charge	Burndown, preplant surface application, PPI	HRAC Group 14. May be surface applied or preplant incorporated (less than 2 inches) from 14 days to 12 hours before transplanting. Beds must be knocked down before applying the product. If not incorporated, timely cultivation after transplanting is required for acceptable weed control. Tobacco may be re-planted in treated soil, but do not retreat or re-bed field. Read precautionary statements.
	Coarse				
	<1.5%OM	0.14-0.19 + 0.016-0.021	5.6-7.6 fl.oz.		
	1.5-3%OM	0.19-0.25 + 0.021-0.028	7.6-10.2 fl.oz.		
	>3%OM	0.25-0.32 + 0.028-0.035	10.2-12.8 fl.oz.		
	Medium				
	<1.5%OM	0.19-0.25 + 0.021-0.028	7.6-10.2 fl.oz.		
	1.5-3%OM	0.25-0.32 + 0.028-0.035	10.2-12.8 fl.oz.		
	>3%OM	0.32-0.38 + 0.035-0.042	12.8-15.2 fl.oz.		
	Fine				
	<1.5%OM	0.25 + 0.028	10.2 fl.oz.		
	1.5-3%OM	0.32 + 0.035	12.8 fl.oz.		
	>3%OM	0.38 + 0.042	15.2 fl.oz.		

[1] When the soil type has less than 1% organic matter, use the rate for the coarse soil texture recommendations. **Coarse** - Sands; loamy sands; sandy loams. **Medium** - Sandy clay loams; loams; silt loams. **Fine** - Clay loam, silty clay loam; clays.

[2] PPI - Preplant incorporated. Delay in growth may result under adverse weather conditions and/or when poor application practices have been used. OT - Overtop after transplanting as a band or broadcast applications. Layby - Application of herbicide to row-middle after last cultivation. Burndown, shielded, directed – broadcast spray before transplanting (burndown), or shielded/hooded spray to row-middles only (shielded), or spray directed toward row-middles and surface of row beds after sequential harvesting of flue-cured tobacco has removed sufficient leaves that the spray will not contact remaining crop leaves (directed).

Precautionary and Restriction Statements

Read all directions, cautions, precautions, and special precautions on each product label.

Aim EC, EW (carfentrazone)

As a contact burndown herbicide for broadleaf weeds, Aim may be applied (1) to kill cover crops prior to no-till transplanting, (2) as a shielded or hooded spray to row middles before layby, or (3) as a directed spray following first harvest of flue-cured tobacco. Spray solution will cause extensive burn to broadleaf plants (and tobacco leaves) on contact. Don't spray when conditions favor drift, such as wind above 10 mph. Don't apply more than 2 oz of Aim or 3 fl oz. of Aim EC or EW per acre per season.

Command 3ME and Caravel (clomazone)

Apply only as specified on the label. Command and Caravel may be tank-mixed with other EPA-registered tobacco herbicides and can be impregnated on dry bulk fertilizer. Bottom leaves of tobacco plants in treated soil may whiten or yellow temporarily, but the crop should grow out of this with no adverse effect on yield or quality. Avoid spraying Command or Caravel within 300 feet of susceptible and desirable plant species, as spray drift can cause foliar whitening or yellowing of some plants. Do not apply Command or Caravel within 1,200 feet of residences, towns, subdivisions, or commercial vegetable or fruit nurseries or greenhouses. Small grains should not be planted in the fall or following spring after product use.

Devrinol 50DF, DF-XT, 2EC, 2-XT (napropamide)

Do not apply more than a total of 2 lb of active ingredient per acre in any one season. After harvest or prior to planting succeeding crops, a deep moldboard or disk plowing operation must be carried out. Do not seed to alfalfa, small grain, sorghum, or corn for 12 months after applying a napropamide herbicide. Injury to rotational crops is lessened by band versus broadcast application. When Devrinol is applied after transplanting or at layby, rainfall or overhead irrigation following application improves weed control.

Poast (sethoxydim)

When mixing Poast, fill sprayer 1/2-2/3 full of water. Add oil concentrate (preferably highly refined vegetable oil) first, with agitation. Add Poast last with remaining volume of water, also with agitation. Agitation must be maintained during application. Do not apply Poast (1) at rates above 1.5 pt/A in the field; (2) to exceed 4 pt/A/season; (3) when grasses are under stress; (4) if rainfall is expected within 1 hour; (5) with any other pesticide, additive, or fertilizer except as specified on the Poast label; (6) through any type of irrigation system; (7) within 42 days of harvest.

Prowl 3.3EC, Satellite 3.3, Prowl H_2O, Satellite HydroCap and Acumen (pendimethalin)

Applied according to directions and under normal growing conditions, pendimethalin should not harm transplanted tobacco, but can temporarily retard growth under stressful conditions (cold/wet or hot/dry weather). *Layby applications should be made as a directed spray in a 16- to 24-inch band centered between rows. Broadcast rates for layby applications must be adjusted based on the width of the intended spray band and soil texture.* Any spray contacting tobacco leaves may cause deformations. Crop injury may result if winter wheat and winter barley are planted in the fall (after a spring application) when no-till planting procedures are used. Do not feed forage or graze livestock for 75 days after planting wheat or barley in treated land.

Spartan 4F, Blanket 4F, Shutdown, and Sulfentrazone 4SC (sulfentrazone)

Do not use in tobacco greenhouses, impregnate on fertilizer, or apply after transplanting. Do not apply to soils classified as sands that contain less than 1 percent organic matter or shallow groundwater. Don't incorporate more than 2 inches deep or perform tillage operations that may concentrate the product in the bed. *Most tobacco fields in Virginia contain coarse to medium-textured soils. The 8 to 10 fl.oz. rates are appropriate for these conditions. Crop injury can occur when incorporation is poor, transplants are set too shallow, or heavy rain falls near transplanting.* Splashing of treated soil onto young tobacco can cause localized burning. Don't apply sufentrazone herbicides more than once per site per season. See label for rotational crop restrictions.

Spartan Charge (*sulfentrazone + carfentrazone*)

Do not use in tobacco greenhouses. May be tank-mixed with liquid fertilizer, but perform a jar test before mixing to ensure compatibility. See label for instructions. Do not apply to soils classified as sands that possess less than 1 percent organic matter. Broadcast applications require at least 10 gallons of water per acre. Don't incorporate more than 2 inches deep or perform tillage operations that may concentrate the product in the bed. *Most tobacco fields in Virginia contain coarse to medium-textured soils. The 5.7 to 12.8 fl.oz. rates are appropriate for these conditions. Crop injury can occur when incorporation is poor, transplants are set too shallow, or heavy rain falls near transplanting.* Splashing of treated soil onto young tobacco can cause localized burning. Don't apply Spartan Charge more than once per site per season. See label for rotational crop restrictions. The following table presents rates of Spartan Charge with rates equivalent to those in Spartan 4F:

SPARTAN CHARGE CONVERSION TABLE	
Rate of Spartan Charge	**Rate of Spartan 4F**
5.7 fl oz/acre	4.5 fl oz/acre
7.6 fl oz/acre	6.0 fl oz/acre
10.2 fl oz/acre	8.0 fl oz/acre
12.8 fl oz/acre	10.1 fl oz/acre
15.2 fl oz/acre	12.0 fl oz/acre

Do not seed small grains within 4 months of application, or plant cotton within 18 months or canola within 24 months. See label for other crop rotational restrictions.

Peanuts

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Maria Balota, Associate Professor, Crop Physiologist, Tidewater AREC
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Failure to control weeds almost always results in yield reductions and lower income. Detailed information on the use of herbicides cannot be included in a guide such as this. Refer to product labels for use suggestions and restrictions. Proper application is required to obtain satisfactory weed control and minimize carry-over residues.

Soil incorporation is necessary for some herbicides. Compliance with the label directions for incorporation is very important in obtaining effective weed control.

With postemergence herbicides, good spray coverage of the target plants, treatment at the proper stage of weed development, and adjuvant selection, and use of relatively small droplets of spray under relatively high pressure are required to ensure good control.

Effective Weed Management requires integration of all control strategies.

1. *Crop rotation.* Peanuts should be grown in rotation with corn, grain sorghum, and/or cotton to aid in management of various pests including weeds. Crop rotation allows for the use of different types of herbicides on the same field in different years. A good rotation and weed management system in each crop prevents the buildup of problem weeds in the field. Most annual and perennial broadleaf weeds can be controlled more economically and easier in corn than in peanuts. For example, there are no registered herbicides for use in peanuts that will effectively control perennial broadleaf weeds such as horsenettle, trumpetcreeper, or maypop passionflower.
2. *Crop competition*. Peanuts are relatively poor competitors with weeds. Horsenette, common lambsquarters, cocklebur, and palmer amaranth have been shown to reduce yield by 17, 40, 70, and 28 percent, respectively. Fewer weeds are required to reduce yield and quality of peanuts than for most other crops. Generally, if peanuts are kept weed free for 6-8 weeks after planting, peanut yield will not be reduced by weed competition. However, late season weeds often interfere with digging and combining of peanuts and reduce harvesting efficiency and peanut quality. Weeds can also negatively impact fungicide deposition in the peanut canopy.
3. *Cultivation*. Cultivation is often required to supplement chemical weed control. In addition, cultivation permits banding of herbicides which reduces herbicide costs. Cultivations must be flat and non-dirting. Soil must not be moved upon or around the peanut plant. Such soil movement results in physical damage to the peanut plant and often results in increased disease problems.
4. *Weed identification and scouting*. Proper weed identification is essential. Generally, one herbicide will not control every weed that is likely to be present in a typical field. Every field should be scouted and mapped for weeds present. Using graph paper, a grower should mark the approximate location of weeds in the fall of each year. Weeds present in the fall will generally have set seed and will be present the following year. Weed seed often will stay viable in the soil for several years. As a result, they will be a problem for many years. By knowing what weeds to expect, a grower will be able to make more intelligent decisions on herbicide applications and save money and time in the process.
5. *Herbicide selection*. To develop a herbicide program, a grower must know what weeds are present, the soil characteristics of the field, and herbicide limitations and capabilities. Seldom will one herbicide provide control of all weeds present. As a result, several herbicides must be used together for a successful program. By knowing what each herbicide provides to the program, the grower may eliminate expensive duplication or choose the herbicide that provides the best overall balance of weed control capabilities, crop safety, and the best buy.

Problem Weeds

Perennial Broadleaf Weeds

Perennial broadleaf weeds such as horsenettle, alligatorweed, Virginia buttonweed, trumpetcreeper, maypop passionflower, and bigroot morningglory cannot be controlled in peanuts. These weeds can be controlled in corn grown in rotation with peanuts. In corn, make a layby application of 1.0 pt/A of 2,4-D amine plus surfactant. After corn harvest, spot spray any remaining infestations with glyphosate or a mixture of 1.0 pt/A of 2,4-D amine plus 0.5 pt/A of Clarity plus surfactant. See glyphosate product labels for suggested application rates.

Bermudagrass

In addition to controlling bermudagrass in the field, efforts should also be directed at controlling bermudagrass on edges of field. This prevents encroachment into the field.

A. Ideally, control procedures should begin in the fall following corn harvest. This allows the grower several options and reduces the risk of yield reduction. After corn harvest, mow the stalks. If the bermudagrass foliage appears wilted or damaged, set the mower low to remove the old foliage. Do not till; allow the bermudagrass to regrow (8-10 inches tall) and be actively growing before applying glyphosate at 3.0 lb ai/A in a spray volume of 15 gpa using flat fan nozzles and 30-40 psi. Apply at least two weeks before frost and wait 14 days before tillage. Using moldboard or chisel plow followed by several diskings spaced at 4-6 week intervals (during the fall and winter if soil conditions allow) is most effective.

B. Glyphosate may also be applied in the spring. Remove old thatch by burning or mowing. Allow bermudagrass to regrow before applying 3 quarts of glyphosate as described above. Wait 14 days before seedbed preparation.

C. Two applications of Poast, Poast Plus, or Clethodim (various formulations) in combination with good crop competition will usually provide good control or suppression of bermudagrass. See Table 5.74 for application rates and weed size for treatment. Always include a crop oil concentrate in the spray mixture.

Nutsedge

Both yellow and purple nutsedge occur in peanut fields. Know which nutsedge species is present; management practices vary for the two species.

Fields infested with yellow nutsedge should receive a preplant-incorporated or preemergence application of Pursuit, Strongarm, or Dual Magnum. Pursuit or Dual Magnum may also be used as ground-cracking applications. Basagran may be applied postemergence when the yellow nutsedge is 6-8 inches tall. Apply 1.5-2.0 pt Basagran per acre. A second application of Basagran at same rate 7-10 days later may be required. The addition of 1 quart per acre of crop oil concentrate with Basagran will improve control. Either Cadre or Pursuit plus nonionic surfactant or crop oil concentrate may be applied for control of either yellow or purple nutsedge at the 1-4 inch stage.

Purple nutsedge is not controlled by Basagran or Dual Magnum. Soil incorporated or preemergence treatments of Pursuit or Strongarm provide suppression of purple nutsedge.

Broadleaf Signalgrass and Texas Panicum

These two annual grasses are becoming more widespread in Virginia's peanut production area. Because management programs vary for the two species, it is important to have accurate information concerning the species present.

A management program for broadleaf signalgrass should begin with a preplant-incorporated treatment of Prowl, Sonalan, Dual Magnum, or Outlook. The preplant-incorporated treatment should be followed by a preemergence or ground-cracking application of Outlook, or Dual Magnum. Broadleaf signalgrass which escapes soil treatments may be controlled with postemergence application of Poast, Poast Plus, or Clethodim. Cracking stage application of Paraquat (various formulations) effectively controls seedling broadleaf signalgrass.

Texas panicum **is not effectively controlled by Dual Magnum, Outlook, Warrant, Zidua, or Pursuit**. Management should begin with a preplant-incorporated application of Prowl or Sonalan. Texas panicum may emerge from deeper in the soil than other annual grasses. As a result, Prowl or Sonalan should be incorporated to a depth of 3 inches (this is deeper than specified on Prowl label). Dual Magnum, Outlook, or Warrant applied preemergence or at ground-cracking provides some suppression. Texas panicum which escapes soil treatments may be controlled with postemergence application of Poast, Poast Plus, or Clethodim. Cracking stage application of Paraquat also effectively controls seedling Texas panicum.

Recommended Herbicides for Weed Control in Peanuts

Table 5.95 - Preplant Incorporated

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
Crabgrass, goosegrass, fall panicum, johnsongrass, broadleaf signalgrass, Texas panicum, carpetweed lambsquarters, pigweed	Pendimethalin 0.75-1.0 lb	Prowl 3.3EC 1.8-2.4 pt or Prowl H_2O 3.8 lb/gal 1.6-2.0 pt	Incorporate into the top 1-2 inches within 7 days of application. Incorporate 3 inches deep for Texas panicum (note this is deeper incorporation than the label specifies). Use higher rate for broadleaf signalgrass, fall panicum, or Texas panicum. May be tank mixed with Dual Magnum, Pursuit, Outlook, Warrant, or Strongarm for control of mixed infestations of nutsedge and annual grasses.
Crabgrass, goosegrass, fall panicum, johnsongrass, broadleaf signalgrass, Texas panicum, carpetweed, lambsquarters, pigweed	Ethalfluralin 0.56-0.75 lb	Sonalan 3HFP 1.5-2.0 pt or Sonalan 10G 5.5-7.5 lb	Incorporate 2-3 inches deep within 2 days of application (incorporation as soon as possible after application is preferred). For Texas panicum incorporate 3 inches deep. Use higher rate for fall panicum, Texas panicum, or broadleaf signalgrass. See label for application rates for particular soil. May be tank mixed with Dual Magnum, Pursuit, Outlook, Warrant, or Strongarm for control of mixed infestations of nutsedge and annual grasses.
Crabgrass, fall panicum, goosegrass, broadleaf signalgrass, pigweed, yellow nutsedge	S-Metolachlor 0.95-1.27 lb	Dual Magnum 7.62EC 1.0-1.33 pt or Dual II Magnum 7.64EC 1.0-1.33 pt or Dual II G Magnum 16% 6.0-8.0 lb/A	Incorporate 2 inches deep within 14 days of planting. Will not control purple nutsedge or adequately control Texas panicum. A sequential application may be used with 1/2 rate applied PPI and 1/2 rate applied either preemergence or at cracking. May be tank mixed with Prowl or Sonalan to obtain control of broadleaf signalgrass and Texas panicum. Use the high rate of Dual Magnum for yellow nutsedge and broadleaf signalgrass.
Crabgrass, fall panicum, goosegrass, broadleaf signalgrass, pigweed	Acetochlor 0.94-1.5	Warrant 3ME 2.5-4pt	Apply and incorporate in top 2 inches of soil. Do not apply more than 3 lb/ A per year. Will not control nutsedge or adequately control Texas panicum.

Table 5.95 - Preplant Incorporated (cont.)

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
Broadleaf weeds and suppression of nutsedges	Diclosulam 0.024 lb	Strongarm 84WDG 0.45 oz	Incorporate into the top 3 inches of the soil within 4 weeks of planting. When applied in tank mixture with other herbicides, follow incorporation directions for the tank-mix partner. May be tank mixed with Dual Magnum, Prowl, Sonalan, Pursuit, Warrant, or Outlook for improved control of annual grasses. Growers are cautioned that Strongarm applied at rates exceeding 0.024 lb/A can injure cotton the following year on soils with a shallow hardpan (less than 10 in) and/or loam soils. Cotton grown under early season stress resulting from conditions such as excessively cool, wet, dry, or crusted soils may be particularly susceptible to carryover of Strongarm.
Crabgrass, fall panicum, goosegrass, broadleaf signalgrass, pigweed, carpetweed, yellow nutsedge	Dimethenamid-p 0.56-0.84 lb	Outlook 6E 12.0-18.0 oz	Incorporate 2 inches deep within 14 days of planting. May be applied in a split application with 1/2 to 2/3 the maximum rate applied PPI and 1/2 to 1/3 the maximum rate applied as a sequential application. Specifically, apply 12.0-18.0 oz/A preplant and incorporate. Follow planting with a preemergence application of Outlook at 7.0-10.0 oz/A sequentially. Do not apply more than 18.0 fl oz/A Outlook per season on course soils and 18.0-21.0 oz/A on medium and fine textured soils. Will not control purple nutsedge or adequately control Texas panicum. May be tank mixed with Prowl or Sonalan for improved broadleaf signalgrass and Texas panicum control. See label for more details. Use the high rate of Outlook for yellow nutsedge and broadleaf signalgrass.
Spurred anoda, pigweeds, prickly sida, velvetleaf, yellow nutsedge, purple nutsedge	Imazethapyr 0.063 lb	Pursuit 2EC 4.0 oz	May be applied and uniformly incorporated 1-2 inches deep prior to planting or applied to soil surface after planting. A sequential application may be used with 1/2 rate applied PPI or preemergence and 1/2 rate applied either at ground crack or early postemergence. Soil incorporated treatments may be tank mixed with Prowl, Sonalan, Dual Magnum, Outlook, Warrant, or Strongarm. Do not apply more than 4 oz/A Pursuit total for all application methods.

Table 5.96 - Preemergence

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
Yellow and purple nutsedge and many broadleaf weeds	Imazethapyr 0.063 lb	Pursuit 2EC 4.0 oz	Apply after planting, preferably before emergence of weeds. May be tank mixed with Dual Magnum, Outlook, or Strongarm. Preemergence application of Pursuit has been less consistent in weed control than either soil incorporated or split (PPI + PRE) application.
Broadleaf weeds and the suppression of nutsedges	Diclosulam 0.024 lb	Strongarm 84WDG 0.45 oz	Apply after planting but prior to crop or weed emergence. May be tank mixed with other herbicides registered for preemergence application.Growers are cautioned that Strongarm applied at rates exceeding 0.024 lb/A can injure cotton the following year on soils with a shallow hardpan (less than 10 in) and/or loam soils. Cotton grown under early season stress resulting from conditions such as excessively cool, wet, dry, or crusted soils may be particularly susceptible to carryover of Strongarm.
Crabgrass, fall panicum, goosegrass, broadleaf signalgrass, pigweed, yellow nutsedge	S-Metolachlor 0.95-1.27 lb	Dual Magnum 7.62EC 1.0-1.33 pt or Dual II Magnum 7.64EC 1.0-1.33 pt or Dual II G Magnum 16% 6.0-8.0 lb	Apply to soil surface before weeds or crop emerge. Good annual grass control except for Texas panicum. Do not use Dual II Magnum or Dual II G Magnum after peanuts have emerged.
Crabgrass, fall panicum, goosegrass, broadleaf signalgrass, pigweed, yellow nutsedge	Dimethenamid-P 0.56-0.84 lb	Outlook 6E 12.0-18.0 oz	Apply to soil surface before weeds or crop emerge. Good annual grass control except for Texas panicum.
Crabgrass, fall panicum, goosegrass, broadleaf signalgrass, pigweed	Acetochlor 0.94-1.5	Warrant 3ME 2.5-4 pt/A	Apply and incorporate in top 2 inches of soil. Do not apply more than 3 lb/ A per year. Will not control nutsedge or adequately control Texas panicum.
Controls most annual grasses and broadleaf weeds in conventional and reduced tillage production systems. Control or temporary suppression of many weeds, including hemp dogbane, yellow nutsedge, and rhizome johnsongrass. Provides residual control of large crabgrass, goosegrass, fall panicum, foxtails, and the suppression of yellow nutsedge.	glyphosate 0.7-0.98 lb ae/A + S-Metachlor 0.9-1.3 lb ai/A	Sequence 2.5-3.4 pt	Apply to soil surface at planting, but before crop emerges. **Do not incorporate.** Crop injury has been observed, especially when heavy rainfall is received shortly after peanut emergence. Do not exceed 3.4 pt/A of Sequence on medium or fine textured soils. Do not apply to sands or loamy-sand soils. May be useful in no-till peanut and for suppression of yellow nutsedge. **Do not apply Sequence to cracking peanuts. See label for additional precautions.**

Table 5.96 - Preemergence (cont.)

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
Broadleaf weeds	Flumioxazin 0.064 lb ai	Valor SX 51% WDG 2.0 oz	Apply within 2 days following planting. Significant injury has been observed if applied 3 or more days after planting. Do not incorporate. Valor will not control nutsedge (purple or yellow) or sicklepod. Effective on ragweed, eclipta, and pigweed. Follow labeled sprayer cleanout instructions. Spray equipment used to apply Valor should not be used to apply other materials to crop foliage. If heavy rain occurs at emergence, foliar injury from splashing Valor can occur. Peanut typically recovers by mid season. Can be mixed with Dual Magnum (1.0-1.33 pt/A), Warrant (2.5-4 pt/A), or Outlook (16.0-21.0 oz/A).

Table 5.97 - Ground Cracking

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
Small annual grasses and broadleaf weeds	Paraquat 0.13 lb	Gramoxone SL 2.0 8.0 fl oz Firestorm or Parazone 3.0 SL 5.4 fl oz	Paraquat is effective only on small emerged weeds (less than 1 inch tall) and does not provide residual control. Add 1 pt of nonionic surfactant per 100 gal of spray solution. May cause foliar burn on emerged peanuts but crop recovers and yield is not affected. May be tank mixed with Basagran (1pt/A), Butyrac or Dual Magnum, Outlook (see label) or Pursuit (2.0-4.0 oz/A, see label). Do not apply Dual II Magnum after peanuts have emerged. Do not apply later than 28 days after ground cracking. Maximum of 16 oz/acre of Paraquat may be used per season in crop. Consult labels of Basagran, Butyrac, Dual Magnum, Outlook, or Pursuit.
Crabgrass, fall panicum, goosegrass, broadleaf signalgrass, pigweed	Pyroxasulfone 0.079-0.112 lb ai/A	Zidua 85WG 1.5-2.1 oz/A	Apply early postemergence from at-cracking to first true leaf stage through beginning of pod development. Provides residual control of weeds germinating after application. Will not control emerged weeds. Will not control nutsedge or adequately control Texas panicum. Zidua may cause temporary leaf burn and stunting, but yield reduction is unexpected. Tank mixes with other pesticides may enhance injury. DO NOT apply more than 2.1 oz/A in a single application. DO NOT apply more than the maximum cumulative amount of 5.0 oz/A per cropping season. No required preharvest interval.

Table 5.98 - Postemergence

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
Mainly cocklebur, annual morningglory (except pitted morningglory), sicklepod	2,4-DB 0.2-0.25 lb	Butyrac 200 0.8-1.0 pt or Butyrac 175 0.9-1.1 pt	Use when weeds are in the seedling stage and actively growing. Apply with 10-30 gpa spray volume and 20-40 psi spray pressure. Cocklebur and morningglory are most susceptible. Ragweed, lambsquarters, jimsonweed, pigweed, and teaweed (prickly sida) are rather tolerant and may only be suppressed. The higher rate should be used if the difficult-to-control species are present. Do not graze or feed treated forage to livestock. May be applied from 2 weeks after planting to within 45 days of harvest. Avoid drift to other crops. See label for tank-mix instructions.
Broad-spectrum broadleaf weed control	Bentazon 0.5 lb + Acifluofen 0.25 lb	Storm 4EC 1.5 pt (premix)	Apply to small, actively growing weeds with a minimum of 20 gpa spray volume and 40 psi. Apply with 1-2 pt/A crop oil concentrate or 1.0 pt of nonionic surfactant/100 gal spray solution. See label and Table 5 for weeds controlled. May be tank mixed with 0.5- 1.0 pt/A 2,4-DB for improved control of certain broadleaf weeds.
Same as for bentazon alone; however, the addition of acifluorfen improves control of pigweeds, morningglories and common ragweed.	Bentazon 0.5-1 lb + Acifluorfen 0.25-0.38 lb	Basagran 4SC 1.0-2.0 pt + Ultra Blazer 2L 1.0-1.5 pt (tank mix)	Apply to small actively growing weeds. Use spray pressures of 40-60 psi. Do not use large-orifice nozzles. Ultra Blazer may be included up to 2.0 pt/A. Apply with 1.0 pt nonionic surfactant/ 100 gal spray solution or a crop oil concentrate at 1.0-2.0 pt/A. Increased leaf burn and weed control is usually observed with use of crop oil and higher rates of Ultra Blazer. Do not apply UAN or AMS. Do not apply within 75 days of harvest.
Cocklebur, jimsonweed, smartweed, prickly sida (teaweed), spurred anoda, wild mustard, yellow nutsedge	Bentazon 0.75-1.0 lb	Basagran 4SC 1.5-2.0 pt	Apply when broadleaf weeds are small and actively growing. Apply with 1.0-2.0 pt/A crop oil concentrate. Peanuts are tolerant at any growth stage. Use minimum of 20 gpa spray volume at 40-50 psi. Split applications 7-10 days apart, applying 1.5-2.0 pt each usually improves nutsedge control. Addition of 2,4-DB improves control of morningglory and spurred anoda. Do not apply more than 4.0 pt/A/season. **Do not add crop oil concentrate, AMS or other additives if Butyrac is in tank mix.**

[1]See Table 5.106 for adjuvant recommendations.

Table 5.98 - Postemergence (cont.)

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
Same as for bentazon alone; however, the addition of 2,4-DB improves control of morningglory and spurred anoda.	Bentazon 0.75-1.0 lb + 2,4-DB 0.12 lb	Basagran 4SC 1.5-2.0 pt + Butyrac 2SC 8 fl oz	Apply in a minimum of 20 gpa spray volume and 40 psi. Apply to actively growing or small weeds. Avoid drift to other crops. **Label directions prohibit addition of oil concentrate or other additives.** Do not apply within 45 days of harvest or make more than two applications/year.
Cocklebur, eastern black nightshade, ragweed, eclipta, jimsonweed, morningglory, and pigweed.	Lactofen 0.2 lb	Cobra 2EC 12.5 fl oz	Apply to actively growing weeds after peanut reaches the 6 true-leaf stage. Do not apply sequential application within 14 days of the first. Good coverage by spray solution is important. Use a minimum of 25-40 gpa and spray pressure of 40-60 psi. No more than 2 appl./season. See label for adjuvant use. Do not apply within 45 days of harvest. May be tank mixed with Butyrac to enhance spectrum of weeds controlled. In tank mixes, use nonionic surfactants, not crop oil.
Common ragweed, jimsonweed, morningglory, pigweed, carpetweed, purslane, cocklebur, tropic croton, lambsquarters, black nightshade, smartweed, spotted and prostrate spurge, wild mustard	Acifluorfen 0.25-0.38 lb	Ultra Blazer 2L 1.0-1.5 pt	Apply when broadleaf weeds are small and actively growing. Refer to label for proper growth stage of weed. Good coverage by spray solution is important. Follow label directions concerning best application procedures and rates for different weed sizes to be controlled. Use a minimum of 25-40 gpa, and spray pressure of 40-60 psi. Do not use flood tips. Add 2.0 pt/A crop oil concentrate or 1.0 pt nonionic surfactant/100 gal of spray solution. Do not apply more than 2.0 pt/A of Ultra Blazer postemergence/season. Allow at least 15 days between sequential applications. May be tank mixed with Butyrac to enhance spectrum of weeds controlled. May be applied at 1 pt/A for control of pitted morningglory, jimsonweed, tropic croton, and common ragweed 2 inches tall or less. Do not apply within 75 days of harvest.

[1]See Table 5.106 for adjuvant recommendations.

Table 5.98 - Postemergence (cont.)

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
Morninglories, pigweeds, velvetleaf, yellow nutsedge, purple nutsedge	Imazethapyr 0.063 lb	Pursuit 2EC 4.0 oz	Apply from ground crack to early postemergence when weeds are actively growing and are less than 3 inches tall. Certain weeds such as common lambsquarters, prickly sida, and velvetleaf should be treated when 2 inches or less. Apply with a nonionic surfactant (1.0 qt/100 gal spray volume). Do not apply more than 0.063 lb ai/A/season (4.0 oz/A). Do not apply within 85 days of harvest. See label for rotational restrictions.
Spurred anoda, morning-glories, pigweeds, velvetleaf, yellow and purple nutsedge, sicklepod	Imazapic 0.063	Cadre 2EC 4.0 oz	Apply when broadleaf weeds are actively growing and are less than 3 inches tall. Certain weeds such as common lambsquarters, prickly sida, palmer amaranth, velvetleaf, and spurred anoda should be treated when 2 inches tall or less. Apply with 1.0 qt/A crop oil concentrate or 1.0 qt nonionic surfactant/100 gal spray solution. Apply as a sequential treatment following application of a soil-applied grass control herbicide. See label for rotational restrictions.
Annual grasses	Sethoxydim 0.28 lb or Clethodim 0.125-0.25 lb	Poast 1.5EC 1.5 pt[1] or Poast Plus 1EC 2.25 pt Select 2EC 8.0-16.0 oz or Select Max 0.97EC 9.0-16.0 oz or various other commercial formulations	Apply to actively growing grasses. See label and Table 3 for maximum grass size to treat. In general, annual grasses should be 2-4 inches for best results. Do not apply within 40 days of harvest. See labels for tank-mix instructions.
Bermudagrass	Clethodim 0.125-0.25 lb + Crop Oil concentrate	Select 2EC 8.0-16.0 oz or Select Max 0.97EC 12.0-32 oz or various other formulations COC 2.0 pt	Apply to actively growing bermudagrass when stolons (runners) are 3 to 6 inches in length. If needed, a second application of 8.0 to 16.0 oz/A may be applied for control of regrowth when stolons are 3 to 6 inches in length.

[1]See Table 5.106 for adjuvant recommendations.

Table 5.98 - Postemergence (cont.)

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
	Sethoxydim 0.28 lb	Poast 1.5EC 1.5 pt[1] or Poast Plus 1.0EC 2.25 pt	Apply to actively growing bermudagrass before plant stolon (runner) length exceeds 6 inches. A second application of 1.0 pt/A Poast or 1.5 pt/A Poast Plus is usually necessary for good control. Make the second application when stolon regrowth is 1-4 inches in length.
Rhizome Johnsongrass	Clethodim 0.125-0.25 lb	Select 2EC 8.0-16.0 oz[1] or Select Max 0.97EC 12.0-32.0 oz or various other commercial formulations	Apply to actively growing johnsongrass when 12 to 24 inches tall. If needed, a second application of 6.0 to 8.0 oz/A may be applied for control of regrowth when plants are 6 to 18 inches tall.
	Sethoxydim 0.28 lb	Poast 1.5EC 1.5 pt[1] or Poast Plus 1EC 2.25 pt or Select 0.97EC 16.0-32.0 oz	Apply to actively growing johnsongrass when 15-25 inches tall. A second application of 1.0 pt/A Poast or 1.5 pt/A Poast Plus may be made when new plants or regrowth are 6-12 inches tall.
Extended late-season residual grass control	S-Metolachlor 0.95-1.27 lb	Dual Magnum 7.62EC 1.0-1.33 pt	Apply over the top of peanuts for control of late-season grasses in years when excessive rains may have reduced the residual control of early-season applications. Will not control emerged grasses. Do not apply within 90 days of harvest. Do not apply more than the equivalent of 2.67 lb ai/A s-metolachlor during any one year. Dual II G Magnum and Dual II Magnum are not registered for this method of application in peanuts.

[1]See Table 5.106 for adjuvant recommendations.

Table 5.98 - Postemergence (cont.)

Weed problem	Chemical Rate Per Acre	Product Per Acre	Remarks
Extended late-season residual grass control	Acetochlor 0.94 to 1.5	Warrant 3ME 2.5-4 pt	Apply over the top to peanut after crop emergence up through the R1 growth stage (beginning bloom) for control of late-season grasses in years when excessive rains may have reduced the residual control of early-season applications. Will not control emerged grasses. Do not apply more than 3 lb/A per year. Will not control nutsedge or adequately control Texas panicum.

[1]See Table 5.106 for adjuvant recommendations.

Table 5.99 - Weed Species Response to Soil-applied Herbicides for Peanuts[1]

	Sonalan	Prowl PPI[2]	Dual PPI/PRE[2]	Warrant PP/PRE[2]	Outlook PPI/PRE[2]	Strongarm PPI/PRE[2]	Pursuit PPI[2]	Pursuit PRE[2]	Sequence PRE[2]	Valor PRE[2]
Texas panicum	G-E	G-E	P	P-F	P-F	P	P-F	P-F	P	PF
Barnyardgrass	G-E	G-E	G	G	G	P	G	G	F-G	PF
Crabgrass	E	E	E	E	E	P	F	P-F	F-G	PF
Goosegrass	E	E	E	E	E	P	P	P	F-G	F
Fall panicum	G-E	G-E	G	G	G-E	P	P-F	P-F	F-G	PF
Signalgrass, broadleaf	G-E	G	G	F-G	G	P	G	G	P-F	P
Foxtails	E	E	G	G	G	P	F-G	F-G	F-G	PF
Nutsedge, yellow	N	N	G	N	F-G	F-G	F-G	F-G	P-F	P
Nutsedge, purple	N	N	P	N	P	F-G	F-G	P	P-F	P
Cocklebur	N	N	P	N	P	G	G	G	N	PF
Jimsonweed	P	P	P	N	P	G-E	G	G	N	G
Lambsquarters, common	G	G	F	F	P	F-G	G	F-G	P	GE
Morningglory	P	P	P	N	P	G	F-G	F-G	N	GE
Pigweed spp.	G	G	G-E	G-E	G-E	G	E	E	F-G	E
Prickly sida (teaweed)	P	P	P	P	P-F	F-G	G	G	N	FG
Ragweed	P	P	P	P	P-F	G-E	P	P	P	GE
Smartweed	P	P	P	N	P-F	G	G	G	P	–
Eclipta	P	P	P	P	P	G	P	P	G	G

[1]Control capabilities:
E = Excellent control, 90% or better G = Good control, 80%-90% F = Fair control, 60%-80%
N = None, less than 20% P = Poor control, 20%-60%

[2]Application method:
PPI = Preplant soil incorporated PRE = Preemergence

Table 5.99 - Weed Species Response to Soil-applied Herbicides for Peanuts[1] (cont.)

	Sonalan	Prowl PPI[2]	Dual PPI/PRE[2]	Warrant PP/PRE[2]	Outlook PPI/PRE[2]	Strongarm PPI/PRE[2]	Pursuit PPI[2]	Pursuit PRE[2]	Sequence PRE[2]	Valor PRE[2]
Carpetweed	G	G	F	F-G	F-G	G	F-G	F-G	E	F
Sicklepod	P	P	P	P	P	P	P	P	N	P
Spurred anoda (cottonweed)	P	P	P	P	P	F-G	G	G	G	F
Velvetleaf	P	P	P	P	P	G-E	F-G	F-G	P	F
Tropic croton	P	P	P	P	P	F	P	P	F	–

[1]Control capabilities:
E = Excellent control, 90% or better G = Good control, 80%-90% F = Fair control, 60%-80%
N = None, less than 20% P = Poor control, 20%-60%

[2]Application method:
PPI = Preplant soil incorporated PRE = Preemergence

Table 5.100 - Weed Species Response to Postemergence Herbicides for Peanuts

	Pursuit AC/EPOE	Paraquat AC[2]	2,4-DB POE	Paraquat + 2,4-DB AC	Paraquat + Basagran AC	Basagran[3] POE	Blazer POE	Cadre[6] POE	Storm [4,5] POE	Select, Select Max or Poast POE	Cobra POE
Texas panicum	P-F	E	N	G-E	F	N	P	G-E	N	E	N
Barnyardgrass	G	G	P	G	P-F	N	P	G-E	N	E	N
Crabgrass	P-F	G	P	G	P-F	N	P	G-E	N	E	N
Goosegrass	P	E	P	G-E	P-F	N	P	G-E	N	E	N
Fall panicum	P-F	E	P	F-G	P-F	N	P	G-E	N	G	N
Signalgrass, broadleaf	G	E	P	G-E	P-F	N	P	G-E	N	E	N
Foxtails	G	E	P	G-E	P-F	N	P	G-E	N	E	N
Nutsedge, yellow	F-G	P-F	P	F	F-G	G	P	G-E	F	N	N

[1]Response expressed as activity on emerged seedlings in early stages of development at relatively low rates.

Control is erratic or poor on weeds if they are larger.
E = Excellent control, 90% or better G = Good control, 80%-90% F = Fair control, 60%-80%
N = Essentially no control, less than 20% P = Poor control, 20%-60%

Stage: PPI = Preplant soil incorporated POE = Postemergence PRE = Preemergence AC = At cracking

[2]Control of emerged weeds only, 1 inch tall or smaller.

[3]Assumes optimum conditions and addition of crop oil concentrate.

[4]Rating assumes optimum rates and ratios of Basagran and Ultra Blazer; see labels.

[5]Rating assumes weeds 2 inches tall or smaller.

[6]Cadre provides G-E control of emerged annual grasses which escape soil applied grass control herbicides.

[7]Rating assumes sequential application of 2,4-DB 10-14 days after initial treatment

Table 5.100 - Weed Species Response to Postemergence Herbicides for Peanuts (cont.)

	Pursuit AC/EPOE	Paraquat AC[2]	2,4-DB POE	Paraquat + 2,4-DB AC	Paraquat + Basagran AC	Basagran[3] POE	Blazer POE	Cadre[6] POE	Storm [4,5] POE	Select, Select Max or Poast POE	Cobra POE
Nutsedge, purple	F-G	P	N	N	N	N	N	G-E	N	N	N
Cocklebur	G	E	E	E	E	E	G	G-E	E	N	G
Jimsonweed	G	E	F	G	E	E	E	F-G	E	N	E
Lambsquarters, common	P	F	G	F-G	F-G	G	G	P-F	G	N	P
Morningglory	F-G	F	E	G-F	F	F-G	G-E	G-E	G	N	G
Pigweed spp.	E	E	G	G	G	P-F	E	E	G	N	E
Prickly sida (teaweed)	P	P-F	F	P	G	G	P	G	F-G	N	G
Ragweed, common	P	F	F-G	F	G	F-G	G	P-F	G	N	E
Smartweed	G	G	F	G	G	E	G	F-G	E	N	F
Eclipta	P	F-G	P	P	F	P	G	F	G-E	N	G
Carpetweed	F-G	F-G	F	F-G	P	P	G	G	G	N	G
Sicklepod	P	G[7]	G[7]	G[7]	G[7]	N	P	E	P	N	P
Spurred anoda (cottonweed)	F-G	P	P	P	G	G	P	G	F	N	F
Velvetleaf	F-G	F	P	F	G	G	P-F	G-E	F-G	N	G
Tropic croton	P	F	P-F	F	F	P	G-E	P	G-E	N	G

[1]Response expressed as activity on emerged seedlings in early stages of development at relatively low rates.

Control is erratic or poor on weeds if they are larger.
E = Excellent control, 90% or better G = Good control, 80%-90% F = Fair control, 60%-80%
N = Essentially no control, less than 20% P = Poor control, 20%-60%

Stage: PPI = Preplant soil incorporated POE = Postemergence PRE = Preemergence AC = At cracking

[2]Control of emerged weeds only, 1 inch tall or smaller.

[3]Assumes optimum conditions and addition of crop oil concentrate.

[4]Rating assumes optimum rates and ratios of Basagran and Ultra Blazer; see labels.

[5]Rating assumes weeds 2 inches tall or smaller.

[6]Cadre provides G-E control of emerged annual grasses which escape soil applied grass control herbicides.

[7]Rating assumes sequential application of 2,4-DB 10-14 days after initial treatment

Table 5.101 - Recommended Weed Sizes for Treatment and Application Rates for Control of Annual Grasses with Poast, Poast Plus, Select, and Select Max

Species	Application Rates and Annual Grass Size							
	Poast[1]		Poast Plus[1]		Select[1]		Select Max[1]	
	Height (in)	Rate (oz/A)	Height (in)	Rate (oz/A)	Height (in)	Rate (oz/A)	Height (in)	Rate (oz/A)
Broadleaf signalgrass	8	16	8	24	2-6	6-8	2-6	12-16
Crabgrass	6	16	6	24	2-6[2]	6-8	2-6[2]	12-16
Fall panicum	8	16	8	24	2-8	6-8	2-8	12-16
Giant foxtail	8	16	8	24	2-12	6-8	2-12	12-16
Green foxtail	8	16	8	24	2-8	6-8	2-8	12-16
Yellow foxtail	8	16	8	24	2-8	6-8	2-8	12-16
Goosegrass	6	16	6	24	2-6[2]	6-8	2-6	12-16
Seedling johnsongrass	8	16	8	24	4-10	6-8	4-10	12-16
Texas panicum	8	16	8	24	2-6	6-8	2-6	12-16
Volunteer corn	20	16	20	24	4-12 12-24[3] 4-12[4]	4-6 6-8 8	up to 12[3] up to 24[3] up to 36	8-12 9-14 12-16

[1]See Table 5.106 for adjuvant recommendations.

[2]Length of lateral growth.

[3]Includes Roundup Ready and Imi volunteer corn.

[4]Sethoxydim resistant corn (suppression only).

Table 5.102 - Plant Size And Application Rates for Control of Perennial Grasses with Poast, Poast Plus, Select, and Select Max

Application	Herbicide	Application Rate	Plant Size
Bermudagrass			
First application	Poast	1.5 pt/A[1]	stolons (runners) 6 inches or less
	Poast Plus	2.25 pt/A[1]	stolons (runners) 6 inches or less
	Select	8-16 oz/A[1]	stolons (runners) 3-6 inches
	Select Max	12-32 oz/A[1]	stolons (runners) 3-6 inches
Second application	Poast	1.0 pt/A[1]	stolons (runners) 1-4 inches
	Poast Plus	1.5 pt/A[1]	stolons (runners) 1-4 inches
	Select	8-16 oz/A[1]	stolons (runners) 3-6 inches
	Select Max	12-32 oz/A[1]	stolons (runners) 3-6 inches
Johnsongrass			
First application	Poast	1.5 pt/A[1]	plants 15-25 inches tall
	Poast Plus	2.25 pt/A[1]	plants 15-25 inches tall
	Select	8-16 oz/A	plants 12-24 inches tall
	Select Max	12-32 oz/A[1]	plants 12-24 inches tall
Second application	Poast	1.0 pt/A[1]	plant/regrowth 6-12 inches tall
	Poast Plus	1.5 pt/A[1]	plant/regrowth 6-12 inches tall
	Select	6-8 oz/A[1]	plant/regrowth 6-18 inches tall
	Select Max	9-24 oz/A[1]	plant/regrowth 6-18 inches tall

[1]See Table 5.106 for adjuvant recommendations.

Table 5.103 - Recommended Weed Sizes for Treatment and Application Rates for Control of Annual Broadleaf Weeds with Basagran, Blazer, and Storm

	1.0 pt/A Basagran		1.5 pt/A Basagran		2.0 pt/A Basagran		1.5 pt/A Storm	
Species	**Max. Leaf Number**	**Max. Ht. (inches)**	**Max. Leaf Number**	**Max. Ht. (inches)**	**Max. Leaf Number**	**Max. Ht. (inches)**	**Max. Leaf number**	**Max. Ht. (inches)**
Prickly sida	—	—	6	3	6-8	4	4	2
Common ragweed	—	—	—	—	4-6[1]	3[1]	4-6	3
Cocklebur	2-4	4	2-6	6	6-10	10	2-6	6
Morningglory								
Pitted	—	—	4[2]	4[2]	SUD[2]	SUD[2]	4	2
Others	—	—	4[2]	4[2]	SUD[2]	SUD[2]	4	2
Smartweed	4[4]	4[4]	6	6	6-10	10	6	6
Jimsonweed	4	4	6	6	6-10	10	6	6
Pigweed	—	—	—	—	—	—	—	—
Lambsquarters	—	—	6[4]	1.5[4]	4-8[4]	2[4]	4-6	2
Tropic croton	—	—	2	2	2-4	4	2[3]	<2
Spurred anoda	—	—	6	3	6-8	4	4[5]	2[5]
Velvetleaf	4	2	4[1]	2[1]	4-6	5	4[5]	2[5]
Eclipta	—	—	6	2	6	2	6	<2

	0.5 pt/A Ultra Blazer[3]		1.0 pt/A Ultra Blazer[3]		1.5 pt/A Ultra Blazer[3]		12.5 fl oz Cobra[12]
Species	**Max. Leaf Number**	**Max. Ht. (inches)**	**Max. Leaf Number**	**Max. Ht. (inches)**	**Max. Leaf Number**	**Max. Ht. (inches)**	**Max. Leaf Number**
Prickly sida	—	—	—	—	—	—	4
Common ragweed	—	—	2	2	4	3	8
Cocklebur	—	—	—	—	2	2	6
Morningglory							
Pitted	2	<2	2	2	4	4	4
Others	—	—	—	—	3	2	4[1]
Smartweed	—	—	4	4	6	6	4[7]
Jimsonweed	—	—	4	4	6	6	4
Pigweed	4	2	6	4	6	4	6
Lambsquarters	—	—	—	—	2[3]	2[3]	—
Tropic croton	—	—	1-2	<2	2	2	4
Spurred anoda	—	—	—	—	—	—	4[7]
Velvetleaf	—	—	—	—	—	—	4[7]
Eclipta	—	—	—	—	6	<2	6

[1]Add crop oil concentrate, UAN, or both according to label directions.

[2]See label for Special Use Directions. Label claims control only with two applications.

[3]Add 1.0 pt of nonionic surfactant/100 gal of spray solution.

[4]Follow with second application of 1.0 pt/A, 7-14 days later if needed.

[5]Control may be inconsistent with this rate of Storm.

[6]Add crop oil concentrate or nonionic surfactant according to label directions.

[7]Suppression only

Table 5.104 - Restrictions on Feeding Herbicide-treated Peanut Vines to Livestock and Preharvest Intervals (PHI) for Peanut Herbicides

Herbicide	PHI	Do not feed treated vines to livestock	No feeding restrictions on label
Basagran	through pegging		X
Ultra Blazer	75 days	X	
Cadre	90 days	X	
Cobra	45 days	X	
Dual	90 days	within 30 days of treatment	
Gramoxone SL 2.0			X
Outlook	80 days	within 80 days of treatment	
Poast/Poast Plus	40 days	X	
Prowl	preplanting		X
Pursuit	85 days	X	
Select/Select Max	40 days	X	
Sonalan	preplanting	X	
Strongarm	30 days	X	
Storm	75 days	X	
Valor		X	
Warrant	through R1	within 90 days of treatment	
Zidua	None		X
2,4-DB (Butyrac)	45 days	X	

[1]NS = not specified on label

Table 5.105 - Suggested Rain-free Periods after Applications of Postemergence Herbicides and Tank Mixes

Herbicide or tank mix	Rain-free period (hours)
2,4-DB	NR1
Basagran	4
Ultra Blazer	4
Cadre	3
Cobra	0.5
Gramoxone SL 2.0	0.5
Poast/Poast Plus	1
Pursuit	1
Select/Select Max	1
Storm	4

NR1 = No restrictions on label. Suggest at least 1 hour for best results.

Table 5.106 - Adjuvant Recommendations for Postemergence Herbicides

Herbicide	Application Method	Adjuvant recommendations
Basagran	Ground	2.0 pt/A crop oil concentrate when treating lambsquarters, common ragweed, hemp sesbania, or yellow nutsedge. Vegetable oils may be used. Use 1.0 gal/A of 30% nitrogen instead of crop oil concentrate if velvetleaf is the primary target weed.
	Air	1.0 pt/A crop oil concentrate when treating lambsquarters, common ragweed, hemp sesbania, or yellow nutsedge. Vegetable oils may be used. Do not use 30% nitrogen with aerial applications.
Ultra Blazer	Ground or Air	Use 0.125 percent nonionic surfactant for most weeds. For lambsquarters, hemp sesbania, or cowpea, use 0.25 percent nonionic surfactant or 0.5 to 1.0 gal/A of 30% nitrogen.
Cadre	Ground only	Use 0.25 percent nonionic surfactant or 2 pt/A crop oil concentrate.
Select	Ground or Air	Always use a crop oil concentrate containing at least 15% emulsifier at 2.0 pt/A (ground) and 1pt/A(air) in the finished spray volume.
Select Max	Ground	0.25% non ionic surfactant, 1% crop oil concentrate, or 1% methylated seed oil.
Gramoxone SL 2.0	Ground	Use 0.125 percent nonionic surfactant in cracking stage sprays.
Poast/ Poast Plus	Ground or Air	2.0 pt/A crop oil concentrate. Vegetable oils may be used.
Pursuit	Ground	Use a petroleum or vegetable seed based oil concentrate at a rate of 1.5 to 2.0 pt/A or a nonionic surfactant containing at least 80% active ingredient at 1 qt/100 gallons of spray mixture.
Storm	Ground or Air	1.0 pt/A crop oil concentrate. Vegetable oils may be used.
Cobra	Ground or Air	Add nonionic surfactant at 1 qt/100 gal or petroleum or vegetable based crop oil concentrate at 1-1.5 pt/A. (See label for specifics.)

Note: Information in this table was taken from product labels. See the labels. See the labels for adjuvant recommendations with specific tank mixes.

Adjuvant rates given in percentages are on a volume/volume basis:
0.125 percent - 1 pint per 100 gallons of spray solution
0.25 percent - 1 quart per 100 gallons of spray solution
0.50 percent - 2 quarts per 100 gallons of spray solution
1.00 percent - 4 quarts per 100 gallons of spray solution

Table 5.107 - Rotational Restrictions for Peanut Herbicides

	Rotational Crop							
	Corn	**Cotton**	**Soybeans**	**Barley**	**Winter Rye**	**Wheat**	**Sorghum**	**Tobacco**
Basagran	NS	NS	NS	NS	NS	NS	NS	NS
Ultra Blazer	AH	AH	NR	AH	AH	AH	AH	AH
Cadre	9M	18M	9M	18M	4M	4M	18M	9M
Cobra	NR	NR	NR	NR	NR	NR	NR	NR
Dual Magnum (PRE, PPI, Cracking)	NR	NR	NR	4.5M	4.5M	4 5M	NR	FY
Outlook	NR	FY	NR	4M	4M	4M	FY	FY
Poast	NR	NR	NR	NR	NR	NR	NR	NR
Poast Plus	NR	NR	NR	NR	NR	NR	NR	NR
Prowl	NR	NR	NR	4M	FY	4M	FY	NR
Pursuit	NR/8.5M[1]	9.5M/18M[2]	NR	9.5M	4M	4M	18M	9.5M
Select/Select Max	1M	1M	NR	1M	1M	1M	1M	1M
Sonalan	FY	FY	NR	AH	AH	AH	FY	FY
Strongarm	18M/10M[3]	10M	NR	4M	6M	4M	18M	18M
Storm	AH	AH	AH	AH	AH	AH	AH	AH
Valor	0.5/1M[4]	1M	NR	4M	3M	1M	1M	1M
Warrant	NR	NR	NR	FY	FY	4	NR	FY
Zidua	NR	2[5]	NR	11	11	1	6	18
2,4-DB	NS	NS	NS	NS	NS	NS	NS	NS

The above table provides a general summary of crop rotation restrictions specified in the labels of herbicide products commonly used for peanuts. Consult product labels for details and specific information.

KEY: M = Month; FY = Following Year; NR = No Restrictions; AH = After Harvest; NS = Crop rotation sequences not specified in label directions

[1] With IMI-Corn (resistant/tolerant varieties) = NR, with Non IMI-Com = 8.5M.

[2] For sandy loam to loamy sand soils with 16 inches of rainfall or irrigation occurring from application through October, 9.5M; (refer to supplemental label of Virginia/North Carolina) otherwise, 18M.

[3] With IMI corn (resistant/tolerant varieties) = 10M, with Non IMI corn = 18M.

[4] 1M restriction for sweet corn, field corn (conventional), 0.5M for minimum or no-till field corn.

[5] 1M restriction for cotton if Zidua is applied at 1 oz/A or less.

Cotton

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Table 5.108 - Early Preplant Burndown and Preplant Incorporated

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Barnyardgrass, broadleaf signalgrass, carpetweed, crabgrass, fall panicum, Florida pusley, foxtails, goosegrass, johnsongrass seedlings, lambsquarters, pigweed, purslane, sandbur, Texas panicum, wild cane, shattercane	Pendimethalin 0.5-0.75 lb ai	Prowl 3.3EC 1.2-1.8 pt or Prowl H_2O 3.8ACS 1.1-1.6 pt	Apply and incorporate 1-2 inches deep within 7 days after application. Follow label for proper soil incorporation procedures. Lower rate is safest to cotton.
Barnyardgrass, broadleaf signalgrass, carpetweed, crabgrass, fall panicum, Florida pusley, foxtails, goosegrass, johnsongrass seedlings, lambsquarters, pigweed, purslane, sandbur, Texas panicum, wild cane, shattercane	Trifluralin 0.5-0.75 lb ai	Treflan 4EC 1.0-1.5 pt	Incorporate within 24 hours after application. Follow label for proper soil incorporation procedures. Lower rate is safest to cotton.
Controls most annual grasses and broadleaf weeds	Glyphosate 0.56-1.13 lb ae	Numerous brands and formulations	Apply any time prior to planting. Control of cutleaf eveningprimrose, field pansy, Carolina geranium, and wild radish may not be adequate. Rates suggested for terminating cover crops: Wheat < 12 in.: 0.56 lb ae Wheat > 12 in.: 0.75 lb ae Rye < 12 in.: 0.56 lb ae Rye > 12 in.: 0.75 lb ae
Many grass and broadleaf weeds	Paraquat 0.65-1 lb ai	Numerous brands and formulations	Apply any time prior to planting to control emerged weeds. Add nonionic surfactant at 1 pt per 100 gal or crop oil concentrate at 1 gal per 100 gal. Follow directions and precautions on label. Not effective on cutleaf eveningprimrose, horseweed, or larger wild mustard and wild radish. Apply 0.63 lb ai for wheat and 0.5 lb ai for rye cover crops.
Many grass and broadleaf weeds	Glufosinate 0.53-0.79 lb ai	Liberty 280 SL 2.34L 29-43 fl oz	Can be applied prior to emergence of any transgenic or conventional cotton variety to control emerged weeds. If greater than 29 oz applied preplant, the seasonal total applied cannot exceed 72 fl oz. Control greatly affected by temperature; apply on a sunny day with temperature above 75 degrees. Less effective than glyphosate on grasses.

Table 5.108 - Early Preplant Burndown and Preplant Incorporated (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Many broadleaf weeds	2,4-D 0.24-0.95 lb ae	Numerous brands and formulations	Most, but not all, brands of 2,4-D may be applied at least 30 days ahead of cotton planting. Excellent control of cutleaf eveningprimrose. Not effective on Carolina geranium. To control glyphosate-resistant horseweed, 0.95 lb ae is needed. **Cotton containing the Enlist trait can be planted anytime following Enlist One application.**
Many broadleaf weeds	Glyphosate 0.74-1.0 lb ae + 2,4-D 0.7-0.95 lb ae	Enlist Duo 3.3S 3.5-4.75 pt	Apply at least 30 days ahead of planting any cultivar not containing the Enlist trait. **Enlist Duo may be applied through planting for Enlist cultivars. See website listed on Enlist Duo label for details on tank mixing and use of drift reduction agents.** Excellent control of cutleaf eveningprimrose. To control glyphosate-resistant horseweed 4.75 pt/A is needed. Current label does not allow tank mixing with other herbicides.
Many broadleaf weeds	Dicamba 0.25 lb ai	Clarity 4S 8 fl oz or Engenia 5S 6.4 fl oz or XtendiMax 2.9S 11 fl oz	Following application of dicamba and a minimum of 1 in. of rainfall, a waiting period of at least 21 days is required before planting and cultivar not containing the XtendFlex trait. **Engenia and XtendiMax can be applied through planting of XtendFlex cultivars. See websites listed on Engenia and XtendiMax labels for details on tank mixing and use of drift reduction agents.** Suppresses Carolina geranium and curly dock. Less effective on cutleaf eveningprimrose than 2,4-D. Clarity will control horseweed.
Lambsquarters, morningglory species, nightshade species, pigweed species, velvetleaf, spurred anoda, purslane, hemp sesbania, prostrate spurge, and Pennsylvania smartweed	Carfentrazone 0.008-0.016 lb ai	Aim 2EC 0.5-1 fl oz	There is no waiting period between application and cotton planting. Added to glyphosate, Aim will increase speed of control and may improve control of some species. Will not control cutleaf eveningprimrose or horseweed.
Common ragweed, smooth pigweed, morningglory species, and velvetleaf	Flumiclorac pentyl ester 0.013-0.027 lb ai	Resource 0.86EC 2-4 fl oz	There is no waiting period between application and cotton planting. Added to glyphosate, Resource will increase speed of control and may improve control of some species. Will not control cutleaf eveningprimrose or horseweed.

Table 5.108 - Early Preplant Burndown and Preplant Incorporated (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Common ragweed, pigweed species, morningglory species, and velvetleaf	Pyraflufen ethyl 0.0008-0.0032 lb ai	ET 0.208EC 0.5-2 fl oz	There is no waiting period between application and cotton planting. Added to glyphosate, ET will increase speed of control and may improve control of some species. Will not control cutleaf eveningprimrose or horseweed.
Lambsquarters, morningglory species, nightshade species, pigweed species, velvetleaf, spurred anoda, purslane, hemp sesbania, prostrate spurge, and Pennsylvania smartweed.	Flumioxazin 0.031 to 0.063 lb ai	Valor SX 1-2 oz	In no-till or stale seedbed system, a minimum of 14 days must pass and a 1 in. rainfall must occur between Valor SX application and cotton planting when Valor SX is applied at 1 oz/A; 21 days must pass when applied at 1.5 to 2 oz/A. If a strip-till operation occurs between Valor SX application and cotton planting, the waiting interval can be reduced to 14 days for the 2 oz/A rate. However, strip-tillage after Valor SX will reduce or eliminate weed control in the tilled strip. Adding Valor SX to glyphosate will improve control of cutleaf eveningprimrose and wild radish. Applied at 1 oz/A, Valor SX will give 2 to 4 weeks residual control of lambsquarters, pigweed, prickly sida, spurge, and Florida pusley. At 2 oz/A, Valor SX will give 6 to 8 weeks residual control of these species. Application to cover crops or dense winter vegetation may reduce residual control. Will not control emerged horseweed. **Carefully follow label direction for cleaning out the sprayer after each day's use. Generic brands of flumioxazin include Outflank and Panther.**
Carolina geranium, common chickweed, curly dock, henbit, swinecress, Virginia pepperweed, wild mustard, and wild radish	Thifensulfuron 0.0156 lb ai + Tribenuron 0.0078 lb ai	Harmony Extra SG with TotalSol 50WDG 0.75 oz	Harmony Extra should be applied at least 14 days prior to planting. Add nonionic surfactant according to Harmony Extra label. Not effective on cutleaf eveningprimrose or horseweed.

Table 5.108 - Early Preplant Burndown and Preplant Incorporated (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Common chickweed, curly dock, dandelion, Carolina geranium, henbit, lambsquarters, pigweed species, smartweed species, velvetleaf, wild mustard, and wild radish	Rimsulfuron 0.0156 lb ai + Thifensulfuron 0.0156 lb ai	Leadoff 33.4 WDG 1.5 oz	Can be applied from late fall to 30 days prior to planting. Controls emerged winter annual weeds plus provides residual control of later emerging winter weeds. See Leadoff label for adjuvant recommendations. Can be tank mixed with glyphosate and 2,4-D. Does not substitute for Valor SX. The best fit for Leadoff is a late fall or winter application (December to early March) followed by another burndown application containing Valor SX 2 to 4 weeks prior to planting. Crusher 50 WDG is a generic containing a 1:1 ratio of rimsulfuron:thifensulfuron.
Carolina geranium, common chickweed, curly dock, henbit, swinecress, Virginia pepperweed, wild mustard, and wild radish	Thifensulfuron 0.008-0.013 lb ai + Tribenuron 0.008-0.013 lb ai	FirstShot SG 50WDG 0.5-0.8 oz	FirstShot should be applied at least 14 days prior to planting. Add nonionic surfactant according to FirstShot label. Weed control similar to Harmony Extra. Not effective on cutleaf eveningprimrose or horseweed. Generic brands containing a 1:1 ratio of thifensulfuron:tribenuron include Edition BroadSpec and Rapport BroadSpec.
Fair control of cocklebur, morningglory species, jimsonweed, sicklepod, prickly sida, and sesbania; good control of lambsquarters, pigweed species, purslane, and ragweed	Diuron 0.5-1 lb ai	Direx 4L 4F 1-2 pt	Apply 15 to 45 days ahead of planting. Can improve control of certain weeds, including cutleaf eveningprimrose, when tank mixed with Gramoxone. If Cotoran is applied preemergence, reduce Cotoran rate to account for residual activity of Direx. Do not apply Di-Syston or Thimet in-furrow.

Table 5.109 - Preemergence

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Fair control of cocklebur, morninglories, jimsonweed, sicklepod, and tropic croton; good control of lambsquarters, pigweed species, prickly sida, and ragweed	Fluometuron 1.0-2.0 lb ai	Cotoran 4L 1.0-2.0 qt	Apply to soil surface after planting, before crop and weeds emerge. **On light, sandy soils, low in organic matter, use no more than 1.0 lb ai/A**. Not labeled for use on sand or loamy sand soils.
Fair control of cocklebur, morninglories, jimsonweed, sicklepod, prickly sida, and sesbania; good control of lambsquarters, pigweed species, purslane, and ragweed	Diuron 0.5-1 lb ai	Direx 4L 1-2 pt or Diruon 4L	Apply to soil surface after planting, before crop and weeds emerge. On light, sandy soils, low in organic matter, use no more than 0.5 lb ai/A. Not labeled for use on sand or loamy sand soils. Do not apply Di-Syston or Thimet in-furrow. May be mixed with Prowl, Reflex, Staple, or Warrant.

Table 5.109 - Preemergence (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Annual grasses and pigweed species	Acetochlor 1.125 lb ai	Warrant 3ME 3 pt	Research to date indicates good crop tolerance. May be mixed with Cotoran, Direx, Prowl, or Reflex. Any conditions that delay emergence of cotton may cause growth reduction and uneven growth. If soil is left undisturbed, a waiting interval of 3 weeks is suggested before replanting cotton. Following a deep tillage operation (heavy enough to bring nontreated soil into the planting zone), cotton may be replanted after waiting 2 weeks.
Annual grasses and many broadleaf weeds	Acetochlor 1.06 lb ai + Fomesafen 0.24 lb ai	Warrant Ultra 3.45CS 3 pt	Warrant Ultra is a premix formulation containing 2.82 lb/gal acetochlor plus 0.63 lb/gal fomesafen. Use preemergence only on coarse-textured soils. **Warrant Ultra at 3 pt/A has the equivalent of 15.4 fl oz/A of Reflex. See comments for Reflex below.**
Barnyardgrass, broadleaf signalgrass, carpetweed, crabgrass, fall panicum, Florida pusley, foxtails, goosegrass, johnsongrass seedlings, lambsquarters, pigweed, purslane, sandbur, Texas panicum, wild cane, shattercane	Pendimethalin 0.5-0.75 lb ai	Prowl 3.3EC 1.2-2.4 pt or Prowl H_2O 3.8ACS 1.1-1.6 pt	Apply at planting or up to 2 days following planting to a firm seedbed.
Pigweed species, eclipta, lambsquarters, eastern black nightshade, purslane, ragweed, prickly sida; partially controls spurred anoda, cocklebur, morninglories, and yellow nutsedge	Fomesafen 0.25 lb ai	Reflex 2L 1 pt	Suggested primarily for control of Palmer amaranth. Also effective on yellow nutsedge. Label restricts application to coarse-textured soils. May be mixed with Cotoran, Direx, Prowl, Staple, or Warrant. See label for specific comments on tank mixing. In a tank mix, one may consider reducing the Reflex rate to 12 fl oz/A to reduce the potential for crop injury.
Redroot pigweed, smooth pigweed, prickly sida, spotted spurge, spurred anoda, velvetleaf, and suppresses jimsonweed, ladysthumb smartweed, Pennsylvania smart and several morningglory species	Pyrithiobac 0.033-0.053 lb ai	Staple LX 3.2SL 1.3-2.1 oz	Use the higher rate for harder to control weeds but do not exceed 2.1 fl oz/A and do not use on soils with less than 0.5% organic matter. Staple Herbicide may be mixed with several other preemergence herbicides (Cotoran, Direx, Karmex, or Cotton Pro) taking care not to exceed recommended rates of these herbicides for soil types. Do not apply more than 5.1 fl oz/A Staple Herbicide per acre per year.

Table 5.109 - Preemergence (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Herbicide-resistant Palmer amaranth	Fluridone 0.15-0.3 lb ai	Brake 1.2F 16-32 fl oz	Label specifies to tank mix with another residual herbicide when Brake is applied at less than 21 fl oz/A. Suggested tank mixes include Cotoran, Direx, Reflex, or Warrant. If applied alone, Brake will be most effective at 32 fl oz/A. See label for rotational restrictions. Suggested primarily for fields infested with herbicide-resistant Palmer amaranth. Preliminary data also suggest Brake has some common ragweed activity.

Table 5.110 - Postemergence Over-the-top: Annual Grasses

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Barnyardgrass, broadleaf signalgrass, fall panicum, foxtails, johnsongrass seedlings, crabgrass, shattercane, Texas panicum, volunteer corn	Clethodim 0.094-0.25 lb ai + (see remarks)	Select 2EC 6.0-16.0 oz or Select Max 0.97EC 9.0-16.0 oz + (see remarks)	Apply to actively growing grasses at the rate and size range indicated on the label for the individual grass species. Apply with 5.0-40.0 gal of water/A and 30-60 psi. Under certain conditions use a minimum of 10.0 gal - see label. Do not use flood-type nozzles. Always add 2.0 pt/A crop oil concentrate to Select. For Select Max, add 0.25% nonionic surfactant, 1% crop oil concentrate, or 1% methylated seed oil. May be weak on goosegrass.
Barnyardgrass, broadleaf signalgrass, fall panicum, foxtails, johnsongrass, crabgrass, shattercane, Texas panicum, and volunteer corn	Sethoxydim 0.19-0.28 lb ai + crop oil concentrate	Poast 1.5EC 1.0-1.5 pt or Poast Plus 1EC 1.5-2.25 + crop oil concentrate 2.0pt	Apply to actively growing grasses at the rate and size range indicated on the label for the individual grass species with 5.0 gal of water/A and 40-60 psi. Do not use flood type nozzles. Always add 2.0 pt/A crop oil concentrate.
Barnyardgrass, broadleaf signalgrass, fall panicum, foxtails, johnsongrass seedlings, Texas panicum, goosegrass, shattercane and volunteer corn	Fluazifop-P 0.19 lb ai + crop oil concentrate or nonionic surfactant	Fusilade DX 2EC 12.0 oz + crop oil concentrate 0.5-1.0% v/v or nonionic surfactant 0.25% v/v	Apply to actively growing grasses at the rate and growth stage indicated on the label. Apply with a minimum of 10 gal of water/A and 30-60 psi. Do not use flood nozzles. Add 0.5-1.0% v/v crop oil concentrate or 0.25% v/v nonionic surfactant to the spray mixture.
Barnyardgrass, broadleaf, signalgrass, crabgrass, fall panicum, field sandbur, seedling johnsongrass, shattercane, Texas panicum, volunteer small grains	Fluazifop-P plus fenoxaprop-P 0.12-0.16 lb ai + crop oil concentrate or nonionic surfactant	Fusion 2EC 8.0-10.0 oz + crop oil concentrate 0.5-1.0% v/v or nonionic surfactant 0.25-0.5% v/v	Apply to actively growing grasses at the rate and growth stage listed on the label in 5.0-40.0 gal of water/A at 30-60 psi. Do not apply Fusion with recirculating sprayers, rope-wick applicators, controlled droplet applicators, or any similar devices. Add 0.5-1.0% v/v crop oil concentrate or 0.25-0.5% v/v nonionic surfactant to the spray mixture.
Barnyardgrass, broadleaf signalgrass, fall panicum, field sandbur, seedling johnsongrass, shattercane, Texas panicum	Quizalofop 0.034-0.069 lb ai + crop oil concentrate or nonionic surfactant	Assure II 0.88EC 5.0-12.0 oz + crop oil concentrate 1% v/v or nonionic surfactant 0.25% v/v	Apply to actively growing grasses at the rate and growth stage listed on the label. Apply with a minimum of 10.0-15.0 gal water/A and 25-60 psi. May be weak on crabgrass. See label for rate to control specific grasses.

Table 5.111 - Postemergence Over-the-top: Perennial Grasses

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Bermudagrass (wiregrass)	Clethodim 0.125-0.25 lb ai + crop oil concentrate + (sequential treatment on regrowth) Clethodim 0.125-0.25 lb ai + crop oil concentrate	Select 2EC 8.0-16.0 oz or Select Max 0.97EC 12.0-32.0 oz + (see remarks) + (sequential treatment on regrowth) Select 2EC 8.0-16.0 oz or Select Max 0.97EC 12.0-32.0 oz + (see remarks)	Apply to actively growing bermudagrass at the rate and stage indicated on the label. Apply the first application to bermudagrass with 3- to 6-inch runners. Apply regrowth treatments to bermudagrass with 3- to 6-inch runners. Always add 2.0 pt/A crop oil concentrate to Select. For Select Max, add 0.25% nonionic surfactant, 1% crop oil concentrate, or 1% methylated seed oil.
	Fluazifop-P + fenoxaprop-ethyl 0.19 lb ai + crop oil concentrate or nonionic surfactant + (sequential treatment on regrowth) Fluazifop P + fenoxaprop-ethyl 0.12 lb ai + crop oil concentrate or nonionic surfactant	Fusion 2EC 12.0 oz + crop oil concentrate 0.5-1.0% v/v or nonionic surfactant 0.25-0.5% v/v + (sequential treatment on regrowth) Fusion 2EC 8.0 oz + crop oil concentrate 0.5-1.0% v/v or nonionic surfactant 0.25-0.5% v/v	Make first application to 4- to 8-inch runners. Apply a second treatment to 4- to 8-inch runners if regrowth occurs. Use a minimum of 15.0 gal/A spray solution. Add 0.5-1.0% v/v crop oil concentrate or 0.25-0.5% v/v nonionic surfactant to the spray mixture.
	Sethoxydim 0.28 lb ai + crop oil concentrate + (sequential treatment on regrowth) Sethoxydim 0.19 lb ai + crop oil concentrate	Poast 1.5EC or Poast Plus 1EC 2.25 pt + crop oil concentrate 2.0 pt + (sequential treatment on regrowth) Poast 1.5EC 1.0 pt or Poast Plus 1EC 1.5 pt + crop oil concentrate 2.0 pt	Apply to actively growing grass. Apply first treatment to bermudagrass plants with stolons (runners) less than 6 inches in length. Apply regrowth treatments to bermudagrass plants with runners less than 4 inches in length. Add 2.0 pt/A crop oil concentrate.

Table 5.111 - Postemergence Over-the-top: Perennial Grasses (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Bermudagrass (wiregrass), Rhizome johnsongrass	Fluazifop-P 0.19 lb ai + crop oil concentrate or nonionic surfactant + (sequential treatment on regrowth) Fluazifop-P 0.125 lb ai + crop oil concentrate or nonionic surfactant	Fusilade DX 2EC 12.0 oz + crop oil concentrate 0.5-1.0% v/v or nonionic surfactant 0.25-0.5% v/v + (sequential treatment on regrowth) Fusilade DX 2EC 8.0 oz + crop oil concentrate 0.5-1.0% v/v or nonionic surfactant 0.25-0.5% v/v	Apply to actively growing johnsongrass 8-18 inches high. Apply regrowth treatments when 6-12 inches high. Add 0.5-1.0% v/v crop oil concentrate or 0.25-0.5% v/v nonionic surfactant to the spray mixture. OR Apply to actively growing bermudagrass with 4- to 8-inch runners. Apply regrowth treatments to bermudagrass with a runner length of 4-8 inches. Add 0.5-1.0% v/v crop oil concentrate or 0.25-0.5% v/v to the spray mixture.
	Quizalofop 0.07-0.08 lb ai + crop oil concentrate or nonionic surfactant + (sequential treatment on regrowth) Quizalofop 0.05 lb ai + crop oil concentrate or nonionic surfactant	Assure II 0.88EC 10.0-12.0 oz + crop oil concentrate 1.0% v/v or nonionic surfactant 0.25% v/v + (sequential treatment on regrowth) Assure II 0.88EC 10.0 oz + crop oil concentrate 1.0 % v/v or nonionic surfactant 0.25% v/v	Apply to actively growing johnsongrass when 10 to 24 inches tall or bermudagrass up to 6-inch runners. Apply regrowth treatments to 6- to 10-inch johnsongrass, or bermudagrass with 3- to 6-inch runners. Add 0.5-1.0% v/v crop oil concentrate or 0.25-0.5% v/v nonionic sufactant to the spray mixture.
Rhizome johnsongrass	Clethodim 0.125-0.25 lb ai + crop oil concentrate + (sequential treatment on regrowth) Clethodim 0.094-0.16 lb ai + crop oil concentrate	Select 2EC 8.0-16.0 oz or Select Max 0.97EC 12.0-32.0 oz + (see remarks) + (sequential treatment on regrowth) Select 2EC 6.0-8.0 oz or Select Max 0.97EC 12.0-32.0 oz + (see remarks)	Apply to actively growing johnsongrass at the rate and stage indicated on the label. Apply the first application to johnsongrass 12-24 inches high. Apply regrowth treatments to 6- to 18-inch johnsongrass. Always add 2.0 pt crop oil concentrate to Select. For Select Max, add 0.25% nonionic surfactant, 1% crop oil concentrate, or 1% methylated seed oil.

Table 5.111 - Postemergence Over-the-top: Perennial Grasses (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
	Fluazifop-P + fenoxaprop-ethyl 0.16-0.19 lb ai + crop oil concentrate or nonionic surfactant + (sequential treatment on regrowth) Fluazifop-P + fenoxaprop-ethyl 0.12 lb ai + crop oil concentrate or nonionic surfactant	Fusion 2EC 10.0-12.0 oz + crop oil concentrate 0.5-1.0% v/v or nonionic surfactant 0.25-0.5% v/v + (sequential treatment on regrowth) Fusion 2EC 8.0 oz + crop oil concentrate 0.5-1.0% v/v or nonionic surfactant 0.25-0.5% v/v	Make first application to actively growing johnsongrass before the boot stage and a second application when regrowth is 4 to 6 inches tall. Add 0.5-1.0% v/v crop oil concentrate or 0.25-0.5% v/v nonionic surfactant to the spray mixture.
	Sethoxydim 0.28 lb ai + crop oil concentrate + (sequential treatment on regrowth) Sethoxydim 0.19 lb ai + crop oil concentrate	Poast 1.5 pt or Poast Plus 2.25 pt + crop oil concentrate 2.0 pt/A + (sequential treatment on regrowth) Poast 1.0 pt or Poast Plus 1.5 pt + crop oil concentrate 2.0 pt	Apply to actively growing johnsongrass. Apply first treatment to johnsongrass 15 to 20 inches high. Apply regrowth treatments to 6- to 10-inch johnsongrass.

Table 5.112 - Postemergence: Over-the-top

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Controls most annual grasses and broadleaf weeds in conventional and reduced tillage production systems. Control or temporary suppression of many perennial weeds including bermudagrass, hemp dogbane, horsenettle, nutsedges, rhizome johnsongrass, and trumpetcreeper	Glyphosate 0.75-1.0 lb ai	Numerous brands and formulations	**For use only on cotton varieties designated as Roundup Ready Flex, GlyTol, Enlist, or XtendFlex.** Some brands of glyphosate are not registered for use on these varieties (see labels). Glyphosate will be most effective as a component of a program that includes the use of standard preplant incorporated, preemergence, and postemergence herbicides. Adjuvant recommendations vary by glyphosate products. **See labels for specification. Observe all labels regarding seasonal maximums and take extreme caution to avoid drift to adjacent vegetation.**

Table 5.112 - Postemergence: Over-the-top (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Controls many annual broadleaf weeds and suppresses annual grasses in conventional and reduced tillage production systems. Suppression may be expected of pigweed spp. and most grasses after just a single glufosinate application.	Glufosinate 0.53-0.79 lb ai	Liberty 280 2.34L 29-43 fl oz	**For use only on cotton varieties designated as LibertyLink, Enlist, or XtendFlex.** Apply postemergence over-the-top to cotton at emergence until the early-bloom stage of cotton development.Flat-fan nozzles and a minimum of 15 gpa are recommended. Application time of day is important. Two hours of sunshine before a morning application is suggested. Do not apply later than 1 hour before sunset. Multiple applications are allowed. Liberty at 22 to 29 fl oz can be applied three times, with a seasonal maximum of 87 fl oz. If applied at rates greater than 29 oz, only two applications are allowed and the season total should not exceed 72 fl oz. For best results, broadleaf weeds should be 2 to 3 in. tall and grasses 1 to 2 in. tall. Liberty should not be mixed with postemergence grass herbicides, such as Assure, Fusilade, Poast, or Select. At least 5 days should separate Liberty and grass herbicide applications.
Controls many annual broadleaf weeds and suppresses annual grasses in conventional and reduced tillage production systems. Suppression may be expected of pigweed spp. and most grasses after just a single glufosinate application.	Glufosinate 0.55 lb ai	Liberty 280 2.34L 29 fl oz	**Phytogen cultivars with the WideStrike trait can be treated with Liberty.** Tolerance to Liberty in these cultivars is not complete, and varying levels of crop injury may be observed. Greater injury can be expected when Liberty is mixed with insecticides or other herbicides. Growers assume the liability of crop injury when cotton with the WideStrike trait is treated with Liberty. It is suggested that the rate not exceed 29 fl oz per application with a maximum of two applications per year. It is also suggested that Liberty not be applied beyond the 8-leaf stage of cotton and that AMS not be included in the application. See above comments concerning Liberty application to Liberty Link cultivars, including application time of day.

Table 5.112 - Postemergence: Over-the-top (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Many broadleaf weeds	Glyphosate 1.0 lb ae + 2,4-D 0.95 lb ae	Enlist Duo 3.3S 4.75 pt	**For use only on cotton varieties designated as Enlist.** Enlist Duo contains the choline salt of 2,4-D. It is the only brand of 2,4-D registered for this use. Can be applied from cotton emergence to mid-bloom. Can be applied twice postemergence; allow minimum of 12 days between applications. See website Enlisttankmix.com for approved adjuvants, drift reduction agents, and other tank mixes. See Enlist Duo federal label for details on drift management, including recommended nozzles and pressures, wind speed, boom height, temperature inversions, buffers, and susceptible plants.
Many broadleaf weeds	2,4-D 0.95 lb ae	Enlist One 2 pt	**For use only on cotton varieties designated as Enlist.** Enlist One contains the choline salt of 2,4-D. It is the only brand of 2,4-D registered for this use. May be mixed with glufosinate. Can be applied from cotton emergence to mid-bloom. Can be applied twice postemergence; allow minimum of 12 days between applications. See website Enlisttankmix.com for approved adjuvants, drift reduction agents, and other tank mixes. See Enlist One federal label for details on drift management, including recommended nozzles and pressures, wind speed, boom height, temperature inversions, buffers, and susceptible plants.

Table 5.112 - Postemergence: Over-the-top (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Many broadleaf weeds	Dicamba 0.5 lb ae	Engenia 5S 12.8 fl oz or XtendiMax 2.9S 22 fl oz	**For use only on cotton varieties designated as XtendFlex.** Should be mixed with glyphosate. Engenia and XtendiMax contain dicamba. These are the only brands of dicamba registered for this use. Can be applied any time from cotton emergence to 7 days prior to harvest. Can be applied multiple times postemergence, not to exceed a total of 51.2 oz Engenia or 88 oz of XtendiMax. Only two postemergence applications suggested, preferably before first bloom. Separate applications by at least 7 days. See websites Engeniatankmix.com and xtendimaxapplicationrequirements.com for approved adjuvants, drift reduction agents, and other tank mixes. See federal labels and supplemental labels for use in dicamba-tolerant cotton for details on drift management, including recommended nozzles and pressures, wind speed, boom height, temperature inversions, buffers, and susceptible plants.
Large crabgrass, goosegrass, fall panicum, foxtails and suppression of yellow nutsedge	S-Metolachlor 0.96-1.25 lb ai	Dual Magnum 7.62EC 1.0-1.3 pt	Apply over-the-top postemergence or directed to the soil surface to cotton at least 3 in tall. Applications should be prior to weed emergence or after clean cultivation since Dual Magnum does not control emerged weeds. At least 1/2 inch of rainfall is required within 10 days after application. If rainfall does not occur, a shallow, uniform incorporation will improve control. Over-the-top postemergence applications should be made not later than 100 days before harvest and directed postemergence applications may be made not later than 80 days before harvest. **Can be applied with glyphosate on Roundup Ready Flex, GlyTol, Enlist, or XtendFlex and glufosinate on LibertyLink, Enlist, or XtendFlex cotton varieties.** Do not add additional spray adjuvants, surfactants, fertilizers, or their additives to these tank mixtures if applied over-the-top, or unacceptable cotton injury may occur. Follow instructions on the Dual Magnum and glyphosate labels for rates, application methods, and application timing restrictions.

Table 5.112 - Postemergence: Over-the-top (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Controls most annual grasses and broadleaf weeds in conventional and reduced tillage production systems. Control or temporary suppression of many weeds including hemp dogbane, yellow nutsedge, and rhizome johnsongrass. Provides residual control of large crabgrass, goosegrass, fall panicum, foxtails, and the suppression of yellow nutsedge.	[Glyphosate + S-metolachlor] 0.70-0.98 lb ae + 0.94-1.31 lb ai	Sequence 5.25L	**For use only on cotton varieties designated as Roundup Ready Flex, GlyTol, Enlist, or XtendFlex**. Apply postemergence over-the-top to cotton that is 3 inches tall to the four-leaf stage of cotton development. Do not apply later or severe crop injury will occur, including yield loss. Do not exceed 2.5 pt/A of Sequence per application or 3.5 pt/A of Sequence per growing season. If tank-mixing or applications follow other s-Metolachlor products, do not exceed 1.9 lb s-Metolachlor ai/A per season on coarse-textured soils. Over-the-top postemergence applications should not be made later than 100 days before harvest. At least 1/2 inch of rainfall is required within 7 days after application to activate the s-Metolachlor. Do not add additional spray adjuvants, surfactants, or fertilizers to Sequence when applied postemergence over-the-top, or unacceptable cotton injury may occur. **Extreme care must be used to avoid drift to adjacent crops or other desirable vegetation**. Do not graze or feed treated cotton. See label.
Fall panicum, crabgrass, foxtails, goosesgrss, pigweeds, carpetweed, purslane, lambsquarters, nightshade, waterhemp	Acetochlor 0.9375-1.5 lb ai	Warrant 3ME 1.25-2 qts/A	Apply this product postemergence to cotton and preemergence to weeds. This product will not control emerged weeds. Apply when the crop is small or direct spray to the soil surface. **Can be applied with glyphosate on Roundup Ready Flex, GlyTol, Enlist, or XtendFlex and glufosinate on LibertyLink, Enlist, or XtendFlex cotton varieties.** DO NOT exceed 4 qt Warrant/A per season when making a second application. DO NOT make postemergence applications using a sprayable fluid fertilizer. DO NOT graze treated area or feed treated forage to livestock following application of this product.
Cocklebur and suppression of yellow nutsedge	MSMA 0.75-1.0 lb ai	Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations)	May be applied over-the-top of crop and weeds when cotton is 3 to 6 inches tall. Crop response may include stunting, stem reddening and delay of maturity. Check label for surfactant recommendations.

Table 5.112 - Postemergence: Over-the-top (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Cocklebur, jimsonweed, pigweed	Fluometuron 1.0 ai	Cotoran 4L 1.0 qt	May be applied over-the-top of crop when cotton is 3 inches, high to layby. Weeds should be 2 inches or less. For use only where crop loss due to weeds is likely. Moderate to severe crop injury may occur and may include maturity delay and yield reduction.
Pigweed species, Pennsylvania smartweed, spurred anoda, velvetleaf, jimsonweed. May be weak against tall morningglory, common cocklebur, and prickly sida	Pyrithiobac 0.065-0.095 lb ai + 0.25-0.50% nonionic surfactant	Staple LX 3.2SL 2.6-3.8 oz + nonionic surfactant at 1.0-2.0 qt/100.0 gal	**Can be applied with glyphosate on Roundup Ready Flex, GlyTol, Enlist, or XtendFlex varieties or glufosinate on LibertyLink, Enlist, or XtendFlex varieties.** Apply 2.6-3.8 oz Staple LX with 0.25-0.50% v/v (1.0-2.0 qt/100.0 gal) nonionic surfactant to control small annual broadleaf weeds listed. Staple may be applied postemergence broadcast over-the-top of cotton, in a band over-the-top of cotton, or post-directed to cotton but over-the-top of weeds. Make applications to small, actively growing weeds after cotton has a true leaf. Cotton may be injured from Staple LX applied under cool, wet conditions. For best control, rainfall should not occur for 4 hours. Do not exceed 5.1 fl oz/A per year. See label.

Table 5.112 - Postemergence: Over-the-top (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Bristly starbur, common cocklebur, coffee senna, volunteer corn (non-IT/IR), Florida beggarweed, hemp sesbania, common lambsquarters, morningglory spp., common ragweed, redweed, sicklepod, velvetleaf, volunteer soybean (non-STS), wild poinsettia, yellow nutsedge.	Trifloxysulfuron-sodium 0.0047-0.0070 lb ai + nonionic surfactant 0.25% v/v	Envoke 75WDG 0.10-0.15 oz + nonionic surfactant 1.0 qt/100.0 gal	**Can be applied with glyphosate on Roundup Ready Flex, GlyTol, Enlist, or XtendFlex varieties or glufosinate on LibertyLink, Enlist, or XtendFlex varieties.** Apply 0.10-0.15 oz/A Envoke with 0.25% v/v (1 qt/100.0 gal) nonionic surfactant to control small annual broadleaf weeds listed. Envoke may be applied postemergence broadcast over-the-top of cotton, or post- directed to cotton but over-the-top of weeds. Make applications to small, actively growing weeds after cotton has a minimum of 5 true leaves. Cotton may be injured from Envoke applied under cool, wet conditions and if cotton is less than in the 5-leaf stage of growth. For best control, rainfall should not occur for 3 hours. The higher rates of Envoke may be required to adequately control yellow nutsedge and velvetleaf. Envoke tank mixed with glyphosate on Roundup Ready Flex, GlyTol, or XtendFlex cotton can cause injury by way of boll loss, delayed maturity, and/or loss of yield. Sequential Envoke applications must be 14 days apart and should be used only for a salvage treatment.
Compared to Envoke alone, mix is better on jimsonweed and spurred anoda. Compared to Staple alone, mixture is better on common ragweed, common lambsquarters, tall morningglory, and sicklepod.	Trifloxysulfuron 0.0047-0.0070 lb + Pyrithibac 0.033-0.053 lb + nonionic surfactant 0.25% v/v	Envoke 75 WDG 0.1-0.15 oz + Staple LX 3.2SL 1.3-2.1 fl oz + nonionic surfactant 0.25% v/v	Postemergence overtop of cotton with at least 5 true leaves. Use a minimum of 10 gal water/A and apply to cotton with at least 5 true leaves. Occasional yellowing of cotton leaves can occur but yields are not affected.

Table 5.113 - Postemergence Directed

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Cocklebur, yellow nutsedge, purple nutsedge	MSMA 2.0 lb ai	Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations)	Apply as a directed spray to cotton at least 3 inches tall. Do not apply after first blooms appear. Refer to the product label to determine if surfactant should be added. Two applications/ season may be made. May be tank mixed with fluometuron.
Cocklebur, jimsonweed, lambsquarters, morningglory, pigweed, ragweed, tropic croton	Diuron 0.8-1.2 lb ai + MSMA 2.0 lb ai	Direx 4L 1.6-2.4 pt + Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations)	Apply as a directed spray to cotton at least 12 inches tall. Rate varies by soil type. See application precautions on label. Add nonionic surfactant at 1 to 2 quarts per 100 gal spray solution or crop oil at 1 gal per 100 gal spray solution. See label for rotational restrictions. Do not apply MSMA after first bloom. Aim (1 oz/A) or Cobra (6 to 8 oz/A) may be added to improve control of larger morningglory. Cotton should be at least 16 inches when applying Aim. Do not allow Aim to contact green stem tissue.
Cocklebur, jimsonweed, lambsquarters, morningglory, pigweed, ragweed, tropic croton, yellow nutsedge, and most annual grasses	Fluometuron 1.0-2.0 lb ai + MSMA 2.0 lb ai + S-metolachlor 0.95-1.27 lb ai	Cotoran 4L 1.0-2.0 qt + Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations) + Dual Magnum 7.62EC 1-1.33 pt	Apply as directed spray to cotton at least 3 inches tall up to first bloom. Do not apply MSMA after first bloom. Add surfactant according to Cotoran label. Dual Magnum gives residual control of annual grasses and pigweed and suppresses yellow nutsedge. See comments for Cotoran + MSMA.
Common cocklebur, common dayflower, dogfennel, Florida beggarweed, Florida pusley, hemp sesbania, common lambsquarters, annual morningglory spp., pigweed spp., prickly sida, purslane, common ragweed, redweed, sicklepod, smartweed, velvetleaf, most annual grasses	[Diuron + Linuron] 1.0 lb ai + MSMA 2.0 lb ai	Layby Pro 4L 2.0 pt + Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations)	Diuron + linuron is a premix product. Apply as directed spray only to cotton at least 15 inches tall. See application restrictions on label. Add crop oil concentrate at 1 gal per 100 gal spray solution. See label for rotational restrictions. Do not apply MSMA after first bloom. Aim (1 oz/A) may be added to improve control of larger morningglory. Cotton should be at least 16 inches when applying Aim. Do not allow Aim to contact green stem tissue.
Cocklebur, jimsonweed, lambsquarters, morningglory, pigweed, ragweed, tropic croton	Fluometuron 1.0 lb ai	Cotoran 4L 1.0 qt	Apply as a directed spray. Apply with a nonionic surfactant at 2.0 qt/100 gal spray solution. Do not apply within 60 days of harvest. See label for crop rotation.

Table 5.113 - Postemergence Directed (con't.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Cocklebur, lambsquarters, morningglory species, nightshade species, pigweed species, velvetleaf, spurred anoda, purslane, hemp sesbania, prostrate spurge, Pennsylvania smartweed, purple nutsedge, yellow nutsedge	Flumioxazin 0.064 lb ai + MSMA 2.0 lb ai	Valor SX 51WDG 2 oz + MSMA Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations)	Apply as directed spray only to cotton at least 16 inches tall. Direct the spray to the lower 2 inches of the cotton stem. Do not allow spray solution to contact green portion of stem. Add nonionic surfactant at 1 qt per 100 gal spray solution. Do not use crop oil concentrate, methylated seed oil, organo-silicant adjuvants, or any adjuvant product containing any of these. Do not apply MSMA after first bloom. No rotational restrictions of concern in Virginia. May be applied under a hood on cotton at least 6 inches tall. Do not allow spray solution to contact cotton
Cocklebur, lambsquarters, morningglory species, nightshade species, pigweed species, velvetleaf, spurred anoda, purslane, hemp sesbania, prostrate spurge, Pennsylvania smartweed, purple nutsedge, yellow nutsedge, most annual grass species	[Flumioxazin + Pyroxasulfone] 0.143 lb ai + MSMA 2.0 lb ai	Fierce 76WDG 3 oz + MSMA Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations	Flumioxazin + pyroxasulfone is a premix product. Can be applied with hooded sprayer after cotton is at least 6 inches tall. Do not allow spray solution to contact cotton. Can be applied with layby applicator after cotton is at least 16 inches tall, but do not contact more than the lower 2 inches of cotton stalk. Add non-ionic surfactant according to label. Do not use crop oil concentrate, methylated seed oil, organo-silicant adjuvants, or any adjuvant product containing any of these. Do not apply MSMA after first bloom.
Cocklebur, jimsonweed, lambsquarters, morningglory, pigweed, ragweed, tropic croton, yellow nutsedge, and most annual grasses	Fluometuron 1.0-2.0 lb ai + MSMA 2.0 lb ai + S-metolachlor 0.95-1.27 lb ai	Cotoran 4L 1.0-2.0 qt + Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations + Dual Magnum 7.62EC 1-1.33 pt	Apply as directed spray to cotton at least 3 inches tall up to first bloom. Do not apply MSMA after first bloom. dd surfactant according to Cotoran label. Dual Magnum gives residual control of annual grasses and pigweed and suppresses yellow nutsedge. See comments for Cotoran + MSMA.
Cocklebur, ragweed, jimsonweed, lambsquarters, pigweed, prickly sida, smartweed, tropic croton, velvetleaf	Lactofen 0.2 lb ai + MSMA 2.0 lb ai	Cobra 2EC 12.5 oz + MSMA (6 lb/gal 2.66 pt formulations)	Apply to cotton at least 6 inches tall. Apply with nonionic surfactant (2.0 pt/100 gal spray mix) or crop oil concentrate (0.5-1.0 pt/A). Apply only with **precision**-directed spray equipment. Make only one application of Cobra/ season.[1] Do not apply MSMA after first bloom.

Table 5.113 - Postemergence Directed (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Cocklebur, ragweed, jimsonweed, lambsquarters, pigweed, prickly sida, smartweed, tropic croton, velvetleaf	Lactofen 0.094-0.2 lb ai + Diuron 0.4-0.6 lb ai + MSMA 2.0 lb ai	Cobra 2EC 6-12.5 oz + Direx 4F 0.8-1.2 pt + Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations)	Apply as directed spray or with hooded sprayer. Cotton should be at least 12 inches tall. See Cobra label for weeds controlled and directions on weed size and application rates. Add 1 qt per acre crop oil concentrate. See rotational restrictions on Direx label. Do not apply MSMA after first bloom.
Cocklebur, ragweed, jimsonweed, lambquarters, pigweed, prickly sida, smartweed, tropic croton, morningglory (suppression)	Prometryn 0.5-0.65 lb ai + MSMA 2.0 lb ai	Caparol 4L 1.0-1.3 pt or Cotton-Pro 4L 1.0-1.3 pt + Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations)	Apply to cotton at least 6 inches tall. Apply only with **precision**-directed spray equipment.[1] Aim (1 oz/A) or Cobra (6 to 12.5 oz/A) may be added to improve control of larger morningglory. Cotton should be at least 16 inches when applying Aim. Do not allow Aim to contact green stem tissue. Do not apply MSMA after first bloom.
Bristly starbur, common cocklebur, coffee senna, volunteer corn (non-IT/IR), Florida beggarweed, hemp sesbania, johnsongrass (seedling), common lambsquarters, morningglory spp., smooth pigweed, redroot pigweed, common ragweed, redweed, sicklepod, velvetleaf, volunteer soybean (non-STS), wild poinsettia, yellow nutsedge	Prometryn 0.790-1.185 lb ai + Trifloxysulfuron-sodium 0.0070-0.0105 lb ai + MSMA 2.0 lb ai	Suprend 80WG 1-1.25 lb + Various brands and formulations 2.66 pt MSMA (6.0 lb/gal formulations)	Apply 1.0-1.5 lb/A Suprend + MSMA to control small annual broadleaf weeds listed and provide some residual control of these weeds. Suprend must be applied post-directed to cotton but over-the-top of weeds. Apply to cotton at least 6 inches tall and only with precision-directed spray equipment. Sequential Suprend applications must be at least 14 days apart. Do not exceed 2.7 lbs/A of Suprend per growing season from all applications. Do not exceed a total of 0.0188 lb ai/A of trifloxysulfuron- sodium per growing season resulting from all applications of Suprend or Envoke. Do not exceed a total of 5.15 lb ai/A of prometryn per growing season resulting from all applications of Suprend, Caparol 4L, or Cotton- Pro 4L. If these totals for trifloxysulfuron-sodium and/or prometryn are exceeded, injury to cotton may result in addition to alterations in crop rotation restriction intervals. Do not apply MSMA after first bloom.

Table 5.113 - Postemergence Directed (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae	Glyphosate See labels	**Roundup Ready Flex, GlyTol LibertyLink, or XtendFlex cultivars only.** Glyphosate alone can be directed up to 7 days prior to harvest. When using glyphosate alone, contact with cotton is not of concern; the primary reason to direct is to obtain better coverage of weeds under the crop canopy. Use of other herbicides, in addition to glyphosate, is recommended to aid in resistance management. When tank mixing, follow directions on the label of tank mix partner concerning cotton size for application, application directions, and rotational restrictions. Glyphosate-resistant Palmer amaranth and common ragweed are present in Virginia.
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + Acetochlor 1.125 lb	Glyphosate See labels + Warrant 3ME 3 pt	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Can be directed up to first bloom. See comments for glyphosate applied alone. Warrant does not control emerged weeds, but it does provide residual control of pigweed and most annual grasses.
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + Carfentrazone 0.016-0.024 lb	Glyphosate See labels + Aim 2EC 1-1.5 oz	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Cotton should be at least 16 inches tall. Extreme care should be exercised in application. See directions and precautions on Aim label. Contact on green stem tissue will lead to severe injury. Add crop oil concentrate according to label. See comments on Aim label concerning sprayer cleanout. Aim will improve control of larger morningglory. See comments for glyphosate alone.
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + Dimethenamid-P 0.56-0.75 lb	Glyphosate See labels + Outlook 6EC 12-16 oz	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Can be directed to cotton up to mid-bloom. Outlook does not control emerged weeds, but it does provide residual control of most annual grasses and pigweed. Suggested rates are 12 oz on coarse soils, 14 oz on medium soils, and 16 oz on fine soils. See comments for glyphosate alone.

Table 5.113 - Postemergence Directed (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + Diuron 0.5-0.75 lb ai	Glyphosate See labels + Direx 4L 1-1.5 pt	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Use 1 pt of Direx on cotton 8 to 12 inches tall. Increase rate to 1.5 pt on cotton greater than 12 inches. Add surfactant according to label of glyphosate brand used. Compared to glyphosate alone, this combination controls larger morningglories and provides residual control of small-seeded broadleaves, such as pigweed. Tank mix may give less grass control of larger grasses than glyphosate alone under dry conditions. See Direx label for rotational restrictions. See comments for glyphosate alone.
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + Flumioxazin 0.031-0.063 lb	Glyphosate See labels + Valor SX 51WDG 1-2 oz	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Cotton should be at least 16 inches tall. Direct the sprayer to the lower 1 to 2 inches of the cotton stem; minimize cotton contact as much as possible. Do not allow spray solution to contact green portion of stem. Add nonionic surfactant at 1 qt per 100 gal spray solution. DO NOT use crop oil concentrate, methylated seed oil, organo-silicant adjuvants, or adjuvant products containing any of these. No rotational restriction of concern in Virginia. Compared with glyphosate alone, the combination will give better control of larger morningglories plus residual control of susceptible broadleaf weeds. May be applied under a hood on cotton at least 6 inches tall. Do not allow spray solution to contact cotton. See comments for glyphosate alone.

Table 5.113 - Postemergence Directed (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + [Flumioxazin + pyroxasulfone] 0.143 lb ai	Glyphosate See labels + Fierce 76WDG 3 oz	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Flumioxazin + pyroxasulfone is a premix. Can be applied with hooded sprayer after cotton reaches 6 inches in height. Do not allow spray solution to contact cotton. Can be applied with layby applicator after cotton is at least 16 inches tall, but do not contact more than lower 2 inches of cotton stalk. Add non-ionic surfactant according to Fierce label. Do not use crop oil, methylated seed oil, organo-silicant adjuvants or adjuvant products containing any of these. See comments for glyphosate alone.
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + Fomesafen 0.25-0.375 lb ai	Glyphosate See labels + Reflex 2L 1-1.5 pt	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Use as a layby application to cotton with a minimum of 4 inches of bark on the stem. Add surfactant or crop oil according to the Reflex label. May include Caparol, Direx, Dual Magnum, Envoke, Layby Pro, or Suprend in the mixture. Do not use Reflex at layby if Reflex was used preemergence. See comments for glyphosate alone.
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + Prometryn 0.5-1 lb ai	Glyphosate See labels + Caparol 1-2 pt	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Direct to cotton at least 6 to 8 inches tall. Use 1 to 1.3 pt of Caparol on cotton 6 to 12 inches tall; rate can be increased to 2 pt on cotton at least 16 inches tall. Add surfactant according to glyphosate label. See precautions and rotational restrictions on Caparol label. Compared to glyphosate alone, this combination with improve control of larger morningglory and provide residual control of small-seeded broadleaves, such as pigweed. This mixture will give less control of larger grasses than glyphosate alone under drier conditions. See comments for glyphosate alone.

Table 5.113 - Postemergence Directed (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + Pyroxasulfone 0.040-0.112 lb ai	Glyphosate See labels + Warrant 3ME 3 pt	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Zidua is labeled at a rate of 0.75 to 1.5 oz/A on coarse- and medium-textured soils and 1.5 to 2.1 oz/A on fine-textured soils. Do not use on soils with greater than 10% organic matter. Avoid contact with cotton foliage. Apply postemergence directed when cotton is from 5-leaf stage to beginning of bloom stage. Do not apply overtop. Zidua does not control emerged weeds but gives residual control of many annual grasses and pigweed species. See comments for glyphosate alone.
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + S-metolachlor 0.95-1.27 lb ai	Glyphosate See labels + Dual Magnum 1-1.33 pt	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Can be applied to cotton 3 inches tall through layby. Dual Magnum does not improve control of emerged weeds, but it can give residual control of annual grasses, pigweed species, and spreading dayflower plus suppression of yellow nutsedge. Do not apply to sand or loamy sand soils. See comments for glyphosate alone.
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	[Glyphosate + S-metolachlor] 0.70 lb ae + 0.94 lb ai	Sequence 5.25L 2.5 pt	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Glyphosate alone can be directed up to 7 days prior to harvest. When using glyphosate alone, contact with cotton is not of concern; the primary reason to direct is to obtain better coverage of weeds under the crop canopy. Use of other herbicides, in addition to glyphosate, is recommended to aid in resistance management. When tank mixing, follow directions on the label of tank mix partner concerning cotton size for application, application directions, and rotational restrictions. Glyphosate-resistant Palmer amaranth and common ragweed are present in Virginia.

Table 5.113 - Postemergence Directed (cont.)

Weed problem	Chemical rate per acre	Product per acre	Remarks and Precautions
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + [Prometryn + Trifloxysulfuron] 0.8-1 + 0.007-0.0088 lb ai	Glyphosate See labels + Suprend 80WDG 1-1.25 lb	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Direct to cotton at least 6 to 8 inches tall. Add surfactant according to glyphosate label. See precautions and rotational restrictions on Suprend label. Compared to glyphosate alone, this combination will improve control of larger morningglory and nutsedge, and provide residual control of small-seeded broadleaf weeds, such as pigweed. This mixture may give less control of larger grasses than glyphosate alone under drier conditions. See comments for glyphosate alone.
Annual grasses, broadleaf weeds, nutsedge, suppression of perennial weeds	Glyphosate 0.75-1.13 lb ae + Trifloxysulfuron 0.0047-0.0094 lb ai	Glyphosate See labels + Envoke 75WDG 0.1-0.2 oz	**Roundup Ready Flex, GlyTol LibertyLink, Enlist, or XtendFlex cultivars only.** Direct to cotton from 6 inches tall through layby. Add nonionic surfactant according to the Envoke label. Compared to glyphosate alone, the combination is more effective on nutsedge and morningglory and provides residual control of susceptible broadleaf weeds. See comments for glyphosate alone.

Table 5.114 - Relative Effectiveness of Herbicides for Grass Weed Control in Cotton[1]

	Goosegrass	Broadleaf signalgrass	Crabgrass	Fall panicum	Foxtails	Johnsongrass (seedling)	Johnsongrass (rhizome)	Texas panicum	Purple & Yellow nutsedge	Shattercane	Bermudagrass
Preplant Incorporated											
Prowl	G	G	E	G	E	G	P	G	N	G	P
Treflan	G	G	E	G	E	G	P	G	N	G	P
Preemergence											
Brake + Reflex	G	F-G	G	–	–	–	N	P	P-G	–	N
Brake + Cotoran	G	P	G	F	F-G	P	N	P	N	–	N
Cotoran	F-G	P	F-G	F	G	P	P	P	P	P	P
Direx	F	P	F-G	F	F-G	P	P	P	P	P	P
Reflex	–	F-G	F-G	–	–	–	–	F	P-G	F	N
Staple LX	P-F	P	P	P-F	P	F-G	N	N	F	–	N
Warrant	E	G	E	E	E	P-F	N	P-F	P	N	N
Warrant Ultra	E	G	E	E	E	P-F	N	P-F	P	N	N
Postemergence/Postemergence Directed											
Assure II/Assure II	E	E	F	E	E	E	E	E	N	E	G
Caparol/Cotton-Pro	P	P	P	P	P	P	P	P	P	P	P
Cobra	P	P	P	P	P	P	P	P	P	P	P
Cotoran	P	P	P	P	P	P	P	P	P	P	P
Dual Magnum[2]	E	G	E	G-E	E	F	N	P-F	F	P-F	N
Enlist Duo	E	E	E	E	E	E	G	P-F	F-G	E	F
Engenia/XtendiMax + Glyphosate	E	E	E	E	E	E	G	E	F-G	E	F
Envoke	P	P	P	P	P	P	N	P	P-G	P	N
Fusilade	E	G-E	G	E	E	E	G-E	G	N	E	G-E
Fusion	E	E	G	E	E	E	G	G	N	E	G
Layby Pro	G-E	G-E	G-E	G-E	G-E	P	P	G-E	N	P	N
Liberty 280	G	G	G	G	G	G	P-G	G	P-G	F	P
Linex	P	P	P	P	P	P	P	P	N	P	N
MSMA/DSMA	G	G	G	G	G	G	F	P-F	F-G	G	P
Poast	E	E	G	E	E	E	G	E	N	E	F-G
Glyphosate	E	E	E	E	E	E	G	E	F-G	E	F
Select Max	F	E	G	E	E	E	G	E	N	E	G
Sequence	E	E	E	E	E	E	G	E	F-G	E	P-F
Staple LX	N-P	N-P	N-P	N-P	N-P	N-P	N-P	N-P	N-F	N-P	N-P
Suprend	P	P	P	P	P	F	P	P	P-G	P	P
Warrant[2]	E	G	E	E	E	P-F	N	P-F	P	N	N
Zidua[2]	E	G	E	G-E	E	F	N	F	P-F	P-F	N

[1]E (Excellent) = 90 to 100 percent control, G (Good) = 80 to 90 percent control, F (Fair) = 60 to 80 percent control, P (Poor) = 20 to 60 percent control, N (None) = less than 20 percent control.

[2]Dual Magnum, Warrant, and Zidua will not control emerged weeds. These products provide residual control only.

Table 5.115 - Relative Effectiveness of Herbicides for Broadleaf Weed Control in Cotton[1]

	Cocklebur	Jimsonweed	Lambsquarters	Morningglory (annual spp.)	Pigweed	Tropic Croton	Common Ragweed	Sicklepod	Smartweed	Spurred anoda	Prickly sida or teaweed	Velvetleaf
Preplant Incorporated												
Prowl	N	N	G	P	G	P	N	N	P	N	N	P-F
Treflan	N	N	G	P	G	P	N	N	P	N	N	N
Preemergence												
Brake + Reflex	G	G	E	F	E	G	G	P	–	G	–	–
Brake + Cotoran	G	G	E	G	E	F-G	E	G	G	G	G	F
Cotoran	F	F	E	F	G	F	G	F	F	F	F-G	F
Direx	F	G	E	F	G	F-G	G	F	G	F	F	P-F
Reflex	G	G	E	P-F	E	F-G	G	P	–	–	–	–
Staple LX	P	F-G	G	P-F	G	F-G	N-P	P-F	G	G	E	E
Warrant[2]	N	N	P-F	N	E	N	P	N	N	N	P	N
Warrant Ultra	G	–	E	P-F	E	F-G	G	P	–	–	–	–
Postemergence/Postemergence Directed												
Aim	G	F	G	G	G	–	P	N-P	G	G	P	G
Assure II/Assure II	N	N	N	N	N	N	N	N	N	N	N	N
Caparol/ Cotton-Pro	E	F-G	G	F	G	G	G-E	F	G	P	F-G	F
Cobra	E	G-E	P-F	P-F	E	F-G	G	P-F	F	F	E	G
Cotoran	E	F-G	G	F	G	P-F	G-E	F	G	P	F-G	P
Dual Magnum[2]	N	N	P-F	N	E	N	P	N	N	N	N	N
Enlist Duo	E	E	E	E	E	E	E	E	G	E	G	E
Engenia/XtendiMax + glyphosate	E	E	E	E	E	E	E	E	E	E	G	E
Envoke	E	E	G-E	E	G-E	P-G	G-E	E	–	P-F	F-G	G
Fusilade	N	N	N	N	N	N	N	N	N	N	N	N
Fusion	N	N	N	N	N	N	N	N	N	N	N	N
Liberty 280	E	E	G-E	E	F-G	E	E	E	E	G-E	E	G-E
Layby Pro	G-E	G	G-E	G-E	G-E	F-G	G-E	G-E	G-E	P-F	G-E	G-E
Linex	G	G	G	F-G	G-E	P-F	F-G	G	F	P	F-G	P-F
MSMA/DSMA	E	F	P-F	P	P-F	P-F	F	P	P	P	P	P
Poast	N	N	N	N	N	N	N	N	N	N	N	N
Glyphosate	E	E	F-G	F	G-E	G	F	G-E	F	G	F-G	G
Select Max	N	N	N	N	N	N	N	N	N	N	N	N
Sequence	E	E	F-G	F	G-E	G	F	G-E	G	G	F-G	G
Staple LX	G-E	E	P	G	E	N	P	N-P	G-E	F-G	F-G	E
Suprend	E	E	G-E	E	G-E	P-G	G-E	E	G	G	F-G	G
Valor	G	F	G	G	G	–	P	N-P	G	G	P	G
Warrant[2]	N	N	P-F	N	E	N	P	N	N	N	P	N
Zidua[2]	N	F	F-G	N	E	N	P-F	N	F	N	N	P

[1]E (Excellent) = 90 to 100 percent control, G (Good) = 80 to 90 percent control, F (Fair) = 60 to 80 percent control, P (Poor) = 20 to 60 percent control, N (None) = less than 20 percent control.

[2]Dual Magnum, Warrant, and Zidua will not control emerged weeds. These products provide residual control only.

Table 5.116 - Burndown Herbicides for Stale Seedbed and Conservation Tillage Cotton for Application 30 to 45 Days Prior to Planting

	Herbicide & Rate per Acre				
Weed Species/ Cover Crop	**2,4D[1] 1.0 pt**	**Gramoxone SL 3.0 pt**	**Glyphosate (see labels for rates)**	**Harmony Extra[2] 0.5 oz**	**Valor[3] 1.0-1.5 oz**
Annual grasses	N	G-E	E	P	P
Carolina geranium	P-F	G-E	P-F	G	G
Chickweed, common	P	E	G	E	P
Curly dock	F-G	N	P-F	G	P
Cutleaf eveningprimrose	G	P	P	F	G
Henbit	P	G	G	E	F-G
Horseweed (marestail)	P-F	P	G	G	P
Wheat/rye	N	E	E[4]	P	P
Wild mustard	G-E	P-F	F	G	F
Wild radish	G-E	P-F	F	G	F

E (Excellent) = 90 to 100 percent control, G (Good) = 80% to 90%, F (Fair) = 60 to 80%, P (Poor) = 20 to 60%, N (None) = less than 20%.

[1]Apply at least 30 days prior to planting.

[2]Apply at least 45 days prior to planting.

[3]Apply at least 30 days prior to planting (tank mixed with glyphosate products).

Table 5.117 - Burndown Herbicides for Stale Seedbed and Conservation Tillage Cotton for Application 7 to 21 Days Prior to Planting

	Herbicide & Rate per Acre		
Weed Species/Cover Crop	**Clarity[1] 8.0 oz**	**Gramoxone SL 3.0 pt**	**Glyphosate (see labels for rates)**
Annual grasses	N	G-E	E
Carolina geranium	G	G-E	P-F
Chickweed, common	P-F	E	G
Curly dock	F-G	N	P-F
Cutleaf eveningprimrose	F-G	P	P
Henbit	F	G	G
Horseweed (marestail)	F	P	G
Wheat/rye	N	E	E
Wild mustard	F	P-F	F
Wild radish	F	P-F	F

E (Excellent) = 90 to 100 percent control, G (Good) = 80% to 90%, F (Fair) = 60 to 80%, P (Poor) = 20 to 60%, N (None) = less than 20%.

[1]Following application of Clarity, a minimum accumulation of 1 in rainfall or irrigation water and a waiting interval of 21 days is required prior to planting cotton.

Table 5.118 - Application Rates and Perennial Grass Sizes for Treatment with Assure, Fusilade DX, Fusion, Poast, Poast Plus, Select[1], and Select Max[1]

(Rain-free period is 1 hour for each herbicide listed below.)

		Weed Size and Herbicide Rate (oz/A)	
Herbicide	**Weed**	**First Application**	**Second Application[2]**
Assure II	Rhizome johnsongrass	10- to 24-inch tall 5.0 oz	6- to 10-inch tall 5.0 oz
	Bermudagrass	up to 6-inch runners 10.0-12.0 oz	up to 6-inch runners 7.0 oz
Fusilade DX	Rhizome johnsongrass	8- to 18-inch tall 12.0 oz	6- to 12-inch tall 8.0 oz
	Bermudagrass	4- to 8-inch runners 12.0 oz	4- to 8-inch runners 8.0 oz
Fusion	Rhizome johnsongrass	8- to 18-inch tall 10.0-12.0 oz	6- to 12-inch tall 8.0 oz
	Bermudagrass	4- to 8-inch runners 12.0 oz	4- to 8-inch runners 8.0 oz
Poast	Rhizome johnsongrass	15- to 25-inch tall 24.0 oz	6- to 12-inch tall 16.0 oz
	Bermudagrass	6-inch runners 24.0 oz	1- to 4-inch runners 16.0 oz
Poast Plus	Rhizome johnsongrass	15- to 25-inch tall 36.0 oz	6- to 12-inch tall 24.0 oz
	Bermudagrass	6-inch runners 36.0 oz	1- to 4-inch runners 24.0 oz
Select	Rhizome johnsongrass	12- to 24-inch tall 8.0-16.0 oz	6- to 18-inch tall 6.0-8.0 oz
	Bermudagrass	3- to 6-inch runners 8.0-16.0 oz	3- to 6-inch runners 8.0-16.0 oz
Select Max	Rhizome johnsongrass	12- to 24-inch tall 12.0-32.0 oz	9.0-24.0 oz
	Bermudagrass	3- to 6-inch runners 12.0-32.0 oz	12.0-32.0 oz

[1]Taken from product labels.

[2]Make second application only if needed to control regrowth or new plants. Size refers to regrowth or new plants.

Table 5.119 - Application Rates and Annual Grass Sizes for Treatment with Assure II, Fusilade DX, Fusion, Poast, Poast Plus, Select[1], and Select Max[1]

(Rain-free period is 1 hour for each herbicide listed below.)

	Poast		Poast Plus		Fusilade DX		Fusion		Assure II		Select		Select Max	
Species	**Height (in.)**	**Rate (oz/A)**	**Height (in.)**	**Rate (oz/A)**	**Height (in.)**	**Rate (oz/A)**	**Height (in.)**	**Rate (oz.)**	**Height (in.)**	**Rate (oz/A)**	**Height (in.)**	**Rate (oz/A)**	**Height (in.)**	**Rate (oz/A)**
Barnyardgrass	8	16	8	24	2-3	12	2-4	8	2-6	8-10	2-8	6-8	2-8	9-16
Broadleaf signalgrass	8	16	8	24	2-4	12	2-4	8-10	2-6	10	2-6	6-8	2-6	9-16
Crabgrass	6	16	6	24	1-2	12	1-4	8	2-6	8-10	2-6	6-8	2-6	9-16
Crowfootgrass	—	—	—	—	—	—	—	—	2-6	7-8	2-6	6-8	2-6	9-16
Fall panicum	8	16	8	24	2-6	12	2-6	8	2-6	7-8	2-6	6-8	2-6	9-16
Foxtails, Giant	8	16	8	24	2-6	12	2-8	7	2-8	7-8	2-12	6-8	2-12	9-16
Foxtails, Green	8	16	8	24	2-4	12	2-4	8	2-4	7-8	2-8	6-8	2-8	9-16
Foxtails, Yellow	8	16	8	24	2-4	12	2-4	8	2-4	7-8	2-8	6-8	2-8	9-16
Goosegrass	6	16	6	24	2-4	8	2-4	8	2-6	7-8	2-6	6-8	2-6	9-16
Seedling johnsongrass	8	16	8	24	2-8	6	2-8	6	2-8	5-8	4-10	6-8	4-10	9-16
Sandbur	3	20	3	30	2-6	12	2-6	8	2-6	7-8	2-6	6-8	2-6	9-16
Shattercane	18	16	18	24	6-12	6	6-12	6	6-12	5-8	4-10	6-8	4-10	9-16
Texas panicum	8	16	8	24	2-8	12	2-8	8	2-4	8-10	2-6	6-8	2-6	9-16
Volunteer corn	20	16	20	24	12-24	6	12-24	6	6-18	5-8	4-12	4-6	4-12	6-12

[1]Taken from product labels; — control not claimed on label.

Table 5.120 - Rotational Restrictions

The herbicides listed below, when used in cotton, may influence one's ability to rotate crops in a normal fashion. Labeled rotational intervals which are discussed below may be influenced by many factors such as the addition of other residual herbicides, soil type, soil pH, etc. Do not use these herbicides unless all rotational restrictions are understood.

Herbicide	**Rotation Restrictions**
Aim	Corn, sweetcorn, popcorn, soybeans, grain sorghum, rice, wheat, barley, oats, buckwheat, pearl millet, proso millet, rye, teosinte, tritcale, and wild rice may be planted any time following an application of Aim. Root and leafy vegetables may be planted after 30 days following an application of Aim. All other crops may be planted after 12 months following an application of Aim.
Assure II	Do not rotate to crops other than soybeans or cotton within 120 days of application. See label for additional rotational crops allowed.
Caparol/Cotton-Pro	Do not plant rotational crops until the following year.
Cobra	No crop rotation restrictions.
Cotoran	Do not plant crops other than cotton within 6 months of the last application of Cotoran/Meturon.
DSMA/MSMA	No restrictive statements listed on label.
Dual	Barley, oats, rye, or wheat may be planted 4 months following application. Crops on Dual label may be planted in the spring following application. All other rotation crops may be planted 12 months after application.

Table 5.120 - Rotational Restrictions (cont.)

The herbicides listed below, when used in cotton, may influence one's ability to rotate crops in a normal fashion. Labeled rotational intervals which are discussed below may be influenced by many factors such as the addition of other residual herbicides, soil type, soil pH, etc. Do not use these herbicides unless all rotational restrictions are understood.

Herbicide	Rotation Restrictions
Envoke	Crop rotation interval restrictions based on a total of 0.4 oz/A of Envoke per season are as follows: winter wheat and transplanted tomato (3 months); cotton, field and sweet corn, grain sorghum, peanut, soybean, and transplanted tobacco (7 months); transplanted bell pepper and Irish potato (12 months but based on field bioassay); and all other crops (18 months). If there is a cotton crop failure and no more than 0.15 oz/A of Envoke has been applied, cotton or STS-soybean (sulfonylurea-tolerant soybean) may be replanted 30 or more days after the Envoke application, or 14 or more days after the first significant rainfall (≥0.5 inches) following the Envoke application.
Fierce	Crop rotation restrictions based on 3 oz/A of Fierce are as follows: Alfalfa (10 months); Conv. till field corn (1 month); Reduced till field corn (7 days); Conv. till cotton (45 days); Reduced till cotton (1 month); Edible peas and other edible beans except field peas (11 months); Grass grown for seed (18 months); Lentils (6 months); Peanuts (4 months); Field Peas (6 months); Potato (4 months); Rice (10 months); Small grains other than wheat (11 months); Soybean (0 days); Sugarbeet (15 months); Sunflower (4 months); Sweet potato (4 months); Tobacco (12 months); Wheat (1 month); Other crops not listed (18 months). Rotational restrictions vary by rate. Consult the label for restrictions at higher rates.
Fusilade DX	Do not plant rotational grass crops such as corn, sorghum, and cereals within 60 days of last application.
Fusion	Do not plant rotational grass crops such as corn, sorghum, and cereals within 60 days of last application.
Glyphosate	No rotational restrictions.
Goal	Do not rotate to barley, corn, oats, sorghum, triticale, or wheat within 10 months following application. Do not direct seed any crops other than Goal-labeled crops within 60 days of treatment. Do not transplant seedling crops other than Goal-label crops within 30 days of treatment.
Layby Pro	Only cotton, corn, and grain sorghum can be planted the spring following the Layby Pro post-directed application. All other crops cannot be planted in the treated area within 1 year after the last Layby Pro application, or severe injury to subsequent crops may occur.
Liberty 280	Canola, corn, cotton, rice, soybeans, and sugar beets may be planted at any time. Root and tuber crops, leafy vegetables, brassica leafy vegetables, and small grains may be planted in 70 days. All other crops may be planted in 180 days.
Linex	Do not plant rotational crops other than corn, soybeans or potatoes within 4 months after application.
Poast/Poast Plus	No rotational restrictions.
Prowl	Winter wheat or winter barley may be planted 120 days after application. Any crop other than sugar-beets, red beets or spinach may be planted the year following application.
Reflex	Cotton, dry beans, snap beans, and soybeans may be planted any time after last Reflex application. Small grains may be planted in 4 months; corn, peanuts, peas, rice, and seed corn in 10 months. To avoid injury, do not plant alfalfa, sunflower, sugar beets, sorghum or any other crop within 18 months after last Reflex application. A maximum of 1.5 pt/A of Reflex may be applied in alternate years in Region 2 (Virginia).
Select/Select Max	No rotational restrictions.
Sequence	Barley, oats, rye, or wheat may be planted 4 months following application. All crops with a label for metolachlor (Dual) may be planted in the spring following the application. All other rotation crops may be planted 12 months after application.
Staple LX	Crop rotation interval restrictions for Staple are as follows: winter wheat (4 months); field corn, peanut, soybean, and transplanted tobacco (10 months); and all other crops are based on field bioassay or a minimum of 10 months. If there is a cotton crop failure following a Staple application, cotton may be replanted anytime (without disturbing original seedbed) or STS-soybean (sulfonylurea-tolerant soybean) may be replanted 30 days after the Staple application.

Table 5.120 - Rotational Restrictions (cont.)

The herbicides listed below, when used in cotton, may influence one's ability to rotate crops in a normal fashion. Labeled rotational intervals which are discussed below may be influenced by many factors such as the addition of other residual herbicides, soil type, soil pH, etc. Do not use these herbicides unless all rotational restrictions are understood.

Herbicide	Rotation Restrictions
Suprend	Crop rotation interval restrictions based on a total of 2.69 lb/A of Suprend (0.0188 lb ai/A of trifloxysulfuron-sodium) per season are as follows: winter wheat and transplanted tomato (3 months); cotton, field and sweet corn, grain sorghum, peanut, soybean, and transplanted tobacco (7 months); transplanted bell pepper and Irish potato (12 months but based on field bioassay); and all other crops (18 months). If there is a cotton crop failure and no more than 1.0 lb/A of Suprend has been applied, cotton or STS-soybean (sulfonylurea tolerant soybean) may be replanted 30 or more days after the Suprend application, or 14 or more days after the first significant rainfall (≥0.5 inches) following the Suprend application.
Treflan	Sugar beets, red beets or spinach should not be planted within 12 months of a spring application. Vegetable crops other than those listed on the Treflan label should not be planted within 5 months of application.
Valor	Crop rotation interval restrictions based on a total of 2 oz/A of Valor per season are as follows: cotton, field corn, sorghum, sunflower, tobacco, and wheat (30 days); barley, dry bean, field pea, rye, and sweet corn (4 months); alfalfa, canola, clover, oats, and all other crops not listed (12 months). At least one inch of rainfall/irrigation must occur between application and planting or crop injury may occur. Successful soil bioassay must be performed prior to planting alfalfa, canola, sugar beets, and other crops not listed.
	Preplant burndown applications of Valor 51WDG may injure cotton if planted too soon. Valor at 1.0 oz/A will give 2 to 4 weeks' control of lambsquarters, pigweed, prickly sida, spurge, and Florida pusley; and at 2.0 oz/A will give 6 to 8 weeks' control of these species. Application to cover crop or dense weed stand may reduce residual control. Tillage after application will reduce or eliminate residual control. A minimum of 14 days and a 1-inch rainfall must occur between Valor application and cotton planting when Valor is applied at 1.0 oz/A; 21 days must pass and a 1-inch rainfall when applied at 1.5 to 2.0 oz/A. Valor at 2.0 oz/A may be applied up to 14 days prior to planting strip-till cotton. A tillage application must occur between application and cotton planting in order to prevent any potential injury to emerging cotton plants. Failure to conduct strip-tillage operation prior to planting may result in cotton injury. Strip-tillage operation must incorporate soil to a depth of 1 to 2 inches.
Warrant	Corn (all types), cotton, soybeans, and milo (sorghum) may be replanted immediately, but could result in crop injury. When planting milo use only seed treated with protectant or safener. DO NOT exceed a total of 3 lbs acetochlor/A if additional product is applied. Nongrass animal feeds such as alfalfa, clover, and vetch species may be planted 9 months, after application. Wheat may be planted 4 months after application. The following crops may be rotated in next season: buchwheat, millet (pearl and proso), oats, rye, and certain bean species *(see label for additional information).*
Zidua	Crop rotation restrictions based on 2 oz/A of Zidua are as follows: Alfalfa (10 months); Canola/ Rapeseed (12 months); Corn (0 days); Cotton (2 months); Edible peas, succulent edible beans, and other edible dry beans (11 months); Grain sorghum (6 months); Grass grown for seed (18 months); Lentils (6 months); Peanuts (4 months); Field Peas (6 months); Potato (4 months); Rice (12 months); Small grains other than wheat (11 months); Soybean (0 days); Sugarbeet (12 months); Sunflower (4 months); Wheat (1 month); Other crops not listed (18 months). Rotational restrictions vary by rate. Consult the label for restrictions at lower or higher rates.

Cotton Growth Regulators

William Hunter Frame, Assistant Professor, Field Crops Agronomist, Tidewater AREC

Table 6.1 - Plant Growth Regulation (PGR)

Objective	Chemical rate per acre	Product per acre	Remarks and Precautions
Plant growth regulation	Mepiquat chloride 0.35 lb or Mepiquat chloride + *Bacillus Cereus* or Kinetin 0.35 lb or Mepiquat pentaborate 0.82 lb	Pix, Mepex 4.0-8.0 oz or Pix Plus, Mepex 4.0-8.0 oz or Pentia 4.0-8.0 oz	Although plant growth regulator applications can be an important part of an overall cotton management program, they can result in reduced yields if applied while plants are undergoing stressful (especially moisture) conditions. Before applying plant growth regulators, variety, soil type, fertility, irrigation potential, and field history must be taken into consideration.

Note: Maximum of 48 oz of Mepiquat chloride may be applied/A/growing season.

Timing Suggestions – the Modified Early Bloom Technique

The modified early bloom strategy involves the use of height to node ratios and the measurement of the most recently expanded internode length. The most recently expanded internode is measured by counting down the plant from the highest mainstem leaf (>quarter size) to the fourth leaf. Examine the internode above and below the fourth leaf and measure the larger of the two. This is a good indicator of the plant vigor over that past week or so. Long internodes will range between 2.5 to 3 inches while short internodes will be below 2.0 inches. The tables below are provided to aid in determining Pix application decisions using the modified early bloom strategy.

Table 6.2 - Matchhead Square (MHS) (typically 3rd to 4th week in June)

	Plant height		
	<17 in	**17-20 in**	**>20 in**
Height to node ratio >1.85 in	4 oz	6 oz	8 oz
Internode[1] >2.5 in	4 oz	6 oz	8 oz

Do not apply if soil moisture is poor.

[1]Most recently expanded internode (see measurement description above).

Table 6.3 - Early Bloom – Use this chart if PGR was applied at MHS

	Plant height			
	<24 in	**24-27 in**	**27-30 in**	**>30 in**
Internode[1] >2.5 in	0 oz	8 oz	10 oz	12 oz

Do not apply if soil moisture is poor.

Do not apply if nodes above the highest first position white bloom <7.

[1]Most recently expanded internode (see measurement description above).

Table 6.4 - Early Bloom – Use this chart if no PGR has been applied

	Plant height			
	<24 in	**24-27 in**	**27-30 in**	**>30 in**
Internode[1] >2.5 in	6 oz	8 oz	12 oz	16 oz

Do not apply if soil moisture is poor.

Do not apply if nodes above the highest first position white bloom <7.

[1]Most recently expanded internode (see measurement description above).

Table 6.5 - 10 to 14 Days after Early Bloom

	Pix applied at early bloom	
	<8 oz	**>8 oz**
Internode[1] <2.5 in	0 oz	0 oz
Internode 2.5-3.5 in	12 oz	8 oz
Internode >3.5 in	16 oz	12 oz

Do not apply if soil moisture is poor.

Do not apply if nodes above the highest first position white bloom <6.

[1]Most recently expanded internode (see measurement description above).

Cotton Harvest Aids

William Hunter Frame, Assistant Professor, Field Crops Agronomist, Tidewater AREC

Table 6.6 - Cotton Harvest Aids

	Defoliation Only, Field Cutout	Defoliation with Regrowth Anticipated	Defoliation and Boll Opening	Defoliation and Boll Opening With Regrowth Anticipation
Def 6/Folex 6EC	1.33-1.5 pt			
Def 6/Folex 6EC + Dropp SC		1.0-1.5 pt + 1.6-6.4 (9.6 NTE fl oz)[1]		
Def 6/Folex 6EC ethephon 6EC[2]			1.0-1.5 pt + 5.3 fl oz	
Def 6/Folex 6EC ethephon 6EC[2] Dropp SC				1.0-1.5 pt + 5.3 fl oz + 1.6-6.4 (9.6 NTE fl oz)[1]
ethephon 6EC[2]			1.33-2.67 pt	
Finish 6SC	1.3-2.0-2.67 pt temperature related		1.3-2.0-2.67 pt temperature related	
Finish 6SC + Dropp SC		1.3-2.0 pt + 1.6-6.4 (9.6 NTE fl oz)[1]		1.3-2.0 pt + 1.6-6.4 (9.6 NTE fl oz)[1]
Finish 6SC + Def 6/Folex 6EC			1.3-2.0 pt + 1.0-1.5 pt	
FirstPick	3.0-3.5 qt		3.0-3.5 qt	
FirstPick + Dropp SC		1.5-2.0 qt + 0.8-3.2 fl oz		1.5-2.0 qt + 0.8-3.2 fl oz
FirstPick + Def 6/Folex 6EC			1.5-2.0 qt + 4.0-12.0 fl oz	
Dropp SC		1.6-6.4 (9.6 NTE fl oz)[1]		
Dropp SC + ethephon 6EC[2]			1.6-6.4 (9.6 NTE fl oz)[1] + 1.33-2.67 pt	1.6-6.4 (9.6 NTE fl oz)[1] + 1.33-2.67 pt

[1]NTE = not to exceed

[2]The active ingredient Ethephon is available as 6EC formulations as a number of trade name products such as Prep, Ethephon, Super Boll, etc.

[3]COC = crop oil concentrate

Defoliation Materials

Def 6, Folex: These phosphate-based compounds have been a standard defoliant for many years and provide good defoliation of older, more mature leaves in well cutout cotton. These products provide minimal regrowth inhibition and are typically mixed with other products (e.g. ethephon-Prep, Super Boll, etc.). They are similar in efficacy and will perform well over a wide range of environmental conditions. However, the high end of the labeled rate performs best in cool conditions. Leaf drop is fast and they only require a rain-free period of two hours. The activity of these compounds improves with increased cutout of the crop. The addition of surfactants or crop oils can increase activity under adverse conditions. The pungent odor of these products may be a consideration in populated areas.

Dropp 50 WP and SC, Freefall 50 WP, etc. (thidiazuron): Dropp and Freefall defoliate mature leaves, have excellent activity on juvenile leaves, and suppress or delay regrowth. A minimum of 0.1 pound per acre WP or 1.6 fl. ounces per acre is needed for 10 to 14 days of regrowth inhibition. Higher rates will result in longer periods of regrowth inhibition. Thidiazuron alone is usually equal to or better than other defoliants in drought-stressed situations where leaves have thick cuticles. Dropp and Freefall are somewhat slower acting than other defoliants and their activity is temperature dependent. Temperatures less than 65°F will reduce activity; however, the addition of crop oil concentrate or a phosphate-type defoliant will help the activity of thidiazuron under cooler conditions. The addition of 2 to 4 ounces per acre of Def or Folex will shorten the 24-hour required rain-free period. The

label provides specific tank clean-out procedures when using thidiazuron-containing materials to avoid premature defoliation when the sprayer is used the following year. When thidiazuron is tank mixed with a phosphate defoliant or insecticide, the label recommends a surfactant to aid in tank clean out. When using the WP formulation, thorough rinsing is critical.

Ginstar: Ginstar is a premix emulsifiable concentrate of thidiazuron (active ingredient in Dropp and Freefall) and diuron. Ginstar has been found to be more active under cool conditions than most thidiazuron-containing materials. Ginstar is a strong inhibitor of terminal regrowth. It is more likely to cause unwanted desiccation and sticking of cotton leaves than thidiazuron alone. Tank mixing and higher rates increase the potential for leaf sticking. Labeled rates are 6.4 to 16 ounces per acre and growers are cautioned not to exceed 8 ounces with this product until more information is available from Virginia. Growers are cautioned that rates in excess of 10 ounces have shown a tendency to desiccate leaves. The label does not allow mixing with phosphate type defoliants (Def, Folex). However, ethephon-containing materials (Prep, SuperBoll, Finish, CottonQuik, etc.) can be tank mixed at low rates for enhanced defoliation. The use of adjuvants with Ginstar is not recommended. Pay close attention to rotational restrictions on the label. Research in Virginia with this product is limited. Pay attention to label for Virginia; some other state labels differ greatly. Pay close attention to rotational restrictions on the label.

Aim, ET, Blizzard, and Resource: These products have different active ingredients (carfentrazone, pyraflufen, fluthiacet, and flumiclorac, respectively) but similar modes of action. They are all contact herbicidal defoliants that do not appear to be extremely temperature sensitive. Research indicates they can cause excessive desiccation at high rates under warm condition where rank, juvenile growth is not present. They perform best in well-cutout cotton and can be beneficial when used as a second application. They provide regrowth control but have no residual activity and are good morningglory desiccants. These products can be mixed with most other defoliants/boll openers. See labels for adjuvant requirements and use restrictions.

Finish: Finish contains the active ingredient in Prep (ethephon) and a synergist (cyclanilide) that aids in defoliation. Finish tends to open bolls more rapidly than Prep alone and thus shortens the time to harvest. It is less temperature sensitive than most products. In situations where regrowth or added defoliation is needed, thidiazuron (Dropp, Freefall, etc) and/or Def/Folex should be added to the tank.

FirstPick: FirstPick weighs 12.45 pounds per gallon and contains 2.28 pounds of ethephon (Prep) and 7.30 pounds of a synergist (AMADS). Like Finish, it is an excellent boll opener. Acceptable defoliation with FirstPick typically occurs within 7 days in well-cutout cotton containing mature leaves. FirstPick also provides limited control of terminal regrowth. Where thick regrowth is a concern, add thidiazuron (Dropp, Prep, etc.). Def/Folex may be added to enhance defoliation of juvenile or rank growth. Thorough rinsing of the tank is recommended following application.

Roundup (glyphosate, many formulations): Glyphosate can be applied as a harvest aid material. Tank mixed with defoliants or ethephon, it provides regrowth inhibition in conventional (non-Roundup Ready) cotton. It also provides excellent control of perennial grasses. Check specific product labels for registrations as a harvest aid.

Boll-opening Materials

Although some boll openers are used to enhance the activity of defoliants, they are typically used to hasten the maturity of boll opening. Boll openers are meant to open mature bolls and can alter micronaire and fiber length if applied too early. They are not systemic, making thorough coverage essential. Boll openers are most beneficial for cotton that needs to be picked between 7 to 14 days following application. The active ingredient in Prep, ethephon, is also found as a premix in several products but is below the boll-opening rate. Check labels to make sure the boll-opening rate is applied, if this is the objective.

Ethephon 6, Prep, Super Boll, FirstPick, Finish (ethephon): With adequate spray coverage, ethephon products expedite natural boll opening. While ethephon can enhance defoliation, tank mixing with defoliation products (Def, Folex, Dropp, Freefall, Ginstar, ET, Blizzard, and/or Aim) is necessary for acceptable defoliation and/or regrowth control. Allow at least 7 days following application before harvest for optimum boll-opening effect. If cotton is not picked for more than 14 days following application, there is likely no advantage to ethephon use. FirstPick and Finish are combinations of ethephon and a synergist to increase defoliation and speed boll opening over ethephon alone. Bolls that are not mature at the time of application have little chance of opening in 14 days regardless of ethephon use. Do not mix with sodium chlorate due the potential for toxic fume formation.

Gramoxone SL (paraquat): Paraquat can enhance defoliation of juvenile growth when applied in combination with other defoliants although it will not inhibit regrowth. It can stimulate boll opening. High rates may result in excessive desiccation and "freezing" of closed bolls. It also can be used as a spot treatment for weed desiccation. It should not be applied at weed desiccation rates before cotton is at least 90% open and the remaining 10% are mature. It is necessary to pick within 7 days following paraquat application to avoid bark contamination. Consult label for use rates and pay close attention to precautions.

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