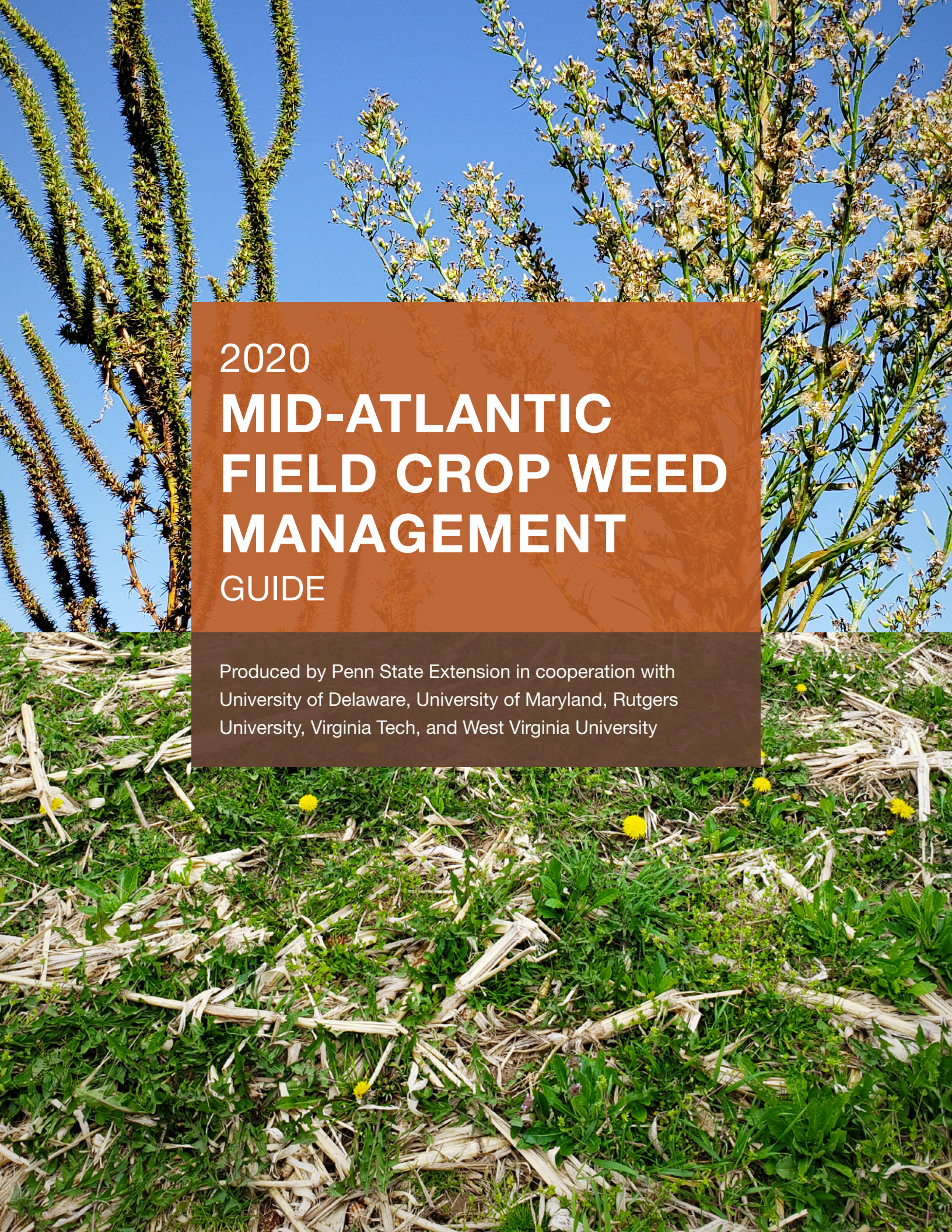

2020

MID-ATLANTIC FIELD CROP WEED MANAGEMENT GUIDE

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PennState Extension

Acknowledgments

Penn State

John Wallace, Assistant Professor of Weed Science and Extension Weed Specialist
Dwight Lingenfelter, Extension Associate, Weed Science

University of Delaware

Mark VanGessel, Professor of Weed Science and Crop Management, Extension Weed Specialist
Quintin Johnson, Extension Associate, Weed and Crop Management

University of Maryland

Kurt Vollmer, Extension Specialist, Weed Management

Rutgers University

Thierry Besancon, Assistant Extension Specialist, Weed Science

Virginia Tech

Michael Flessner, Assistant Professor and Extension Weed Science Specialist

West Virginia University

Rakesh Chandran, Professor and Extension Weed Specialist

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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 (Fig. 1-1): 117,000

Figure 1-1. Pigweed.

Contact or Translocated

Contact herbicides kill or injure only the part of the plant with which the spray droplets come into 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 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 Non-selective

Non-selective herbicides kill or injure almost all plants, while selective herbicides kill some plants but do little or no damage to others (Fig. 1-6). 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 by placement is accomplished by avoiding or minimizing contact between the herbicide and the desired crop. 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 and site of action is helpful in knowing what groups of weeds are killed, specifying application techniques, diagnosing herbicide injury problems, and preventing herbicide-resistant weeds.

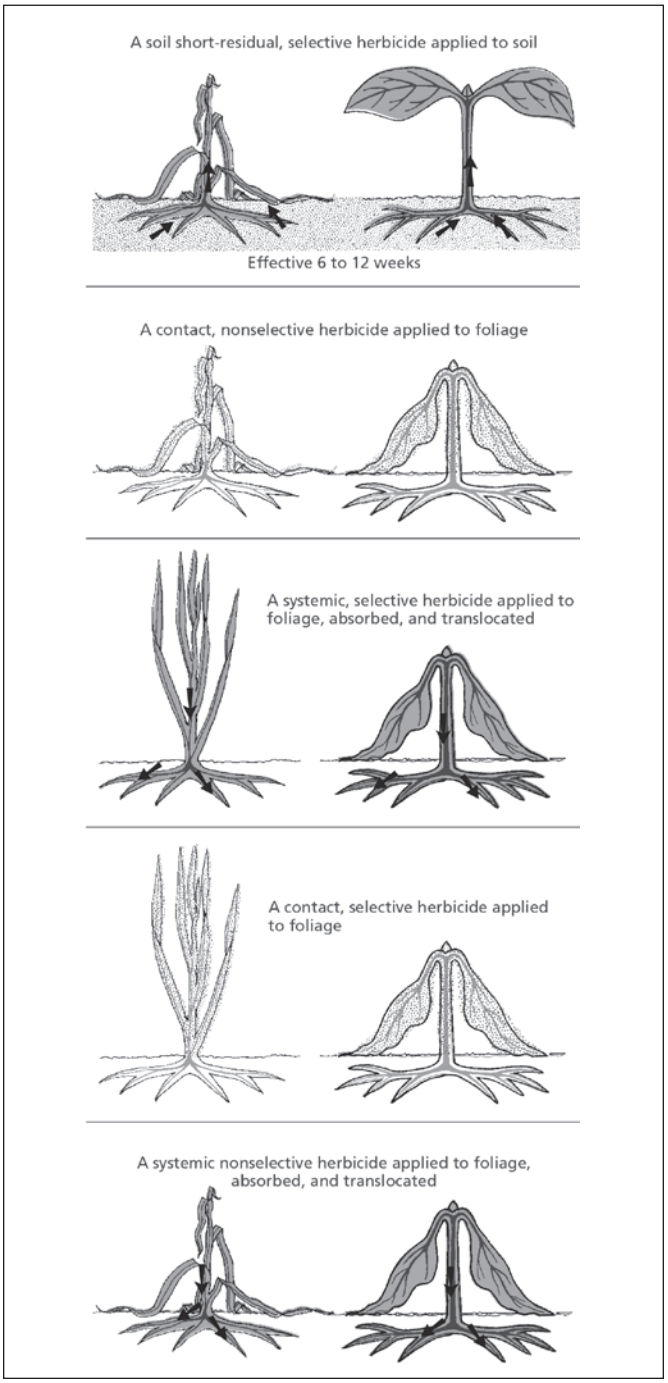

Figure 1-6. Chemical weed control.

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 1-1 lists several groups of herbicides and information related to their mode 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 1-1.

Plant Growth Regulators (PGRs)—Groups 4 and 19

Also called auxins, synthetic auxins, and hormones, 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, straplike 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 and water 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 an 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. See Table 1-2.) 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 2 to 4 days, established perennials in 2 to 4 weeks. Plants become straw colored several days or weeks after treatment, gradually turn brown, and die.

Fatty Acid (Lipid) Biosynthesis Inhibitors—Group 1

These herbicides are rapidly absorbed by grasses and 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" and "graminicide" 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 easily 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

Table 1-1. 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 (acetyl CoA carboxylase)	15	Aryloxyphenoxy-propionate (fops)	fenoxaprop	Puma, Tacoma
				fluazifop	Fusilade
				quizalofop	Assure II, Targa
			Cyclohexanedione (dims)	clethodim	Select Max
				sethoxydim	Poast
			Phenylpyrazolin	pinoxaden	Axial XL
	Amino Acid Synthesis Inhibitors				
2	ALS Inhibitors (acetolactate synthase)	52	Imidazolinone	imaxamox	Beyond, Raptor
				imazapic	Plateau
				imazapyr	Arsenal
				imazethapyr	Pursuit
				pyrithiobac	Staple
			Pyrimidinylthio-benzoic acid	flucarbazone	Everest
			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	Cimarron, *others*
				nicosulfuron	Accent Q
				prosulfuron	Peak
				rimsulfuron	Matrix, Resolve
				sulfosulfuron	Maverick
				thifensulfuron	Harmony
				tribenuron	Express
				triflusulfuron	UpBeet
			Triazolopyrimidine	cloransulam	FirstRate
				flumetsulam	Python
				pyroxsulam	PowerFlex
9	EPSP Synthase Inhibitor (5-enolpyruvyl-shikimate-3-phosphate)	17	Organophosphorus	glyphosate	Roundup, Touchdown, *others*

	Herbicide Class/MOA				
WSSA Group[1]	**Site of Action**	**No. Resistant in U.S.**	**Family**	**Common Name**	**Trade Name**
	Growth Regulators				
4	T1R1 Auxin Receptors (synthetic auxins)	10	Arylpicolinate	halauxifen-methyl	Elevore
			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 Inhibitors (mobile) different binding than 6 and 7	26	Phenylcarbamate	phenmedipham	Spin-Aid
			Triazine	atrazine	Atrazine
				prometon	Pramitol
				simazine	Princep
			Triazinone	hexazinone	Velpar
				metribuzin	Glory, Metribuzin, TriCor
			Uracil	terbacil	Sinbar
6	Photosystem II Inhibitors (non-mobile) different binding than 5 and 7	1	Benzothiadiazole	bentazon	Basagran
			Nitrile	bromoxynil	Maestro
7	Photosystem II Inhibitors (mobile) different binding than 5 and 6	11	Urea	diuron	Direx, Karmex
				linuron	Linex, Lorox
				tebuthiuron	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	Balance Flexx
			Pyrazole	pyrasulfotole	*component of Huskie*
			Pyrazolone	tolpyralate	Shieldex
				topramezone	Armezon, Impact
			Triketone	mesotrione	Callisto
				tembotrione	Laudis

(continued)

	Herbicide Class/MOA				
WSSA Group[1]	**Site of Action**	**No. Resistant in U.S.**	**Family**	**Common Name**	**Trade Name**
	Cell Membrane Disrupters				
14	PPO Inhibitors (protoporphyrinogen oxidase)	2	Aryl triazolinone	carfentrazone	Aim
				fluthiacet	Cadet
				sulfentrazone	Authority, Spartan
			Diphenyl ether	acifluorfen	Ultra Blazer
				fomesafen	Reflex
				lactofen	Cobra, Phoenix
				oxyfluorfen	Goal
			N-phenylphthalimide	flumiclorac	Resource
				flumioxazin	Château, Valor
			Oxadiazole	oxadiazon	Ronstar
			Pyrimidinedione	saflufenacil	Kixor, Sharpen
22	Photosystem I Electron Diverter	6	Bipyridylium	diquat	Reglone
				paraquat	Gramoxone
	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	cycloate	Ro-Neet
				EPTC	Eptam, Eradicane
15	Long-chain Fatty Acid Inhibitors	1	Acetamide	napropamide	Devrinol
			Chloroacetamide	acetochlor	Breakfree, Degree, Harness Topnotch, Warrant, *others*
				dimethenamid	Outlook
				metolachlor	Dual, Cinch, *others*
			Oxyacetamide	flufenacet	Define
			Pyrazole	pyroxasulfone	Zidua
16	Specific Site Unknown	0	Benzofurane	ethofumesate	Nortron
	Cell Wall Synthesis Inhibitors				
20	Cellulose Inhibitor (Site A)	0	Nitrile	dichlobenil	Casoron, *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, based on site of action, developed by the Weed Science Society of America.

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Table 2-1. Corn 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
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 2EC	carfentrazone-ethyl	14	FMC	—	—	12
Anthem Maxx 4.3SC	pyroxasulfone + fluthiacet	15/14	FMC	—	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-P	27/15	BASF	—	yes	12
Assure II 0.88E/Targa	quizalofop	1	AMVAC/Gowan	—	—	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
Bicep II Magnum 5.5L/ Cinch ATZ	*S*-metolachlor + atrazine + safener	15/5	Syngenta/Corteva	yes	yes	24
Bicep Lite II Magnum 6L/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	Bayer CropScience	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 7.64E	*S*-metolachlor + safener	15	Syngenta	—	yes	24
Durango DMA/Duramax 4S	glyphosate	9	Corteva	—	—	4
Elevore 0.57L	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

Trade Name	Common Name	Site of Action Number	Manufacturer	Restricted-use Pesticide[1]	Water Quality Advisory[2]	Worker Reentry (Hours)[3]
EverpreX 7.62E	*S*-metolachlor	15	Corteva	—	yes	24
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
FirstShot 50WDG	thifensulfuron + tribenuron	2/2	FMC	—	—	12
FulTime NXT 4.04EC	acetochlor + atrazine	15/5	Corteva	yes	yes	12
Gramoxone SL 2S	paraquat	22	Syngenta	yes	—	12–24
Halex GT 4.39EC	*S*-metolachlor + mesotrione + glyphosate[4]	15/27/9	Syngenta	—	yes	24
Harmony Extra SG 50WDG	thifensulfuron + tribenuron	2/2	FMC	—	—	12
Harmony SG 50WDG	thifensulfuron	2	FMC	—	—	4
Harness 7E	acetochlor + safener	15	Bayer CropScience	—	yes	12
Harness MAX 3.85L	acetochlor + mesotrione	15/27	Bayer CropScience	—	yes	12
Harness Xtra 5.6/6L	acetochlor + atrazine	15/5	Bayer CropScience	yes	yes	12
Impact 2.8SC/Armezon	topramezone	27	AMVAC/BASF	—	—	12
ImpactZ 4.26SC	topramezone + atrazine	5/27	AMVAC	yes	yes	12
Keystone LA NXT 6SE	acetochlor + atrazine	15/5	Corteva	yes	yes	12
Keystone NXT 5.6SE	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
Metribuzin 75DF/4L	metribuzin	5	various	—	yes	12
Outlook 6EC	dimethenamid-P	15	BASF	—	yes	12
Panoflex 50WDG	thifensulfuron + tribenuron	2/2	FMC	—	—	12
Peak 57WG	prosulfuron	2	Syngenta	—	yes	12
Permit 75WG	halosulfuron	2	Gowan	—	—	12
Permit Plus 74WDG	halosulfuron + thifensulfuron	2/2	Gowan	—	—	12
Princep 4L/Simazine 90DF	simazine	5	Syngenta, others	—	yes	12
Prowl 3.3E	pendimethalin	3	BASF	—	—	24
Prowl H2O 3.8CS	pendimethalin	3	BASF	—	—	24
Python 80WDG/Accolade	flumetsulam	2	Corteva/FMC	—	yes	12
Realm Q 39WDG	rimsulfuron + mesotrione + safener	2/27	Corteva	—	yes	12
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 0.86EC	flumiclorac	14	Valent	—	—	12
Revulin Q 51.2WDG	nicosulfuron + mesotrione	2/27	Corteva	—	—	12
Roundup WeatherMAX 4.5S/PowerMAX 4.5S	glyphosate	9	Bayer CropScience	—	—	4

(continued)

Trade Name	Common Name	Site of Action Number	Manufacturer	Restricted-use Pesticide[1]	Water Quality Advisory[2]	Worker Reentry (Hours)[3]
Sequence 5.25EW	glyphosate + *S*-metolachlor	9/15	Syngenta	—	yes	24
Sharpen 2.85SC	saflufenacil	14	BASF	—	yes	12
Shieldex 400SC	tolpyralate	27	Summit Agro	—	yes	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/ Bayer CropScience	—	yes	12
Surpass NXT 7E	acetochlor + safener	15	Corteva	—	yes	12
TopNotch 3.2ME	acetochlor + safener	15	Corteva	—	yes	12
Touchdown Total 4.17S	glyphosate	9	Syngenta	—	—	12
ValorSX 51WDG	flumioxazin	14	Valent	—	—	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 3.67SC	*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 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 glyphosate-resistant corn hybrids only (Roundup Ready).
[5] For use on glufosinate-resistant corn hybrids only (LibertyLink).
[6] For use only on IMI (IR/IT) or Clearfield (CL) corn hybrids.

Table 2-2. Corn herbicide prepackaged mixes, or co-packs, and equivalents.

Trade Name	Components (ai/gal or lb)	Site of Action Number	If You Apply (per acre)	You Have Applied (ai)	An Equivalent Tank Mixture of
Acuron 3.44SC	2.14 lb *S*-metolachlor	15	2.5 qt	1.34 lb *S*-metolachlor	1.4 pt Dual II Magnum 7.64E
	0.24 lb mesotrione	27		0.15 lb mesotrione	4.8 fl oz Callisto 4SC
	0.06 lb bicyclopyrone	27		0.038 lb bicyclopyrone	0.038 lb bicyclopyrone
	1 lb atrazine	5		0.625 lb atrazine	0.625 qt atrazine 4L
Acuron Flexi 3.26SC	2.86 lb *S*-metolachlor	15	2 qt	1.43 lb *S*-metolachlor	1.5 pt Dual II Magnum 7.64E
	0.32 lb mesotrione	27		0.16 lb mesotrione	5.12 fl oz Callisto 4SC
	0.08 lb bicyclopyrone	27		0.04 lb bicyclopyrone	0.04 lb bicyclopyrone
Anthem Flex 4SE	3.733 lb pyroxasulfone	15	3.5 fl oz	0.102 lb pyroxasulfone	3.1 fl oz Zidua 4.17SC
	0.267 lb carfentrazone	14		0.007 lb carfentrazone	0.47 fl oz Aim 2EC
Anthem Maxx 4.3SC	4.174 lb pyroxasulfone	15	4 fl oz	0.133 lb pyroxasulfone	4.1 oz Zidua 4.17SC
	0.126 lb fluthiacet	14		0.004 lb fluthiacet	0.56 oz Cadet 0.91EC
Armezon PRO 5.35EC	0.1 lb topramezon	27	24 fl oz	0.017 lb topramezon	0.76 fl oz Armezon 2.8SC
	5.25 lb dimethenamid-P	15		0.84 lb dimethenamid-P	18 fl oz Outlook 6EC
Autumn Super 51WDG	0.06 lb iodosulfuron	2	0.4 oz	0.002 lb iodosulfuron	0.024 oz ai iodosulfuron
	0.45 lb thiencarbazone	2		0.011 lb thiencarbazone	0.18 oz ai thiencarbazone
Axiom 68DF	0.544 lb flufenacet	15	16 oz	0.544 lb flufenacet	17 oz Define 4SC
	0.136 lb metribuzin	5		0.136 lb metribuzin	2.9 oz Metribuzin 75DF
Basis Blend 30DF	0.20 lb rimsulfuron	2	0.825 oz	0.01 lb rimsulfuron	0.64 oz Resolve 25DF
	0.10 lb thifensulfuron	2		0.005 lb thifensulfuron	0.16 oz Harmony SG 50DF
Bicep II Magnum 5.5L/ Cinch ATZ	2.4 lb *S*-metolachlor	15	2.1 qt	1.26 lb *S*-metolachlor	1.33 pt Dual II Magnum 7.64E
	3.1 lb atrazine	5		1.63 lb atrazine	1.63 qt atrazine 4L
Bicep Lite II Magnum 6L/Cinch ATZ Lite	3.33 lb *S*-metolachlor	15	1.3 qt	1.08 lb *S*-metolachlor	1.13 pt Dual II Magnum 7.64E
	2.67 lb atrazine	5		0.87 lb atrazine	0.87 qt atrazine 4L
Callisto GT	0.38 lb mesotrione	27	2 pt	0.095 lb mesotrione	3.04 fl oz Callisto 4SC
	3.8 lb glyphosate	9		0.95 lb glyphosate	1.8 pt Touchdown
Callisto Xtra 3.7SC	0.5 lb mesotrione	27	24 fl oz	0.09 lb mesotrione	3.04 fl oz Callisto 4SC
	3.2 lb atrazine	5		0.6 lb atrazine	1.2 pt atrazine 4L
Capreno 3.45SC	2.88 lb tembotrione	27	3 fl oz	0.068 lb tembotrione	2.5 fl oz Laudis 3.5SC
	0.57 lb thiencarbazone	2		0.013 lb ai thiencarbazone	0.21 oz ai thiencarbazone
Corvus 2.63SC	1.88 lb isoxaflutole	27	5.6 fl oz	0.083 lb isoxaflutole	5.3 fl oz Balance Flexx 2SC
	0.75 lb thiencarbazone	2		0.033 lb thiencarbazone	0.52 oz ai thiencarbazone
Curtail 2.38L	0.38 lb clopyralid	4	2 pt	0.095 lb clopyralid	0.25 pt Stinger 3S
	2 lb 2,4-D	4		0.5 lb 2,4D	1.0 pt 2,4-D 4S
Degree Xtra 4.04ME	2.7 lb acetochlor	15	3 qt	2.03 lb acetochlor	2.3 pt Harness 7E
	1.34 lb atrazine	5		1 lb atrazine	1 qt atrazine 4L
DiFlexx Duo 1.53SC	1.26 lb dicamba	4	32 fl oz	0.32 lb dicamba	10.25 oz DiFlexx 4SC
	0.27 lb tembotrione	27		0.068 lb tembotrione	2.5 fl oz Laudis 3.5SC
Enlist Duo 3.3SL	1.6 lb 2,4-D choline salt	4	4.75 pt	0.95 lb ae 2,4-D	30 fl oz Enlist One 3.8SL
	1.7 lb glyphosate	9		1.0 lb ae glyphosate	32 fl oz Durango DMA
Expert 4.88L	1.74 lb *S*-metolachlor	15	3 qt	1.3 lb *S*-metolachlor	1.4 pt Dual II Magnum 7.64E
	2.14 lb atrazine	5		1.6 lb atrazine	1.6 qt atrazine 4L
	0.75 lb ae glyphosate	9		0.75 lb glyphosate	1.5 pt glyphosate 4S
Fierce 76WDG	0.335 lb flumioxazin	14	3 oz	0.063 lb flumioxazin	2 oz Valor SX 51WG
	0.425 lb pyroxasulfone	15		0.08 lb pyroxasulfone	1.5 oz Zidua 85WG
FulTime NXT 4.04CS	2.7 lb acetochlor	15	3 qt	2 lb acetochlor	2.5 qt TopNotch 3.2ME
	1.34 lb atrazine	5		1 lb atrazine	1 qt atrazine 4L

(continued)

Trade Name	Components (ai/gal or lb)	Site of Action Number	If You Apply (per acre)	You Have Applied (ai)	An Equivalent Tank Mixture of
Halex GT 4.39EC	2.09 lb *S*-metolachlor	15	3.6 pt	0.94 lb *S*-metolachlor	1 pt Dual Magnum 7.62E
	0.209 lb mesotrione	27		0.09 lb mesotrione	3 fl oz Callisto 4SC
	2.09 lb glyphosate	9		0.94 lb glyphosate (ae)	24 fl oz Touchdown HiTech
Harness MAX 3.85L	3.52 lb acetochlor	15	2 qt	1.76 lb acetochlor	2 pt Harness 7E
	0.33 lb mesotrione	27		0.165 lb mesotrione	5.3 fl oz Callisto 4SC
Harness Xtra 6.0L	4.3 lb acetochlor	15	2 qt	2.15 lb acetochlor	2.46 pt Harness 7E
	1.7 lb atrazine	5		0.85 lb atrazine	0.85 qt atrazine 4L
Harness Xtra 5.6L	3.1 lb acetochlor	15	2.5 qt	1.94 lb acetochlor	2.21 pt Harness 7E
	2.5 lb atrazine	5		1.56 lb atrazine	1.56 qt atrazine 4L
ImpactZ 4.26SC	4 lb atrazine	5	10.7 fl oz	0.33 lb atrazine	10.6 fl oz atrazine 4L
	0.26 lb topramezone	27		0.02 lb topramezone	1 fl oz Impact 2.8SC
Keystone LA NXT 6SE	4.3 lb acetochlor	15	2.3 qt	2.47 lb acetochlor	2.7 pt Surpass NXT 7EC
	1.5 lb atrazine	5		1.43 lb atrazine	1.95 pt atrazine 4L
Keystone NXT 5.6SE	3.1 lb acetochlor	15	2.5 qt	1.94 lb acetochlor	2.22 pt Surpass/Breakfree NXT
	2.5 lb atrazine	5		1.57 lb atrazine	3.15 pt atrazine 4L
Lexar EZ 3.7SC	1.74 lb *S*-metolachlor	15	3 qt	1.3 lb *S*-metolachlor	1.36 pt Dual II Magnum 7.64E
	0.224 lb mesotrione	27		0.168 lb mesotrione	5.36 oz Callisto 4SC
	1.74 lb atrazine	5		1.3 lb atrazine	1.3 qt atrazine 4L
Lumax EZ 3.67SC	2.49 lb *S*-metolachlor	15	2.7 qt	1.67 lb *S*-metolachlor	1.75 pt Dual II Magnum 7.64E
	0.249 lb mesotrione	27		0.168 lb mesotrione	5.36 oz Callisto 4SC
	0.935 lb atrazine	5		0.625 lb atrazine	0.625 qt atrazine 4L
Permit Plus 74WDG	0.662 lb halosulfuron	2	0.75 oz	0.031 lb halosulfuron	0.67 oz Permit 75WG
	0.078 lb thifensulfuron	2		0.004 lb thifensulfuron	0.12 oz Harmony 50SG
Realm Q 38.75WDG	0.075 lb rimsulfuron	2	4 oz	0.019 lb rimsulfuron	1.2 oz Resolve 25WG
	0.313 lb mesotrione	27		0.078 lb mesotrione	2.5 fl oz Callisto 4SC
Resicore 3.29SE	2.8 lb acetochlor	15	2.5 qt	1.75 lb acetochlor	2 pt Surpass NXT 7E
	0.3 lb mesotrione	27		0.18 lb mesotrione	5.76 fl oz Callisto 4SC
	0.19 lb clopyralid	4		0.119 lb clopyralid	0.3 pt Stinger 3S
Resolve Q 22.4WDG	0.184 lb rimsulfuron	2	1.25 oz	0.014 lb rimsulfuron	0.9 oz Resolve 25DF
	0.04 lb thifensulfuron	2		0.003 lb thifensulfuron	0.1 oz Harmony 50SG
Revulin Q 51.2WDG	0.144 lb nicosulfuron	2	4 oz	0.036 lb nicosulfuron	1.1 oz Accent Q 54.5WG
	0.368 lb mesotrione	27		0.094 lb mesotrione	3 fl oz Callisto 4SC
Status 56WG	0.4 lb dicamba	4	5 oz	0.125 lb dicamba	4 fl oz Banvel 4S
	0.16 lb diflufenzopyr	19		0.05 lb diflufenzopyr	0.05 lb diflufenzopyr
Steadfast Q 37.7WG	0.125 lb rimsulfuron	2	1.5 oz	0.012 lb rimsulfuron	0.76 oz Resolve 25WG
	0.252 lb nicosulfuron	2		0.02 lb nicosulfuron	0.7 oz Accent Q 54.5WG
Stout 72.5WDG	0.675 lb nicosulfuron	2	0.75 oz	0.031 lb nicosulfuron	0.67 oz Accent 75DF
	0.05 lb thifensulfuron	2		0.002 lb thifensulfuron	0.05 oz Harmony 75DF
SureStart II 4.25SE or TripleFLEX II	3.75 lb acetochlor	15	2 pt	0.94 lb acetochlor	1.1 pt Surpass NXT 7E
	0.29 lb clopyralid	4		0.075 lb clopyralid	3.2 fl oz Stinger 3S
	0.12 lb flumetsulam	2		0.03 lb flumetsulam	0.6 oz Python 80WDG
Verdict 5.57EC	5 lb dimethenamid-P	15	13 fl oz	0.5 lb dimethenamid-P	11 fl oz Outlook 6EC
	0.57 lb saflufenacil	14		0.058 lb saflufenacil	2.6 fl oz Sharpen 2.85L
Yukon 67.5WDG	0.125 lb halosulfuron	2	4 oz	0.03 lb halosulfuron	0.67 oz Permit 75WG
	0.55 lb dicamba	4		0.125 lb dicamba	4 fl oz Clarity 4S
Zemax 3.67SC	3.34 lb *S*-metolachlor	15	2 qt	1.67 lb *S*-metolachlor	1.75 pt Dual II Magnum 7.64E
	0.33 lb mesotrione	27		0.165 lb mesotrione	5.36 fl oz Callisto 4SC

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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. 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. 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 3-4. 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 Atrazine 4L	atrazine	5	grain, forage	1.8–2.2 lb 1.6–2 qt	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 have 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, 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 (DMA salt)	4	grain, forage	8 oz	0.25 ae
Clarity 4S	dicamba (DGA 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
• Only certified applicators who successfully complete the paraquat-specific training can mix, load, or apply paraquat. • Application of paraquat "under the direct supervision" of a certified applicator is no longer allowed; registered technicians cannot apply. • Required training at http://usparaquattraining.com; certified applicators must repeat training every three years. • 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 one 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.*					
Glyphosate[2]	glyphosate	9	grain, forage	varies with formulation	0.75–1.5 ae
• Use at least 1.13 lb 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 they may be less effective on certain annual grasses and perennials. • Do not use glyphosate with suspension-type liquid fertilizers.					

Trade Name[1]	Common Name	Site of Action Number	Sorghum Type	Product/A	lb ai/A
Lexar EZ 3.67SC	mesotrione +	27	grain	3 qt	0.168
	S-metolachlor +	15			1.3
	atrazine	5			1.3
Lumax EZ 3.7SC	mesotrione +	27	grain	2.7 qt	0.168
	S-metolachlor +	15			1.68
	atrazine	5			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 sorghum 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 control spectrum, 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 1-4 (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 1-2 (glyphosates table).

Table 3-5. Water solubility and longevity of soil-applied herbicides.

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	Estimated 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) may be necessary if soil is dry at time of application, for soils with higher clay content, or if 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) that weed species are sensitive to the herbicide(s) applied.

Trade Name	Solubility (ppm)	Relative Moisture Amount Required to Activate	Duration of Residual Weed Control
Atrazine	33	Very high	4–5 weeks
Callisto	1,500	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	Constituents
Bicep II Magnum/Cinch ATZ	Dual II Magnum (or Cinch), atrazine
Bicep Lite II Magnum	Dual II Magnum, atrazine
FulTime NXT	Topnotch, 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

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Table 4-3. Relative effectiveness of burndown herbicides for control of weeds in no-till full-season soybeans.

Relative effectiveness of herbicides on individual weeds that 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	Dogbane, Hemp; Dewberry; Milkweed; etc.	Evening Primrose, Cutleaf	Fleabanes, Annual	Foxtail spp.	Garlic, Wild	Geranium, Carolina	Groundsel, Common[3]	Henbit/Deadnettle	Horseweed/Marestail[2,3]	Lambsquarters	Mustard spp.	Quackgrass	Ragweed, Common[2]	Smartweed	Thistle, Canada	Violet, Field/Pansy
2,4-D (spring-applied) (1 lb ae/acre)	4	N	7	6	8	7	N	9	7	N	7	—	6	N	8+	9	9	N	9	7	8	6
Dicamba (spring-applied) (0.5 lb ae/acre)[4]	4	N	7	6	7	8	N	8	7	N	7	—	6	N	9	9+	6	N	9	8	8	6
Elevore	4	N	—	N	—	N	—	N	6	N	6	6	—	8+	9	9	6	N	9	—	6	N
Glyphosate (fall-applied)[3]	9	9	8+	9	9	7	8+	7	8	—	9	8	9	8	8+[3]	—	9	9	—	—	9	7
Glyphosate (spring-applied)[3]	9	9	7	9	6	6	7	6	7+	9+	8	7	9	6	8[3]	9	8	8	9	7	8	6
Glyphosate + 2,4-D or dicamba (fall-applied)	9/4	9	9+	9	9	7	9	9+	9[5]	—	9	8	9	8+[6]	9+[3]	—	9[4]	9	—	—	9+	7
Glyphosate + 2,4-D or dicamba (spring-applied)	9/4	9	7+	9	8	7	7+	9	8	9+	8	7	9	8+	9[3]	9	9	9	9	8+	8+	7+
Glyphosate + metribuzin	9/5	9	7	9	6	6	7	6	8	9	8	7	9	8+	8+	9	9	9	9	9	8	8
Gramoxone	22	7	N	8+	N	N	6	7	6	9	6	8	8+	7	7	8	8	6	8	7	6	8
Gramoxone + 2,4-D or dicamba[3]	22/4	7	7	9	7	7	6	9	7	9	7	8	8+	8	8+	9	9	6	9	8+	8	8+
Gramoxone + metribuzin	22/5	7	6	9	N	N	6	8	6	9	6	9	8+	8	8	8	8+	6	9	9+	6	8
Harmony Extra	2/2	N	6	9[2]	6	8	6	7	N	N	8+	—	9	8	7+	9	9	N	6[2]	9+	8	N
Liberty, Interline, Scout, others	10	6	6	8	6	—	N	—	8	8	—	—	7	6	8	8	8	6	8	8	6	N
Sharpen	14	N	N	6	7	—	N	N	7+	N	—	—	8	6	8	8	8	N	8	8	6	N
Sharpen + glyphosate	14/9	9	7	9	8	—	7	6	8	9+	—	—	9	6	9	9	9	8	9	9	8	6
Valor	14	—	N	9	7[7]	N	N	6	N	N	—	—	7	N	6	9	8	N	7	7	N	8+

1 See Table 1-4 (generics table) for additional herbicides that contain these active ingredients.
2 Harmony Extra will not control ALS (Group 2) resistant common 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/acre) for dicamba resistant soybeans.
5 Based on control in early spring. Emergence of seedlings in the spring will reduce full-season control.
6 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.
7 Valor provides control of germinating dandelion seedling; however, it is weak on dandelion when applied POST.

Table 4-4. Relative effectiveness of herbicides for control of common cash or cover crops in the spring before planting soybeans.

Cover crop 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

Herbicide	Rate (lb ai or ae/acre)[1]	Alfalfa[2]	Bluegrass/Timothy[2]	Bromegrass/ Orchardgrass/Fescue[2]	Clover, Crimson	Clover, Red[2]	Clover, White	Mustards/Radish/ Rapeseed	Rye, Cereal	Ryegrass, Annual	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**	N	N	N	N	**9**
Glyphosate	0.75	6	**9**	8	8	7	6	6	**9**	8	**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	**9**	8	**9**	**10**
Glyphosate + dicamba	0.75 + 0.5	**9**	**9**	8	**9**	**9**	**9**	7	**9**	8	**9**	**10**
Gramoxone	0.5	N	7	6	8	7	7	7	7	6	8	7
	0.75	N	7+	7	**9**	8	7	8	8	6	**8+**	8
Gramoxone + 2,4-D	0.75 + 0.5	7+	7	6	**9**	**8+**	8	8	8	6	**8+**	**10**
Gramoxone + dicamba	0.75 + 0.5	**9**	7	6	**10**	**8+**	8	**8+**	8	6	**8+**	**10**
Gramoxone + metribuzin	0.5 + 0.25	7	**9**	8	**10**	**8+**	7	**8+**	**8+**	7	**8+**	**9**

[1] 0.75 lb glyphosate = 32 fl oz of a 41% glyphosate; 0.5 lb paraquat = 2 pt Gramoxone SL; see Table 1-2 (glyphosate table) for more information on glyphosate formulations.
[2] Application in the fall can improve control with some herbicides.

Table 4-5. 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 rotation restrictions that require soybeans only 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 Preplant Burndown Control

Products containing cloransulam (FirstRate), chlorimuron (Classic), and thifensulfuron (Harmony) have some activity on emerged broadleaf weeds and can improve preplant burndown control. However, these products will not control ALS-resistant biotypes. When using an 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 the following:

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

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 pt	0.25–1 lb ae
Enlist One 3.8SL	2,4-D choline	4	1.5–2 pt	0.71–0.95 lb ae

- For spring applications, the 2 pt 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 2 pt 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 (e.g., Salvo, Shredder E-99, Weedone 650).
- Enlist One may be applied through planting of Enlist E3 soybean varieties only.
- 2,4-D amine at 2 pt 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, sweet potato, 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.

Trade Name	Common Name	Site of Action Number	Product/A	lb ai/A
Banvel 4S	dicamba DMA salt	4	0.5–1 pt	0.25–0.5 lb ae
Clarity 4S	dicamba DGA salt		0.5–1pt	
Engenia 5S	dicamba BAPMA salt		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/ Canopy Blend 58.3DG	chlorimuron +	2	4–8 oz	0.026–0.053
	metribuzin	5	5–9 oz	0.16–0.32

- Metribuzin will enhance the activity of paraquat or glufosinate when used as a tank mixture for burndown weed control.
- See comments in preemergence section.

Canopy EX 29.5DG	chlorimuron +	2	1.1–3.3 oz	0.016–0.047
	tribenuron			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 required for some species.
- Applications must include either a crop oil concentrate or a non-ionic 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 it will not provide season-long control.

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 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 prepackaged mixtures, but glyphosate rate may not be adequate for burndown control.

(continued)

Trade Name	Common Name	Site of Action Number	Product/A	lb ai/A
Gramoxone SL	paraquat	22	2–4 pt	0.48–1

- 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).

Paraquat Use Restrictions

- Only certified applicators, who successfully complete the paraquat-specific training, can mix, load or apply paraquat.
- Application of paraquat "under the direct supervision" of a certified applicator is no longer allowed; registered technicians cannot apply.
- Required training at http://usparaquattraining.com; certified applicators must repeat training every three years.
- *Restricted-use pesticide.*

Liberty, Interline, Scout, others 2.34SL	glufosinate	10	32–43 oz	0.53–0.66

- Liberty 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 Liberty280. Weed control may be reduced when applications are made to weeds under stress from drought or cool temperatures.
- Applications should be made between 2 hours after sunrise and 1 hour before sunset to avoid the possibility of reduced weed control.
- Liberty has been observed to antagonize grass control with postemergence grass herbicides.
- Liberty performs better as a POST herbicide or burndown for double-cropped soybeans compared to burndown applications in April.
- Glyphosate at 32 fl oz/ac may added in burndown before double-cropped soybeans for additional control of marestail.
- Liberty 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).

Sharpen 2.85SC	saflufenacil	14	1–2 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 oz of Sharpen and soybean planting.
- All other soils: no waiting period if 1 oz of Sharpen is 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 on coarse-textured soils with less than 2% organic matter, and a minimum of 14 days is required on all other soil types (see label).
- Local research indicates 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, 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	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 contains cloransulam (FirstRate).

[1] See Table 1-2 (glyphosate formulations) for information on various formulations of this herbicide.

Table 4-6. Water solubility and longevity of soil-applied herbicides.

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	Estimated 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) may be 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) that 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	Very high	4–5 weeks
	pH 6.5: 450	Medium	
	pH 7: 1,200	Low	
Command	1,100	Low	2–4 weeks
Dual II Magnum	530	Medium	4–5 weeks
Express	pH 5: 48	Very high	1–2 weeks
	>pH 7: >2,040	Low	
FirstRate	pH 5: 3	Very high	2–4 weeks
	pH 7: 184	High	
Harmony SG	pH 5: 223	High	1–2 weeks
	>pH 7: >2,240	Low	
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
Reflex/Flexstar	600,000	Low	2–4 weeks
Sharpen	pH 5: 30	Very high	1–3 weeks
	pH 7: 2,100	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

(continued)

Premix	Constituents
Afforia	Valor SX, Harmony SG, Express
Anthem Maxx	Cadet, Zidua
Authority First/Sonic	Spartan, FirstRate
Authority Supreme	Spartan, Zidua
Authority MTZ	Spartan, metribuzin
Authority XL	Spartan, Classic
Boundary	Dual, metribuzin
Canopy DF/Blend	Classic, metribuzin
Canopy EX	Classic, Express
Envive	Classic, Valor SX, Harmony SG
Fierce	Valor SX, Zidua
Gangster/Surveil	Valor SX, FirstRate
OpTill	Sharpen, Pursuit
Permit Plus	Harmony SG, Sandea
Prefix	Dual, Reflex
Sequence	Dual, glyphosate
Synchrony XP	Classic, Harmony SG
Trivence	Classic, Valor SX, metribuzin
Valor XLT	Valor SX, Classic
Verdict	Sharpen, Outlook
Warrant Ultra	Warrant, Reflex

Chapter 5.
Small Grains Weed Management

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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 integrated pest management (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. It is difficult to get a uniform stand by spinning small grain seeds on the soil surface and incorporating the seeds with a vertical tillage implement. Lack of uniform wheat stand complicates weed management. Furthermore, many herbicides require a planting depth up to 1 inch deep, which is not achieved by incorporating with a vertical tillage implement.

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 through 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 weed control programs that reduce triazine residues.

Specific Weed Issues

Downy brome control is listed on Finesse, Maverick, Olympus Flex, and PowerFlex labels. (Refer to label to determine if chess or cheat species will be controlled). 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 soybean 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 (Corteva) at 0.3 to 0.4 pint per acre 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 ounces per acre of Valor SX (plus other burndown herbicides) at least 7 days before planting wheat (see Table 5-8 for specific comments). Dimetric EXT 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). See Table 5-8 for comments on crop safety with metribuzin and Valor.

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 rotation 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. Refer to the corn weed control section for information on the effect of pH on triazine residues and 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 pint per acre for oats. Certain varieties, especially 'Pennuda', are more sensitive to 2,4-D than other small grains.

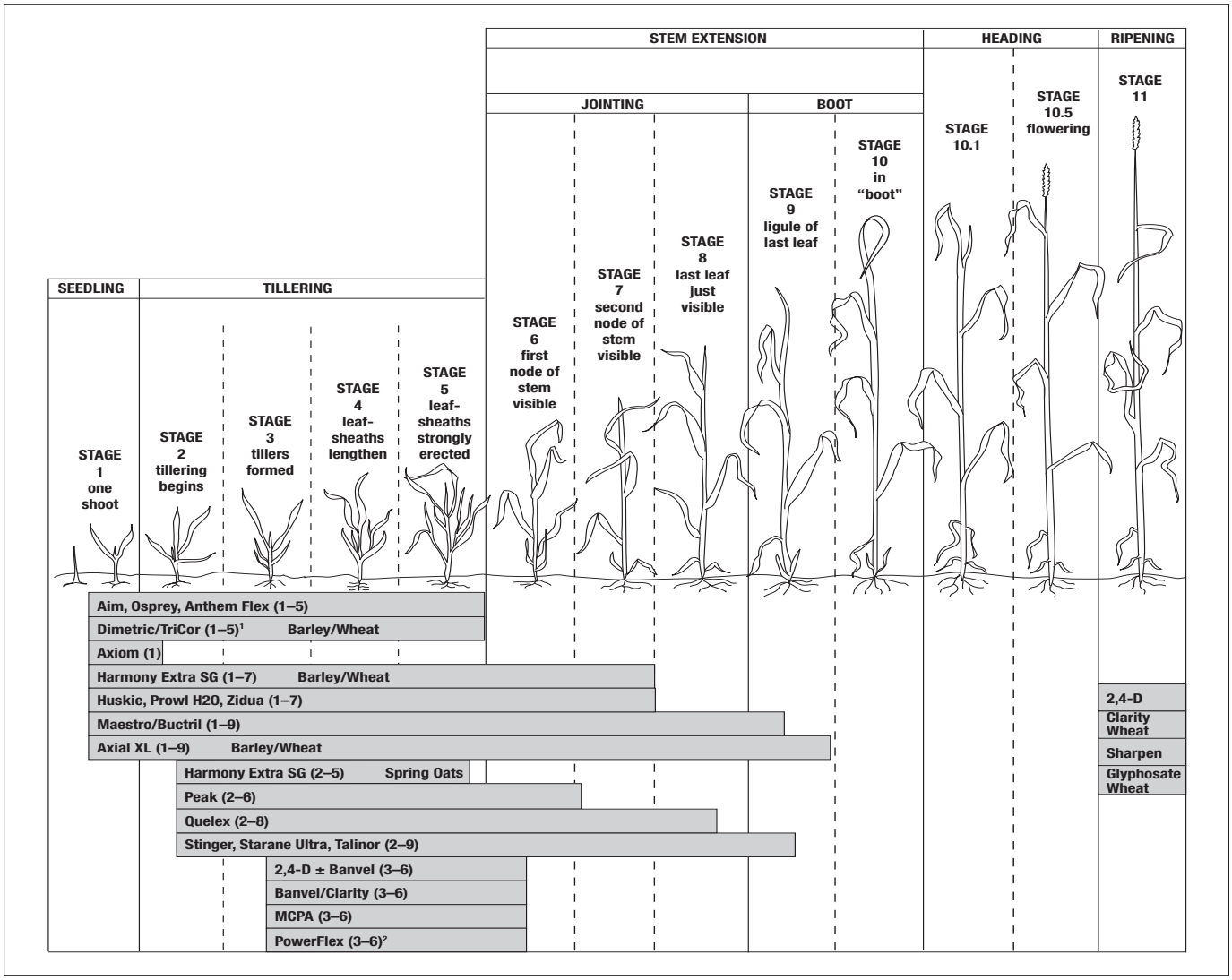
Callisto: For use on to oats only (Callisto should not be applied to other small grains). If PRE, apply 6 fluid ounces per acre of Callisto prior to oat emergence. If POST, apply 3 fluid ounces per acre of Callisto after oat emergence but before weeds reach 5 inches tall. Callisto controls many broadleaf 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 5-leaf stage.

Harmony Extra: On spring-seeded oats, apply at 3-leaf to before jointing (growth stages 2–5). Apply at 0.45 to 0.6 ounce per acre. Do not use on 'Ogle', 'Porter', or 'Premier' oat varieties.

Harmony SG: On spring-seeded oats, apply at three-leaf to before jointing (growth stages 2–5). Apply at 0.45 to 0.6 ounce per acre. Do not use on 'Ogle', 'Porter', or 'Premier' oat varieties.

MCPA amine or ester: Safer than 2,4-D (amine formulation only) on oats underseeded with legumes, but use the lower rate (0.25–0.5 pint) and apply in 5–10 gallons of water per acre; legumes should be 2–3 inches tall and cereal should be 8 inches tall to provide canopy to protect legume.



[1] Local research has demonstrated that Dimetric/TriCor should be applied during greenup in early spring to reduce risk of crop injury.
[2] Local research has found fall applications of PowerFlex is the best timing to reduce risk of crop injury.

Figure 5-1. Growth stages in cereals when herbicides may be applied.

Table 5-1. Small grain herbicides and their restrictions.

Trade Name[1]	Common Name	Site of Action Number	Manufacturer	Restricted-use Pesticide[2]	Water Quality Advisory[3]	Worker Reentry[4] (hours)
2,4-D (4 lb/gal)	2,4-D	4	Several	—	—	12–48
Aim 2EC	carfentrazone	14	FMC	—	—	12
Anthem Flex 4SE	pyroxasulfone + carfentrazone	15/14	FMC	—	yes	12
Axial Bold 0.69L	pinoxaden + fenoxaprop	1/1	Syngenta	—	—	48
Axial Star 1.15L	pinoxaden + fluroxypyr	1/4	Syngenta	—	—	48
Axial XL 0.42L	pinoxaden	1	Syngenta	—	—	48
Axiom 68DF	flufenacet + metribuzin	15/5	Bayer CropScience	—	—	12
Callisto 4SC[5]	mesotrione	27	Syngenta	—	—	12
Clarity 4S/Banvel 4S	dicamba	4	BASF	—	—	24
Curtail 2.38L	clopyralid + 2,4-D	4/4	Corteva	—	yes	48
Dimetric EXT[6]/TriCor 75DF	metribuzin	5	WinField/UPI	—	yes	12
Elevore	halauxifen	4	Corteva	—	yes	12
Express 50SG	tribenuron	2	FMC	—	—	12
Finesse Cereal and Fallow 75DF	chlorsulfuron + metsulfuron methyl	2/2	FMC	—	—	4
Gramoxone SL 2S	paraquat	22	Syngenta	yes	—	12
Harmony Extra 50DF	thifensulfuron + tribenuron	2	FMC	—	—	12
Harmony SG 50DF	thifensulfuron	2	FMC	—	—	4
Huskie 2.06L	pyrasulfotole + bromoxynil	27/6	Bayer CropScience	—	yes	24
Huskie Complete 2.4L	pyrasulfotole + bromoxynil + thiencarbazone	27/6/2	Bayer CropScience	—	yes	24
Maestro 2EC	bromoxynil	6	Nufarm	—	—	24
MCPA (4 lb/gal)	MCPA	4	Several	—	—	12–48
Osprey 4.5WDG	mesosulfuron	2	Bayer CropScience	—	—	4
Outrider 75WDG	sulfosulfuron	2	Valent	—	—	12
Peak 57WDG	prosulfuron	2	Syngenta	—	—	12
PowerFlex HL 13WDG	pyroxsulam	2	Corteva	—	—	12
Prowl H2O 3.8CS	pendimethalin	3	BASF	—	—	24
Quelex 20.4WDG	halauxifen + florasulam	4/2	Corteva	—	yes	12
Roundup PowerMAX 4.5S/ Roundup WeatherMAX 4.5S/other glyphosates	glyphosate	9	Bayer CropScience/ others	—	—	4–12
Sentrallas 1.55L	thifensulfuron + fluroxypyr	2/4	FMC	—	—	24
Sharpen 2.85SC	saflufenacil	14	BASF	—	yes	12
Starane Ultra 2.8L	fluroxypyr	4	Corteva	—	—	24
Stinger 3S	clopyralid	4	Corteva	—	yes	12
Talinor 1.77EC	bicyclopyrone + bromoxynil	27/6	Syngenta	—	yes	24
Valor SX 51WDG/ Valor EZ 4L	flumioxazin	14	Valent	—	—	12
Zidua 85WDG/Zidua 4.17SC	pyroxasulfone	15	BASF	—	yes	12

1 Generic alternatives to some of these products are available. See Table 1-4 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 labels 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 Delaware, Maryland, New Jersey, Pennsylvania, and West Virginia. TriCor is approved for use under 24(c) label in Virginia.

Table 5-2. Herbicides labeled for use in small grains by small grain species.

Trade Name	Fall-seeded				Spring Oats
	Wheat	Barley	Rye	Triticale	
2,4-D[1]	x	x	x		x
Aim	x	x	x	x	x
Anthem Flex	x				
Axial Star	x	x			
Axial XL, Axial Bold	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			
Harmony Extra, Express	x	x		x	x
Harmony SG	x	x		x	x
Huskie	x	x	x	x	
Huskie Complete	x				
Maestro	x	x	x	x	x
MCPA	x	x	x		x
Osprey	x			x	
Outrider	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			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.

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Table 6-6. 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 Timing	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 1 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 3 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	3–4
• Eptam provides approximately 1 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	established: POST	1 fl oz	0.016
• Aim only controls small, emerged weeds (no residual activity). It is not a rescue treatment. • Apply in spring or summer immediately after cutting but before 3 inches of new growth. • A 5- to 8-day or 10- to 14-day delay in cutting may be observed with applications made to 3- and 6-inch alfalfa, respectively. • 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 a crop, such as alfalfa, is in dormancy fall through early spring applications. • There are no crop rotation or overseeding restrictions for labeled crops; see label. • *Water quality advisory.*					
Butyrac 200 2E (2,4-DB)	2,4-DB	alfalfa, birdsfoot trefoil, CRP	seedling: POST established: POST	1–3 qt	0.5–1.5 ae
• 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 2 to 4 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 crop rotation 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.*					

Trade Name[1]	Common Name	Crop(s)	Application Timing	Product/A	lb ai/A
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.

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 crop rotation 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	1–2 pt	0.25–0.5
			established: dormant	2–3 pt	0.5–0.75
			between cuttings	1 pt	0.25
			spot treatment	0.2–0.7 fl oz/gal	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 crop rotation 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 sq ft) 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.*

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 55°F 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.*

(continued)

Trade Name[1]	Common Name	Crop(s)	Application Timing	Product/A	lb ai/A
Maestro 2EC	bromoxynil	alfalfa and alfalfa/ small grain companion seedings, CRP	seedling: POST	1–1.5 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 4-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 6-7.

MCPA amine 4S	MCPA	alfalfa, clovers, or trefoil with small grain companion seeding, CRP	seedling: POST	0.25–0.5 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 to 3 inches tall.
- Do not use more than 5 to 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 crop rotation 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.*

Metribuzin 75DF	metribuzin	alfalfa and alfalfa-grass mixtures	established: dormant	0.5–1.3 lb	0.38–1

- 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 2 inches tall or 2 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 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.*

Poast 1.5E	sethoxydim	alfalfa, clovers, and birdsfoot trefoil	seedling: POST	1–2.5 pt	0.19–0.47
			established: POST	1–2.5 pt	0.19–0.47
			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/1,000 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 ft^2) to provide thorough coverage.
- 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 sq ft) 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).

Trade Name[1]	Common Name	Crop(s)	Application Timing	Product/A	lb ai/A
Prowl H2O/ Satellite HydroCap 3.8AS	pendimethalin	alfalfa	seedling: POST	0.5–1 qt	0.5–0.95
			seedling: dormant	0.5–1 qt	0.5–0.95
			established: dormant	1.1–4.2 qt	1–4
			between cuttings	1.1–4.2 qt	1–4

- Prowl H2O 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 H2O.
- Apply to seedling alfalfa after the legume has 2 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 that 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.
- Rotation restrictions are based on Prowl rate used, rainfall received, and time of year applied; see label.

Pursuit 2S	imazethapyr	alfalfa and alfalfa-grass mixtures, birdsfoot trefoil, clover, CRP	seedling: POST	3–6 fl oz	0.047–0.094
			seedling: dormant		
			established: POST		
			established: dormant		
			between cuttings		

- 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 crop rotation section; small grains can be planted 4 months after application; see label.
- *Water quality advisory.*

Raptor 1AS	imazamox	alfalfa	seedling: POST	4–6 fl oz	0.031–0.047
			seedling: dormant		
			established: dormant		
			between cuttings		

- Raptor controls or suppresses many annual and some perennial broadleaf weeds, as well as several grasses when they are small.
- Raptor also provides approximately 1 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 to 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 to 18 months (see label), and sorghum 9 months after application.

Roundup 3S[2] or	glyphosate	alfalfa, clover, and alfalfa or clover-grass mixtures	spot treatment	2% solution	
Roundup WeatherMAX 4.5S[2]			wiper applicator	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 sq ft) 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 7 days after application, and make applications at least 7 days before a killing frost.
- There are no crop rotation restrictions when applying glyphosate in legume forages.

(continued)

Trade Name[1]	Common Name	Crop(s)	Application Timing	Product/A	lb ai/A
Roundup 3S or Roundup WeatherMAX 4.5S[2]	glyphosate	alfalfa or alfalfa-grass mixtures	preharvest	32–63 fl oz 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 crop rotation restrictions when applying glyphosate in legume forages.

Roundup PowerMAX or Roundup 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.
- 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 cannot exceed 4.1 qt/A per year. The combined total for all applications (in-crop and establishment) cannot exceed 5.3 qt/A per year.
- There are no crop rotation 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.

Select 2EC or Select Max 1EC	clethodim	alfalfa, birdsfoot trefoil	seedling: POST	6–16 fl oz or 12–32 fl oz	0.09–0.25 or 0.09–0.25
			established: POST	6–16 fl oz or12–32 fl oz	0.09–0.25 or 0.09–0.25
			spot treatment	0.33–0.65 fl oz/gal	0.25–0.5% 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 to 16 fl oz Select or 12 to 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 6-7.
- 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 sq ft) 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).

Trade Name[1]	Common Name	Crop(s)	Application Timing	Product/A	lb ai/A
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 cannot 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 2 years following an application of Sinbar.
- Do not use any spray adjuvants. See Table 6-7.
- *Water quality advisory.*

Velpar 2L or 75DF	hexazinone	alfalfa	established: dormant between cuttings	2–6 pt 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 2 inches tall or 2 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.
- *Water quality advisory.*

Warrant 3 SL	acetochlor	alfalfa	established: dormant	1.25–2 qt	0.94–1.5

between cuttings

- Warrant can be applied after alfalfa after emergence to control of several grass and broadleaf weeds prior to their emergence, but it will not control weeds that are present at the time of application.
- Can be used on newly established and established alfalfa stands.
- Do not use this product on alfalfa grown for seed production.
- Remove domestic livestock from alfalfa stands before making applications of this product.
- Allow a minimum of 20 days between an application and subsequent cutting for forage or hay, or before open grazing of forage and livestock.
- Do not exceed a total of 3 applications or a combined total of 4 qt (3 lb ai) per acre per year.
- *Water quality advisory.*

[1] See Table 6-1 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 6-17. 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	March	April	May	June	July	August	September	October	November
Winter Annual Weeds (Chickweed, Henbit, etc.)									
Summer Annual Weeds (Pigweed, Ragweed, etc.)									
Biennial Weeds (Wild Carrot, Bull Thistle, etc.)									
Herbaceous Perennials									
Buttercup spp.									
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									

Chapter 7.
Problem Weeds

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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 (pigweed) family. 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, including in North Carolina, Palmer amaranth has developed resistance to dinitroanilines (Group 3), triazines (Group 5), HPPD inhibitors (Group 27), and PPO inhibitors (Group 14).

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 Bicep II Magnum, 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, Degree Xtra, FulTime NXT, Warrant plus atrazine, Lexar, or Lumax. Follow up with a timely postemergence application of 2,4-D, Clarity, Huskie, 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,), 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 or Anthem products), 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 (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 or 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, whereas broadleaf dock's 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 herbicide applications may be more effective. Contact herbicides readily control top growth, but regrowth from taproots will occur.

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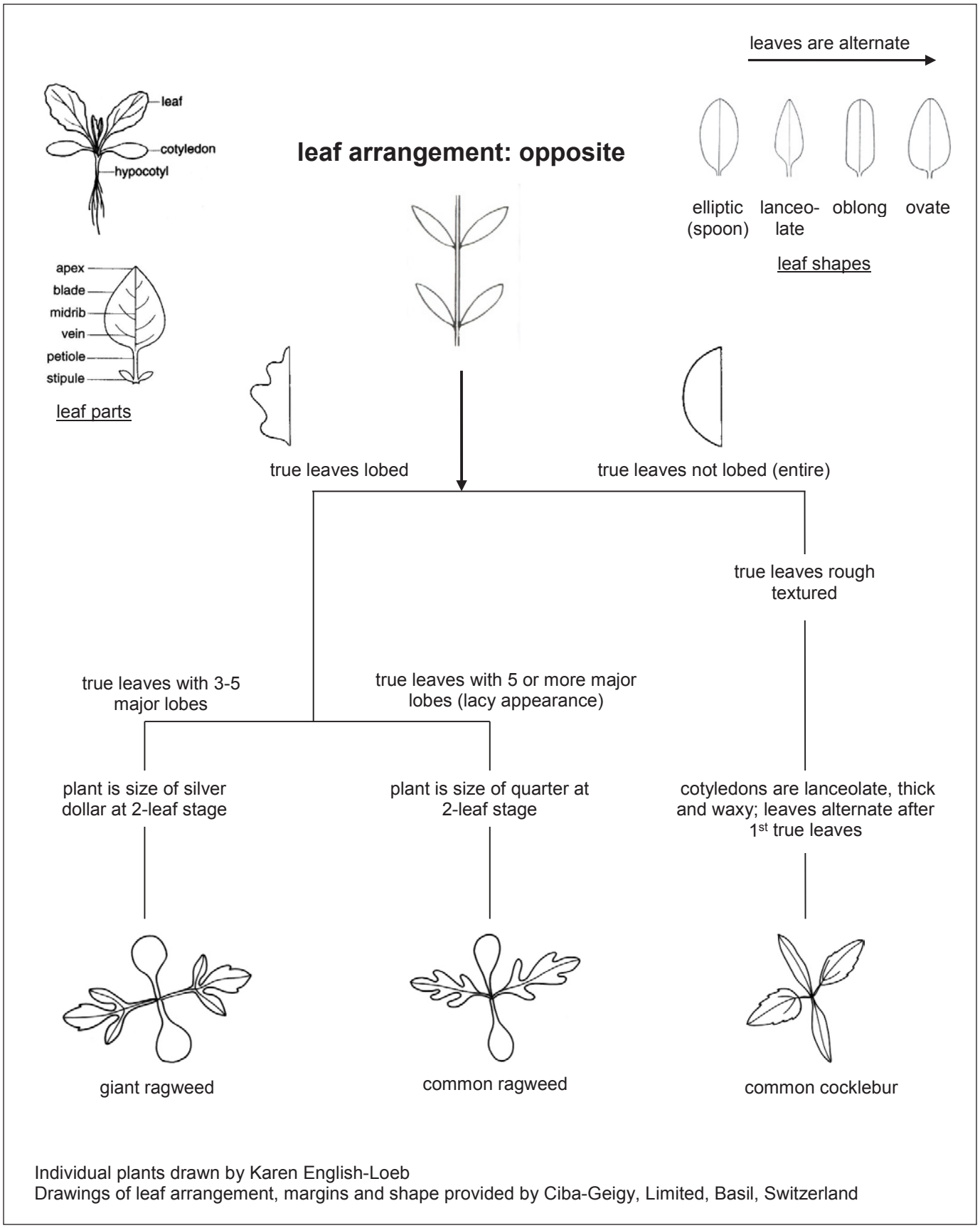

Individual plants drawn by Karen English-Loeb
Drawings of leaf arrangement, margins and shape provided by Ciba-Geigy, Limited, Basil, Switzerland

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