

Weed Management Strategies

Weed management requires a multifaceted approach built on an understanding of weeds and the crop. Weed management may involve nonchemical methods, chemical methods (herbicides), or a combination of the two. The aim of any weed management strategy should be to manage the weed population so it is below a level that will reduce your economic return (economic threshold). It is important to consider the impact of weeds on yield and quality of the current crop, as well as the potential for increasing weed problems in future years if weeds go to seed. Deciding which methods to use depends on environmental concerns, marketing opportunities, desired management intensity, labor availability, weed pressure, and the crop. In some instances, the cost of controlling weeds may be more than the economic return from any yield increase that season. This situation occurs when a few weeds are present or the weeds germinate late in the season. In those instances, the best strategy may be to do nothing, or to do the minimum required to prevent seed production and dispersal. In other situations, weed populations and other considerations may require combining herbicides with nonchemical approaches.

The first step in weed management is to identify the weeds and understand their life cycles. Consult identification guides, such as *Weeds of the North Central States* (University of Illinois Agricultural Experiment Station Bulletin 772), for assistance. Weeds can be categorized by life cycles, and management strategies developed accordingly.

Annual weeds complete their life cycles in one year and reproduce solely by seeds. Annuals can be divided into summer or winter annuals, depending on when they grow. Primary tillage operations often control winter annuals before a crop is planted in the spring. The most common vegetable crop weeds (e.g., barnyard grass,

giant foxtail, common purslane, redroot pigweed, and common lambsquarters) are summer annuals.

Perennial weeds live for more than two years and can reproduce by seed or vegetative structures (stolons, rhizomes, corms, bulbs, tubers, or roots). Because perennial weeds are difficult to manage in vegetable crops, it is usually better not to use a field with severe perennial weed problems.

Many nonchemical weed management methods are common sense farming practices. These practices are of increasing importance due to consumer concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides.

Cultural Practices

Farm practices should aim to establish a vigorous crop that competes effectively with weeds. This starts with land selection. A general rule is not to plant vegetables on land with a history of heavy weed infestation, especially perennial weeds. Crop selection can reduce the effects of weed competition. One criterion in selecting a crop should be the weed problems of the field. Plant the most competitive crops in the most weed-infested fields, and the least competitive crops in the cleanest ones. Consider planting heavily infested fields as long-term set-aside acres or in non-row crops such as alfalfa. Permanent cover should help prevent buildup of annual weeds.

Crop rotation is another practice that can reduce weed problems. The characteristics of the crop, the methods used to grow it, and the herbicides used, inadvertently allow certain weeds to escape control. Rotation also affects the weed management tools at your disposal. Rotating between crops will improve crop growth and competitiveness. Related vegetables should not be grown in the same location in successive years (see Botanically Related Vegetables).

Botanically Related Vegetables

Alliums	Apiums	Corn	Cucurbits	Goosefoot Family	Legumes	Mustard Family	Nightshade Family	Sunflower
Chive Garlic Leek Onion Shallot	Carrot Celery Fennel Parsley Parsnip	Dent corn Sweet corn	Cantaloupe Cucumber Pumpkin Summer squash Watermelon Winter squash	Beet Chard Spinach	Dry bean Lima bean Pea Snap bean Soybean	Broccoli Brussels sprout Cabbage Cauliflower Collards Horseradish Kale Kohlrabi Radish Turnip	Eggplant Pepper Potato Tomato	Lettuce

Wild proso millet is an example of a problem weed where rotation is important for management. Rotation from sweet corn to small grains, early-planted peas, or alfalfa almost completely eliminates wild proso millet because these crops are established before the soil is warm enough for wild proso millet seed germination. A rotation from sweet corn to broadleaf crops would allow the use of postemergence grass herbicides to manage wild proso millet.

Once a crop is selected, use adaptive, vigorous varieties resistant to diseases. Disease-infected plants cannot effectively compete with weeds. Varieties suited for cultivation in regions covered by this publication are listed in each crop section of this guide.

Narrower row spacings and proper plant densities assure crop canopy closure. Closed canopies shade out later emerging weeds and prevent germination of weed seeds that require light. Weeds seldom are a problem after canopy closure. Proper row spacing and plant density also allow row cultivation.

Correct planting time is another cultural method that can improve crop competitiveness. Crops can be divided into warm- or cool-season plants, depending on the optimum temperature for their growth. Planting date affects the time until emergence and the crop's early seedling vigor, both of which are important in determining crop competitiveness. Cool-season crops germinate at cooler soil temperatures, so compete better against early emerging weeds than warm-season crops. The Classification of Vegetable Crops According to Their Adaptive Field Temperatures table (below) lists crops according to their adaptation to field temperatures. Time plantings so temperatures are favorable for crop growth. Adequate fertilization and appropriate insect and disease management are important in assuring competitive

crops. Adequate fertility assures rapid, uniform stand establishment and good crop growth, which enhance the crop's competitiveness. Disease management information and insect management information are contained in this guide. While poor insect and disease control reduce a crop's competitiveness, inadequate weed control also can cause insect and disease problems.

Mulching can be useful in managing weeds. Mulches can be classified as either natural (e.g., straw, leaves, paper, and compost) or synthetic (plastics). Because natural mulches are difficult to apply over large areas, they are best for small, specialized areas. Natural mulches should be spread evenly at least 1 to 1.5 inches thick over the soil to prevent light penetration. Natural mulch materials must be free of weed seeds and other pest organisms and be heavy enough so they will not be easily displaced by wind or water. A major advantage of natural mulches is that they add organic matter to the soil and do not need to be disposed of at the end of the season.

Synthetic mulches are easy to apply, control weeds within the row, conserve moisture, and increase soil temperature. Black or clear plastic mulches are the most common and are effective in improving early-season growth of warm-season crops such as tomato, cantaloupe, watermelon, or pepper. Fast early-season growth of these crops improves their competitive ability against weeds. Plastic mulches used in combination with trickle irrigation can also improve water use efficiency.

A disadvantage of plastic mulch is disposal at the end of the season. Many landfills do not accept plastic mulches. Photodegradable plastic mulches have been developed, but their season-long persistence has been a problem, and they degrade into small pieces of plastic that contaminate the environment. Biodegradable plastic mulches are available.

Classification of Vegetable Crops According to Their Adaptive Field Temperatures

Cool-season		Warm-season	
Hardy ¹	Semi-Hardy	Tender	Very Tender
Asparagus	Carrot	Snap bean	Cantaloupe
Broccoli	Cauliflower	Sweet corn	Cucumber
Cabbage	Chinese cabbage	Tomato	Eggplant
Horseradish	Lettuce		Lima bean
Onion	Potato		Okra
Pea			Pepper
Spinach			Pumpkin
			Squash
			Watermelon

¹Hardy crops are most tolerant of cool temperatures and frost. Very tender crops are most susceptible to frost and cool temperatures.

Mechanical Practices

Mechanical weed management relies on primary and secondary tillage implements such as moldboard plows, disks, rotary hoes, and row cultivators. Mechanical weed management starts with seedbed preparation. Few no-till systems have been developed for vegetable crops. No-till suggestions are discussed in the sections on biological practices and reduced tillage systems.

Moldboard plowing is usually the first step in mechanically managing weeds. Moldboard plowing is particularly useful in controlling emerged annual weeds. Rotary hoeing is often an important second step in mechanically managing weeds in large-seeded vegetable crops (sweet corn, snap bean, lima bean, and pea). Rotary hoeing should be done after the weeds germinate but before they emerge. Rotary hoeing does not control large-seeded weeds such as velvetleaf and shattercane.

Once the crop has emerged or transplants are established, a row cultivator can be used to manage emerged weeds. Adjust the cultivator sweeps or teeth to dislodge or cover as many weed seedlings as possible. Seedling weeds can be killed by cultivating 1 to 2 inches deep. Best weed control is obtained with a row cultivator in relatively dry soils by throwing soil into the crop row to cover small weed seedlings. Avoid crop injury from poor cultivation, which will reduce crop yields.

In some vegetable crops, such as asparagus, mowing can be an effective weed management tool. Mowing can prevent weed seed production and kill upright weeds, reducing competition. Mowing must be carefully timed to eliminate perennial, biennial, or annual weeds that would compete strongly in vegetables because of their upright growth habits. Timely, repeated mowing also helps deplete the food reserves (root systems) of perennial weeds.

Mechanical control has many limitations that must be considered when designing weed management systems. Because mechanical management relies on relatively dry soil, a rainy period may prevent the use of mechanical weed management options and lead to severe weed competition. Relying entirely on mechanical practices to manage weeds is labor intensive, and many growers will use herbicides combined with nonchemical approaches to control especially difficult weeds. Some of these difficult-to-control weeds include wild proso millet in sweet corn, Canada thistle, hemp dogbane, field bindweed, quackgrass, and johnsongrass. Newly introduced problem weeds often show up in scattered patches along headlands and field borders. These are best controlled or eradicated with herbicides before large areas are infested.

Biological Practices

Currently, no management system tools exist in the Midwest for using insects or diseases to control weeds common in vegetable crops. Most biological weed management systems to date have been developed to control problem weeds in rangeland areas in the West. One biological system that has potential in the Midwest is the use of cover crops to suppress weed development. These systems are still experimental, but have promise for reducing herbicide use once they are fully developed.

The most promising cover crop system is winter rye. Winter rye is planted in late summer or early fall and overwinters as a cover crop. In the spring, the rye is killed two weeks prior to planting the desired crop. Rye can be killed using herbicides, or, once it has reached the reproductive stage, by mowing, or rolling and crimping. The rye is left as a mulch on the soil surface, and the crop is no-till planted. The system appears to provide early season control of many annual weeds. To obtain acceptable weed control, additional herbicides and/or mechanical control are usually required. The system should be evaluated in small areas before it is adopted.

The Summary of Nonchemical Weed Management Practices table (page 66) summarizes some nonchemical weed management practices. The most effective weed management system is an integrated approach that combines many different practices. This approach must be adaptive, aiming to prevent weed problems or cope with any that occur.

Chemical Weed Management Strategies

Several herbicides are often labeled for a particular crop. Scouting your area to determine which weeds are present will allow you to select the herbicides that will give you the best control.

All the herbicides labeled for a crop are not necessarily listed in this guide. If you are unfamiliar with an herbicide, conduct a small test under your environmental conditions and cultural practices before using the herbicide extensively.

Herbicide Labels

Always Read and Understand the Herbicide Label Before Use. Reading the herbicide label is a very profitable use of your time. Information on the label will direct you to the correct uses, application methods, rates, and potential environmental hazards of the product. Follow label directions for the best possible control with minimal crop injury and environmental contamination. The label contains restrictions on use and discusses environmental and soil conditions that affect crop injury, influence the effectiveness of weed control, and can cause nontarget site effects.

Do Not Use Any Herbicide Unless the Label States That It Is Cleared for Your Particular Use and Crop.

Using a nonregistered pesticide can cause harmful residues in the vegetable crop, which can result in crop seizure and consumer injury. The label also states whether the herbicide is a restricted-use or general-use pesticide. Restricted-use pesticide labels contain a statement that the products are restricted and that only licensed applicators can buy them and supervise their application. The information in this production guide is current as of the date of publication. Watch for notices of changes in the U.S. Environmental Protection Agency (EPA) registration of herbicides in the *Illinois Fruit and Vegetable News* (ipm.illinois.edu/ifvn), the *Pest Management and Crop Development Bulletin* (bulletin.ipm.illinois.edu), the *Indiana Vegetable Crops Hotline* (vegcropshotline.org), or the *Weed Control Guide for Vegetable Crops* (Michigan State University Extension publication E-0433, available at msuag.info/E433/index.php).

Reduced Tillage Systems

Reduced tillage systems combat soil erosion. These systems often include the use of glyphosate or paraquat outside the normal growing season to control emerged weeds. Weeds should be growing actively, and the application must be made before the crop has emerged. If you are applying glyphosate to control perennial weeds, apply it before the soil is disturbed. After it is applied, glyphosate must be allowed to translocate throughout the perennial weed for several days, or incomplete control may result. Follow glyphosate label directions carefully for rates and timing of applications. If perennial weeds are not a major problem, you can eliminate early weed

flushes by applying glyphosate or paraquat to all weeds that emerge. Plant the crop with minimal working of the soil. Never apply glyphosate or paraquat to an emerged crop because severe crop injury or death will occur.

Glyphosate and paraquat will control most annual broadleaf and grass weeds. Neither herbicide has any soil residual activity, so other weed control measures will be necessary during the growing season. Paraquat will suppress perennials by killing their shoots, but it does not control regrowth of perennial weeds from rhizomes or other underground storage organs. Glyphosate is better for controlling perennials because it will kill shoots and translocate to destroy underground parts. Glyphosate will only suppress some particularly hard-to-control perennials such as bindweed, hemp dogbane, and milkweed. To control these perennials, high application rates, repeat applications of glyphosate (within label guidelines), or mechanical removal may be necessary.

Herbicide Rates and Guidelines for Use in Vegetable Crops

All herbicide rates given in this guide are in amount of product per broadcast acre. Adjust amounts accordingly for banded applications. Make preemergence applications before weeds emerge or after removing any weeds present. Make postemergence applications after weeds have emerged. Several materials may be used between crop rows if appropriate steps are taken to prevent spray from contacting the crop. Some of these materials require shielded sprayers, while others require hooded sprayers. The herbicide recommendations in this guide do not replace careful reading of current herbicide labels. Re-registration of older herbicides has affected the availability of many products. Some of the older herbicides not re-registered are not listed in this bulletin, but may be available, and old stocks can still be used.

Environmental and Health Hazards of Herbicides

Herbicides can have nontargeted effects, so it is very important that you educate yourself about these effects and consider them when designing weed management systems. The following section contains discussions of some of the potential environmental and health hazards of herbicides.

Environmental Hazards

Adverse environmental effects from herbicides can have long-term consequences that are difficult to correct, and must be avoided. Some environmental hazards, such as herbicide drift and carryover, will mainly affect your operation, while other hazards, such as water contamination, affect all residents in the area. The following sections discuss some of the potential hazards and methods to avoid them.

Herbicide carryover. Herbicide carryover from persistent herbicides has been a particular problem to vegetable crop growers. Persistence depends on herbicide characteristics (method of degradation, water solubility, and rate of application) and site characteristics (soil type, rainfall, and temperature). Avoid carryover because correcting carryover problems after they have occurred is virtually impossible. The most important method to avoid herbicide carryover is to follow label rotation restrictions. Label Restrictions (in Months) on Rotating to Vegetable Crops (page 67) summarizes some of the label restrictions. Always refer to the label for specific information. If there are differences between the table and herbicide label, always follow label information.

Herbicide drift. Another frequent hazard to vegetable growers is crop injury from herbicide drift. Certain herbicides, if not used correctly, can injure nontarget plants. Herbicides such as clomazone (Command[®]), dicamba, and 2,4-D can drift up to a mile and seriously damage grapes, tomatoes, peppers, other vegetables, fruit trees, and ornamental plants. Before spraying clomazone, dicamba, or 2,4-D, survey the area for desirable plants.

Spray only on calm days, and use drift inhibitors when appropriate. Minimize drift by applying herbicides with nozzles that produce large droplets. Use an amine formulation of 2,4-D to reduce vapor drift. Spray clomazone, dicamba, and 2,4-D when the temperature is expected to be lower than 80°F to 85°F for several days after treatment. Avoid applying clomazone to wet soils.

Spray tank residuals. Dicamba or 2,4-D residues in spray tanks also can injure susceptible vegetable crops. Carefully follow label directions for cleaning spray equipment after using dicamba or 2,4-D. If possible, do not use the same spray equipment to apply 2,4-D or dicamba that you use to apply other pesticides.

Herbicide resistance. More than 180 weed species have developed resistance to one or more herbicides. Herbicide-resistant populations tend to develop when herbicides with the same mode of action for killing

weeds are used every year in the same field. The Herbicide Resistance Action Committee (HRAC) groups herbicides according to their modes of action.

Weeds resistant to herbicides in HRAC Group B (ALS inhibitors) make up 30 percent of the documented resistant biotypes. Sandea[®], Permit[®], Matrix[®], Raptor[®], and Pursuit[®] are vegetable herbicides in this group. Weeds resistant to herbicides in HRAC Group C1 (Photosystem II inhibitors) make up another 20 percent of the documented resistant biotypes. Atrazine, Sencor[®], and Sinbar[®] are in this group. Widespread glyphosate use in agronomic crops has led to the development of glyphosate-resistant weeds, although they still only represent 3.5 percent of resistant biotypes.

Approaches that aim to prevent herbicide resistance combine the use of herbicides, mechanical (cultivation), and cultural (crop rotation) weed management practices. It is important to avoid relying on herbicides from a single HRAC group year after year. Rotate between, or use tank-mixes of, herbicides with different modes of action. For example, in asparagus rotate between Sencor[®] and Treflan[®]. Use tillage to control weeds that escape from herbicide applications. To minimize any weed resistance that does occur, it is especially important to scout your fields, paying special attention to any patches of a weed normally controlled by the herbicide. Herbicide labels may contain additional information about avoiding

Water quality. Residues of some herbicides such as atrazine, metolachlor, and metribuzin have been found in surface and ground water. Detected levels have normally been low, but contamination of water resources is a growing concern. For example, groundwater contamination from pesticides and nitrates is a particular concern in areas of the Midwest with sandy soils and shallow groundwater.

Factors determining the potential for groundwater and surface water contamination include herbicide solubility in water, rate of degradation, volatility, and tendency for the herbicide to attach to soil particles or organic matter. Herbicides that have high water solubility and long persistence are a particular concern.

Site characteristics (soil type, soil depth, water table depth, slope, and weather) also can lead to contamination of water resources from herbicides. You should be aware of the potential problem of herbicide contamination and take all possible steps to avoid contamination of surface and subsurface water resources.

Summary of Nonchemical Weed Management Practices

Cultural	
Land selection	Avoid fields with a history of weed problems.
Crop selection	Grow the most competitive crops in fields with histories of weed problems.
Crop rotation	Rotate between vegetables and non-row crops such as alfalfa. Rotate between vegetables in different botanical categories.
Adapted crop varieties	Select crop varieties adapted for your area.
Proper row spacings and plant densities	Use row spacings and plant densities that assure rapid crop canopy closure.
Correct planting times	Plant crops when soil temperatures favor rapid germination and emergence. Do not plant warm-season crops too early in the season.
Appropriate crop management	Vigorous, healthy crops are more competitive against weeds and insects.
Mulch	Natural mulches may be appropriate on small acreages. Synthetic (plastic) mulches are useful to manage weeds within the row in warm-season crops. Consider disposal problems when using plastic mulches.
Mechanical and Thermal	
Moldboard plowing	This can eliminate emerged annual weeds.
Rotary hoeing	This is useful to manage small-seeded weeds in large-seeded crops such as sweet corn, snap bean, lima bean, and pea.
Row cultivator	Dislodge or cover as many weed seedlings as possible. Avoid damaging crop root systems.
Mowing	Mow weeds as soon as flowers appear so no viable weed seed is produced.
Flame weeding	Flame weeding, or using a hot flame to kill weeds, is effective for stale seedbed weed removal or weeds that emerge before the vegetable crop. Flame weeding is effective for weed control in vegetables such as onions, parsnips, and carrots. Some growers have successfully used flame weeding on transplanted onions that are 8-10 in. tall. Sweet corn that has just emerged and potatoes up to 2 in. tall can be flame weeded.
Biological	
Cover crops and living mulches	Cover crops and intercrops can reduce weed pressure in a variety of ways: they can compete with weeds to reduce weed seed production, release allelochemicals that suppress weed seed germination and growth, or produce residue that acts as a mulch to suppress weed growth.
Insect or disease pests or weeds	No current systems use insects or diseases to manage weeds in common vegetables.



The lesions on this sweet corn leaf were caused by drift from a contact herbicide. Reduce the possibility of herbicide drift by paying attention to weather conditions and using nozzles that apply the products in large drops.

Label Restrictions (in Months) on Rotating to Vegetable Crops¹

Herbicide	Tomato	Pea	Snap Bean	Sweet Corn	Cucurbits	Potato	Cole Crops
Soybean Herbicides							
Authority Assist [®]	30+FB	10	10	18	30+FB	26	18-40V
Authority First [®] , Sonic [®]	30+FB	9-12-30+FB,V	30+FB	18	30+FB	18	30+FB
Boundary [®]	12	8	12	4	12	0	12
Canopy [®] , Canopy EX [®]	9-10 ²	9-12	9-12	18	18-30V	1830	18-30V
Classic [®]	10 ²	12	12	18	18-30	30	30
Command [®]	9	AT	9	9	AT	9	V
Envive [®]	12 ¹	12	12	18	18-30V	18-30V	18-30V
Extreme [®]	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V	18-40+FB,V	26	18-40+FB,V
First Rate [®]	18	9	9	18	18	18	18
Flex Star [®]	10 ²	4	0	10	10-12	0	18
Optill [®]	40+FB	4	4	18	40+FB	26	40+FB
Prefix [®]	10	10	0	10	18	1	18
Pursuit ^{®3}	40+FB	AT	2	18	40+FB	26	40+FB
Python [®]	26	4	4	10.5-18V	26	12	26
Raptor [®]	9	AT	AT	9	9	9	V
Reflex [®]	10 ¹	4	0	10	10-12	0	18
Sencor [®]	4	8	18	4	18	12	18
Scepter [®]	18	18	11-15	18	18	18	18
Spartan [®]	AT ²	12	12	18	12	12	12V
Synchrony XP [®]	9 ²	9-12	9-12	18	18-30	18	18-30
Valor [®]	12+FB	3-12+FB	3-12+FB	3-12+FB ⁴	12+FB	12+FB	12+FB
Valor XLT [®]	12	12	12	18	18	18	18
Corn Herbicides							
Aatrex [®] and others	NNY	NNY	NNY	AT	NNY	NNY	NNY
Accent [®] , soil pH < 6.5	10	10	10	10	10	10	10
Accent [®] , soil pH > 6.5	18	18	18	18	18	18	18
Acuron [®]	18	18	18	AT	18	18	18
Anthem [®] , Anthem ATZ [®]	18	11	11	AT	18	4	18
Aim [®]	AT	AT	AT	AT	V	V	12
Balance Pro [®]	18V	18V	18V	6	18V	6	18V
Basis [®]	1	10	10	10	18	AT	18
Beacon [®]	18	8	8-18	8	18	8-18	18
Bicep I MagnumI [®]	NNY	NNY	NNY	AT	NNY	NNY	NNY
Callisto [®]	18	18	18	AT	18	18	18
Camix [®]	18	18	18	AT	18	18	18
Celebrity Plus [®]	10-18V	10	10	10-15V	10-18V	10-18V	10-18V
Corvus [®]	17-24V	17-24V	17-24V	9-17V	17-24V	17-24V	17-24V
Define [®]	12	12	12	AT	12	1	4-12V
Hornet [®]	26	10.5-18V	10.5-18V	10.5-18V	26	18	26
Harness Xtra [®]	NNY	NNY	NNY	AT	NNY	NNY	NNY
Impact [®]	18	9-18V	9-18V	AT	18	9	18
Lariat [®] , Bullet [®]	NNY	NNY	NNY	AT	NNY	NNY	NNY
Laudis [®]	10	10	10	AT	18	10	18
Leadoff [®]	1	10	10	10	10-18	1	18
Lightning [®]	40	9.5	9.5	18	40	26	40
Lumax [®] , Lexar [®]	18	18	18	AT	18	18	18
Marksman [®]	NNY	NNY	NNY	NY	NNY	NNY	NNY
Northstar [®]	18	8	8	8	18	8	18
Permit [®]	2-8 ¹	9	2-9	3	2-9	9	15-18
Prequel [®]	18	18	10-18V	10	18	6	18
Princep [®]	NNY	NNY	NNY	AT	NNY	NNY	NNY
Resolve DF [®] , ResolveQ [®]	1-1.5	10	10	10	18	18	18
Revulin Q [®]	18	18	18	10-15V	18	18	18
Spirit [®]	10-18V	10V	10V	8V	18	18	18
Steadfast [®]	10-18V	10	10	10-15V	10-18V	10-18V	10-18V
Stinger [®]	18	18	18	AT	18	18	AT
Surestart [®]	26+FB	NY	26+FB	10.5-18V	26+FB	40+FB	26+FB
Surpass [®] , TopNotch [®] Ful-Time [®]	NNY	NNY	NNY	NY	NNY	NNY	NNY
Zidua [®]	18	4-11	11	0	18	4	18

¹AT=anytime herbicide labeled for the crop or no rotation restriction exists, FB= field bioassay required before planting the crop, NY=the crop can be planted the year after application, NNY= not next year, the crop cannot be planted the following year, V=variable, intervals vary by crop variety or other conditions specified on label.

²Transplanted tomatoes only.

³In Indiana, the replant restriction for transplanted tomatoes and peppers, cabbage, melons, and cucumbers is 18 months.

Relative Effectiveness of Herbicides for Vegetable Crops¹

Ratings Key		Barnyardgrass	Crabgrass	Fall Panicum	Foxtails	Goosegrass	Yellow Nutsedge	Morningglory, Annual	Galinsoga	Jimsonweed	Lambsquarters	Nightshade	Pigweed	Purslane	Common Ragweed	Smartweed	Velvetleaf	
Preplant Incorporated Herbicides	Balan*	G	G	G	G	G	P	P	P	P	F	P	G	P	P	P	P	
	Devrinol*	G	G	G	G	G	N	N	P	N	F	N	G	G	N	P	N	
	dimethenamid-P	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N	
	Eptam*	G	G	G	G	G	F	P	P	N	F	F-P	G	G	P	P	F	
	pendimethalin	G	G	G	G	G	N	N	N	N	G	P	G	G	P	P	P	
	Prefar*	G	G	G	G	G	N	N	N	N	F	N	F	F	N	N	N	
	Ro-Neet*	G	G	G	G	G	F	N	F	N	F	P	G	F	P	P	P	
	s-metolachlor	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N	
Preemergent Surface Applied Herbicides	Sonalan*	G	G	G	G	G	N	N	N	N	F-G	F	F-G	F-G	N	P	N	
	trifluralin	G	G	G	G	G	N	F	N	N	G	P	G	G	P	P	P	
	acetochlor	G	G	G	G	G	G	P	G	P	G	G	G	F	F	P	P	
	acetochlor+atrazine	G	G	G	G	G	F	G	G	G	G	G	G	G	G	G	F	
	Acuron*	G	G	G	G	G	G	F	G	G	G	G	G	G	G	G	G	
	alachlor	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N	
	Anthem*	G	G	G	G	G	P	F	N	F	F	G	G	G	F	P	F	
	Anthem ATZ*	G	G	G	G	G	F	F	G	G	G	G	G	G	G	G	F	
	atrazine	G	G	P	F	G	F	F-G	G	G	G	G	G	G	G	G	F	
	Callisto*	N	N-P	N	N	N	N	F	G	G	G	G	G	N	P	G	G	
	Camix*	G	G	G	G	G	G	F	G	G	G	G	G	G	F	G	G	
	Chateau*	F	F	F	F	F	N	G	N	G	G	G	G	G	G	G	G	
	Command*	G	G	G	G	G	N	F	P	F	G	P	P	G	G	G	G	
	Curbit*	G	G	G	G	G	N	N	F	N	F	F	G	G	P	P	N	
	Dacthal*	G	G	G	G	G	N	N	P	P	F	N	F	F	N	N	N	
	Define*	G	G	G	G	G	F	N	N	N	F	F	F	G	F	N	N	
	dimethenamid-P	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N	
	halosulfuron	P	P	P	P	P	G	N	G	P	G	P	G	F	G	G	G	
	Karmex*	G	F	F	G	G	P	G	G	G	G	G	G	G	G	G	G	
	Kerb ²	F	F	P	F	F	P	P	P	P	F	P	P	G	F	F	P	
	League*	F	F	N	F	N	G	N	G	N	G	F	G	G	G	N	N	
	Lexar*	G	G	G	G	G	G	F	G	G	G	G	G	G	G	G	G	
	linuron	F	F	F	F	F	N	P	G	F	G	F	G	G	G	G	G	
	Lumax*	G	G	G	G	G	G	F	G	G	G	G	G	G	F	G	G	
	Matrix*	G	P-F	G	G	G	P	P	N	F	F	P	G	F	P-F	F	F	
	metribuzin	F	F	F	F-G	F	N	N	G	F	G	N	G	G	G	G	G	
	oxyfluorfen	P	F	F	P	P	N	F	G	F-G	G	G	G	G	G	G	F	
	pendimethalin	G	G	G	G	G	N	N	N	N	G	P	G	G	P	P	P	
	Pursuit*	P	P	P	G	P	P	P	G	F	F	G	G	G	P	G	F	
	Sinbar*	G	G	G	F-G	G	P	F-G	G	G	G	G	F-G	G	G	G	G	
	Sharpen*	N	N	N	N	N	N	P-F	G	F-G	G	G	G	F-G	G	G	G	
	s-metolachlor	G	G	G	G	G	F	N	G	P	F	G	G	G	P	P	N	
	Solicam*	G	G	G	G	G	F	N	G	N	F	F	F	F	G	F	F	
	Spartan*	F	F	F	F	F	G	G	G	G	F	F	G	G	N	G	F	
	Strategy*	G	G	G	G	G	N	F	P	F	G	P	F	F	F	F	G	
	Zidua*	G	G	G	G	G	F	P	G	P	F	G	G	G	P	P	N	
	Postemergent Herbicides	2,4-D	N	N	N	N	N	N	G	G	F	G	G	G	P	G	P	F
		Aim*	N	N	N	N	N	N	G	N	N	G	G	F-G	N	F	F	G
		Anthem*	P	P	P	P	P	P	G	N	G	G	F	F	N	P	F	G
		atrazine + oil	G	G	F	F-G	G	G	F-G	G	G	G	G	G	G	G	G	G
bentazon		N	N	N	N	N	G	F	G	G	F	P	P	F-G	F	G	G	
bromoxynil		N	N	N	N	N	N	G	N	G	G	G	F	P	G	G	G	
Cadet*		N	N	N	N	N	N	N	N	F	F	F	F	N	N	N	G	
Callisto*		N	N-P	N	N	N	N	F	G	G	G	G	G	N	F	G	G	
clethodim		G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	
clopyralid		N	N	N	N	N	N	N	G	G	P	F	P	N	G	F	N	
dicamba		N	N	N	N	N	N	G	G	F	G	G	G	G	G	G	G	
Evik ³		G	G	G	G	G	F	G	G	G	G	F	G	F	G	G	G	
fomesafen		N	N	N	N	N	N	N	N	N	N	F-G	N	N	F-G	N	N	
Fusilade*		G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	
glyphosate		G	G	G	G	G	F	G	G	G	G	G	G	G	G	G	G	
halosulfuron		N	N	N	N	N	G	F	G	N	P	N	F-G	N	G	F-G	G	
Impact*		F	F	P	P-F	F	N	P	G	G	G	G	G	N	G	G	G	
Laudis*		G	G-F	F	F-G	G	N	F	G	P	G	G	G	N	G	G	G	
League*		F	F	N	N	N	G	G	G	N	N	N	G	G	N	F	N	
linuron		F	F	F	F	F	N	G	G	F	G	G	G	G	G	G	G	
Matrix*		G	P-F	G	G	G	F	F	N	N	F	P	G	F	P-F	F	F	
metribuzin		F	F	F	F	F	N	F-G	G	F	G	P	G	G	G	G	G	
nicosulfuron		G	P	G	G	G	P	G	P	G	P-F	P	G	P	P	G	P	
Option*		G	F	G	G	G	P	F	P	G	G	G	G	G	G	F	G	
oxyfluorfen		P	P	P	P	P	N	F	G	G	F	G	F	G	G	F	F	
paraquat		G	G	G	G	G	G	F-G	G	G	G	G	G	G	G	G	G	
Poast*		G	F-G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	
quizalofop		G	G	G	G	G	N	N	N	N	N	N	N	N	N	N	N	
Raptor*		G	G	N	G	N	P-F	P-F	N	G	F	G	G	F	P-F	G	G	
Revulin Q*		G	F	G	G	N	P	F	G	G	G	G	G	N	F	G	G	
Shieldex*	F	G	N	G	F	N	F	N	N	G	F	G	N	G	F	G		
Spin-aid*	N	N	N	N	N	N	F	G	F	G	F	P	G	G	G	F		
Starane*	N	N	N	N	N	N	G	N	F	P	F	P	G	G	P	G		
Thistrol*	N	N	N	N	N	N	F	N	N	F	N	F	N	N	F	N		

¹ For pre-packaged mixtures, see ratings for individual components.

² Excellent against quackgrass.

³ Post-directed spray.

Selected Information About Recommended Herbicides

This table includes selected information about the herbicides recommended in this guide. The products are listed alphabetically by the **Trade Name**. The table also lists a **Common Name** of active ingredient.

The **Usage** column indicates when the product is applied: preplant incorporated (ppi — applied before weeds emerge and mechanically incorporated into soil), preemergence (pre — applied before weeds emerge), or postemergence (post — applied after weeds emerge).

The **Signal Word** column indicates a product's possible toxicity. If the signal word is set in bold, the product is a restricted use product (RUP). See page 33.

The **WSSA/HRAC Code** column indicates the product's mode of action. WSSA/HRAC stands for Weed Science Society of America/Herbicide Resistance Action Committee Mode of Action Classifications: hracglobal.com/tools/classification-lookup.

The **Runoff/Leaching Potential** column provides ratings from the USDA-NRCS WIN-PST Pesticide Properties database: go.usa.gov/Kok. There are three ratings for potential runoff/leaching:

1=high

2=intermediate

3=low

Trade Name	Common Name	Usage	Signal Word	WSSA/HRAC Code	Runoff/Leaching Potential
Aatrex 4L®	atrazine	ppi, pre, post	Caution	5/C1	2/1
Accent®	nicosulfuron	post	Caution	2/B	3/1
Aim EC®	carfentrazone	post	Caution	14/E	3/3
Assure II®	quizalofop	post	Danger	1/A	1/2
Banvel®	dicamba	post	Caution	4/O	3/1
Basagran®	bentazon	post	Danger	6/C3	3/1
Cadet®	fluthiacet-methyl	post	Warning	14/E	3/3
Callisto®	mesotrione	post	Caution	27/F2	3/1
Caparol®	prometryn	pre, post	Caution	5/C1	2/2
Casoron®	dichlobenil	pre	Caution	20/L	
Chateau SW®	flumioxazin	pre	Caution	14/E	2/3
Clarity®	dicamba	post	Caution	4/O	3/1
Clethodim 2E®	clethodim	post	Caution	1/A	3/3
Command 3ME®	clomazone	pre	Caution	13/F4	3/2
Curbit EC®	ethalfluralin	ppi, pre	Danger	3/K1	1/3
Dacthal W-75®, Dacthal Flowable®	DCPA	pre	Caution	3/K1	1/3
Devrinol DF-XT®	napropamide	ppi, pre	Caution	15/K3	2/2
Dual Magnum®	metolachlor (s-)	ppi, pre	Caution	15/K3	2/1
Eptam 7E®	EPTC	ppi	Warning	8/N	3/3
Firestorm®	paraquat	post	Danger/Poison	22/D	1/3
Formula 40®	2,4-D	post	Danger	4/O	3/1
Fusilade DX®	fluazifop-P	post	Caution	1/A	2/3
Goal XL®	oxyfluorfen	pre, post	Warning	14/E	2/3
Goaltender®	oxyfluorfen	pre, post	Warning	14/E	2/3
Gramoxone SL®	paraquat	post	Danger/Poison	22/D	1/3
Harness®	acetochlor	ppi, pre	Warning	15/K3	3/2
Impact®	topramezone	post	Caution	27/F2	2/1

continued next page

Selected Information About Recommended Herbicides (continued)

Trade Name	Common Name	Usage	Signal Word	WSSA/HRAC Code	Runoff/Leaching Potential
Karmex®	diuron	pre, post	Caution	7/C2	2/2
Kerb SC®	pronamide	pre	Caution	3/K1	2/1
Laudis®	tembotrione	post	Caution	27/F2	2/1
League®	imazosulfuron	pre, post	Caution	2/B	3/2
Liberty 280SL®	glufosinate	post	Warning	10/H	3/3
Lorox DF®	linuron	pre, post	Caution	7/C2	2/2
Matrix SG®	rimsulfuron	pre, post	Caution	2/B	3/2
Micro-Tech®	alachlor	ppi, pre	Caution	15/K3	3/2
Moxy 2E®	bromoxynil	post	Warning	6/C3	2/3
Nortron SC®	ethofumesate	pre, post	Caution	8/N	3/2
Optill®	saflufenacil+imazethapyr	pre,post	Caution	14/E and 2/B	2/1
Option®	foramsulfuron	post	Caution	2/B	3/2
Outlook®	dimethenamid-p	ppi, pre	Warning	15/K3	3/2
Permit®	halosulfuron	post	Caution	2/B	3/2
Poast®	sethoxydim	post	Warning	1/A	3/3
Prefar 4E®	bensulide	ppi	Caution	8/N	1/2
Prowl 3.3EC®	pendimethalin	ppi, pre	Caution	3/K1	1/3
Prowl H2O®	pendimethalin	ppi, pre	Caution	3/K1	1/3
Pursuit®	imazethapyr	ppi, pre, post	Caution	2/B	2/1
Quinstar 4L®	quinclorac	post	Caution	4/O	2/1
Raptor®	imazamox	pre, post	Caution	2/B	2/1
Reflex®	fomesafen	post	Danger	14/E	2/1
Reglone®	diquat	post	Caution	22/D	1/3
Rely 280®	glufosinate	post	Warning	10/H	3/3
Ro-Neet	cycoate	ppi	Caution	8/N	3/2
Roundup Ultra®, others	glyphosate	post	Caution	9/G	1/3
Sandea®	halosulfuron	post	Caution	2/B	3/2
Scythe®	pelargonic acid	post	Warning	26/Z	3/3
Select Max®	clethodim	post	Caution	1/A	3/3
Sharpen®	saflufenacil	pre	Caution	14/E	3/2
Shieldex® 400 SC	tolpyralate	post	Caution	27/F2	N/A
Sinbar WDG®	terbacil	pre, post	Caution	5/C1	2/1
Solicam DF®	norflurazon	pre	Caution	12/F1	2/2
Spartan 4F®	sulfentrazone	pre, post	Caution	14/E	2/1
Spin-Aid®	phenmedipham	post	Danger	5/C1	2/3
Spur®	clopyralid	post	Caution	4/O	3/1
Starane Ultra®	fluroxypyr	post	Warning	4/O	2/3
Stinger®	clopyralid	post	Caution	4/O	3/1
Surpass EC®	acetochlor	ppi, pre	Warning	15/K3	3/2
Targa®	quizalofop	post	Danger	1/A	1/2
Thistrol®	MCPB	post	Warning	4/O	3/1
Treflan 4EC®	trifluralin	ppi	Caution	3/K1	1/3
TriCor DF®, others	metribuzin	pre, post	Caution	5/C1	3/1
UpBeet®	triflurosulfuron	post	Caution	2/B	3/3
Valor®	flumioxazin	pre	Caution	14/E	2/3
Weedar 64®	2,4-D	post	Danger	4/O	3/2
Zidua®	pyroxasulfone	pre	Caution	15/K3	3/2

Preharvest Intervals (Days) and Entry Intervals (Hours) for Herbicides Registered for Use on Midwest Vegetables in 2019¹

	2,4-D	acetochlor	acetochlor+atrazine	Acuron®	Aim®	alachlor	Anthem®, Anthem ATZ®	Assure II®/Targa®	atrazine	atrazine+dimethenamid-P	atrazine+s-metolachlor	Balan®	bentazon	bromoxynil	Cadet®	Callisto®	Caparol®	Casoron®	Chateau®	clethodim	clopyralid	Command 3ME®	Curbit®	Dacthal®	Devrinol®	dicamba	dimethenamid-P	diuron	Eptam®	Expert®	fomesafen	Fusilade®	glyphosate	Goal®, Galigan®						
Asparagus	X				5										X			X	1		14			X	1		X					1	X							
Beet					X															30	30														X					
Broccoli					X															30				X											X	X				
Cabbage					X															30	45			X											X	X				
Cantaloupe					X															14	X	X	X												X					
Carrot					X												30			30													45	X						
Cauliflower					X															30				X											X	X				
Celery																	40																							
Collard					X															14				X												X				
Cucumber					X															14	45	X														X				
Dry Bean					X		30													30							70	X		45	60	X				X				
Eggplant					X															20				X	X												X			
Endive/Escarole					X															14																	X			
Garlic					X								112						X	45							30						45	X	60					
Horseradish					X															30				X		40										X				
Kale					X															14				X													X			
Leek					X															14				X										14	X					
Lettuce					X							X								X															14	X				
Lima Bean					X								30							30																	X			
Mint		40					30					X	70						80	21	45	84														X	X			
Mustard					X															14				X													X			
Okra					X												14																					X		
Onion, dry bulb					X									X					45	45				X		30								45	X	45				
Onion, green bunching					X									X						14				X		30									14	X				
Parsley					X												30			14																	X			
Parsnip																				30																		X		
Pea					X		30					30								21																	X			
Pepper					X															20	X			X														X		
Potato					X															30							40	45	70									X		
Pumpkin					X															14		X																X		
Radish					X															15																		X		
Rhubarb					X										X	40	X			30	X															14	X			
Snap Bean					X		15					30								21	45								X	30								X		
Spinach					X															14	21																	X		
Squash					X															14	45	X																	X	
Sweet Corn	X	X	X	X	X	X	X	X	50	X		X		40	45					30							50		X									X		
Sweet Potato					X															30	95			X												14	X			
Tomato					X															20				X	X													X		
Turnip, greens					X															14	15			X														X		
Turnip, root					X															30	30			X														X		
Watermelon					X															14	X	X	X															X		
Re-Entry Intervals (hours)	48	12	12	24	12	12	12	12	12	12	24	12	12	24	12	12	12	12	12	12	12	12	24	12	12	24	12	12	12	24	24	12	12	12	24	12	24			

Preharvest Intervals (Days) and Entry Intervals (Hours) for Herbicides Registered for Use on Midwest Vegetables in 2019¹ (continued)

	halosulfuron	Impact®	Kerb®	Laudis®	League®	linuron	Matrix®	metribuzin	nicosulfuron	Optill®	Option®	paraquat	Poast®	Prefar®	Priority®	pendimethalin	Pursuit®, Thunder®	Pyramin®	Quinclorac®	Raptor®	Revulin Q®	Ro-Neet®	Sandea® or Profine 75®	Sharpen®	Shieldex®	Simbar®	s-metolachlor	Sollicam®	Sonalan®	Spartan®	Spartan Advance®	Spartan Charge®	Spin-Aid®	Starane®, Starane Ultra®	Strategy®	Thistrol®	trifluralin	Valor®	Zidua®						
Asparagus					1		14					6	1					X					1			5		14												X					
Beet													60				X					X					X							60											
Broccoli													30	X		60																									X				
Cabbage												X	30	X		70														X		X									X				
Cantaloupe				48								X	14	X		35							57				X										X								
Carrot					14		60						30			X											64														X				
Cauliflower													30	X		70																									X				
Collard													30	X		21											X														X				
Cucumber													14	X									30			X										45									
Dry Bean											X	30			X	60		X				30			X		X														X				
Eggplant											X	20	X									30																			X				
Endive/Escarole			56										15	X																											X				
Garlic											X	30	X		45											X																			
Horseradish													60																	X		X													
Kale													30	X		21										X															X				
Leek													30			30																													
Lettuce			55								X	15-30	X																																
Lima Bean													15			X		X				30			X																	X			
Mint													20			X									60				X											40	X				
Mustard													30	X		21										30																X			
Okra													14										30			60														X					
Onion, dry bulb												60	30	X		45										60															60				
Onion, green bunching													30			30										21																			
Parsley					30								15	X																															
Parsnip					X								14																																
Pea									X				15			X	X		X				X		X				X	X	X										X				
Pepper				21							X	20	X		X								30			X																X			
Potato				45	X	60	60						30			X										40-60																X			
Pumpkin												X	14	X									30			30													X						
Radish													14													X																X			
Rhubarb													30																																
Snap Bean													15			X			X				30			X																X			
Spinach													15														50																		
Squash											X	14	X										30			30																45			
Sweet Corn	30	45	X					X		45	X	30		30	X							45	30	35	X																31				37
Sweet Potato																																											X		
Tomato				21		45	7					30	20		X								30			90			X												X				
Turnip, greens													14			21											30																		
Turnip, root													14													X																			
Watermelon				48							X	20	X		35								57		70	60														X					
Re-Entry Intervals (hours)	12	12	24	12	12	24	4	12	4	12	12	12-24	12	12	12	24	12	12	12	4	12	12	12	12	24	12	24	12	12	12	12	24	12	24	12	24	24	12	12	12	12	12			

X=check label for details.