Weed Management Strategies

Reviewed by Dan Brainard – Sep 2021

Weed management requires a multifaceted approach built on an understanding of weeds and the crop. Successful weed management entails preventative strategies to reduce weed populations before planting, cultural practices to give crops a competitive advantage over weeds, and direct approaches including chemical physical, and biological tactics.

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.

Weed Identification

The first step in weed management is to identify the weeds and understand their life cycles and susceptibility to different weed management practices. 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, crabgrass, 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. Among the most common perennial weeds encountered in Midwest vegetable crops are quackgrass, horsenettle, and yellow nutsedge.

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.

Prevention and Weed Seedbank Management

Prevention is a critical component of successful weed management. Many weed species produce thousands of seeds that survive for decades in the soil, making up the weed seedbank. Avoiding “deposits” to the weed seedbank by preventing weeds from shedding seed is important for reducing the number of weeds emerging each year. This may mean mowing, tilling or applying herbicides after crop harvest to manage weed escapes, or planting a thick cover crop in non-crop areas to suppress weed growth and reproduction. The seedbank may also be depleted by encouraging “withdrawals” of seeds through repeated cultivation which stimulates seed germination and kills emerging weeds. Stale (or false) seedbed techniques aim to deplete weed seeds in the top few inches of soil through repeated shallow disturbance to stimulate seed germination followed by herbicide applications or flame weeding prior to planting the crop. This approach can be highly effective for late-planted vegetable crops such as fall carrots or beets, but is less practical for crops planted early in the spring. Additional details on weed seedbank management strategies can be found in the web resource, *Manipulating Weed Seed Banks to Promote their Decline* at eorganic.org/node/2807.

Cultural Practices

Site Selection. 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. 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). This is important both to ensure healthy crop growth for weed competitiveness, but also to avoid buildup of problematic weed species that are well adapted to specific vegetable crops. Crop rotation helps keep weeds 'off-balance' by applying different selective pressures including variations in the timing of tillage and type of herbicides applied.

Wild proso millet is an example of a problem weed where rotation is important for management. Rotation from sweet corn to 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 also allows the use of postemergence grass herbicides to manage wild proso millet.

Competitive Cultivars and Planting Methods. Each crop has a Critical Weed Free Period (table below) for which weed competition should be eliminated to ensure a good crop. Use adaptive, vigorous varieties resistant to diseases and insects. Unhealthy plants cannot effectively compete with weeds. Varieties suited for cultivation in regions covered by this publication are listed in some sections 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.

Critical Weed Free Period[1]	Crop
First third of cultivation period	Potato, Pumpkin, Sweet Corn
First half of cultivation period	Asparagus, Beans, Cole Crops, Lettuce, Pepper, Tomato
2 weeks after first half of cultivation period	Carrots, Celery, Beet, Peas
4 weeks after first half of cultivation period	Garlic, Leek, Onion
None	Chives, Parsley, Fennel, Swiss Chard, Spinach

[1]Modified from *Practical weed control in arable farming and vegetable cultivation without chemicals* PPO 352 (2006), from Wageningen University & Research Applied Plant Research unit, at edepot.wur.nl/24553.

Mulches. 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 whichs 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.

Mechanical Practices

Mechanical weed management relies on a wide range of primary and secondary tillage implements including moldboard plows, disks, rotary hoes, row cultivators and various 'in-row' tools. It typically begins with primary tillage with a moldboard or chisel plow, followed by disking, field cultivating and bed formation. These operations are important for successful production of most vegetable crops for several reasons including formation of a good seed bed, incorporation

of soil amendments, and breaking the life cycle of pests. For weed management, these tillage operations help eliminate established winter annual and perennial weeds, as well as summer annuals that emerge prior to planting.

A good introduction to mechanical cultivation be found in the publication *Steel in the Field* available online at sare.org/wp-content/uploads/Steel-in-the-Field.pdf, and video footage demonstrating the nuances of many of these tools and techniques can be seen in the North Central SARE-funded videos *In-Row Mechanical Weed Control Options for Farmers Large and Small*, as well as in the *Weed 'Em and Reap Part 1: Tools for Organic Weed Management in Vegetable Cropping Systems* video series found at eorganic.org/node/3411.

Pre-plant, or pre-crop emergence weeds. After bed preparation, shallow cultivation tools including rotary hoes and flextine cultivators can be used to uproot small weeds including those that have germinated but not yet emerged from the ground (white thread stage). These tools can be used prior to planting to drain weed seeds from the top 1-2" of soil without bringing new seeds to the soil surface (see stale seed bed above). For large-seeded vegetable crops such as sweet corn, snap beans or cucurbits, flextine cultivators may also be used after planting but before crop emergence.

Weeds after crop emergence. Many cultivation tools are available, and are generally categorized as either between-row, near-row, or in-row tools, based on the zone they target. The flextine cultivator mentioned above can also be used after crops have emerged and are firmly anchored (1-2 leaf growth stage), scratching the soil of between- and in-row areas uprooting and burying weeds at their white-thread stage.

Between-row weeds. Removing weeds between crop rows is relatively easy, and there are several options available. Between row tools include various row-crop cultivators equipped with knives and sweeps that are capable of killing larger weeds. These tools may also be used to throw soil into the crop row at later crop growth stages, burying small weed seedlings. Other between-row tools include basket weeders (e.g. Buddingh or Tilmor) and rolling cultivators (e.g. Lilliston or Hillside). Basket weeders are designed to work close to the crop row, throwing minimal soil while uprooting small weeds. They require level soil that is relatively stone free. Rolling cultivators are more aggressive tools that are equipped with sets of toothed discs (spider gangs) that can be easily adjusted to accommodate different levels of desired soil disturbance and angles. They are particularly useful on edges of beds and in situations where crop or cover crop residue would interfere with less forgiving knives or sweeps.

Near-row weeds. Tools such as side knives (sometimes referred to as beet knives or tender plant hoes) or cutaway disks are designed to disturb soil near the row without disturbing the crop, leaving a 1.5-3" band of undisturbed soil centered on the crop row. Success with these tools requires straight rows, and attention to precise steering and depth control. To best accomplish this, they should be mounted on parallel linkage with gauge wheels and steered either on the belly of a cultivating tractor, or on a steerable toolbar.

In-row weeds. Weeds in the row are the most challenging to manage without disturbing the crop. This zone may be managed by burying small weeds by throwing soil into the row using sweeps, hilling disks or ridgers. Alternatively, specialized in-row tools such as finger weeders or torsion weeders may be used to reach into the crop row and uproot small weeds. In all cases, a size difference between the crop and weed is essential for success. As with near-row tools, these tools also require investments in depth control and steering for optimal performance.

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.

Cover Crops for Biological Weed Suppression

One biological system that has potential in the Midwest is the use of cover crops to suppress weed development. Cover crops 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.

Successful cover cropping for weed suppression in vegetables requires use of competitive species that match the season and soil type. Summer cover crops with good weed suppressive ability include sorghum-sudangrass and buckwheat. Cool season cover crops like oats and oilseed radish can effectively suppress weeds beginning in late summer through the fall before winter killing in most areas of the Midwest. Winter cover crops such as winter rye or hairy vetch may provide weed suppression during the winter as well as a weed suppressive mulch if allowed to grow through early spring.

One cover crop system that works well in parts of the Midwest for some large-seeded vegetable crops like pumpkins involves growing winter rye as a weed suppressive mulch. Winter rye is planted in late summer or early fall and overwinters. 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 can provide early season control of many annual weeds, but generally this requires a thick uniform stand that is at least 4 feet tall to adequately suppress weeds. In most cases,additional herbicides and or mechanical control may be required. The system should be evaluated in small areas before it is adopted.

Refer to Examples of Integrating Cover Crops section, the Summary of Nonchemical Weed Management Practices table, and the *Weed 'Em and Reap Part 2: Reduced Tillage Strategies for Vegetable Cropping Systems* video series found at eorganic.org/node/3409 for additional information. 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 from your state Extension service.

Herbicides for 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. The Corn Herbicide Rotation Restrictions table and Soybean Herbicide Rotation Restrictions table 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 2 (ALS inhibitors) make up 30% of the documented resistant biotypes. Sandea, Permit, Matrix, Raptor, and Pursuit are vegetable herbicides in this group.

Weeds resistant to herbicides in HRAC Group 5 (Photosystem II inhibitors) make up another 20% 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% 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

Practice	Notes
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.
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.
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.