

Chapter 14

Weed Management for Organic Crops

Weed management continues to be one of the biggest challenges for organic field crop producers. Weeds can be considered a significant problem because they tend to decrease crop yields by increasing competition for water, sunlight, and nutrients while serving as host plants for pests and diseases. **Farmers who wish to become organically certified are restricted from using synthetic herbicides for weed control under the Organic Foods Production Act of 1990 and the National Organic Program (NOP), section 7 of the Code of Federal Regulations (CFR), Part 205, also known as the NOP Final Rule.** They meet this challenge by selecting from a wide range of acceptable techniques and strategies, all with the goal of achieving economically acceptable weed control and crop yields. The primary weed control strategies for organic systems are cultural and mechanical, focusing on prevention, crop rotation, crop competition, and cultivation. Organic weed management is a holistic system involving an entirely different approach to managing a farming system. The organic farmer is not interested in eliminating all weeds but wants to keep the weeds at a threshold that is both economical and manageable. A farmer who manages weeds organically must be intimately familiar with the type of weeds and their growth habits to determine which control methods to employ.

# Weed Management for Organic Crops

## Cultural Weed Control

Any tactic that makes the crop more competitive against weeds is considered cultural control. Some cultural practices—in particular, crop rotation and altering planting dates—can be critical components of weed management in organic production systems. Cultural methods are the first line of defense in weed management. Following are several crop management practices that can enhance crop competitiveness toward weeds.

### Managing Weeds with Cover Crops

Cover crops offer many benefits to an organic farming system, including protection against soil erosion, improvement of soil structure, soil fertility enhancement, and weed suppression. Cover crops can be used in a variety of ways to suppress weeds. First, cover crops occupy the space and limit weed growth through direct competition for light, nutrients, and moisture. Second, many cover crops and their residues release allelochemicals into the soil that prevent or hinder weed seedling growth. Third, a vigorous cover crop can change the environment for weed seeds on and in the soil—inhibiting germination due to a heavy crop canopy. Finally cover crops can enhance the vigor, and therefore weed competitiveness of the following cash crop, by providing nitrogen (e.g., legumes), enhancing availability of other nutrients, or improving soil conditions.

#### Cover Crops as Living Mulches

Winter cover crops can occupy the niche that exists after a summer crop is harvested and before the next season’s crop is planted.

#### Allelopathic Cover Crops

Many cover crop species produce allelochemicals as they grow and during decomposition, meaning that both living cover crops and decaying residue (incorporated or on the surface) can help to suppress weeds e.g clover, alfalfa, oat, rye, sorghum, chickpea, summer squash etc.

### Role of Crop Rotation in Weed Management

Crop rotation provides the foundation for long-term weed management. Planting a wide variety of crops with varied characteristics reduces the likelihood that specific weed species will become adapted to the system and become problematic. In designing a crop rotation for weed control, the overall key to success is diversity. The following principles or practices are commonly incorporated into successful rotations.

### Selecting Crop Varieties that Better Compete with Weeds

Organic systems need varieties that actively suppress weeds. Quick germination and establishment, rapid early and vigorous growth, and the ability to rapidly cover the soil and shade it (prostrate or tall varieties) in order to out-compete weeds at an early a stage in the crop cycle, are all desirable traits that will potentially shade out weeds. Crop varieties with a larger seed size have also been shown to exhibit greater initial vigor of emergence and growth, which may subsequently provide extra competitive ability. Tall grain crops are generally more competitive with weeds because they intercept light.

### Adjust Crop Planting to Disrupt Pest Habitat

Crop planting can be adjusted both in space and time to reduce the development of large pest populations.

#### Altering the Planting Dates to Control Weeds

Altering planting dates to disrupt weed life cycles can be timed to limit competition from potentially troublesome weed populations. In some instances, it is wise to seed or transplant a cash crop early to get canopy closure as soon as possible.

#### Adjusting Seeding Rate to Control Weeds

Increasing the seeding rate is another common strategy for organic growers to control weeds. The theory is that the greater amount of space taken up by the crop in the rows, the less space is available for the weeds to invade. There is also an allowance for potentially lower germination rates and loss of crop by mechanical weeders.

### Mulches for Weed Control

Mulch is any kind of material applied to the soil surface for protection or improvement of the area covered. Mulches contribute to weed management in organic crops by reducing weed seed germination, blocking weed growth, and favoring the crop by conserving soil moisture and sometimes by moderating soil temperature. Where a mulch layer is sufficiently deep, few weeds will grow. There are various types of mulches available and may be divided into synthetic and organic mulch.

#### Advantages and Disadvantages of Mulching

Advantages and disadvantages in using mulches for weed control are as follows:

#### Synthetic Mulches

Synthetic mulches like black polyethylene film (the most widely used plastic mulch) are laid on a prepared seedbed just before transplanting or seeding a vegetable crop through holes or slits cut into the mulch. Mechanization, with equipment such as tractor-drawn bed shapers, mulch layers, and planters, allows the farmer to mulch and plant a field. Black plastic, other opaque (non-transparent) materials and infrared-transmitting (IRT= Alows IR light to pass through so that it can warm soil) mulch effectively block weed emergence, and promote soil warming and early crop growth.

 

Fig. Maize grown by using plastic mulch

#### Organic Mulches

Organic mulches cover the soil and provide many of the same benefits as cover crops, especially the prevention of soil erosion. Many organic materials, such as straw, leaves, pine needles, and wood chips, can be effective mulches. Straw and other materials that are easily decomposed are applied to strawberries and vegetables during the growing season. The mulch can be tilled in at the end of the season, where it will quickly decompose.

#### Guidelines for Mulches and Weed Barriers

USDA Organic Regulations define mulch as any material that serves to suppress weed growth, moderate soil temperature, or conserve soil moisture. Mulches and weed barriers are production inputs on organic farms. All mulches and weed barriers, synthetic or non-synthetic, must be included in the producer’s annual Materials Inventory. Guidelines for acceptable and unacceptable mulches are listed as follows:

## Controlling Weeds by Tillage and Cultivation

Primary tillage, such as moldboard plowing of the soil leads to the uprooting and shredding of large weeds that have grown in a field during the fall to the early spring season. Moldboard plowing can also bury the weed seeds deep within the soil where they will not be able to emerge. Secondary tillage, such as disking and harrowing, will lead to the shredding of the weed biomass and further dislodging of shallow-rooted weeds. Often, secondary tillage is used repeatedly to enhance weed germination to deplete the weed seed bank. Although both primary and secondary tillage often lead to a quick destruction of weeds in a field, they do not provide a lasting solution, especially if weed seeds are still present close to the surface of the soil. Follow up practices requiring cultivation are needed to dislodge and uproot the weeds that emerge after tillage as well as creating a good seedbed for uniform crop establishment, which is a critical part of a crop’s ability to compete with weeds. Cultivation is performed after the crop is planted and is probably the most widely used weed control method in organic farming operations. Cultivation kills weeds by digging them out, burying them, breaking them apart, or drying them out. Shallow cultivation usually is best, since it brings fewer weed seeds to the soil surface. Cultivation is more effective in dry soils because weeds often die by desiccation and mortality is severely decreased under wet conditions. Cultivating when the soil is too wet will damage the soil structure and possibly spread perennial weeds. In addition to controlling weeds, cultivation can break up soil crusting and thus can increase crop emergence, water infiltration, mineralization of nutrients, and soil aeration. **This section provides a more in depth discussion on cultivation practices for pre-emergence and post-emergence weed control, implements used for in-row and for between row weed control, and addresses other factors—such as soil and weather conditions—that enter into decisions about weed management.**

### Tillage and Cultivation Practices in Managing Weeds

The use of tillage and cultivation practices as a means in controlling weeds has required the organic growers to become knowledgeable not only in annual weed life cycles but also in the life cycles of perennial weeds.

#### Annuals

The first line of defense against annual weeds is cultivation. The ideal time to cultivate is when weeds are in the “thread stage,” when they’ve just germinated and are no thicker than a thread. At that point, they are easily destroyed with a series of quick cultivation passes. Cultivation operations should be as shallow as possible to avoid bringing new weed seeds to the soil surface.

#### Perennials

The strategy in controlling perennial weeds is just the opposite of that for the annuals. Perennials have the ability to reproduce by seed as well as vegetatively—a unique characteristic that promotes the survival of a perennial species. In vegetative (asexual) reproduction, a new plant develops from a vegetative organ such as a stem, root, or leaf. Several modifications of these organs are common in perennial weeds, such as underground stems (rhizomes), above-ground stems (stolons), bulbs, corms, and tubers. The combination of these factors can make perennial weed control a difficult process especially since reproductive structures can be produced any time a plant reaches maturity. Control of perennials is usually achieved through multiple management tactics and at different times than annuals. For example, a moldboard plow can be used to control of deep-rooted perennial weeds to sever the taproot deep in the ground and to completely bury the weed’s crown.

### Stale (or False) Seedbed Tillage

An often overlooked weed management practice is the stale seedbed technique; a weed management practice in which weed seeds just below the soil surface are allowed to germinate and then killed prior to planting the cash crop while minimizing soil disturbances. The stale seedbed technique is based on the premise weeds that germinate and emerge before the crop is planted, are easier to manage. Stale seedbed works by targeting weed seeds in the shallow layer (i.e., germination zone) of the soil. When adequate moisture is available, most weeds will emerge from the top 2.5 inches (1 cm) of the soil profile. These non-dormant seeds are allowed to germinate and then flamed or very gently cultivated just prior to planting the cash crop.

### Blind Cultivation

Blind cultivation can be performed before the crop emerges. To minimize crop damage, blind cultivation should be done before the crop has emerged and/or once it is well rooted. Blind cultivation takes advantage of the difference in size and sprouting depth between crop and weed seeds. Most weed seeds are smaller than crop seeds, and they germinate shallower in the soil. The crop seeds are safely below this layer and are not hurt by a shallow weeding before emergence.

#### Crops Suitable for Blind Cultivation

Certain types of crops tolerate blind cultivation better than others. In general, crops that quickly develop large taproots after germination; larger-seeded crops, including corn and soybean; and crop seeds that are planted an inch or deeper will tolerate the blind cultivation.

#### Timing of Blind Cultivation

The success of the first blind cultivation is extremely important because it must give the crop an initial head start. The intention, of course, is to remove the weeds without harming the crop. Usually, the first blind cultivation pass is done right before crop emergence, with a second pass done about a week later, depending on conditions.

#### Weeds Susceptible to Blind Cultivation

Weed species vary in their vulnerability to blind cultivation. Broad-leafed weed seedlings with their growing point above ground are easily killed when their tops are broken, while grasses with growing points below the soil surface need to be uprooted and desiccated.

#### Implements Used for Blind Cultivation

Implements used for blind cultivation are designed to be able to contact crop plants without significant damage, yet remove young weed seedlings. Examples of implements used for blind cultivation include: (1) flex-tine harrows, (2) spring-tooth harrows, (3) spike-tooth harrows, (4) chain-link harrows, and (5) rotary hoes.

**Flex-tine Harrows**: Flex-tine harrows, also known as tine weeders, are the most widely used tools for blind cultivation. Flex-tine harrows have multiple rows of flexible metal tines that are mounted on a toolbar, wiggling slightly as they are pulled along, uprooting or dislodging very small weeds. The spines vibrate perpendicularly to the direction in which the tractor is moving. The tractor speed will increase the vibration of the tines as they are pulled through the soil. The vibrating tines uproot and shake the soil loose from the newly germinated weeds, bringing them to the soil surface to desiccate and die. Many makers allow individual tines to be raised up over crop rows while other tines are down for inter-row, post-emergence cultivation.

**Spring-tooth Harrows.**Spring-tooth harrows are extremely aggressive, but they are sometimes used for weeding. Because of their potential to do crop damage, spring-tooth harrows are generally only used in emergencies where the crop will otherwise be lost.

**Spike-tooth Harrows**. Spike-tooth harrows are very effective weeders. They can both uproot and bury weeds. The angle of the spikes can usually be adjusted with a handle from straight up and down to angled back at a flat angle to the soil. Rocks are a big problem with spike-tooth harrows.

**Rotary Hoes**. Rotary hoes work before or after crops are up, as long as crop seed is more deeply rooted than weeds and crop tissue damage is not too severe. Weeds must be very small or not yet emerged for good control. Rotary hoes work primarily by uprooting weeds and/or by loosening the soil from the tiny roots of the weed seedlings. Rotary hoes are used for “broadcast” cultivation, i.e. lightly tilling their full width at one to two inches deep without regard to crop rows. They are very gentle on the crop and can be used when more aggressive weeders cause too much crop damage. Crops with strong, flexible stems suffer the least damage. Crops such as corn, soybean and various field beans tolerate one or several cultivations with the rotary hoe.

**Chain-link Harrows**. Chain-link harrows have short shanks fitted on chains rather than a rigid frame, so that they hug the ground (See Figure 14.7). They are especially effective on light soils and prior to crop emergence, or in short crops. Chain harrows are best for light soils and before crop emergence. Chain-link harrows are especially well suited for crops with rapid initial growth (e.g., peas, string beans and sweet corn).

### In-Row Cultivation

In-row cultivation, also called intra-row cultivation, is accomplished with cultivators that control weeds within the crop row. Mechanical weeding within the crop row requires selectivity between the crop and weeds, and can be a difficult job given that both are often at similar growth stages at the time of cultivation. In-row weeders require very precise operation and are often operated at slow speeds with narrow (one or two crop row) equipment. Weed control is greatest when weeds are very small—often with two leaves or less. These tools usually need to be combined with more aggressive between-row cultivators. Cultivators for intra-row cultivation include specialized precision tools such as finger weeders, torsion weeders, retracting tree/vine cultivators, and the French plow.

#### Finger Weeders

The finger weeder is a simple mechanical intra-row weeder that uses two sets of steel cone wheels to which rubber spikes, or “fingers” are affixed. These fingers point horizontally outwards at a certain angle and operate from the side and beneath the crop row with ground driven rotary motion. The rubber fingers work the soil just below the surface, uprooting small weeds located very close to the crop. There are a very large range of options on the basic design, including different diameters/sizes, a wide range of materials used for the weeding fingers, from steel, through a range of plastics, fabric reinforced rubber and even brushes.

#### Torsion Weeders

The torsion weeder is a very simple, affordable design consisting of two steel rods, one on each side of the crop row to uproot small weeds while pushing soil into the row. Torsion weeders work by breaking up the soil in the intra-row, but with more of a shattering effect than the mixing/churning effect of finger weeders. Torsion weeders use spring tines connected to a rigid frame and that are bent so that two short tine segments are parallel to the soil surface and meet near the crop plant row. This arrangement allows crop plants to pass through the tine pairs.

#### Retracting Tree/Vine Cultivators

These cultivators have developed mechanical cultivators for orchards and vineyards. Many of them use a trigger bar to pull the device around the trunks and posts, allowing weeding in the tree-row. They are mounted to a side frame or a rear 3-point hitch. The device is mounted on the right side of the tractor, providing operator visibility. They can also be outfitted with other implement heads, such as sweeps, disks, and rakes making it a versatile piece of machinery for orchard and vineyard operations.

### Between-Row Cultivation

Between-row cultivation, also called inter-row cultivation, controls weeds that grow between the rows, and therefore is only used in row crops. Inter-row cultivation is done three to fiveweeks post planting. Inter-row cultivation is low risk to the crop compared to intra-row (i.e., within the row) operations. Generally, cultivation is performed at depths less than two inches so that crop roots are not damaged and soil moisture is conserved. If the young crop is in danger of becoming buried by soil or weeds during cultivation, shields can be used on the cultivator. Implements used for inter-row cultivation can include basket weeders, brush weeders, rolling cultivators, rotary tillers, field cultivators, and flex-tine harrows.

#### Field Cultivators

Field cultivators are the most common machine used for mechanical weed control for row crops when they a few inches tall. Commonly used cultivation setups consist of a shank, which is typically long and narrow (either straight, C-, or S-shape) attached to a toolbar, with a cultivating tool (e.g., duckfoot, goosefoot, shovel, sweep, knife, hilling disk) attached to the bottom of the shank. Usually there are three to five shanks, called a gang, mounted on a toolbar. The distance between the crop rows and the precision of the implement determine the working width of the gangs.

#### Rolling Cultivators

Rolling cultivators have gangs of three to five “spider wheels” (wheels of strong, curved, cutting teeth radiating from a center hub) that mount independently on a toolbar. The angle that they work the soil, and thus their aggressiveness, is usually adjustable. The number of gangs grouped together determines cultivator width, and these are usually rear-mounted, but pairs of gangs may be belly mounted to work a row or two. Soil can be thrown into row to bury small weeds or away from the crop row, depending on angle of the gangs.

#### Flex-Tine Harrows

Flex-tine harrows, which can also be used for between-row cultivation consists of a series of flexible tines mounted in overlapping rows vibrate as they drag through soil, ripping out small weeds . As previously mentioned, these tools are most effective when weeds are in the “white-thread” stage (single white roots are visible on weeds when soil is disturbed, often before leaf appearance).

#### Basket Weeders

Basket weeders, also referred to as rolling cages, are cylindrical, made of quarter-inch spring wire, and ground-driven. Basket weeders consist of two rows of metal baskets that roll across the soil surface at different speeds. The first set of baskets loosens the soil and the second pulverizes it, uprooting young weed seedlings. The first row is ground driven, which also drives a chain to power the rotation of the second row.

#### Rotary Cultivators

Rotary cultivators, also known as rotary tillers, have blades anchored on rotors that are bolted directly to a single horizontal power shaft that is 8 to 12 inches (20 to 30 cm) above the soil surface.

#### Brush Weeders

Brush weeders uses flexible brushes made of fiberglass or nylon rotated about vertical or horizontal axes. These weeders mainly uproot, but also bury and break weeds. The soil must not be too hard or too fine.

### Weather and Soil Conditions Suitable for Cultivation

Weather and soil conditions play a very important part in the success of cultivation. Ideally, soil conditions should be dry and warm to desiccate and kill the weeds on the surface. Dry soil will enable the cultivator to be effective at uprooting the weeds without creating clods or “root balls.”

## Controlling Weeds by Mowing (cutting, trimming) (22/4/2020 Wednesday)

Mowing is another option used by organic growers in controlling weeds in orchards and vineyards. It is a relatively fast operation that causes minimal soil disturbance, although soil compaction may become an issue where mowing is frequent. Mowing weeds or cover crops can be used to produce mulch material for weed suppression in the inter-row or intra-row areas. Growers should consider a program of mowing alternate rows, allowing the uncut rows to provide habitat and food sources for beneficial insects in the orchard or vineyard.

### Types of Mowers

There are three basic types of mowers: the sickle-bar, rotary, and the flail. The sickle-bar consists of a cutting bar with attached guards and a knife (sickle) that is driven back and forth in a horizontal direction. Rotary mowers have blades that rotate parallel to the ground, which coarsely chop and cut weeds that are growing on the orchard or vineyard floor. They can be mounted on the front or back of a tractor. Flail mowers have numerous small blades that rotate perpendicular to the soil surface, which cut the weeds into smaller pieces. Flail mowers are often mounted in the rear of the tractor. Mowers are often the preferred method for managing weeds, especially on hillside orchards and vineyards, where growth is very vigorous, and in no-till systems. Flail and rotary mowers with side-delivery chutes can be operated to place the clippings as mulch within tree/vine rows, **helping to move nutrients from the row middles** to the tree/vine row and suppress weed growth.

## Flame Weeding

Many organic farmers have included propane (LP) flame-burners as an additional tool in their weed management toolbox. Heat from the flamer kills the plant by rupturing cell walls, not burning the plant tissue. After flaming, weeds that have been killed change from a shiny to a dull finish. The length of time the flame is applied depends on the age, size, and tenderness of the weed. Flaming is used particularly during times of high field moisture when tillage with large machinery is not feasible. In drier weather, flaming is used in conjunction with cultivation. Flaming is most effective on annual broadleaf plants that have relatively thin (non-succulent) leaves and aboveground or unprotected growing points. In general, younger plants, especially newly emerged seedlings, are more susceptible to flaming than older plants. Flaming is least effective on weeds that can effectively avoid or tolerate high temperatures—for example, those with pubescent (pu ba sent) (young hairy) leaves (common purslane=Kulfa) or those that can initiate new growth after flaming, such as those with below-ground growing points (annual grasses). Weeds that have germinated, but are not yet emerged, will also not be affected by flame weeding. Because flaming does not control grasses or perennials well, rotary hoeing (revolving) or harrowing may be a better option.

### Advantages and Disadvantages of Flame Weeding

Flame weeding is an increasingly attractive weed control method because it provides multiple advantages over chemical and mechanical weed management methods used in both conventional and organic farming operations. Compared with the use of chemical herbicides with conventional crop systems, flame weeding does not leave chemical residues in or on plants, soil, air, or water.

### Timing of Flame Weeding

Timing is probably the most important factor that influences the success of flaming, and it must be timed to balance weed damage with crop damage. In general, it is best to flame weeds when they are newly emerged or still very small in stature and when crops have yet to emerge or are large enough to withstand flaming without significant damage.

### Flame Weeding Treatments

Two basic approaches are used to control weeds with flaming: **(1)** non-selective flame weeding or across crop rows (“cross” flaming) so that flames are in contact with both weed and crop plants, and (2) selective flame weeding (“parallel” and “middle” flaming) and often with the crop protected by a metal shield or a fan of water sprayed between the flame and crop row.

#### Non-Selective Flame Weeding

During non-selective flame weeding treatments (also known as broadcast treatments), everything in the treatment path—weeds and crops—is fully exposed to heat.

#### Selective Flame Weeding

Selective flame weeding treatments (also known as banded flame weeding) are done after the crop has emerged and aims to treat weeds without damaging the crop. This selectivity is usually achieved through torch configuration or by shielding the torches with various hoods. Banded flame weeding only treats widths of about 12 inches (30 cm) in the center of the crop row, in contrast to the treatment of the full row width (e.g., 30 in, 76 cm) with broadcast flame weeding.

### Equipment Used for Flame Weeding

Flame weeders come in a range of configurations. Market-farming equipment options include handheld single-torch flamers, as well as push-wheeled multiple-torch flamers mounted under a flame hood. These small-scale units are easy to operate and very convenient for flaming on farms with many small, sequential plantings of crops.

##  Soil Solarization for Weed Control

Soil solarization is a non-chemical soil treatment that utilizes solar radiation and a thin film of transparent mulch, usually of polyethylene, to heat the soil to a range of 100 to 122 degrees F **(38–50°C)** to a depth of about four to eight inches (10 to 20 cm) for soil pasteurization. In addition to pasteurization, it has been known to also control weeds as a pre-emergent control in terminating weed seeds in the ground before and during germination. The degree of weed suppression achieved with solarization varies with weed species, depth of seed in the soil, and length of solarization. In general, solarization is more effective against annual weed species and less effective against perennial weeds. Perennial weeds are more difficult to control than annual weeds because their underground vegetative structures—rhizomes, tubers, or bulbs—allow them to survive most non-chemical controls, including cutting, cultivation, and mowing. The drawbacks of solarization include the use of plastics in agriculture and their associated disposal problems (though sheets may be re-used if they are not used as in-season mulch), and the fact that land is taken out of production during the summer.

### Mechanism of Soil Solarization

Soil solarization is conduction of heat by entrapment of solar irradiation through the greenhouse effect. Very thin (25 to 50 µm) transparent polyethylene (PE) mulch is commonly used to trap solar heat because it is permeable to the short-wavelength solar radiation, but does not transmit longer-wavelength radiation (heat) from the ground back into the atmosphere.  Although the thin PE mulches are less durable and are susceptible to wind and animal damage, it is more effective in raising the soil temperature and controlling weeds than the thicker PE mulches of 50 to 100 µm. The second mechanism of soil solarization is through a solar heating process by soil moisture.

### Time of Soil Solarization

Generally, soil solarization is conducted for a minimum of four to six weeks during the warmer time of year, when there is high solar irradiation and minimal cloud and precipitation, thus its effect is climate dependent. It has been attempted in the spring and fall, but may not be as reliable then because temperatures are cooler. In addition, depending on soil texture, solarization heat penetrates to different soil depths.

### Methods of Soil Solarization

#### Broadcast Solarization

Broadcast solarization and strip solarization are the two main methods of soil solarization. Broadcast solarization consists of completely covering a whole field with PE.

#### Strip Solarization

Strip solarization is simply applying the sheets of PE without attaching them together.

### Solarization Practices for Controlling Weeds

To use solarization successfully, organic farmers should rely on these practices:

## Bio rational Control of Weeds

A biorational pesticide is a term used to define any pesticide material that relatively causes no harm to humans or animals and does no damage to the environment. An increasing number of herbicides are permitted for use in organic agriculture. These materials are based on naturally occurring compounds such as plant oils, corn gluten meal, fatty acids, acetic acid, and biological materials. Most products are categorized as plant oil extracts and act as a nonselective contact on weeds. High spray volumes must be used to ensure adequate coverage of the target weeds. These products are not recommended as a sole management tactic and are best utilized as a supplement to an established organic integrated weed control strategy. They generally provide no systemic control, which can lead to inconsistent activity and poor control of perennial weeds. In addition, repeat applications may be needed to get adequate and consistent control of late weed flushes and suppress perennials. If needed, repeat applications should be done shortly after the initial application so weeds not completely killed are not allowed to recover. Certain plant families, such as grasses, and leaf characteristics, such as a **waxy surface**, are usually more tolerant of natural products.

### NOP Requirements for Using Herbicide Products

Natural products may be used if the requirements of **National Organic Program (NOP)** are met. The rule states that if preventive, mechanical, physical, or other weed management practices do not provide adequate control certain substances can be used as long as they are documented and approved in an organic system plan. In order to legally use any biorational for weed control, the product must be labeled as an herbicide or qualify for exemption under the Federal Insecticide, Fungicide, and Rodenticide Act. Adjuvants, including surfactants and wetting agents, may be needed to improve herbicide activity.

### Types of Biorationals Used for Weed Control

Several OMRI-certified contact herbicides are available. The active ingredients of these herbicides include citric acid, garlic, thyme and clove oils, and acetic acid (vinegar). Many different brands of natural product herbicides are marketed for use in organic production systems for weed control. Manufacturers of natural product herbicides frequently modify their product formulations, and market availability and active ingredient concentrations will differ over time.

#### Acetic Acid (Vinegar)

Acetic acid is an ingredient found in several products that is on the Organic Materials Review Institute approved list as a non-synthetic pesticide. Acetic acid, commonly known as vinegar, but also known as ethanoic acid, affects the cell membranes of a plant, causing rapid breakdown/desiccation of foliage tissue on contact. Herbicidal vinegar is stronger than household vinegar: the acetic acid concentration for herbicidal use is 10 to 20 percent, compared to five percent acetic acid for household use.

#### Corn Gluten Meal

Corn gluten meal (CGM) is a granular product that must be applied prior to weed germination to provide control of germinating seedlings. CGM is a by-product of corn milling that has been sold as an organic fertilizer and animal feed. As a non-selective pre-emergence herbicide CGM inhibits root development, decreases shoot length, and reduce plant survival of weed and crop seedlings.

#### Cinnamon(Dar Cheni) Oil

Essential oils include substances that collect in plant cells and have been found to have herbicidal characteristic.

#### Citrus Oils and Extracts

Citrus oil extracted from citrus fruit rinds, provides broad-spectrum control of various grass and broadleaf weeds.

#### Clove (Long) Oil

Clove oil is the active ingredient in a number of organically approved post-emergent non-selective herbicides. Clove oil is believed to kill plants by decreasing cell membrane integrity. Weeds found to be tolerant to clove oil applications are thought to have increased **leaf waxes** that may hinder activity. Clove oil is most effective when weeds are green and actively growing.

#### Lemongrass Oil

Essential oils from lemongrass have been used in products including perfumes, cosmetics, and soaps.