



Weed Management

F O R O R G A N I C F A R M E R S

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Organic Farming Requires Weed Management

Organic farmers use a wide variety of tools and strategies to control weeds without synthetic chemicals. Successful organic farmers continually adapt their weed management practices as weed populations shift. Producers should have a good understanding of the philosophies and legalities of organic farming before they plan their weed management strategies. A brief overview of organic agriculture follows; for further details, see Iowa State University Extension publication *Organic Agriculture* (PM 1880). (See page 8 for ordering instructions.)

Mechanical tillage is an important component of organic weed management.



K. DELATE

Weed Management

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Why Organic?

Environmental, economic, and food safety concerns are among the many reasons why some farmers choose organic production. For example, certified organic soybeans in Iowa averaged a 200–300 percent premium price over conventional soybeans. On the environmental front, organic farmers hope to reduce the 240 million pounds of herbicides applied each year in the Midwest. Organic farmers also express concerns about weed resistance to herbicides and the transfer of herbicide-resistant genes to wild plants that may occur with increasing reliance on herbicide-resistant crops.

According to the federal Organic Farming Production Act (OFPA) of 1990, and the USDA National Organic Program (NOP), anyone selling products as “organic” must follow a set of prescribed practices that includes avoiding synthetic chemicals in crop and livestock production and in the manufacturing of processed products. Organic certification agencies, serving as the required third party certification, include private agencies, such as the Organic Crop Improvement Association (OCIA), and public programs, such as the State of Iowa Department of Agriculture and Land Stewardship (IDALS) organic certification program. For more information, see *Organic Agriculture* (PM 1880).

Natural mulches can regulate the soil temperatures and moisture, improve soil quality, and suppress weeds in organic crops.

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Weed Productivity and Ecology

A weed is simply a plant that takes advantage of unused resources made available by cropping practices. Nutrient availability is usually high at the beginning of the season and decreases during the season. Water availability depends on the weather pattern of the particular year, but it is typically higher in the beginning and lower at the end of the season. Light under the crop canopy that is available for weeds is high at beginning, low in the middle, and generally high again at the end of the season when crop leaves are senescing. Knowing the ecology (germination and growth period) of the weeds on your farm is key to organic weed management.



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Ecological Weed Management

Most organic farmers rely on multiple tactics for their weed management. Ecological weed management promotes weed suppression, rather than weed elimination, by enhancing crop competition and phytotoxic effects on weeds. Specific methods include the following:

Crop Rotations

Crop rotations are the foundation of organic farming. Organic certification requires that a small grain and/or legume be planted after row crops to maintain soil health and biologically based pest management. As an example, if the legume is plowed under as a cover crop in the fifth year, four years of row crops could be grown prior to the green manure crop year. The same crop cannot be grown in sequential years; thus, soybeans cannot be grown in the same field year after year. The ideal crop preceding soybeans is winter rye. Soybean fields are rotated to a small grain (oats, barley, wheat, or rye) or corn.

A typical crop rotation in Iowa is corn followed by a winter cover of rye, soybeans, and oats with an underseeding of alfalfa or red clover in the third year. Rye, with its allelopathic properties, will help prevent weed establishment. In the spring, rye that is less than 8" in height can be killed with a field cultivator. Taller rye plants should be mowed or cut with a stalk chopper before cultivating. A second cultivation or disking may be necessary to turn

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under any remaining rye plant residues to avoid competition with the germinating crop.

There is a strong correlation between biomass, tillering (multiple stems), and weed competitiveness. Barley, for example, has a more extensive tillering system and is more competitive with weeds than wheat. Because small grains also are planted in narrower rows, these crops are more competitive with weeds than corn or soybeans. Many organic farmers opt to fallow a field to a rye for an entire season if weeds have presented a persistent problem in the past.

Maintaining soil fertility through crop rotations, cover crops, intercrops, and biologically-based fertilizers will enhance the competitiveness of the crop plant and inhibit weed growth. Reports indicate that humic and fulvic acids in compost may mitigate weed seed germination. Small-seeded weeds also may be more susceptible to pathogens associated with high organic matter in compost. Compost placed close to the crop plant reduces the amount of nutrients available to weeds between crop rows. Mulch also is effective in suppressing weed establishment.



Organic crops are required to be grown in rotations, as demonstrated by the corn-soybean-oat-alfalfa rotation, shown at the ISU Neely-Kinyon Farm.

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Production Practices

- **Cultivar or variety selection.** Organic farmers select crop varieties that compete well with weeds. Quick canopy-forming varieties assist the crop competitiveness over weeds within and between rows.
- **Crop density.** Planting at the maximum adapted population will provide the crop an increased competitive edge over weeds.
- **Row spacing.** Closer row spacing generally leads to greater crop competition with weeds in row middles. Some organic farmers have drilled soybeans with rye and obtained excellent weed control but lower yields.
- **Seed grade.** High germination rates are critical for a rapid canopy.
- **Sowing date.** To provide a competitive advantage, warm season crops (e.g., corn, soybeans, and dry beans) are planted when the soil is adequately warmed (usually later than May 10) to facilitate rapid germination. Warmer soils allow quicker emergence and a more competitive crop without major losses in yield.

Physical Tactics for Organic Weed Management

Physical controls are a key factor for weed management on all organic farms. Physical methods of control include cultivation, propane flame burning, and mulching.

Mechanical Cultivation

Depending on the crop, cultivation offers the least labor-intensive weed control method. Although more than 95 percent of Iowa's row crop acres are treated with herbicides, cultivation remains a viable weed management strategy, in conjunction with other controls. Timely cultivation is critical in organic weed management. While no prescription is available for managing weeds in an organic system, certain practices have been used successfully by the majority of Iowa's organic farmers. Each farmer



must develop his/her own management plan based on specific farm/field conditions. A harrow or field cultivator with a drag- or spring-tooth harrow attachment can be used in the spring to kill weeds before planting. Cultivation then is timed with the pulses of weed seed germination and growth. The initial

cultivation occurs when the weeds are at the most vulnerable stage. Fields are rotary hoed at a slow speed (5 mph) three to five days after planting to kill weeds in their initial development or white-thread stage. A harrow also can be used at this stage. One week later, after plants have emerged, fields are hoed again but at a slightly faster speed (7–9 mph). To avoid killing soybean seedlings, it is critical that soybeans are not hoed in the crook stage when the soybean hypocotyl is just at the soil surface. Soybeans also should not be hoed when plants are greater than 8" in height. For vegetable cropping systems, various in-row weeding tool sets, including finger weeders, basket weeders, Bezzeries[®] torsion weeders, Spydres[®], Weed Badgers[®], and brush weeders, can be used alone or in combination on a multiple component weeding frame (See *Steel in the Field* (EDC 125), produced by the USDA



Row cultivators are used two to three times to control weeds between rows.



Sustainable Agriculture and Research Education [SARE] Sustainable Agriculture Network [SAN]. (See page 8 for ordering information.)

Two to three row cultivations are typical for Midwestern organic farmers. The first cultivation occurs at a slow speed as soon as rotary hoeing ends. The second cultivation usually is completed at mid-season at a faster speed to throw about 1" of soil around the base of plants. The third cultivation is again performed at a slow speed (5 mph). Various attachments, such as guidance systems, and plant protection devices, such as shields, can be added to cultivators (see *Steel in the Field*).

The number of acres covered when cultivating will depend on the size of the cultivator and the speed of cultivation. A 6-row cultivator, at speeds of 6–7 mph, can cover 100 acres in 11 hours. Cultivators with open-top shields and low-profile single sweeps throw less than 1" of soil into the row at this speed. Higher speeds may throw excess soil onto the plant row and damage small crops. Disk hillers can be used to pull soil away from the plant



when plants are small and turned outward on later passes to throw soil around the base of the plant when they are taller.

The Long-Term Agroecological Research (LTAR) projects funded by Iowa State University's Leopold Center for Sustainable Agriculture have compared weed populations and management costs in organic and conventional grain crops (Delate et al., 1999). In general, soybeans with a quicker closing canopy had less weed pressure than organic corn. Soybean yields were the same as conventional soybeans. Once the fields were in their third year of rotation, corn weed pressure was diminished. Despite lower corn yields in one year, organic corn provided a greater return overall than conventional corn due to organic premium prices. The results are summarized in Table 1.

Another study in Chariton, Iowa, compared weed populations and yields in organic systems under different primary tillage methods (Table 2). Treatments included fall moldboard plowing, fall Kverneland® plowing, spring moldboard plowing,

Table 1
Costs and Effectiveness of Weed Control Measures in Organic vs. Conventional Systems

System	Weed Populations	Management Costs	Yields	Returns
Organic soybeans: Southwest Iowa	Statistically the same as conventional	Less than conventional (\$103/acre)	Statistically the same as conventional (48 bu/acre)	368% greater than conventional
Organic corn: Southwest Iowa	Statistically equal to conventional in 2 out of 3 years	Similar to conventional (\$172/acre)	Statistically similar in 2 out of 3 years (average: 130 bu/acre)	228% greater than conventional

Table 2
Effect of Tillage on Weed Management and Yields

System	Weed Populations	Yields
Organic soybeans: Southeast Iowa	Statistically greater grasses in Rotavator® in Year 1; no statistical differences in Year 2	No statistical differences in Year 1; spring-plowed greater in Year 2 (59 bu/acre)
Organic corn: Southeast Iowa	Statistically greater broadleaves in spring-plowed; statistically greater grasses in Rotavator®	Spring-plowed greater (227 bu/acre), but no statistical differences between spring and fall moldboard plowed

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and fall and spring Rotavator® plowing. Kverneland® plows are reported to disturb less of the soil profile and are very effective on CRP land. Rotavators® are equally effective on CRP land and provide a more friable seed bed. Results of this two-year study (soybeans—two years and corn—one year only) showed greater yields in spring-plowed fields overall. Weed populations were greater in the Rotavator® treatment over two seasons and three weed-scouting periods.

Propane Flame Burning

Many organic farmers have included propane (LP) flame-burners as an additional tool in their weed management toolbox. 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. Flame weeding of corn can be accomplished when corn is less than 2" in height and when corn is 8" to 1.5' in height. Other growth stages are considered potentially damaging to the corn meristem (growing point).

According to several Iowa farmers, soybeans can be flamed prior to emergence and at the 1' to 1.5' height stage. Caution must be used in flaming soybeans, however. Mixed results have been reported, including damaged soybeans and decreased yields. Because the growing terminal of corn is more protected within the whorl, corn can withstand greater damage from flaming, compared to soybeans with their exposed growing points. Several flame burners are commercially available, including complete units and individual burner kits that can be attached to tractor tool bars. Flamers

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Propane flame burners can be used on organic farms to control weeds between and within rows.

are usually run at 38–40 psi with a tractor speed of 4 mph, but specific rates will be based on the crop stage, weed species present, and the manufacturer's recommendations.

Mulching

Many organic horticultural operations rely on manual labor and a combination of mulching/cultivation for adequate weed control. Natural mulches and synthetic mulches, including polyethylene film and polypropylene landscape fabric, are used in organic operations. Synthetic mulches have proven their durability in numerous vegetable production systems. According to certified organic regulations in Iowa, however (IDALS, 2000), synthetic mulches must remain intact during the growing season and must be removed from the field at the end of the season. Despite the labor-saving aspect of synthetic mulches, most organic growers in Iowa prefer natural mulches for weed control. Natural mulches are used to regulate surface soil temperatures and moisture, improve soil quality, and suppress weed activity. Organic mulches add organic matter to the soil during decomposition, thus increasing nutrients, soil porosity, water holding capacity, microbial populations, and cation exchange capacity. Straw mulch is commonly used in organic horticultural operations, such as garlic, strawberry, and herb farms, to control weeds and protect against harsh environments.



Mulch can be made from small grain, soybean straw, or baled corn stalks. A Bale Chopper®, pulled by a tractor along a raised vegetable bed, can be used to shred small square straw bales for rapid mulch application. Other methods of straw mulch application include hand-rolling round hay bales across vegetable beds before planting. Wood chips, shredded newspaper, and other plant-based residues can be used as mulches, typically in tree crops.

Caution must be taken to select materials free of synthetic substances, such as preservatives in wood or synthetic dyes in paper products. Your organic certification could be jeopardized if synthetic chemicals are introduced through mulch materials. Mulch made from materials grown on organic farms prevents any possibility of pesticide residues from conventionally grown materials. Wood chips should not be applied to a rapidly growing crop, such as an annual plant, to avoid competition with the crop's nitrogen source as the wood chips degrade.

Other mulches include living and mowed residues of cover crops (SAN, 1998). Under cover crop residue mulches, weed emergence is decreased by reductions in both light transmittance and daily soil temperatures. Hairy vetch (*Vicia villosa* Roth) and rye (*Secale cereale* L.) residue mulches are used in many organic operations. Mulches should be maintained at a depth of 6 inches to prevent stimulation of weed growth. Results with living mulches have ranged from unwanted competition with the crop and delaying fruit set, to having no effect on yields. Much of the effectiveness of living mulches depends on the availability of field moisture for both crop and mulch.

Many horticultural crops, such as medicinal and culinary herbs, produce greater yields when mulched, rather than cultivated for weed management. Two natural fiber mulches that are currently in the research stage for organic horticultural crop production are a flax straw mat and a wool mat. These mulches may prove effective for organic operations, provided the mats are approved for the certified organic label.

Effects on Soil Quality

Organic farmers are concerned about the effect of multiple tillage passes on soil quality, including erosion. In our studies to date, no differences in soil quality (physical and chemical properties) were observed among the different tillage treatments. In research at the Neely-Kinyon Farm in Southwest Iowa, after one growing season under organic management, microbial biomass carbon was 228 percent greater in the organic system, maggroaggregate stability was 15 percent greater, organic carbon was 6 percent greater, particulate organic matter carbon was 8 percent greater, and N mineralization potential was 7 percent greater. Nitrate-N was 44 percent greater in the conventional system, as reflected in the excess corn stalk nitrate detected in the first year. Potential effects on soil quality will continue to be monitored, but practices employed by organic farmers, such as adding organic matter through crop rotations, cover crops, green manures, manure and compost applications, and other biological fertilizers, will help mitigate the erosive effects of tillage.

Conclusion

Integrated weed management on organic farms requires extensive planning and management. Crop rotations are the basis for successful organic farming and are necessary for breaking weed, insect, and disease cycles. Cultivation must be completed with properly set equipment under soil conditions that are not conducive to compaction. Monitoring weed growth stages also is critical in determining ideal cultivation times. Trial and error will govern many decisions in the first years of organic farming. Learning from other organic farmers and following advice from Iowa State University may help in the transition.

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References

- Bowman, G. (ed.). 1997. *Steel in the Field—A farmer's guide to weed management tools*. Sustainable Agriculture Network, USDA, National Agriculture Library, Beltsville, MD.
- Delate, K., and C. Cambardella, 2000. *Integrating organic soybeans following CRP land*. USDA-SARE Annual Report, N.C. SARE, University of Nebraska, Lincoln, NE.
- Delate, K., C. Cambardella, K. Taylor, and B. Burcham. 1999. *Comparison of organic and conventional rotations at the Neely-Kinyon Long-Term Agroecological Research (LTAR) site: First year results*. Leopold Center for Sustainable Agriculture Annual Report, Iowa State University, Ames, IA.
- IDALS (Iowa Department of Agriculture and Land Stewardship). 2000. *Iowa Organic Certification and Organic Standards*. Des Moines, IA.
- Rynk, R. 1992. *On-Farm Composting Handbook*. NRAES-54. Northeast Regional Agricultural Engineering Service. Ithaca, NY.
- Sustainable Agriculture Network (SAN). 1998. *Managing cover crops profitably*. 2nd Edition. Sustainable Agriculture Network, USDA National Agriculture Library, Beltsville, MD.

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