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Weed Management in Organic Small Grains

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This publication introduces the multifaceted, comprehensive strategy of weed management used for organic small grain production, combining techniques including crop rotation, sanitation, cultural practices, variety and seed selection and planting, cover crops, tillage, use of organic herbicides, and others.

Contents

Rolling pea to provide armor. Photo: Jay Fuhrer, courtesy of NRCS

Introduction

Weed management is one of the biggest concerns in organic small grain production. Often, when a conventional grower considers organic farming, the difficulty of weed control is the first objection. Clean, weed-free fields are a source of pride for most farmers, and it can be difficult to imagine clean fields without the use of herbicides.

I personally was skeptical until my first on-the-ground encounter with organic farming. In 1996, I was invited to tour three organic small grain farms in Big Sandy, Montana. I was expecting to see fields covered in weeds, with poor, spotty stands of grain. Instead, I saw clean fields, healthy crops, and a crop diversity beyond the typical wheat and fallow system. The farmers were growing specialty wheats, sunflowers, buckwheat, alfalfa, lentils, and more. Compared to their neighbors' conventional monocultures, their diversity was impressive.

These farmers were not "organic by neglect." In other words, they didn't keep on farming like their conventional neighbors but neglect to spray herbicides and apply fertilizer. Instead, they learned the biological principles of pest control and put them into practice. This takes more effort and experimentation than using herbicides, but the important message is that clean fields are possible in an organic system.

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www.attra.ncat.org

Organic Small Grain Production Overview

Farmer Profiles: Two Organic Grain Farm Case Studies

Disease and Insect Management in Organic Small Grains

Nutrient Management in Organic Small Grains

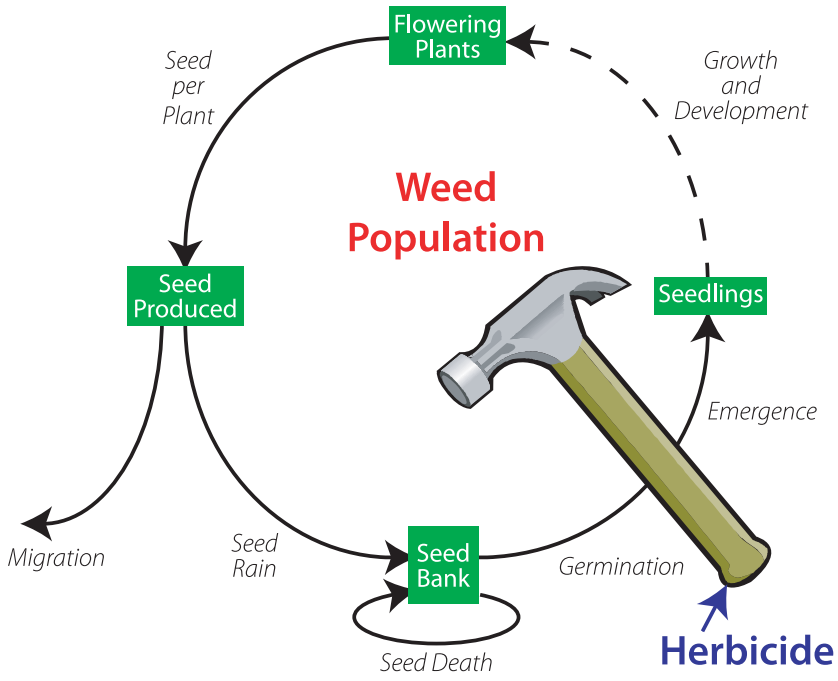
Principles, Not Prescriptions

Organic weed management is based on biological principles and is not simply a prescription or substitution of an organic input for a conventional input. Biology is very complex and, therefore, unpredictable. It requires constant observations and adaptive management.

Manipulating the biology of the system requires a keen eye for how the crop and its associated weed community are developing, and it requires responsive management decisions. In some cases, the weeds may actually be beneficial, and their impact on yield should be balanced with their potential benefit to the soil microbial ecology, contribution to pollination of crops and other desirable species, and their potential for providing habitat for beneficial and mutualistic species.

The first step should be to assess whether the weeds are truly having a significant impact on yield or crop quality. In many organic systems that have been in place for 5 to 10 years, weed communities are more diverse than in conventional systems, and the weed impact per crop plant is less than in conventional, herbicide-managed systems. It is not clear why this is the case, but it has been shown in experiments and verified by organic farmers (Maxwell, 2010).

Figure 1. The Big Hammer



Courtesy of Bruce Maxwell, PhD, MSU

Many Little Hammers

Conventional crop production manages weeds with the "big hammer" of herbicides. This big hammer controls weeds at one point in their life cycle: emergence. See *Figure 1: The Big Hammer.*

In an organic system the manager must rely instead on "many little hammers" throughout the life cycle of the weeds (Liebman and Gallandt, 1997). See *Figure 2: Many Little Hammers,* opposite page.

In order to manage weeds most effectively, many techniques must work together in a comprehensive strategy. These techniques can include crop rotation, sanitation, variety selection, row spacing, seeding density, using larger seed sizes, timing of emergence, timing of control, cover crops, tillage, grazing, and others.

Organic Weed Control Hierarchy

The National Organic Program (§ 205.206) requires that weed control practices follow a hierarchical approach (National Organic Program, 2010). The regulation states that weed control should start with crop rotation, sanitation, and cultural practices. These techniques are the basis of any good pest-management strategy. Without them, mechanical strategies will not be as effective.

Next in the hierarchy are mechanical techniques such as mowing, tilling, and flaming. These strategies are used whenever and wherever the grower feels they are necessary.

Finally, a grower can use biological or allowed synthetic substances for weed control. See the *ATTRA Biorationals Database* at *www.attra.ncat.org/attra-pub/biorationals* to find specific weed control products for organic production, listed by the Organic Materials Review Institute (OMRI). Check with your certifier before applying products. Although some allowed substances, such as vinegar, have shown some ability to kill weeds, these are not commonly used in organic small grain production, and producers should place their emphasis on the techniques of crop rotation, cultural practices, and mechanical control instead. Simply substituting an approved

pesticide for one not allowed is not consistent with the fundamental principle of organic production: farming with nature, not against it.

Figure 3. Organic Weed Control Hierarchy

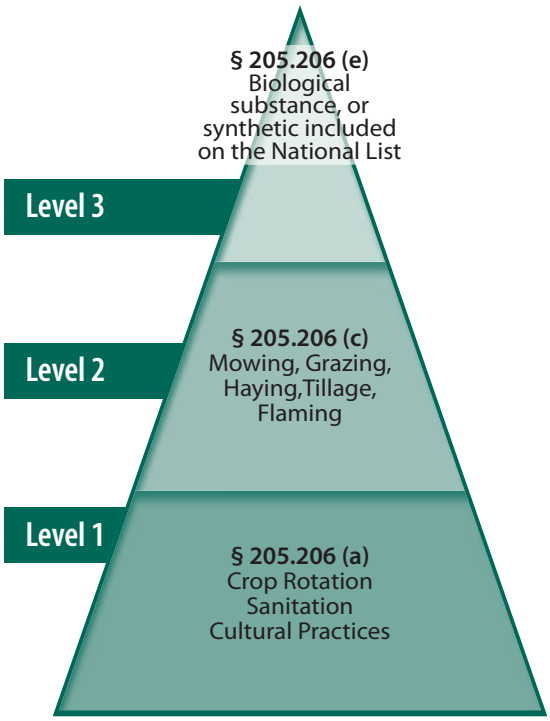
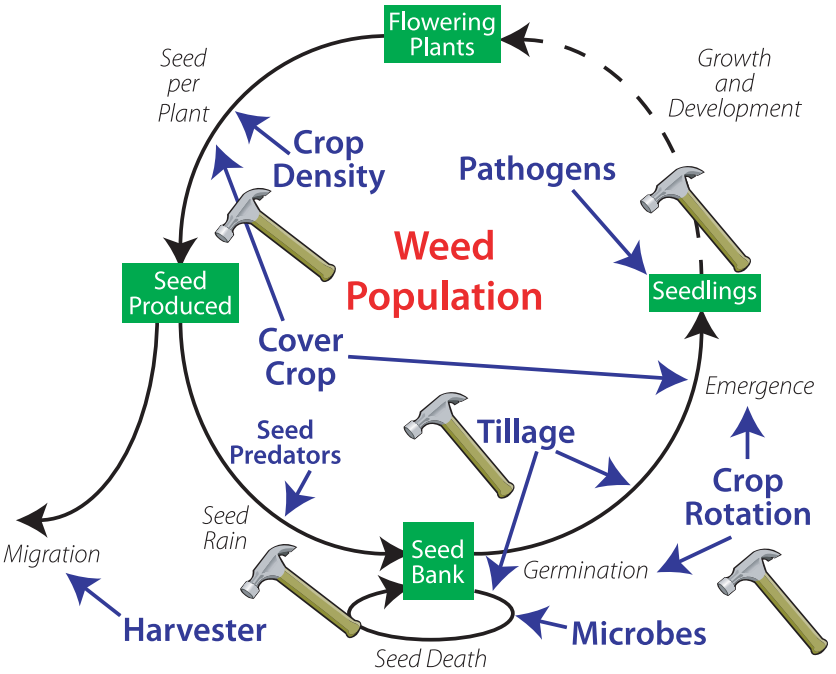


Figure 2. Many Little Hammers



Courtesy of Bruce Maxwell, PhD, MSU

Crop Rotation

Rotating between spring-planted and fall-planted grains helps to break weed cycles by changing the timing of the tillage window from one season to the next. In a small grain system, tillage timing is important for weed kill. Unlike corn or other row crops, small grains cannot be tilled during the growing season. The only opportunities for cultivation, therefore, are prior to planting and after harvest. Consequently, controlling weeds before they become a problem is critical.

Although fall-planted grains usually provide greater yields than spring-planted grains, the spring grains allow for an extra tillage pass or two before seeding. The following photo illustrates the weed control capability of an extra spring tillage pass. This field of spring peas had an extra tillage pass around the edge before seeding. The tansy mustard is growing in the area that did not receive the extra tillage.

Evaluating Tradeoffs

While this extra tillage pass did eliminate the tansy mustard in this field, it may not have been necessary. These peas were terminated through tillage about week after this photo was taken. Because of this, the mustard did not get the chance to go to seed. While the field may look better without the mustard, this particular weed does not threaten the field. In this case, the extra

Spring peas with Tansy. Photo: Susan Tallman, NCAT

spring tillage may have only served to promote soil moisture loss and soil erosion. *A farmer must carefully evaluate whether weed control is actually worth the cost, or whether letting some weeds grow is preferable.*

Weed Inventory

Prior to organic transition, take a weed inventory of your fields. Which weed species are currently a problem? Are they annuals or perennials, grasses or broadleaves?

Remember that weeds like to mimic their host crop. For example, a major weed in winter wheat is downy brome, or "cheat grass." Cheat grass is a winter annual, just like winter wheat. The key to limiting cheat grass in a field is to switch to spring-planted crops or broadleaf crops so that spring seedbed preparation kills the weed seedlings. Switching to a different crop allows for a modified tillage window and gives the mimic weed no place to hide. A farmer can limit weed and disease pressure by rotating through a diverse range of crops.

Switching to a different crop allows for a modified tillage window and gives the mimic weed no place to hide.

When taking an inventory of fields, take special note of any persistent perennial species. During the transition to organic, the dominant weed species may change, and perennial weeds may become more predominant (Renz, 2009). For this reason, it is important to identify perennial weeds in the first two to three weeks of growth, when they are easier to control. In this early stage, prior to establishment, perennial weeds are easier to kill by tillage, flaming, or grazing.

In the Northern Great Plains, Canada thistle and field bindweed are of special concern. *Take particular care to control these weeds before beginning an organic crop system.* Producers have had some success controlling Canada thistle by rotating to alfalfa and haying it. Not only does the alfalfa compete with the thistle for water and nutrients, but the haying knocks back the thistle's growth. Farmers who have had the most success with this technique say that leaving the alfalfa in for several years is more effective than having the field in alfalfa for a single year.

Repeated tillage of Canada thistle can help to control this weed as well. Restrict tillage only to the infested patch—not the entire field. Till seedlings several times as they emerge throughout the growing season. The key to managing this weed is to deplete the root reserves enough to limit the plant's growth and spread.

There are fewer options for organic field bindweed control, and this weed can become almost impossible to control once it gets out of hand. As an extreme example, one organic farmer in Montana left organic production for a conventional no-till system after bindweed overran his fields. However, one method that has shown some promise is grazing field bindweed with sheep. The weed should be grazed several times during the growing season to deplete the root reserves. Flaming might be another strategy with some promise. Use a hand-held flaming unit over the patch after each flush of growth during the growing season.

Tillage of field bindweed can be somewhat effective, but care must be taken, as tillage may make the infestation worse. Tillage breaks the weed into small, spreading stems that are then transported to other areas of the field where they can take root and grow. If using tillage to control bindweed, limit the tillage to the patch with the infestation. Till throughout the growing season with each flush of new growth. Take care to clean off equipment after use, so as not to spread bindweed to other fields.

Further Resources

See the ATTRA publication *Field Bindweed Control Alternatives* at https://attra.ncat.org/attra-pub/summaries/summary.php?pub=141

Types of Weed Problems

All weeds are not created equal. Some weeds in grain fields may not be particularly harmful and may actually block other more problematic weeds.

Dr. Perry Miller at Montana State University recently had a significant amount of pennycress in one of his organic wheat plots, with about 250 pennycress plants per square meter. While this sounds like a lot, the weeds were quite small and formed a solid understory in the wheat canopy. He theorizes that this pennycress prevented more competitive broadleaf weeds, such as prickly lettuce, from establishing. He and others have concluded that if you

must have weeds present, pennycress is a good one to have because its rapid growth cycle may prevent establishment of other weed seedlings. In addition, it stops using water and nutrients very early in the season, making it less competitive with the cash crop than other weed species (Miller, 2009).

Sanitation

Sanitation is an often-overlooked part of weed management, but it is one of the foundational principles of organic weed management. Make sure your farm machinery is not spreading weed seeds or rhizomes across your farm. Clean your toolbar when moving from one field to the next.

Also, make sure you avoid mature weed patches with your combine at harvest. The straw spreaders only serve to disperse weed seeds across a wider area. When possible, leave these patches alone and drive around them (Wichman, 2007). Alternatively, Canadian researchers found that it was worthwhile to pull a wagon behind the combine to collect weed seeds and reduce return to the field (Maxwell, 2010). Green weed patches with no mature seed can be combined effectively as long as there is no risk of clogging the threshing mechanism.

The Weed Seedbank

Never let weeds go to seed. This is especially important in an organic system. Some weeds can produce up to 200,000 seeds per plant, and these seeds can lie dormant in the soil for decades (Davis et al., 2005). This creates a weed seedbank, with weed seeds ready to germinate given the right conditions.

To avoid adding to the weed seedbank, it may be best to disc in the weedy patches of the field before they go to seed. Although this will sacrifice a portion of the cash crop, it may help avoid a large weed infestation in years to come.

Understand the growth habits of your dominant weed species to know when they germinate. If you can control weeds right after they first germinate, you greatly reduce the chance that they will produce mature seed.

Cultural Practices

Variety Selection

Variety selection is an important cultural practice for weed management. Certain varieties compete with weeds better than others. The key in selecting a good variety is early emergence and canopy closure. Organic grain farmers should choose a variety that will close the canopy as quickly as possible to minimize the critical early period of weed seedling growth.

Variety selection helps with weed control. Photo: courtesy of Dr. Fabian Menalled

Dr. Heather Mason at the Northwest Montana Experiment Station in Kalispell has done research regarding organic wheat variety selection. In her work in Canada, she found that medium-height varieties were better for organic production than semi-dwarf varieties. These medium-height varieties were better at competing with the weeds and establishing a canopy cover (Mason et al., 2007).

When selecting a variety, remember that cultivars vary in their competitive ability. Competitive traits include height, early season growth, tillering capacity, leaf area, and ability to withstand repeated harrowing (Mason and Spaner, 2006).

Researchers at North Dakota State University also have studied the best varieties of grains for organic production. In 2002, they conducted field trials on 13 varieties of spring wheat, 10 varieties of oats, and five varieties of barley to see whether any varieties were more suited to organic farming than others.

These researchers compared older varieties of grain, released prior to 1970, with modern varieties and found that in contrast to what some may think, "grain yield and quality may be maximized when modern rather than older commercial cultivars are grown in organic environments. The value of using high-quality seed lots for superior small-grain crop performance

also was reinforced in this project" (Carr, 2003). In other words, when selecting a grain variety, older is not necessarily better. Look at the whole range of traits, including yield potential, leaf area, and tillering ability. Purchasing seed of reputable quality, such as Certified Seed, is also important to ensure minimal weed-seed infestation and vigorous seedling growth.

Variety Trials

There are several state agricultural experiment stations that are now providing organic grain variety trials as well as conventional variety trials. North Dakota State University is doing organic variety trials at their Carrington research station. They have found that in general, varieties that perform well in conventional systems also perform well in organic systems. You can find these reports online at www.ag.ndsu.nodak.edu/carringt/agronomy_program.htm (Zwinger, 2009).

Closer row spacings are another cultural practice organic grain growers use to out-compete the weeds.

Rather than just comparing existing conventional varieties, some breeders are beginning to breed grains under organic conditions. Researchers at Washington State University have hypothesized that varieties bred in organic conditions will perform better on organic farms and are beginning a breeding program to test this theory.

Likewise, the University of Nebraska is doing some wheat breeding specifically for organic production. They are starting at the F6 generation and selecting under organic conditions from that point on. You can link to this program at http://organic.unl.edu/. Organic wheat variety recommendations for Nebraska can be found at http://organic.unl.edu/wheat/wheat.shtml.

Seeding Density

Another strategy for more rapid canopy closure is to plant at a higher seeding density than in a conventional system. This may require some trial and error to determine the optimum seeding rate for your location. However, one rule of thumb is to increase the seeding rate by 20 to 30% and, if there is good soil moisture, increase the rate by 50 to 60% (Maxwell, 2010).

For example, in Montana, a typical conventional wheat seeding rate is about 60 pounds per acre. In contrast, organic wheat farmers should plant about 80 pounds per acre.

Conventional crop system research at the Northwestern Montana Experiment Station in Kalispell has shown that increasing seeding density, along with using larger seeds, helps spring wheat compete with wild oats.

> Averaged across all other factors, the use of higher seeding rates and larger seed sizes improved yields by 12% and 18%, respectively. Accordingly, grain yield was more highly correlated with seed size than with seeding rate effects. However, the combined use of both tactics resulted in a more competitive cropping system, improving grain yields by 30% (Stougaard and Xue, 2004).

Likewise, *The Organic Field Crop Handbook,* published by the Canadian Organic Growers, states that "oats are normally seeded at 1.5 to 2 bushels per acre, but in weedy fields are planted at 2 to 3 bushels per acre" (2001).

Calculating Seeding Rate with 1,000-Kernel Weight and Plant Population Density

Since kernel size is variable, the number of seeds can vary from one bushel to the next. Rather than calculate seeding rate based on bushels, the best way to calculate an optimum seeding rate is to weigh 1,000 kernels of the seed and calculate the desired plant population from there. Alberta has developed a good website calculator available at www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex81?opendocument .

Notice that you will have to provide the desired plant population density to make this formula work. Your local Extension agent or land grant university should be able to provide the average plant population densities for your region.

Row Spacing

Closer row spacings are another cultural practice organic grain growers use to out-compete the weeds. The principle here is the same "little hammer" that is used in variety selection: rows are placed closer together to close the canopy faster and limit sunlight for any weed seedlings. In the Northern Plains, organic farmers typically plant in 7.5-inch spacings to limit weed seedling growth. This exact spacing distance may vary in different regions of the country. ***This is a very important tactic for small grain***

production and should be the main cultural practice employed to manage weeds (Maxwell and O'Donovan, 2007).

Seed Size

Seed size can make a difference in the ability of a crop to establish an early, vigorous stand, with seedlings from larger seeds out-competing weeds better than seedlings from smaller seeds. Research conducted in northwest Montana found that larger seeds, along with increased seeding rates, help to control wild oats.

> The combined effect of large seed plus increased seeding rate reduced wild oat biomass and seed production 45%. Results demonstrate that the use of large seed size and increased seeding rates can improve wheat competitiveness and provide an effective means to reduce wild oat biomass and seed production (Stougaard and Xue, 2002).

So why do larger seeds have more vigorous early growth? Larger seeds have more carbohydrates in storage, which give the young seedling more food reserves. This helps give the young plants an early competitive advantage over weed seedlings (Stougaard, 2009). Select seed with the highest test weight possible, since higher test weight usually correlates with large, plump kernels.

Cover Crops

Cover crops are often used for weed control. A cover crop that exhibits vigorous growth can smother weed seedlings and effectively compete for sunlight and nutrients.

However, care must be taken when using cover crops in a small grains system because they can fail to control weeds if not managed properly. Establishment of a quick, dense cover crop stand is critical to successful weed suppression. If this doesn't occur, weeds can emerge, establish, and reproduce. If enough weeds establish and grow, consider terminating the cover crop before the weeds flower. This will prevent the seedbank from increasing and result in fewer weeds in future years (Renz, 2009).

Weed the Soil, Not the Crop

Eric and Anne Nordell successfully combined rotation, tillage, and cover crops to overcome a quackgrass infestation on their Pennsylvania vegetable farm. An article on their system, "Weed the Soil, Not the Crop," from Acres USA is available at www.acresusa.com/toolbox/reprints/June09_Nordells.pdf

For more detailed information, you can order a book and DVD directly from the Nordells at 3410 Rt. 184, Trout Run, PA 17771.

Managing Cover Crops for Weed Control

The secret to using a cover crop for effective weed control is to use haying, intensive grazing, mowing, or tillage to terminate the cover crop during the growing season, before weeds are allowed to go to seed.

Haying

One of the most effective strategies for managing Canada thistle is planting alfalfa in infested areas. Not only does alfalfa compete with Canada thistle for water, but regular haying knocks back the weeds as well. If Canada thistle is a particular problem for you, rotate out of small grains and switch to a perennial hay crop. After several years of hay, switch back to an annual crop for only one or two years, then rotate back to the perennial hay crop (Renz, 2009).

Haying can also be a helpful tool for managing grassy annual weeds such as wild oats. Planting a hay or forage crop and then taking the crop off the field before the weeds go to seed can be a useful technique for limiting weed pressure. Randy Hinebauch in Chinook, Montana, used this technique when first converting a field to organic wheat production. (For more of his story, see the *Farmer Profiles* publication in the ATTRA *Organic Small Grains* series.)

A cover crop that exhibits vigorous growth can smother weed seedlings and effectively compete for sunlight and nutrients.

Grazing

Intensive livestock grazing also can limit weed growth in a cover crop. A forage crop such as a pea and oat mixture can be grown both for weed competition and livestock feed. If animals are stocked at a high enough rate, and turned into the pasture at the right time, they can effectively mow the weeds and keep them from going to seed.

Researchers at Michigan State University have found that grazing can be an effective control for Canada thistle, particularly when it is young. "Canada thistle is an example of a weed that is

successfully grazed by sheep and cattle when it is a seedling because it does not yet have spines or an established root system. Older Canada thistle, especially plants that are flowering, can be grazed by goats but extensive root systems and the presence of underground buds greatly increase the chance of regrowth" (Taylor et al., 2008).

Further Resources

Michigan State University Extension has published two excellent weed management bulletins that include information on grazing for weed control, as well as tillage methods, crop rotation, flaming, cover crops, using compost, on-farm case studies, and more.

The first bulletin is *Integrated Weed Management: One Year's Seeding…* Bulletin E-2931, March 2007. 112 p.

The second bulletin is *Integrated Weed Management: Fine Tuning the System.* Bulletin E-3065, December 2008. 132 p.

Order from Michigan State University Extension at www.bookstore.msue.msu.edu or call 888-678-3464.

Predator Refuges

One of the more interesting cultural practices for weed control is to provide ecological refuges within or on the edge of fields. These refuges provide habitat for the small mammals and insects that eat weed seeds. Predation rates are extremely high near field edges that maintain good cover for mice, carabid beetles, and other predators (Maxwell, 2010).

Chisel plow. Photo: Susan Tallman, NCAT

Further Resources

"Weed Seed Predation in Agricultural Fields," 2007. Bob Hartzler, Matt Liebman, and Paula Westerman. Iowa State University, www.weeds.iastate.edu/mgmt/2006/seedpredators.shtml

"Promoting Weed Seed Predation and Decay," 2010. Mark Schonbeck, Virginia Association for Biological Farming, www.extension.org/article/18544

Some farmers create brush or rock piles at the edges of fields for refuge. Another strategy is to leave a permanent vegetative strip along the border of the grain field.

Tillage

Tillage is usually the main reactive weed control measure for organic grain farmers. However, tillage can be detrimental to the organic matter content and structure of the soil, and increased tillage leads to greater risk of soil erosion. In dry climates, it also increases the loss of stored soil moisture. Therefore, tillage should be used only when it is most effective and will result in the greatest kill of weed seedlings.

One key to minimizing tillage disturbance is to use a chisel plow or Noble blade to cut the weed seedlings under the soil surface. A chisel plow in combination with a rod-weeder is also an effective tool. Discs are commonly used to break up large amounts of residue but should be used sparingly since they can pulverize the soil structure.

Harrows are another implement used for weed control. Most farmers agree that from the date of seeding there is a five-day window for harrowing. However, use of harrows varies from one region to the next. Most organic grain farmers in the Northern Great Plains do not use an in-crop harrow after seeding because they do not find it effective enough to be worth the trouble.

When possible, tillage should occur after a flush of seedlings. Shallow cultivation with a chisel plow on a hot day should kill any seedlings in a fallow field. Take care not to till too deep, since this brings more weed seeds to the surface and encourages their germination.

Care must also be taken when tilling weeds that spread by rhizomes, such as field

bindweed and quackgrass. In many cases, tilling only serves to spread these weeds further. Special treatment of rhizomatous perennial weed patches may be needed, using techniques such as solarization with clear plastic, intensive grazing, or hand weeding.

Flaming

While there are recommendations for using flaming tools in vegetables, vineyards, and other row crops, there are currently no recommendations for using flaming during the growing season in small grains.

Dr. Stevan Knezevic at the University of Nebraska has done some preliminary work on flame weeding in winter wheat. In the initial experiment, he applied varying levels of propane flame at different growth stages of winter wheat during the spring. He found that flaming damaged the wheat too much to be a viable weed control for organic farmers. However, he is planning future experiments on flaming winter wheat during the fall when the crop is not as developed. Dr. Knezevic also hypothesizes that not all varieties of wheat will tolerate flaming in the same manner. More work needs to be done to support this hypothesis (Knezevic, 2009).

Although field-width flaming in small grains has yet to be perfected, localized flaming of weedy patches is still a viable option. Canada thistle and field bindweed might be excellent candidates for this technique, since they usually grow in localized patches. The ideal time to flame Canada thistle is before it is 4 inches tall. Early identification of weed seedlings is critical for making this technique work.

Localized flaming is best used for broadleaf weed control and is not as effective for grassy weeds. The growing point of a broadleaf plant is at the top, making it more vulnerable to flame from above. In contrast, the growing point of a grassy weed is toward the base of the plant, allowing it to withstand flaming better than a broadleaf plant.

Further Resources

Flame Engineering in LaCrosse, Kansas, sells hand-held Red Dragon propane flaming systems. 888-388-6724
www.flameengineering.com

Using a hand-held propane torch. Photo: Courtesy of Flame Engineering

Burning

While flaming is an allowed organic practice for weed control, burning crop residues is not. National Organic Program regulations state that "the producer must not use burning as a means of disposal for crop residues produced on the operation: Except that, burning may be used to suppress the spread of disease or to stimulate seed germination" (§ 205.203 (e) (3)). If you have a compelling reason to consider burning for weed control, check with your certifier before using this technique.

Organic Herbicides

Biological and allowed synthetic substances can be used for weed control, but there must be evidence that the first- and second-tier strategies are already in place, as defined by the National Organic Program. Currently, most organic small grains producers do not use organic herbicides for field-scale weed control. However, these substances may have some application for weed control in localized areas such as along fencelines, on ditch banks, or in limited weed patches. As with any new purchased input, check with your certifier prior to using the substance.

All organic herbicides are very limited in their effectiveness. These substances are non-selective and kill only the portion of the plant they contact directly. Because they do not kill the entire plant, repeated treatments will be necessary to use up the energy reserves in the roots as the weeds re-sprout. Because they are non-selective and will also injure the cash crop, organic herbicides should not be used as a method of in-crop weed control.

Low-toxicity herbicides are available from several suppliers. Scythe, produced by Dow AgroSciences, is made from fatty acids (Scythe Pesticide Label, www.greenbook.net/Docs/Label/L75204.pdf). Scythe acts fast as a broad-spectrum herbicide, and results can often be seen in as little as five minutes. It is used as a post-emergent herbicide sprayed directly on the foliage. It has no residual activity and is not effective on non-green, woody portions of plants.

Because they are non-selective and will also injure the cash crop, organic herbicides should not be used as a method of in-crop weed control.

Vinegar is an ingredient in several organic herbicides. One example, Burnout II, is a post-emergent herbicide that is sprayed onto the plant to burn off top growth, but is not guaranteed to kill the entire plant. The label on Burnout II states that perennials may regenerate after a single application and require additional treatment (www.biconet.com/lawn/infosheets/burnoutIIConcMSDS.pdf). Burnout II is 23% acetic acid. In contrast, household vinegar is about 5% acetic acid. Vinegar is corrosive to metal sprayer parts—the higher the acidity, the more corrosive. Plastic equipment is recommended for applying vinegar.

Further Resources

A USDA-ARS study tested the effectiveness of vinegar at different concentrations on various weed species in a greenhouse trial. View their results at the following abstract:
Vinegar as a Non-toxic and Safer Weed Control Option. 2002. BARC Poster Day.
J. Radhakrishnan, J.R.Teasdale, and C.B. Coffman.
www.ars.usda.gov/research/publications/publications.htm?seq_no_115=131932

AllDown is another organic herbicide containing acetic acid. It also contains citric acid, garlic, and yucca extract. One brief California study compared the effectiveness of several organic herbicides to Roundup Pro. In this instance, AllDown provided the best control of broadleaf weeds after Roundup Pro (Wilen and Boise, No date). While Roundup controlled 100% of the broadleaf weeds, AllDown had about an 80% control rate. However, this same study estimated the cost of Roundup Pro at $81 per acre, while the cost of AllDown was $1733 per acre. Regardless of its effectiveness, the cost of AllDown would be prohibitive except on the most difficult weed patches.

Further Resources

Check the ATTRA Biorationals Database for more information on approved organic weed-control substances: www.attra.ncat.org/attra-pub/biorationals/.

The organic herbicides mentioned above can be purchased from the following dealers:

1. Peaceful Valley Farm and Garden Supply, Grass Valley, CA, 888-784-1722 www.groworganic.com/browse_442_Herbicides.html
2. Biocontrol Network, Brentwood, TN 800-441-BUGS, www.biconet.com

Extreme Cases

Farmers who have tried the strategies above, yet still have a problem with weeds, may need to consider special management for the infested sections. **Isolate these sections and manage them differently.** For example, disc in a patch of wild oats before it goes to seed in a wheat field. Sacrificing this portion of the field will save grain in the long term. Moreover, do not mow or combine weedy patches when any seeds may be present.

Minimize tillage of creeping perennials such as bindweed. Tillage only serves to spread bindweed further by chopping up the rhizomes and distributing them throughout the field.

In very extreme cases, take problem areas out of organic production and treat them conventionally. While this is the option of last resort, it is better to take part of one field out of organic production for three years than to lose the entire productivity of your farm for many years to come. Organic regulations will allow for this strategy, as long as there is a reasonable buffer area between the organic and

the non-organic areas. The definition of an acceptable buffer is not specifically given in the organic regulations, so check with your certifier to understand what they will require. In most cases, a buffer of 20 to 30 feet should be adequate.

Finally, be proactive. Do not wait for a weed problem to occur. Organic farmers must control weeds before they get established. Focus efforts on controlling perennial weeds. Dr. Mark Renz encourages farmers to "Do whatever you can to keep them under control, even if you have to get out there and dig them up with a shovel" (2009).

Further Resources

Ecological Management of Agricultural Weeds. 2001. Matt Liebman, Charles Mohler, and Charles Staver. Cambridge University Press. An excellent, in-depth book with topics such as crop diversification, grazing, tillage and more. Reads like a college textbook and is more of an academic approach than some other resources.

Non-chemical Weed Management. 2007. M.K. Upadhyaya and R.E. Blackshaw (eds). CAB International, Cambridge, MA. Edited by two Canadian researchers, with contributions from researchers around the world. Topics include mulching, flaming, use of arthropods, allelopathy, and more. Written in an academic style.

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