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INTRODUCTION TO ORGANIC VEGETABLES

Creating a Weed Management Plan for Your Organic Farm

Successful weed management can make or break a new organic farm. These steps will help you get the upper hand on weeds.

STEP 1: KNOW YOUR WEEDS

Why should it matter which weeds you have in your field? You are just going to cultivate them anyway, right? Don't be fooled.

Empower Yourself with Knowledge

Successful organic farming is knowledge intensive. Knowing a little about weeds, their biology, and ecology can go a long way toward reducing their impact. Making a list of the weed species that you have is a great first step and can be easy with the help of a good guidebook or weed identification website (e.g., *Weeds of the Northeast* by Uva, Neal, and DiTomaso).

Know Your Weeds to Avoid Problem Fields

Before you rent or buy a new farm, make sure you know if you have a severe infestation of especially problematic weeds. Farmers usually name perennials like Canada thistle, johnsongrass, and quackgrass as their top problem weeds. Perennials store energy in rhizomes, corms, and roots. For example, johnsongrass

emerges from rhizomes (underground storage structures that look like thick creamy-colored roots) in mid-May and can grow to 7 feet tall by July. Giant ragweed is an annual weed that can be just as much of a nuisance. Take the time to identify weeds on your farm so that you can avoid an uphill battle when you're starting off.



Know your enemy. Young johnsongrass plants look a bit like corn, but don't be fooled. Photo courtesy of J. DiTomaso.

Johnsongrass, in particular, can make it practically impossible to farm organically until you get it under control. Because this plant has rhizomes, it will come back when you hoe it until you starve all the energy out of the rhizomes. A new Pennsylvania organic farmer had to abandon her vegetable field due to johnsongrass that grew 8 feet tall.

Know Where Your Weeds Are on Your Farm

Some weeds are good at growing everywhere, but most weeds occur in patches. By knowing where these patches are on your farm, you can increase management intensity and reduce their density to a tolerable level.

- What are the main weeds in each crop on the farm?
- When and where do these weeds cause problems: preplant, preemergence, early or later in crop development, between the row, within the row?
- Map your weeds. Note on your field map where your problem weeds occur and how this changes year to year.

STEP 2: DESIGN YOUR ROTATION TO OPTIMIZE WEED SUPPRESSION

“Rotation of crops . . . is the most effective means yet devised for keeping land free of weeds. No other method of weed control, mechanical, chemical or biological, is so economical or so easily practiced as a well-arranged

sequence of tillage and cropping.”

—C. E. Leighty, 1938 Yearbook of Agriculture

Rotate, rotate, rotate. Growing the same crop year after year will favor the same weeds. Rotate crops to prevent weeds from becoming adapted to your farm.

Protect Poor Competitor Crops by Planting Them after “Cleaning” Crops

Slow-growing crops like alliums and carrots should follow a crop that reduces weed populations. This might be a short-season crop, such as lettuce, that is harvested before weeds have a chance to go to seed, or a competitive cover crop that smothers out weeds.

Rotate Between Crops Having Different Characteristics

Diversity is key to keeping your crops from being overrun by weeds. Many weed species are adapted to specific environments, so rotating between different groups of crops can be very effective at reducing weed problems. For example, summer annual weeds like

Quackgrass is a weed you should learn to recognize. If you have it on your farm, you will want to know where it is, contain it, and work hard to manage it. Quackgrass produces rhizomes, underground shoots that look like roots (as well as seeds). These rhizomes spread quickly, up to 10 feet per year from the parent plant. Even when chopped into small pieces, each piece can grow into its own plant.

Weeds like quackgrass can quickly overtake your organic garden or field. However, once you know how it grows, it is possible to control it. If the infestation is not severe, regular hoeing or cultivation of the quackgrass can eliminate the plant. Try to remove the shoots before the fourth leaf develops—this is the point at which carbohydrates are transported back to replenish rhizome energy reserves.

For severe infestations, use a cultivated fallow in the summer. Use a spring or spike-tooth harrow during the hot, dry part of summer to bring rhizomes to the surface where the sun can dry and kill the rhizomes. If a harrow is not available, repeated disking at intervals that allow small pieces of rhizome to regrow and exhaust the rhizome, but do not put any more energy back into the rhizome will starve the rhizomes (Westwood et al.).



Quackgrass has distinctive clasping auricles that grasp the stem at the base of each leaf. Photo courtesy of D. Swan, Washington State University.



Know your enemy. A single quackgrass rhizome node can produce 14 rhizomes with a total length of 458 feet in one year. Photo courtesy of E. Gallandt, University of Maine.

pigweed, lambsquarter, and foxtail germinate in early summer when soil is warm and we cultivate, bringing weed seed to the surface. When rotating, to a fall crop, summer annuals are less likely to germinate. By the next year, fewer weed seeds will be left to germinate after fungi and insects attack them.

Follow Weedy Crops with Crops Easy to Keep Clean

Some crops are more difficult to keep weed free than others. For example, unmulched winter squash always has a few weeds by the end of the season. The trailing vines make it difficult, if not impossible, to cultivate or even hoe once they are established. Follow weedy crops with a rapid succession of short-season crops like spinach or lettuce that will be harvested before weeds can set seed. Crops that are easy to cultivate, like potatoes, are another good choice after weedy crops.

For weed-infested fields, consider including a tilled fallow period in the rotation to flush out and



Rotation with bare fallow. Field cultivators with rows of tines or sweeps can be used to dig up and lift quackgrass rhizomes to the soil surface where they will dry out and die in hot, dry weather. Photo courtesy of V. Grubinger, Vermont Extension.



Minimize niches for weeds in the field. Terry Kromer from Clear Springs Farm in Easton, Pennsylvania, got "tired of killing weeds all the time" and started planting annual ryegrass between beds with a drop seeder. She uses a flat plastic layer that allows her to mow right up to the bed.

destroy annual weeds. In a tilled fallow, you are setting aside a few weeks or months to repeatedly stimulate weed seeds to germinate and then killing them with cultivation. This can reduce the weed seed bank in your soil.

First, you till the soil. Most seeds need light to germinate. Light is a cue that tells the seed there is not a lot of competition. Tillage gives buried seeds the flash of light needed to stimulate germination, and you generally get a flush of weeds as a result. Tillage also releases a burst of nitrogen, which can also prompt germination.

When the weeds are still tiny, follow up the flush of weeds with shallow cultivation (or flaming). In especially problematic areas you may need to repeat this practice a few times. This practice works best when there is adequate rainfall to facilitate the germination of weed seeds, so keep an eye on the weather and consider irrigation, if possible. A tine weeder does a good job of this shallow tillage.



Tine weeder. Courtesy of V. Grubinger, Vermont extension.

In 2005 researchers at Cornell University had a sweet corn crop with ineffective weed control. Four- and five-foot-tall pigweed shed thousands of seeds. Researchers measured 12,000 seeds per square foot. They knew if they followed sweet corn with early salad mix or another early crop without a lot of cultivation they would be in trouble. Instead, in 2006 they planted fall cabbage. The cabbage was easy to cultivate. Cultivation and just one pass with a hand hoe kept pigweed from going to seed. When they measured the seed bank again, there were only 3,000 seeds per square foot, one-quarter of what they had the year before (Mohler 2011).

Keep in mind that this strategy does not allow cash cropping during the fallow period, but this is part of the “cropping system.”

Use a Stale Seedbed to Protect Slow-to-Germinate Crops

First, form your seedbed. After the first flush of weeds germinate, kill them with flame weeding. Your crop will then germinate into a relatively clean seedbed. The trick is to avoid disturbing the soil surface, which might bring up new weeds. For example, carrots are one of the hardest crops to protect from weeds. Most weeds germinate in 3–5 days, while carrots germinate in 7–21. If you seed your carrots and flame a day or two before they germinate, there should be many fewer weeds for carrots to compete with.

The advantage to flaming versus more tillage is that you do not disturb the soil at all. This way you do not bring up new weed seeds to the surface where they will germinate. Instead the crop germinates into a “clean” bed and has a head start on the weeds.

STEP 3: GROUP CROPS WITH SIMILAR MANAGEMENT

In order to simplify your weed management practices, group crops that will be managed similarly. This will save time on adjusting equipment and allow you to

Design Your Rotation to Optimize Weed Suppression: Nordell’s Beech Grove Farm Example

Anne and Eric Nordell use a fallow year before onions to reduce weed pressure and spread weed management throughout the season.

Fallow Year

Fall: First cover crop—rye after previous cash crop or spring oats (mowed before head) prevents mustards and others from going to seed.

June or July: Plow in first cover.

July–August: Harrowing every 2–3 weeks brings roots and rhizomes of perennials to the surface to dry in the sun and prevent annual weeds from establishing.

August: Seed second cover crop, generally Canadian field peas and/or oats that will winter kill. A winter-killed cover crop allows you to get in an early spring cash crop the following year.

Crop Year

Onions.

block similar crops close to each other in the field. For rotation management, farmers usually group crops together that are in the same family (see the Start Farming Fact Sheet “Planning a Crop Rotation from the Start”). For weed management it also helps to group crops within families or group together families that have similar row spacing or other management commonalities.

For example, tomatoes, peppers, and eggplants may all be mulched with black plastic on your farm. Grouping them together means you can lay all the plastic at once. Root crops such as carrots, beets, and turnips are not all in the same family, but they are often grown on the same spacing. If you are using mechanical cultivation, you can set your cultivator to run between three rows and do that entire section of your field with the least time spent adjusting equipment.

Common groups for weed management might be as follows:

- Brassicas: cabbage, broccoli, cauliflower
- Cucurbits: summer squash, cucumbers, winter squash
- Greens: spinach, lettuce, chard, kale
- Legumes: peas, beans
- Roots: carrots, beets, turnips
- Solanaceous crops: tomatoes, peppers, eggplants

Note: Because these groups include multiple families, you may need to avoid multiple groups the next year to avoid disease problems.

STEP 4: HAVE THE RIGHT TOOL FOR YOUR SYSTEM

Ever try to use a wrench as a hammer? Having the right tool for the job can make a big difference in how successful you are with weed management. Don’t expect your equipment to do more than its share. Also, make sure your system and your tools work together. If your cultivator is only 4 feet wide, a 5-foot-wide bed may be difficult to handle. When designing your system think about the following:

- Which crop groups will have mechanical versus mulch-type weed control?
- What tools do you already have?
- What resources are available or less expensive in your area?
- What tools do you want to acquire? Think about what might be affordable and appropriate to your scale.
- What bed and row spacing will you use to optimize the efficiency of your tools and accommodate optimal row spacing for your crop?

One of the most overlooked aspects of mechanical weed management is adjusting the action of the implement. Just because the settings on your cultivator

worked well last year doesn't mean they will work again in a new field under different conditions. Before going into a crop field, it's important to adjust cultivators and test their action to make sure they are doing what you want them to do. Be sure to also check what they are doing to the crop plants once you start cultivating.

Weed Management during Transition

Organic vegetables are often established on old hay fields or pastures to shorten time to certification. These fields may have severe infestations of perennial weeds and dense seed banks of annuals.

- Avoid planting vegetables the first year.
- Start with a cover crop.
- Till in the cover crop before perennials get large or annuals go to seed.
- Repeat at 4- to 6-week intervals all summer.
- Tilled fallow will deplete the seed bank and exhaust perennial roots.
- In early August plant a cover crop that will winter kill, such as sudax or buckwheat. This cover will compete with weeds in the fall and leave the field ready for planting in the spring.
- If weeds are still likely, start with short season crops like lettuce that will be out before weeds go to seed.

From Mohler and DiTommaso (in press, p. 57).



Kubota with belly mounted sweeps.

STEP 5: MAKE CULTURAL PRACTICES WORK FOR YOU

Too often organic farmers focus on tillage and cultivation to control weeds. True, as a new organic farmer you will need to choose an appropriate cultivation scheme for your farm. But, like many things, an ounce of prevention is worth a pound of cure. In addition to preventing weed problems, there are a number of little things that you can do to give your crops an advantage over weeds. These little things are called cultural practices, and although they may not be very effective alone, when combined they can be very powerful. This approach of combining cultural weed management practices is known as the “many little hammers” approach. Together, many tactics that each reduce the number or size of weeds by 5–10 percent can provide important and often cheap control.

Prevent the Arrival of New Weed Species

“A healthy crop is my most important weed management tool.”

—Farmer Jim Monroe (Integrated Weed Management 2005)

Weed seeds may hitch a ride to your farm in cover crop or forage seed, straw, hay, compost, or manure. For example, at the Seed Farm in Vera Cruz, Pennsylvania, cocklebur was introduced to the farm with municipal compost. Knowing the source of your inputs and discussing weed seed contamination with the farmer or company you get them from is a good practice. One way to reduce introducing foreign weed seed is to clean your seed (especially cover crop seed) and use farm-generated inputs such as mulch, compost, and manure. Mowing adjacent areas and field edges is also a good practice to prevent weed seeds from blowing into your fields.



Galinsoga covering this bed likely arrived with compost added the year before.

Prevent Weed Reproduction

Weeds are notorious for producing copious amounts of seeds. For example, one common purslane plant can produce two million seeds. One way to keep weeds from going to seed is cleaning up the field (mowing or tilling) quickly after the crop is harvested. Delaying cleanup by a month can increase seed production by

Have the Right Tool for Your System: Market Garden Example

Available tools:

5-inch stirrup hoe
3¼-inch stirrup hoe

Available resources:

Straw from farm
Paper mulch from year before

Tools to acquire:

Wheel hoe with 8-inch and 5-inch blade to increase efficiency and provide control between beds

Bed and row spacing:

Beds are on 5-foot (60-inch) centers with a 1-foot pathway and 4-foot beds; rows spaced 60 inches (1 row), 24 inches (2 rows), 10 inches (4 rows), or 5 inches (6 rows)



Wheel hoe, 3¼-inch stirrup hoe, 5-inch stirrup hoe, straw, plastic mulch

System/tool for each crop group:

Crop group	System/between-row spacing	Tool
Brassicas	2-row, 24-inch spacing	5-inch stirrup hoe
Cucurbits	straw mulch, 24-inch spacing	
Greens	4-row, 10-inch spacing	5-inch stirrup hoe
Leafy Greens	6-row, 4-inch spacing	3¼-inch stirrup hoe
Legumes	2-row, 24-inch spacing	5-inch stirrup hoe
Roots	4-row, 10-inch spacing	5-inch stirrup hoe
Solanaceous crops	black plastic mulch, 60-inch spacing	

Note: Nothing is planted closer together than the width of the narrowest hoe (8-inch stirrup hoe for pathways)!

Have the Right Tool for Your System: Quiet Creek Farm, Lehigh County Example

Available tools and equipment:

Kubota cultivating tractor with belly-mounted sweeps
Williams tool bar with tine weeder
Bezzeredi spider cultivators

Bed and row spacing:

5-foot centers (43-inch bed tops with 17 inches between beds); rows are spaced 15 inches apart (3 rows), 30 inches apart (2 rows), or 60 inches apart (1 row)



Bezzeredi spider cultivators will break a crust but not throw much soil.



Kubota with belly-mounted cultivators and tool bar with fine weeders.

System/tool for each crop group:

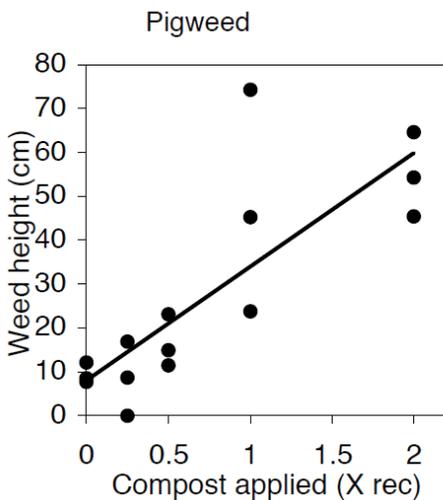
Crop group	System/between-row spacing	Tool
Brassicas	2-row, 30-inch spacing between rows	Belly mounted sweeps + tine weeder
Early cucurbits	Black plastic, 1 row	Raised bed mulch layer
Late cucurbits	Cultivated, 1 row	Belly mounted sweeps + tool bar with 13-inch side knives (pumpkin knives)
Legumes	2-row, 30-inch spacing between rows	Belly mounted sweeps + tine weeder
Roots and greens	3-row, 15-inch spacing between rows	Belly mounted sweeps + tine weeder
Solanaceous crops	Black plastic, 1 row	Raised bed mulch layer + Bezzeredi spiders between plastic

one hundred fold. Cutting off or hand-pulling a few weeds that are about to go to seed before the crop is harvested can also help control the weed seed bank. (See Table 1.)

Match Soil Fertility with Crop Demand

Weeds can be better at taking up nutrients than crops. More nutrients equal bigger weeds. For example, in a study at the Marten Farm in New York, pigweed grew about twice as fast when compost was applied and supplied nutrients at double the recommended rate (Figure 1, Bjorkman 2008). Ideally, highly available soluble fertilizers should be avoided when possible. Instead, compost and cover crops should be used to provide nutrients that are released slowly over time. This is because nitrogen in organic matter needs to be mineralized, a process that is dependent on soil microorganisms. Soil organic matter acts as a resource sponge and can mediate competition between crop and

FIGURE 1: OVERLY FERTILE SOIL GROWS LARGE WEEDS.



The change in pigweed growth in corn at the Marten Farm in August 2007 when the corn had filled in between the rows. From Bjorkman (2008).

TABLE 1. YEARS REQUIRED FOR A REDUCTION IN THE WEED SEED BANK.

Species	50 percent reduction	99 percent reduction
Common lambsquarter (<i>Chenopodium album</i>)	12	78
Field pennycress (<i>Thlaspi arvense</i>)	6	38
Giant foxtail (<i>Setaria faberi</i>)	>1	5
Prostrate knotweed (<i>Polygonum aviculare</i>)	4	30
Yellow foxtail (<i>Setaria glauca</i>)	5	30

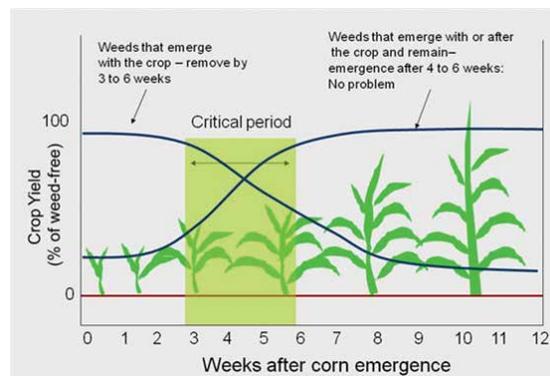
Adapted from Schonbeck 2010a and 2010b.

weed plants. If you do have to apply highly available nutrients like blood meal or composted chicken manure, try to apply them close to the crop so that the crop—not the weeds—receives the nutrients, and work them into the soil. Make sure they are not applied too close or the crop might be injured.

Let the Crop Suppress the Weeds

Vigorous crops can often suppress weeds, especially once they have formed a canopy that shades the soil surface. Using transplants creates a size hierarchy between the crop and emerging weeds that gives crops a major advantage. Another important way to get a weed-suppressing canopy quickly is to pay attention to planting depth and uniform spacing. Planter skips and uneven seeding depth can result in gaps in the crop canopy where weeds will establish. Try to keep your planter in good repair and well adjusted so you get uniform, quick emergence. With hand-push seeders this can be especially difficult (see Seeder Reviews in the Start Farming Fact Sheet “Selecting the Right Seeding and Transplanting Techniques” for ideas). An even soil surface with few clods will also help increase uniform stands.

FIGURE 2: CRITICAL WEED-FREE PERIOD.



If you can manage weeds in the first few weeks, the canopy will close and the few weeds that escape are not likely to reduce your yield. Figure courtesy of B. Curran.

STEP 6: CREATE A WEED CONTROL CALENDAR AND GET YOUR TIMING RIGHT

If you have ever tried to chop down a garden of weeds waist high, you learned the first lesson of timing: get 'em while they're small. But when there are transplants to set out, crops to harvest, and a farmers' market to go to, it is easy to miss the critical windows of opportunity. Those windows are when the crop is first planted, when the flushes of weed seedlings are just emerging, and during the crop's minimum weed-free period.

In business, location is everything, but in weed management, timing trumps all. Once you have

the basics down, refine your management plan by improving your timing of management practices.

White Thread Stage

It is critical to target weeds while they are susceptible to control practices. Weeds are easiest to kill when they are just emerging, before you can see their leaves. This period is called the “white thread stage” because weeds in this stage look like little white strings in the soil. Experienced organic farmers will tell you that if you can see the weeds from the tractor seat, you missed your window of opportunity.

To help ensure you don’t miss those windows, create a weed control calendar based on your planting and transplanting dates. For example, at Liberty Gardens in Coopersburg, Pennsylvania, they schedule cultivation one or two weeks after setting out transplants. By that point most crops have formed a canopy and weed growth is minimal (in fields where they have reduced the weed seed bank). Many producers plan their seeding and transplanting dates using spreadsheets. Add another column to the spreadsheet that calculates “projected” weed control dates. Of course, Mother Nature and other factors will often shift your dates, but the calendar will serve as a reminder and help you hit the windows of opportunity.

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