



TRANSITION TO ORGANIC COURSE

CHAPTER 3

CROPS

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Photo Credit: Jack Sherman

CHAPTER 3

CROPS

INTRODUCTION

In the first two chapters of this course, we've talked about the basic principles of organic farming and how the USDA's National Organic Program (NOP) certification system works. We've covered some fundamentals of soil science and emphasized how, in organic agriculture, the focus is on building and caring for the soil. If your soil is in good shape, chances are your crops and livestock—and your bottom line—will be, too.

In this chapter, we'll dig into the details of organic crop management: planning crop rotations and working with cover crops; sourcing seeds and other planting materials in accordance with organic regulations; and developing effective weed and pest management strategies. We'll also talk briefly about harvesting and certification of wild crops, known as wildcrafting.

LESSON 1: ROTATIONS

OVERVIEW

In real estate, experts say, there are three key factors: location, location, location. Likewise, there are three key factors in sustainable farming: rotation, rotation, rotation. Rotate your crops, rotate your cover crops and rotate your tillage. Sounds simple enough, but in practice it takes thought, planning, observation, and flexibility.

Crop rotations and cover crops are part of the answer to nearly every farm management issue discussed in this course. Many organic farmers say they've included more cover crops in their rotations as they've gained experience and realized new things the cover crops could do. A good crop rotation keeps the soil covered with vegetation for as much of the year as possible. Protecting the entire soil surface with growing crops is a big first step in soil improvement.

Effective crop rotations can supply fertility, improve soil quality, help manage weeds, and help reduce pests and diseases. They can also help you balance your workload and spread risk.

Research has established that crops grown in rotation outperform monoculture, for example ([Berzsenyi et al., 2000](#)); ([Mourtzinis et al. \(2017\)](#)); and ([Pimentel et al. \(2005\)](#)). While scientists have not yet figured out all the reasons why crops grown in rotation perform better, several reasons have been established, including increased soil organic matter, enhanced soil aggregate stability, and other soil quality parameters—all leading to increased nutrient and water use efficiency.

GLOSSARY TERMS

Crop rotation: The practice of alternating the annual crops grown on a specific field in a planned pattern or sequence in successive crop years so that crops of the same species or family are not grown repeatedly without interruption on the same field. Perennial cropping systems employ means such as alley cropping, intercropping, and hedgerows to introduce biological diversity in lieu of crop rotation. (*NOP definition*)

Organic matter: The remains, residues, or waste products of any organism. (*NOP definition*)

Crop rotations also enables crops to fill as many different ecological niches as possible, so your crops and cover crops complement one another.

Researchers are also studying how diverse cropping systems foster a greater number of other kinds of organisms, from soil microorganisms to beneficial insects to birds and bats. This complex variety of organisms is called biodiversity. Understanding how they interact will take further investigation. But in the end, what matters most about rotations is that they work.

WHAT THE STANDARDS SAY ABOUT ROTATIONS

The NOP definition of crop rotation highlights the basic principle of crop rotations, which is to alternate different types of crops within a single field over time. Rotations can include alternating:

- Crops from different plant family groups
- Annual crops with perennial crops
- Row crops, drilled crops, and sod-forming crops
- Cool-season crops with warm-season crops
- Heavy feeders, medium feeders, and light feeders
- Deep-rooted crops with shallow-rooted crops

Section [205.205](#) of the Standards sets requirements for the producer to implement a crop rotation including but not limited to sod, cover crops, green manure crops, and catch crops. The crop rotation must provide functions that are applicable to the operation. These functions include maintaining or improving soil organic matter content, providing for pest management in annual and perennial crops, managing deficient or excess plant nutrients, and providing erosion control.

Note that §205.205 applies to all kinds of organic crops: managers of orchards, vineyards or other perennial crops must use “alley cropping, intercropping, and hedgerows to introduce biological diversity in lieu of crop rotations” (§[205.2](#), “Crop rotation”).

GOALS OF A SUCCESSFUL CROP ROTATION

Adequate cash flow and overall farm profitability. Spread your major cash crops over your rotations to ensure cash flow at different times of the year from different crops. Consider the value of crops with multiple marketing outcomes such as alfalfa which can be sold as hay, fed as haylage, or harvested for seed.

Sustainable on-farm fertility from a crop sequence that balances soil-improving crops (perennial forages, annual green manures) with soil-depleting crops (most cash crops). Successful rotations can improve fertility over time.

Cover crops that provide multiple benefits. Scheduling cover crops into the rotation wherever possible can protect the soil from erosion, supplement nitrogen fixation with legumes, build organic matter, smother weeds, suppress soil pests and diseases, and manage nutrients.

Sustainable pest management. Crops sequenced in a diverse rotation that helps break the cycles of insect pests, diseases, and weeds.

Crop rotation based on available resources. Crop rotations vary widely according to region and farm type. You need to develop a rotation based on available resources, including soil, equipment, labor, market opportunities, and storage capacity. Good organic crop rotations include both cash crops and cover crops. If you've got plenty of land, you can include long periods of hay or pasture to break weed cycles and build fertility. If you're pressed for space, you may need to rely more heavily on composts or other soil amendments to supply fertility.

Generally speaking, your certifier will expect to see a rotation sequence of three to five crops suitable to your part of the country. You will need to outline your basic rotation sequence (or sequences) when you fill out your Organic System Plan. The best cropping plans are flexible so you can respond to changing conditions. The plans can be different for various fields.

PLANNING CROP ROTATIONS

Rotations require you to think in several dimensions at once. This can be tricky at first. You



Photo Credit: Rodale Institute

Winter rye no-tilled (at 2.5 bushels per acre) after corn harvested for grain (yield about 120 bushels per acre), shown in April. The rye planting yielded about 1,500 pounds of dry matter per acre as a cover crop.

need to integrate field-level decisions with farm-level decisions, short-term needs with long-term objectives, soil capacity with economic outcomes. Key characteristics of successful crop rotations are flexibility and farm-by-farm application.

These tips will help you as you plan your crop rotations.

- Talk to experienced organic farmers in your area to find out what works and what doesn't.
- Consider various candidates for winter cover crops. Winter cereals such as rye, wheat, and barley are excellent candidates. Oats, soybeans, and peas work well for vegetable rotations.
- Consider fertility, pH, drainage, moisture, and temperature requirements before selecting cover crops.
- Pay attention to disease potentials associated with unrelated crops in sequence. For instance, avoid following legumes with legumes to reduce disease problems.

WORKING OUT THE ECONOMICS

Concerned about how a shift to organic rotations will affect your cash flow? Good. The agronomics of rotations work out after a while, but you have to keep the economics front and center from the get-go.

Remember that it's the overall economics of the whole rotation that count, not the revenue of any one component alone. Whereas conventional farm subsidy programs and broad-spectrum herbicides reward an ever-decreasing number of crops on a farm, organic farming works best with a wide repertoire of crops. You need to use care in selecting crops that will grow well and yield a high-quality product that you'll be able to sell at a profit.

Fortunately, organic markets have tended to reward diversity, making it possible in most parts of the country to plan healthy, long-term crop rotations that improve soil, avoid serious pest problems and offer better financial returns per acre. Good crop rotations let you go into the marketplace with more than one income option, spreading risk as weather and markets fluctuate. As you expand your inventory of crops, you'll probably need to identify new markets as well. We'll discuss marketing issues at greater length in the Marketing chapter.

CHECK YOUR NUMBERS

Use the [Crop Conversion Calculator](#) to project what your returns might look like using different cropping sequences. You can obtain current prices from commodity boards, and prevailing organic prices from our [Organic Price Report \(OPR\)](#).

COVER CROPS: ESSENTIAL LINKS IN ORGANIC ROTATIONS

No matter how carefully you sequence your cash crops, there will always be opportunities to supply more fertility, more crop residue, more weed suppression or some other biological boost. That's where cover crops come in. These are crops grown primarily for their benefit to other crops or to the soil, instead of for direct use or sale.

When choosing a cover crop, first consider

TAKING COVER

A cover crop can act as a ...

Smother crop or living mulch to suppress or outcompete weeds. Sorghum-Sudangrass, buckwheat, soybeans and cowpeas are all used in this manner.

Nurse crop for other, slower-growing crops. Oats are frequently used as a nurse crop for alfalfa or clover.

Mulch crop to help control weeds, shelter beneficial insects and reduce the spread of splashborne disease. Standing cover crops can be converted to mulch by mowing, chopping or rolling.

Biofumigant crop to rid soils of pathogens. Broccoli and other brassicas have been shown to inhibit root diseases, problem nematodes and even weed germination.

your needs—to add nitrogen or organic matter, cover bare soil, suppress weeds, etc.—and then compare the windows in your rotation to the planting requirements of the different species suited to your area. Experienced cover-crop farmers use combinations of grasses, legumes, and even brassicas to achieve multiple cropping system objectives.

Like the rotations they're a part of, these mixtures can function synergistically, providing more benefits than the individual species grown alone. The most common mixtures include a legume and a cereal grain, such as cereal rye and hairy vetch. The cereal germinates and grows readily through the fall and into the winter, protecting the soil and capturing any nitrogen that might remain at the end of the season. Legumes such as hairy vetch, crimson clover, and Austrian winter peas establish more slowly, putting on most of their growth in the spring. With proper biological inoculation, legumes can fix 70 to 200 pounds of nitrogen per acre, much of it available to crops in the following growing season. Take your time, experiment with different species and see what works best on your farm.

For tables outlining some basic characteristics of frequently used legume, grass-family and other cover crops, click [here](#).

ORGANIC VEGETABLE CROP ROTATIONS

On highly diversified vegetable farms—such as community-supported agriculture (CSA) farms, which often grow as many as 45 or 50 different crops—field plans become so complicated that they are best managed in blocks or groups. Since closely related crops often have similar pest and disease problems, most farmers use vegetable plant family groups as the primary basis of their rotations. As with agronomic crops, other factors to consider include nutrient requirements (heavy feeders vs. moderate feeders), belowground characteristics (shallow-, medium- and deep-rooted crops), and growth season (warm-season vs. cool-season crops).



Photo Credit: Jack Sherman

Picture of field borders

Anne and Eric Nordell of Pennsylvania developed a rotation that captures many benefits on the market farm by balancing crop types, seasonality and over-wintering traits. Each field rotates between a cash crop and cover crops every other year. The cash crops alternate between early and late, while the cover crops rotate between winterkill and winter-hardy. Winterkill cover crops, like oats and peas, precede early cash crops, while overwintering cover crops, such as rye and

vetch, precede late cash crops. Click [here](#) for details.

A further consideration in crop placement is the need to maintain borders or “buffer” zones between certified fields and adjoining fields where non-organic practices might be used. These areas need to protect your crops against contamination from prohibited substances such as drifting pesticides or wind-borne or insect-borne pollen from genetically modified crops. We’ll talk about buffer zone requirements at more length in the Certification chapter.

DISTURBING SOIL—CAREFULLY—CAN BE OKAY

Some people suggest that one pass with a plow destroys the soil’s ability to build and retain organic matter. This is not our experience. In our Farming Systems Trial, nearly three decades of organic management with standard tillage have resulted in gains in soil organic matter levels 70% greater than those reported for no-till agriculture as typically practiced.

In ecological terms, farming is a “disturbance” of the landscape, a knocking back of the flora and fauna to an earlier state in its long development toward a stable biological community.

Many ecologists believe that occasional disturbance, such as a wildfire that spurs new growth, is a healthy feature of complex biological communities. Our challenge as farmers is to manage disturbance well so that our farms function as stable, productive agricultural systems.

SOIL FERTILITY THROUGH THE TRANSITION

In a balanced organic farming system, local conditions will determine how best to improve soil fertility and health. Fertility on an organic farm comes from several parts of the cropping system, including rotation, cover crops, manure, and compost.

It’s a good idea to have your soil tested when you first start your transition to organic and again at least every two to three years. The test gives you chemical analysis, which is just one tool in determining the health of the soil. Check crop

growth, and perhaps do tissue tests as well, and consult with local experts.



Photo Credit: FarmHack

A no-till roller crimper rolling down cover crop

using cover crops to supply fertility during the growing season.

At Rodale Institute, we use hairy vetch as a cover prior to corn, and rye prior to soybeans. Every five years, we provide about 10 tons of compost to our small grain. Finally, hay does wonders for conserving and even increasing soil fertility.

Legumes vary in the amounts of dry matter and N they contain. A higher percentage of biologically fixed N will accumulate in their top growth than in their roots. That's why it's important to let legumes grow long enough to produce their full potential in biomass. Make sure you get them knocked down before they set seed, however, to prevent your covers from becoming weeds in future seasons. We've found that waiting for full flower stage but before soft seed development is best for producing maximum amounts of nitrogen and building soil organic matter.

Hairy vetch, alfalfa and Austrian winter peas contain 3 to 4% N by dry weight and can contribute up to 200 pounds per acre of N; most other legumes are 2 to 3% nitrogen; cereals and ryegrass possess 1.2 to 2.4% nitrogen. Unlike synthetic fertilizers, which are prone to leaching, the N that's not immediately used by plants can remain available and even contribute to building the soil.

REGIONAL ORGANIC CROP ROTATIONS

Here are some examples of good crop rotations in use by organic farmers in different parts of the country. Remember, every farm's rotation needs are different; these are just ideas for you to consider.

Dryland grains, Washington

See [The Wilke Project – An Analysis of Alternative Crop Rotations in the Intermediate Rainfall Area of Eastern Washington](#)

Dryland wheat, Great Plains

On the Great Plains, where soil moisture is a limiting factor, organic farmers have had success replacing the conventional wheat-fallow rotation with wheat-corn-millet-fallow or wheat-corn-sunflower-fallow, achieving better wheat yields

RESEARCH

Rodale Institute no-till roller-crimper allows farmers to combine the benefits of no-till (saving fuel, time and soil) with the benefits of using a winter cover crop. On fields where weed pressure is under control, the system allows for organic no-till where the rolled cover crop can provide mulch that suppresses weeds and holds moisture. A legume cover crop will also provide nitrogen.

Read more: [No-till+](#)

NITROGEN NEEDS

Many farmers considering a shift to organic ask how they can supply enough nitrogen (N) to achieve the kinds of yields they are used to.

It's not that difficult to get all the fertility you need from some combination of cover crops (often termed green manures), manures, compost, and other types of organic soil amendments. In fact, experienced organic farmers tend to focus as much on using cover crops to store excess fertility at the end of the growing season as they do on

and improved soil organic matter levels.

Fourth-generation farmer Bob Quinn, who converted his 2,400-acre Montana spread to organic in 1989, runs a 4- to 5-year rotation beginning with hard red winter wheat and followed by red lentils, Kamut, or durum wheat in year two. Year three is buckwheat, soft wheat, or barley, undersown with alfalfa. If the alfalfa overwinters, it can be cut for hay for a year before returning to winter wheat in year five. If it winterkills, the field can be used for peas before returning to winter wheat in year four.

Rice-grains, California inland

California's diverse environments have spawned a variety of organic rotations. This one works well for Ed Sills on good soils in northern California's Sacramento Valley.

- Year 1: rice
- Year 2: dry beans
- Year 3: wheat, followed by hairy vetch cover
- Year 4: corn or popcorn

Litter from free-range turkey farms is available to boost fertility for the rice or corn crops once within the 4-year cycle. Cover crops and crop rotation improve soil fertility and condition, and help to suppress weeds in the rice to a degree comparable to that of conventional systems using herbicides. Rice straw is incorporated into the biologically active soil. A fallow season, and plantings of vetch with a nurse crop of oats, can extend the rotation to nine years in different combinations.

For a 7-year rotation, some farmers in the area use corn, soybeans, wheat, oats, red clover, hay, and adzuki beans.

Intensive vegetables, California coast

Frequent cover cropping creates healthy soils for improved water management and vigorous vegetable crops.

- Year 1: fall-plant perennial rye
- Year 2: mow/plowdown rye; fall-plant onions/garlic on beds
- Year 3: harvest onions/garlic; plant/incorporate summer cover (includes

annual buckwheat, sorghum-Sudangrass, and vetch); plant winter cover (includes vetch, bell beans, oats, and peas)

- Year 4: incorporate cover; plant brassicas/greens/carrots; fall-plant winter cover
- Year 5: incorporate cover; plant/harvest potatoes; fall-plant winter cover
- Year 6: incorporate cover; plant/harvest sweet corn or bush beans; fall-plant winter cover
- Year 7: incorporate cover; plant/harvest squash/pumpkins; fall-plant winter cover
- Year 8: incorporate cover; plant miscellaneous crops (includes cucumbers, summer squash, peppers, eggplant, brassicas, basil and other herbs, flowers); fall-plant winter cover

A mechanical spader is usually used in the spring to incorporate winter cover crops. Strawberries and dry-farmed tomatoes can be fit into this rotation as conditions allow.

Mixed crops-livestock, Midwest

Many organic grain farmers in the Midwest also keep livestock, and virtually all organic livestock producers also raise at least some of their own grain. Having crops and livestock together on the same farm adds flexibility to your system and makes it possible to use longer rotations while still bringing in a good income.

A common organic rotation on fertile Midwestern soils looks something like this:

- Year 1: corn
- Year 2: soybeans
- Year 3: corn
- Year 4: oats, underseeded with mixed grass-legume hay
- Years 5, 6, 7: mixed grass-legume hay

This system draws residual N from the hay legume and supplemental N from the soybeans while rotating tillage and using perennial plantings to good advantage.

Cotton-hay, New Mexico

See [Converted to Organic Cotton, for Health and Profit](#)

Potatoes-hay-covers, Maine

A four-year rotation on a commercial seed potato farm in the short-seasoned Northeast needs to provide fertility and optimal soil conditions for healthy crops.

- Year 1: seed potatoes
- Year 2: spring wheat or oats underplanted with clover and timothy grass
- Year 3: clover sod (cut once for hay, then rotationally grazed through fall, and again in early spring)
- Year 4: plow down clover sod, plant/plow down buckwheat (as a weed suppressant), plant/plow down rapeseed (as a biofumigant)

This rotation uses about one-quarter of the rotated land for the primary cash crop each year, while the remainder contributes to the farm's needs for fertility, soil health, soil tilth, pest suppression (weeds, insects and diseases), and providing habitat and alternate food sources for beneficial insects. The rotation is primarily focused on producing disease-free organic seed potatoes.

Mixed grain-vegetable rotation, Northeast

Here's another example from the Northeast, which includes vegetables as well as agronomic crops:

- Year 1: field corn
- Year 2: soybeans or red kidney beans
- Year 3: spring small grain (oats or barley), underseeded with medium red clover
- Year 4: winter grain (wheat, spelt, triticale, rye, or barley), underseeded with medium red clover
- Year 5: field corn or processing vegetables

In this rotation, the red clover supplies nitrogen for the corn, the small grain straw and red clover add plenty of organic matter, and the alternation between row and sod crops allows for good weed and pest management. In addition, the inclusion of winter small grains helps spread the workload across the year. The rotation is diverse in its ability to provide financial stability, minimizes exposure to pest problems and should improve the health of the soil.

Crop-livestock rotations, Southeast
Farmers in the humid South are experimenting with more intensive organic rotations. This rotation was developed in Virginia:

- Year 1: corn, with winter wheat no-till drilled into the corn stubble
- Year 2: winter wheat grazed by livestock; foxtail millet no-till seeded into the grazed wheat, then grazed or cut for hay; alfalfa no-till drilled in the fall
- Year 3: alfalfa grazed or cut for hay
- Year 4: alfalfa grazed or cut for hay, followed by more intensive grazing in the fall and winter to weaken the alfalfa in preparation for planting corn in the spring

A variation on this sequence is to till the alfalfa under in the fall and seed a cover crop of winter rye and vetch in order to get better weed control in the corn the following year.

A team of researchers in Florida, Georgia and Alabama has demonstrated that standard cotton and peanut rotations can be improved by including bahia grass pasture grazed with beef cattle. The bahia grass is hayed in the first year and rotationally grazed in the second. The grass adds organic matter and helps break up hardpan clay layers. Cotton is planted in the third year and peanuts in the fourth, before returning to bahia grass in the fifth. The cotton and peanuts typically yield 50 to 150% more than standard, non-rotated cotton and peanut yields for the region.

Revenue from the beef cattle in this rotation more than compensates for the reduced cash-crop acreage over the four-year span. This allows good income without greatly expanding farmed areas.

VEGETABLE ROTATIONS SHOULD BE

Planned according to botanical family groupings:

- Nightshade family (Solanaceae): Tomatoes, peppers, eggplant, potatoes
- Cabbage or mustard family (Brassicaceae): Broccoli, cabbage, cauliflower, kale, collards, radishes, Brussels sprouts, arugula

- Beet-spinach family (Chenopodiaceae): Beets, chard, spinach
- Pea family (Fabaceae, also known as Leguminosae): Beans, peas
- Carrot family (Umbelliferae): Carrots, parsnips, celery, parsley
- Squash family (Cucurbitaceae): Cucumbers, winter squash, summer squash, melons, pumpkins
- Composite family (Compositae): Lettuces

...while also considering growing season:

- Warm-season: Cucumbers, eggplant, melons, peppers, pumpkins, snap beans, squash, sweet corn, sweet potatoes, tomatoes
- Cool-season: Asparagus, broccoli, Brussels sprouts, cabbage, carrots, cauliflower, celery, lettuce, onions, parsley, peas, potatoes, spinach

...rooting depth:

- Shallow (18-24 in.): Broccoli, Brussels sprouts, cabbage, cauliflower, celery, Chinese cabbage, corn, endive, garlic, leeks, lettuce, onions, parsley, potatoes, radishes, spinach
- Moderately deep (36-48 in.): Bush beans, pole beans, beets, carrots, chard, cucumbers, eggplant, muskmelons, mustard, peas, peppers, rutabagas, summer squash, turnips
- Deep (>48 in.): Artichokes, asparagus, lima beans, parsnips, pumpkins, winter squash, sweet potatoes, tomatoes, watermelons

...and nutrient demand:

- Heavy feeders: Corn, tomatoes, cabbage family crops
- Light feeders: Root crops, bulbs, herbs

Sample strategy: follow a high-nutrient-demanding, shallow-rooted vegetable crop such as lettuce or spinach with a deeper-rooted crop or cover crop that can utilize the available nutrients left in the soil.



Rotating a perennial sod crop (such as alfalfa) with small grains and corn varies seasonal periods, rooting depth, nutrient cycling and biomass contribution—all elements of a successful rotation to suppress weeds in the mini-pumpkin strip in this mixture (young plants, center).

A ROTATION MIX

This relatively simple vegetable crop rotation mixes families, seasons, root types and nutrient needs:

- Year 1: Sweet corn, followed by a fall-seeded winter rye/hairy vetch cover crop
- Year 2: Pumpkins or winter squash, followed by a fall cover crop of rye or oats
- Year 3: Tomatoes, peppers, or potatoes, followed by a fall rye/vetch cover crop
- Year 4: Mixed vegetables such as brassicas, green beans, carrots, or onions, followed by a fall rye cover crop
- Year 5: Spring-planted oats or summer buckwheat followed by fall-seeded rye/vetch; or, if enough land is available, one to three years of clover or alfalfa

Since most vegetable crops are broad-leaved species (dicotyledons), the use of grass-family (monocotyledon) covers is a good way to break pest cycles. For the most part, pests and diseases of the monocots don't much bother dicots, and vice versa.



Photo Credit: Edwin Remsberg

Buckwheat (top), a summer annual, and hairy vetch (bottom), a winter legume, each have particular uses in rotations.

COVER-CROP DECISIONS

Several factors will influence your cover-crop choices. These factors include climate, soil moisture, field layouts, equipment, labor resources, and the amount of land you have available relative to your production targets.

Determine your primary constraint and use that as a baseline. For instance, cultivation capacity is a major constraint for many farmers. You can determine your cultivation capacity by calculating how many acres a day for a given crop you can cultivate using your existing equipment. Next, compare that number of acres to the length of time and climate conditions for your region to determine your cultivation capacity.

Cover crops can also be classified as either winter (or cool-season) covers and summer (or warm-season) covers. Species sown in fall to serve as winter annual covers include vetches; fava and bell beans; peas; small grains such as oats, barley, wheat, and rye; grasses such as annual and perennial rye grass; and brassicas such as forage radish, oilseed radish, rapeseed, and canola.

Summer annual legumes include lablab bean, cowpeas, crotalaria (sunn hemp), hemp sesbania, and forage soybeans. Warm-season non-legumes include varieties of millet, buckwheat, and

sorghum-Sudangrass.

Other more region- or application-specific cover crops include bur clover, lespedeza, lupines, soybeans, velvet beans, ladino clover, sour clover, and field peas.

For a cover crop choices chart, click [here](#).

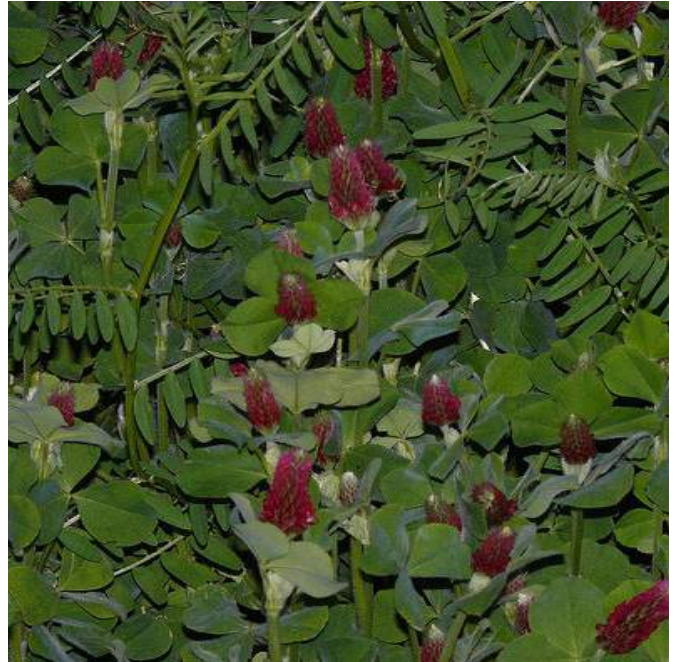


Photo Credit: Kurt Morrow

Vigorous spring growth of crimson clover and vetch in central Pennsylvania.

TROUBLESHOOTING YOUR DRAFT ROTATION

Once you've sketched out a rotation, go back through it step by step. Ask yourself if it includes:

- The right crops. Does my intended rotation feature crops that will perform well and find a reliable, profitable market?
- The right soil impact. Will the rotation control erosion, minimize pest damage and disease, break weed cycles, and improve the quality of my soil?
- The right resources. Will it make effective use of available resources, including labor and equipment?

SUMMARY

As a caretaker of the land, you will find that crop rotations and cover crops are the answer to many organic farm management issues.

Think about your crop rotation plan and the cover crops you will use. Make sure your rotation plan has the right crops that will provide the right soil impact. Think about the economic impact of your crop rotation plan and your resources.

Before we move on to the Seeds and Plants lesson, take a break and update your Organic System Plan.

Complete Part 2: Farm Plan Information. Attach updated field history sheets showing all fields, field numbers, acres, crops planted, projected yields, and inputs applied.

- Indicate whether you have managed all fields for three or more years. If you have not, you must submit signed statements from the previous manager stating the use and all inputs applied during the previous three years on all newly rented or purchased fields.
- Indicate whether all fields requested for certification are located at the main address listed in Part 1. Complete the information for the main farm address and each parcel in a separate location from the main farm.

LESSON 2: SEEDS AND PLANTS

OVERVIEW

Seeds and planting stock are the building blocks of any rotation, and special care must be taken to ensure that your seeds are sourced and your planting stock is propagated in keeping with

organic regulations. Another key feature of most vegetable operations is greenhouse production, particularly in northern climates. Quality seed and healthy planting stock grown out in a responsibly managed greenhouse is the best head start you'll get against the challenges that wait out in the field.

WHAT THE STANDARDS SAY ABOUT SEEDS AND PLANTS

Section [205.204](#) of the NOP Standards states that producers “must use organically grown seeds, annual seedlings, and planting stock.” This is the basic goal you should keep in mind. There are, however, a number of exceptions:

1. Untreated, non-organic seeds or planting stock may be used if organic seeds or planting stock of a given or equivalent variety are not commercially available.
2. Non-organic seeds and planting stock treated with a permitted synthetic substance may be used if untreated seeds or planting stock of a given or equivalent variety are not available.
3. Non-organic annual seedlings or transplants can be used with special permission in the case of natural disaster or for research purposes (see [§205.290](#)).
4. For perennial crops, non-organic planting stock can be used, but the plants need to be managed organically for at least a year before any organic crop can be sold.
5. Seeds, annual seedlings, and planting stock treated with prohibited materials may be used when such use is required by state or federal phytosanitary regulations.

GLOSSARY TERMS

Annual seedlings: A plant grown from seed that will complete its life cycle or produce a harvestable yield within the same crop year or season in which it was planted. *(NOP definition)*

Planting stock: Any plant or plant tissue other than annual seedlings but including rhizomes, shoots, leaf or stem cuttings, roots, or tubers, used in plant production or propagation. *(NOP definition)*



Organic seed treated with organic-allowable materials is now available for some crops and varieties.

Note that organic seed must be used for the production of edible sprouts.

Two key phrases in the points listed above

are “commercially available” and “equivalent variety.” The standards leave it up to the certifier to determine whether a given variety was commercially available and whether you made a good-faith effort to find organic seeds to fit your cropping plan.

A common rule of thumb is to try three potential sources before resorting to non-organic seed. Keep copies of telephone notes, emails, and other correspondence documenting your efforts to source organic seeds. The organic inspector will want to see this documentation.

GLOSSARY TERMS

Commercially available: The ability to obtain a production input in an appropriate form, quality or quantity to fulfill an essential function in a system of organic production or handling, as determined by the certifying agent in the course of reviewing the organic plan. (*NOP definition*)

SEED QUALITY MATTERS

Certified organic seed does tend to be more expensive than non-organic seed, but don’t fall for the temptation of choosing a variety you know is not commercially available in organic form in order to avoid paying the higher price. The organic seed industry is changing rapidly, with more varieties in larger quantities to choose from all the time. Prices will probably come down as supply increases, but supply will increase only in response to increased demand.

As a general rule, you shouldn’t be trying to skimp on your seed costs anyway. Seed quality is hugely important in organic systems—the last thing you want to do is introduce weeds or

FARMER-TO-FARMER

“Try to find out the name and reputation of the seed breeder responsible for every variety you grow.

Where seeds come from can make a huge difference in performance.”

—Richard DeWilde
Viroqua, WI



Note that “certified seed” is different from “certified organic” seed. Non-organic “certified seed” is a quality standard administered through state departments of agriculture for many conventional agronomic crops. It guarantees specific requirements for germination, cleanliness and genetic purity, but does not address organic compliance.

disease with low-quality seed. Some good habits to develop:

- Talk to other organic farmers about their experience with different seed companies
- Double-check seed packages or bags prior to planting to make sure you haven’t accidentally received treated, genetically modified, damaged, or contaminated seed
- Source your seed well in advance of when you’ll need it to make sure you don’t get left short

ON-FARM SEED PRODUCTION

Another option for organic seeds is a traditional one: save your own. Many organic farmers get into the habit of harvesting and saving their own small grain, vegetable, or cover-crop seeds. You can even set up seed-exchange networks with other farmers in your area.

Raising a crop for seed can require even greater attention to crop quality, weed management, harvest techniques, and storage conditions than raising one for feed or food.

A number of organizations, including the [Organic Seed Alliance](#) in Washington state and the [Carolina Farm Stewardship Association](#) in North and South Carolina, have launched projects to improve organic seed quality and to train more farmers to produce organic seed. If you get good at seed saving, you may want to consider organic seed production as a value-added marketing opportunity.

If you do save your own seed, remember to maintain your field records. You’ll need to show that you have the acreage, equipment, and time to do it.

BREEDING FOR ORGANICS

As organically grown seed becomes more widespread, an interesting discussion has sprung up among farmers and researchers about breeding crop varieties and livestock lines specifically for organic systems. Organic crops and livestock face growing conditions distinct from those of non-organic crops and livestock, and so varieties or species that perform well in non-organic systems may not be the same as those that perform well in organic systems.

Organic crops need stronger root systems to forage for soil nutrients and stand up to the physical stress of cultivation, for instance. Organic livestock need to have good grazing abilities to do well on pastures with limited supplemental grain feeding.

Some organic farmers are working with heirloom varieties (nonhybrid varieties introduced prior to 1940) and heritage livestock breeds, reasoning that breeds and varieties developed before agricultural chemicals came into widespread use may have a better chance of performing well in organic systems.

At Rodale Institute, we've compared the performance of existing corn and soybean varieties under organic management and have found that they vary dramatically in their



Photo Credit: SARE

Austrian winter peas are an excellent winter annual legume for nitrogen production where winters are mild.

ability to tolerate and suppress weeds. Consider conducting simple side-by-side variety trials on your own farm.

GROWING ORGANIC SEEDLINGS

Most organic vegetable producers grow their own organic seedlings to use as transplants. Organic greenhouse management is governed by the same basic standards that apply to other forms of organic production.

All soil-mix ingredients, fertility products, foliar sprays, and/or pest and disease management materials used in organic greenhouse operations must comply with the National List. Use of treated wood in greenhouse construction is permitted only if it does not come in contact with crops or growing media. It's generally okay for the construction of greenhouse end walls, for example, but not for benches or for raised beds (in the case of in-ground production).

If you maintain both organic and non-organic greenhouses on your farm (parallel production), you'll need to have systems in place to keep these areas separate and to prevent cross-contamination and commingling of organic and non-organic materials and crops. This includes preventing drift of prohibited materials through ventilation systems and runoff from irrigation/fertigation systems.

VEGETATIVE AND PERENNIAL PLANTING STOCK

The same rules apply for vegetative plant propagation materials such as potatoes, sweet potato slips, and onion starts—certified organic material must be used if commercially available.

Perennial planting stock—fruit trees, brambles, grapevines, etc.—may be brought to the farm from non-organic sources but must be managed organically for at least a year before any fully certified organic crop can be sold.

Strawberry plants have been something of a gray area, since in most U.S. growing regions they are perennials treated as annuals. Organic strawberry plants are beginning to be available for purchase. Check with your certifier and other growers in your area.

GREENHOUSES AND HOOPHOUSES

Hoophouse or high-tunnel production is also gaining popularity among organic growers. Hoophouses are economical, unheated greenhouses with flexible ventilation options used for season extension and other objectives. Many hoophouses are designed with roll-up sides to provide maximum airflow as the weather warms up. Some are used in combination with trellising systems to maximize the use of the space under cover.

By sheltering plants from rain and allowing for more intensive management, high tunnels can reduce disease incidence and increase yields. Organic soil management under hoophouses can be more challenging than regular soil production because of the physical constraints and lack of exposure to the elements. Various movable hoophouse designs have been created to address this issue.

GREENHOUSE MANAGEMENT

Many standard commercial potting mixes are not acceptable for organic production because they contain pre-blended synthetic fertilizers. While there are a few organic-approved potting mixes on the market, you may find it more cost-effective to make your own.

The goal is a well-drained, pathogen-free medium with sufficient fertility to give young plants a strong start. Most recipes start with a base of compost, peat moss, sand, perlite, or vermiculite and then add smaller amounts of bone meal, blood meal, alfalfa meal, or greensand. Some growers also use lime or phosphate rock.

Organic growers use a variety of plastic seed trays, pots, or soil blocks in the greenhouse. Seed trays may (and generally should) be reused for several seasons but should be disinfected to prevent the spread of disease. A number of organic-approved oxidizing products are good for this purpose.

Proper watering is essential in the greenhouse. Plants can be stressed by too much or too little water, and stressed plants are more susceptible to insect and disease problems. Watering should be done thoroughly, generally at mid-morning, with a check made mid-afternoon



Photo Credit: Rodale Institute

The most successful greenhouse mix (center) at the Rodale Institute includes three parts screened on-farm compost (bottom right) and one part each, clockwise from lower left, coir (ground coconut fiber), peat moss, perlite and vermiculite.

during the hotter months.

Sticky traps can be used in the greenhouse to monitor aphid, whitefly and thrips populations. Releasing beneficial insects can be effective in controlling aphids, thrips, leaf miners, scale, mealybugs, spider mites, and whiteflies. For disease management, the two keys are ventilation and sanitation.

SUMMARY

Remember, annual seedlings must be produced according to organic standards. Non-organic perennial planting stock must be managed organically for at least one year prior to harvest of crop or sale of the plant as certified organic plant stock. Organic seedlings and planting stock must be used if commercially available. If you have both organic and non-organic greenhouse production on your farm, pay close attention to maintaining organic integrity.

Before we move on to the weed management lesson, you may want to take a break and update your Organic System Plan.

LESSON 3: WEEDS

OVERVIEW

Many organic farmers say dealing with weeds is their biggest challenge.

It's easy to understand why; weed management can be tough in organic systems, especially transitioning ones. But the idea that an organic field is a weedy field is outmoded. Skilled organic management can achieve near-total weed control even in challenging crops like soybeans, small grains, carrots, and strawberries.

Another misperception is that organic weed management relies entirely on mechanical cultivation. It's true that you'll be better off if you know your way around a cultivator. But cultural weed-management methods are just as important, if not more so. Crop rotations, adjusted planting dates, mulches, and other preventive methods can all be critical components of a successful organic weed-management plan.

Where weeds are concerned, an ounce of prevention is worth a pound of cure. Using a good mix of organic weed-management practices that work together to lower weed pressure is especially important when weather is uncooperative or other complications arise.



Photo Credit: Rodale Institute

Even in soybeans, our most weed-sensitive crop, we can manage weeds adequately through biological, cultural, and mechanical practices.

WHAT THE STANDARDS SAY ABOUT WEED MANAGEMENT

Section [205.206](#) of the NOP Standards requires the use of crop rotations, sanitation and cultural practices to prevent weed problems and enhance crop competitiveness. Weeds may also be managed through the use of mulches, mowing, livestock grazing, mechanical cultivation, hand weeding, and thermal or flame weeding.

If—and only if—these methods are insufficient, there is a short list of organic-approved herbicides you can turn to, provided you comply with any restrictions and document where and how you used them in your Organic System Plan. Most of these are cost prohibitive on all but the highest-value crops.

The Organic System Plan forms also ask about your monitoring and evaluation practices with regard to weed management: the effectiveness of your weed management plan, how you evaluate that effectiveness, and whether you're planning any changes.

Any weed management inputs you use should be listed on your Field History Sheet. It's a good idea to keep records of cultivation passes and other mechanical weed-management practices as well. These can be as simple as a field log or working calendar to record tillage, planting, cultivation, and other jobs. The organic inspector will be checking to see that your stated weed-management methods bear a plausible relationship to your observed weed pressure.

ORGANIC WEED MANAGEMENT FUNDAMENTALS

The organic approach to dealing with weeds is best described as ecologically based weed management or integrated weed management (IWM). IWM brings together a wide variety of strategies—from well-designed crop rotations to adjusting planting methods to novel techniques like flame weeding—that together offer an effective weed-management program. Iowa State University weed ecologist Matt Liebman refers to this as the “many little hammers” approach—going after weeds with many small, varied strategies instead of a one-shot approach, as with herbicides.

IWM emphasizes an ecological

understanding of how weeds behave in farming systems. Virtually every field activity you engage in—from soil amendments to crop selection to tillage methods—can have an impact on your weed levels and how they interact with crops.

There are a few basic principles of IWM to keep in mind.

Don't let weed populations get out of hand. This means if you see a patch of weeds developing or if you notice that a certain field has become weedy, you need to increase the intensity of management in that area. This can be as simple as scouting and targeting patches of problem weeds or rotating a field into a weed-suppressive crop.

Don't let weeds get adapted to your operation. This means using multiple and diverse tactics to manage weed populations. Weeds can easily survive and persist if the same management practices are done at the same time of year every year.

The amount of damage weeds can do to a crop can vary. There are many ways to make crop plants more competitive so the negative impact on crop yield from weeds is reduced. Just as every field operation can affect weed levels, weed-crop competition can be affected as well. The key is to manage your system so that the crops are given as much of an advantage as possible over the weeds.

FARMER-TO-FARMER

"Weed control really isn't a battle. It's about learning to understand soil structure and soil health."

—Gary Zimmer
Blue Mounds, WI

FOCUS ON PREVENTION AND ATTENTION

Preventive weed management includes good sanitation and other practices to limit the spread of weed seeds on your farm. Be sure to:

- Use high-quality, weed-free seed. Commercial seed packages should state their weed seed percentage on the label. If you save seed, make sure you clean it well.



Compost piles of manure and other organic matter that reach 60 degrees C will kill many weed seeds.

- Limit weed seed production in field margins and other areas. Some farmers clip weed seedheads over standing soybeans with a high cutter bar. An hour of bean-walking or thistle-stumping can be a good investment.
- Don't spread weed seeds from one field to another via tillage equipment or other tools. Hose down muddy tires and cultivators if necessary.
- Avoid plowing down a fresh crop of weed seeds in the fall. Weeds in the top few inches of soil have a relatively low survival rate, while those deeper down are more likely to germinate when brought to the surface next season.
- Compost manures and plant materials thoroughly. Buy compost only from reputable sources. High-temperature composting with active microorganisms should break down any weed seeds.

High-value vegetable crops require particular vigilance, since acceptable weed thresholds are much lower. Vegetables are not very competitive with weeds, and the hand-harvesting involved makes weed management through cultivation and

cultural practices your number-one priority.

Cultivation is best done every week until you can no longer clear plants. Rows should be marked with a mechanical cultivator if you are planting or seeding by hand. Flameweeding is very useful on slow-germinating vegetable crops such as carrots and beets prior to emergence. Insufficient attention to weed management in the early years of an organic operation can be fatal to the success of your overall enterprise.

USE ROTATIONS TO KEEP WEEDS IN CHECK

Diverse crop rotations are among your best strategies for reducing weed populations. Alternating row crops with solid-seeded crops, including one or more years in hay or pasture, and filling gaps in your rotation with aggressive covers like rye and hairy vetch can all help reduce annual weed pressure and contributions to the weed seed bank in your soil. By limiting and varying the bare-soil periods during which weeds can germinate, rotations increase the likelihood that weed seeds will decompose or be eaten by predators before they have a chance to grow.

Rotations also help with weed management by building soil fertility, [tilth](#), and organic matter, creating conditions in which the crop plants can thrive at the expense of the weeds.

Another way to use rotations for weed management is to take advantage of certain crops' allelopathic, or natural weed-suppressive qualities. Rye and sorghum-Sudangrass are strongly allelopathic; sunflower, sorghum, and many brassicas are less strongly so. Certain varieties of wheat and rice are also thought to inhibit weed seed germination. Plants like these can be used as primary crops or plow-down smother crops to clean up a field with severe weed pressure.

Sod crops, when mowed or grazed regularly, also help manage weeds. Pasture and hay crops

GLOSSARY TERMS

Tilth: An indicator of soil health pertaining to its ability to aggregate, allowing for good drainage and air circulation.

can go a long way to suppress weeds while also building organic matter and enhancing soil health.

Paying attention to weed management in the early years of transitioning to organic is critical—a couple of bad seasons can give you serious weed problems for years to come.

PLANTING STRATEGIES TO BEAT WEEDS

Organic farmers use a number of different planting and seeding techniques to meet the challenges of herbicide-free farming. Planting at higher densities, on narrower row spacing, or at higher broadcast rates can increase crops' competitiveness against weeds, compensate for losses during cultivation, and get the canopy closed faster. Seeding rates can be as much as 10% to 20% higher than those recommended for non-organic systems.

If you can, choose crop varieties that canopy rapidly to shade and outcompete weeds. Most modern cultivars of wheat, barley, and oats have been selected for reduced top growth and straw length, but varieties with stronger vegetative growth may work better for organic production.

Organic vegetable growers also shift planting methods to make weed management easier. Transplanted crops are easier to cultivate than direct-seeded crops, for instance, so organic growers typically use transplants as much as possible. For direct-seeded crops, a precision seeder that will limit the need for thinning can be a big advantage. Straight, evenly spaced rows will make cultivation more efficient.

RESEARCH

Iowa State University researchers have found that weed predation by field mice can reduce weed seed populations by 40% in just one night.

Maintaining unmown, biodiverse borders around your fields provides habitat for the mice and provides you with some free weed-control service.

Read more: [Free weed-control service: Mice](#)

ADJUST PLANTER, CHECK PLACEMENT

A well-adjusted planter is one of your most valuable weed-control tools. Uniform, proper placement of the crop seed will result in even, vigorous growth. Seed depth is a critical decision based on seed size, soil temperature and moisture, seedling vigor, and where you are on the calendar.

Don't assume that just because a planter is relatively new, it's doing a good job. The planter frame and individual planting units should be regularly inspected for bending or warping.

Older planters with worn seed disks, gauge wheels, closing wheels, or other parts can result in uneven planting. Worn parts should be replaced or repaired. Retrofitting with shoes, firming points, specially designed seed tubes, or "eccentrically bored" gauge-wheel bushings can help achieve more uniform seed placement. Residue-manager wheels in front of the gauge wheels will sweep away clods and stones, making for a level surface and more uniform planting.

Seed placement is important for any crop system, but the weed management constraints of organic farming make it more critical to do quality control as a routine part of planting. New rig or old, what matters is that the seed is placed snugly in the soil at the depth you want. Make sure it is. Get off the tractor regularly and dig up the seed to check planting accuracy and make adjustments if necessary. This should be done not only in good parts of a field but also in uneven or difficult areas. Avoid planting into wet or particularly lumpy soil.

TILLAGE IN WEED MANAGEMENT

After all this crop planning, it's finally time to get on the tractor and stir some soil. Mechanical weed management can be divided into four phases:

1. Field preparation
2. Pre-plant tillage
3. Pre-emergent tillage
4. Post-emergent tillage

All can be very effective, but all come with costs in terms of time, money, and risk. As we've mentioned elsewhere, reduced tillage is a big

priority in organic farming right now, with no-till weed-management strategies at the cutting edge of organic farming research. Annual weeds are the pioneer plants of a natural ecological succession. When soil is disturbed by tillage, weed seeds are stimulated to germinate. Reducing soil disturbance greatly reduces the germination of weed seeds, so weed problems are different with no-till than with standard-till farming.



Photo Credit: Jack Sherman

Rotary hoeing is most effective at the "white string" stage, before weeds even emerge from the soil.

PRE-EMERGENT STRATEGIES

Stale, or false, seedbedding is an excellent way to reduce weed populations in a subsequent crop. For best effect, the seedbed should be prepared 10 days before the desired crop planting date. Soil preparation will encourage a crop of weeds to germinate. These tiny seedlings are then killed in the white-string stage by a pass with a harrow, rotary hoe, or other tool.

The second pass should be done as shallowly as possible to avoid bringing new weed seeds to the surface. Multiple passes can be done if conditions permit, but weigh your need to eliminate weeds against the danger of overworking the soil. Best results are achieved when soil temperatures are warm enough to stimulate good

weed germination. In some cases, irrigation is used to enhance the effect of the stale seedbed.

Flameweeding can be used to good effect for everything from blind tillage through mid-season weed control on crops with heat-resistant stems, such as cotton. One of the big advantages of flame weeding is that it doesn't disturb the soil and thereby cause more weeds to germinate.

Flaming works best when the weeds have two true leaves or fewer. Field-scale models are common in the Upper Midwest and the South, while backpack or hand-truck models for vegetables and orchards are popular among market farmers.

A pane of glass can be used to help predict crop emergence and improve timing for flameweeding. The glass is set over a small area of the field, raising the soil temperature and causing the crop seeds underneath to germinate a few days earlier than the rest of the crop.

PRE-EMERGENT CULTIVATION: FLYING BLIND

Blind cultivation is your easiest and best opportunity to destroy weeds that will otherwise grow up within the rows and offer direct competition with the crop. In blind cultivation, the entire field is tilled shallowly at a relatively high speed, paying little attention to where the rows are.

The point of blind cultivation is to stir the top half inch of soil, adding air and causing the millions of tiny germinating weed seeds to dry out and die. The larger crop seeds are below the level of the cultivation and remain undamaged. Weed seedlings are at their most vulnerable at this stage. Effective blind cultivation will give you the biggest possible crop/weed size differential.

Blind cultivation can also break a soil crust, allowing crop seedlings to emerge. Depth control is critical, as is an awareness of crop seedling development to make sure the young shoots are not approaching too close to the soil surface.

The first blind-cultivation pass is usually done right before crop emergence, with a second pass about a week later, depending on conditions. For soybeans, avoid blind cultivation during the sensitive "crook stage," when the seedling is

FARMER-TO-FARMER

"Make the first cultivation the deepest so that new weed seeds aren't brought to the soil surface in later passes."

"Use cultivation equipment with the same number of rows as your planter, so you don't end up taking out the 'guess rows.'"

Source: *Integrated Weed Management: "One Year's Seeding..."* (Michigan State University Extension, 2005)

curling upward to become an erect stem.

Blind cultivation is best done when the sun is shining, a light breeze is blowing, and the soil is fairly dry.

Common blind-cultivation implements include coil-tine harrows, rotary hoes, and finger weeders. Some of the most advanced tools are produced in Europe and imported to North America.

POST-EMERGENT CULTIVATION

Once the crop is in the ground, everything you do to manage weeds has to be balanced against the impact on the crop. Mechanical weed controls—from cultivation to flaming to mowing—differ mainly in how they treat the weeds compared to the planted or growing crop.

While cultivation implements are getting better and more varied all the time, there are still three basic ways to kill weeds by cultivation:

- Burying weed seeds and seedlings deep enough so they can't grow
- Uprooting weeds so they dry and die
- Severing or damaging weeds enough so the parts can't regenerate

Weeders and cultivators generally do a combination of all three. It's important to know exactly what your cultivator is doing in order to time the operation correctly and make proper adjustments. Factor in soil conditions, weed pressure, tractor speed, and distance between steel and crop row, as well as crop status. Shallow tillage and no-tillage techniques are recommended for keeping weed seeds in the upper inches of soil, where they're most vulnerable to biological

breakdown and predation.

When the crop rows are clearly visible, it's time for between-row cultivation. This has to be done slowly and carefully to avoid taking out the crop plants.

Many farmers make two passes, one to take out the majority of the weeds and a second to eliminate weeds stimulated to grow by the first. A second cultivation aerates the soil and can be used to hill up soil from between the rows toward the base of the crop plants, helping to limit weeds within the row.

If you do your second cultivation late enough, the crop canopy will prevent further weed germination. With a broadcast seeder, you can apply cover-crop seed at the same time, allowing it to establish in the low-light conditions and then take off after harvest.



Photo Credit: Rodale Institute

S-tine cultivator blades are designed to vibrate side-to-side in response to soil contact to maximize their shattering impact on weed roots. Set in gangs as shown here, they can effectively manage shallow-rooted weeds. Choose shank-style blades to meet goals of slicing, burying or uprooting weeds.

WEEDS, WEATHER, AND TIMING

Weed species vary widely in their susceptibility to being killed by cultivation equipment. Ragweed sends down a taproot very quickly, making it difficult to uproot almost as

soon as it comes up. Mustard has very shallow roots at first and is easily plucked out until it is quite large. Summer annual grasses form small seedlings with few reserves that are easily destroyed by burying or uprooting.

Large-seeded weeds like velvetleaf can emerge from deep in the soil and are very resistant to shallow cultivation. Redroot pigweed is difficult to kill by burying or uprooting once it gets a few inches tall because it can re-root and push up out of fairly deep soil. Purslane can also re-root even if pulled all the way out and left lying on top.

In periods of drought, weeds may go into semi-dormancy, leading farmers to stop cultivating or to set cultivators less aggressively. The soil hardens, making it difficult for equipment to penetrate to the proper depth. Deep-rooted weeds are held tightly in the soil, although they may show little aboveground growth. A cultivator run too shallow can bury these weeds without dislodging the roots, creating a field that looks clean but in fact harbors plenty of weeds ready to shoot up at the first sign of moisture.

A rain on freshly cultivated soil, on the other hand, will make it stick together, crusting slightly as it dries. Under these conditions, buried weeds will die quickly and seldom manage to push back out. Any crop plants buried by cultivators just before a rain, however, are usually lost, too.

Weather conditions can play a major role in the effectiveness of tillage operations. If possible, look for a stretch of dry weather before you start your tillage. Wet weather may allow weeds to re-root. Cold, wet conditions can slow weed seed germination, reducing the effectiveness of stale

WHEN DO WEEDS WAKE UP?

For problem weeds like quack grass and yellow nutsedge, repeated but ill-timed tillage may cause weed proliferation. Tillage done during hot, dry conditions has the best chance of being effective.

With bindweed and Canada thistle, some organic farmers will take highly infested fields out of production for a fallow period to reduce the population. With perennial weeds, persistent mowing before seed set can be effective.

seedbedding. Choose the time of day that will cause the most stress on disrupted weeds, whether by sun, wind, or overall exposure.

Never work ground that is too wet. You'll cause compaction, which encourages weeds that prefer hard ground and makes later cultivation less effective.

VEGETATIVE AND SYNTHETIC MULCHES

Mulches can be very effective at controlling weeds. Mulch changes the environment around the soil surface, making it difficult for weed seeds to germinate and grow. Vegetative mulches, such as rye straw, can also suppress weeds by allelopathy. Research shows that rye mulch can reduce weed seed germination by 75 to 95% while leaving large-seeded crops such as corn, peas, cucumbers, or beans unaffected.

Natural or non-synthetic mulches such as straw or leaves can have the additional benefit of boosting soil organic matter over time, and even adding fertility. Be careful whenever you import mulch (or compost) materials such as leaves, loose straw, or grass clippings that you avoid potential contaminants or debris. Avoid glossy inks from newspaper inserts and magazine waste.

"Living mulches" are cover crops of clover, grasses, or other species used to suppress weeds in orchards and some other types of cropping systems. These can be mowed regularly or seasonally to maintain the stand.

Synthetic mulches: many organic vegetable growers use plastic mulches to manage weeds in crops like tomatoes, peppers, squash, and cucumbers. Plastic mulches can be laid down with specialized bed-former/mulch-layer implements, or, on a smaller scale, laid by hand after beds have been formed. Drip irrigation tape is usually laid

down beneath the plastic. A variety of different-colored plastic mulches (black is standard) can be used to influence soil temperature and other factors.

Natural and synthetic mulches can also be used together, of course, with straw or clover used between raised beds covered in plastic.

Synthetic mulches are classified as a "restricted" input under the National Organic Program Standards, meaning they must be used in compliance with the stated annotations. Regulations require that all synthetic mulches be removed from the field at the end of the growing season.



Photo Credit: Rodale Institute

Natural mulches boost soil organic matter over time, even adding fertility, but they can also add potential contaminants if you're importing them from off-farm.

GLOSSARY TERMS

Mulch: Any nonsynthetic material, such as wood chips, leaves, or straw, or any synthetic material included on the National List for such use, such as newspaper or plastic that serves to suppress weed growth, moderate soil temperature, or conserve soil moisture. (*NOP definition*)

OTHER WAYS TO MANAGE WEEDS

Livestock: Intensive rotational grazing is widely recognized for its effectiveness in limiting perennial weeds in pasture. But in some specialized systems, farmers have developed additional ways to use livestock for weed management. Chickens confined to small pens and rotated through fields have been shown to be effective at eradicating yellow nutsedge. Geese preferentially eat grasses, and so can be used to weed strawberry fields without damaging the

crop. Some tree-crop farmers use sheep to graze the alleys between rows of trees or coffee bushes.

Organic herbicides: Very few input products are available for organic weed management. Corn gluten meal has use as a fertilizer (10% N) as well as an herbicide, but to be permitted in organic farming it must be made from non-GMO corn. It is prohibitively expensive for most crops, although it may have uses in greenhouse or specialty crop systems.

Other organic-approved herbicides on the market are vinegar-based, like Matran, a vinegar-clove product. To be effective, concentrations in the range of 10 to 12% acetic acid are needed, although lower concentrations may work on small annual weeds. For organic use, the acetic acid must be derived from natural fermentation—industrial acetic acid is not permitted. At these concentrations, acetic acid is legally required to be labeled as a pesticide, which limits the number of products available.

Always check the OMRI list and consult with your certifier before investing in a new input material.

Night-time tillage: Some farmers and researchers are experimenting with night tillage using infrared goggles. Weed species such as lambsquarters, ragweed, pigweed, smartweed, mustard, and nightshade require just a fraction of a second of light to trigger germination. The idea of night tillage is to eliminate that trigger. [Ascard \(1993\)](#) reported two studies that illustrated the effectiveness of night-time weed management in managing weeds. In one experiment, harrowing one hour after sunset reduced weed emergence by 40% compared with harrowing during the daytime. In another experiment, a light-proof cover on the harrow in daylight significantly reduced weed emergence compared with conventional harrowing.

SUMMARY

Organic weed management does require a shift in attitude. Striving for 100% weed eradication in organic systems is not essential. The fact is, most crops can tolerate a few weeds without showing any impact on yield or quality.

Research at the Rodale Institute, moreover,

has shown that organic crops actually have a greater ability to tolerate weeds than non-organically managed crops do. In almost 30 years of side-by-side trials, our organic plots have consistently yielded as well as our non-organic plots, even though the organic plots usually have heavier weed pressure. It may be that the organic crops suffer less competition from weeds because soil quality is better, making nutrient and water resources more plentiful.

FARMER-TO-FARMER

“[Most farmers] want to see a perfectly clean field. Economically, that’s not possible. The costs of making a perfectly clean field are pretty astronomical.”

—Dean McIlvane
West Salm, OH

Or, it may be that more complex ecological interactions are taking place. After all, weeds can play a variety of useful roles within your farming system. They can help protect the soil from wind and water erosion. They provide food and habitat for wildlife and beneficial species. They can increase biodiversity, aid nitrogen fixation, add organic matter, and catch excess nutrients. They serve as trap crops for pests and provide grazing for livestock.

My organic weed-management plan features a variety of strategies designed to reduce weed pressure as much as possible. However, my basic goal is just to keep weed pressure below the economic threshold—the point at which it has an impact on the crop.

LESSON 4: PESTS AND DISEASES

OVERVIEW

Dealing with pests probably requires the biggest leap of faith for farmers new to organic management. When you’re used to having an arsenal of chemical controls at your disposal, it’s scary to think about what might happen when you give them up.

Fortunately, most farmers find that after an

initial “balancing out” period, pest and disease pressures in field crops diminish under organic management. Just as in weed management, effective crop rotation is the primary method of organic insect pest and disease management. In the absence of pesticides, beneficial insect populations return, helping to stabilize pest populations. In organic farming, the early years may be challenging, but things get better over time. Compare this to non-organic farming, in which things can get tougher over time as pests develop resistance and input costs go up.

WHAT THE STANDARDS SAY ABOUT PEST AND DISEASE MANAGEMENT

Section [205.206](#) of the NOP Standards requires producers to rely first of all on management practices to prevent crop pests and diseases. These practices include:

- Crop rotations and other soil and nutrient management practices
- Sanitation measures to remove disease vectors and habitat for pest organisms
- Cultural practices to enhance crop health, such as selecting plant species and varieties that are resistant to prevalent pests and diseases

In addition, the Standards permit the control of pest problems “through mechanical or physical methods including but not limited to:”

- Releasing beneficial organisms
- Developing habitat for beneficial organisms
- Using lures, traps and repellents
- And disease control via:
- Management practices to suppress the spread of disease organisms
- Application of nonsynthetic biological, botanical, or mineral inputs

After producers have tried or considered all of these strategies, they are allowed to turn to approved pest-management materials.

JEFF MOYER: THE FARMER AS NATURALIST

In my years as an organic farmer, I’ve learned a lot about what you might call the biological backdrop of the Rodale Institute farm. Insects are an important part of that backdrop. For every corn borer or aphid I find in the field, I know there are dozens of other species—predatory ground beetles and wolf spiders, parasitic flies and wasps, bees that act as pollinators—out there benefiting my crops.



Photo Credit: Rodale Institute

Bean beetle damage on soybeans

I try to keep this in mind as I consider my pest management options, because I know that every time I get out a pest-control material, even one approved for use in organic systems, I risk harming the good insects while I’m trying to eliminate the bad ones.

I also know that vigorous, healthy crops grown in balanced, well-managed soils can stand up to a certain amount of pest pressure. When a pest appears in a crop, I don’t automatically decide I have to do something about it—the key is to pay close attention, see if it spreads, and know what level of damage I can tolerate for the markets I’m targeting for that particular crop.

This is the same “economic threshold” concept we talked about with regard to weeds,

and it's why many organic farmers prefer to talk about "pest management" rather than "pest control." The idea is not to eliminate every last pest—usually impossible anyway—but to create stable agro-ecological systems in which pests are naturally held at low levels.

Finally, as with weeds, I try to look at insect pests as indicators of how the whole farm system is working, not just as a problem of the moment. Pest pressure in the fields can be affected by beneficial insect populations, rotation decisions, tillage methods and many other factors, such as how we manage our windbreaks and field edges. Checking to see if the bluebird boxes are occupied is a lot more enjoyable than getting out the spray rig—and ultimately, I've come to realize, it's more effective, too, because it teaches me something instead of just being a chore I cross off my list.

EMPHASIZE CROP HEALTH

Most organic farmers use cultural methods for pest management, such as:

- Delaying planting to avoid critical pest life-cycle stages
- Planting small "trap crop" areas to attract pests away from the primary crop
- Choosing several varieties instead of a single crop variety in order to create a less uniform landscape for pests to move across

Biological or physical methods include using row covers to exclude flea beetles and applying beneficial nematodes to control undesirable nematodes. Biological or physical methods are usually practical only in high-value, intensive crops such as fruits and vegetables.

Choosing crops that grow well in your area and providing optimum conditions for crop growth should be your number-one pest-management strategy. Even the huge vegetable farms in California's Salinas Valley, which have gone organic with over 12% of their production and which have all the latest pest-management tools at their disposal, use this "grow crops in their best place" strategy as their first line of defense against pests on their organic acreage. Plants are like people; if they're eating right and

enjoying good living conditions, they can fight off most infections and heal cuts and bruises quickly.

Organic farmers have long maintained that synthetic fertilizers and pesticides make pest problems worse. Recent research has begun to support those observations. Plant susceptibility to insect feeding has been linked to high plant nitrogen levels, which in turn are related to the high soluble fertilizer inputs typical of non-organic agriculture. Free amino acids, again associated with high N applications, have also been reported to increase pest attacks. Compost-fed plants have lower soluble N levels and are thus less attractive to pests.

Other good farming practices also help reduce pest pressures. Good field preparation, skillful seed placement, timing planting to take advantage of optimum soil temperatures, and wise use of irrigation (if applicable) will give you strong young plants that are better able to withstand pests.

VARIETIES DIFFER IN PEST-RESISTANT TRAITS

Another part of good crop selection is good variety selection. There are many pest-resistant and pest-tolerant varieties available, with more being developed all the time. Although they



Photo Credit: Rodale Institute

Scab-resistant varieties of apples improve skin condition at harvest in the Rodale Institute orchard

sometimes lack the yield numbers or commercial recognition of less-resistant varieties, you may find that they work better for you overall in your new organic system.

In Hawaii, for example, organic ginger growers have discovered that yellow ginger is more insect-tolerant than the more commonly grown white ginger, and that while it has lower yields, it also has a stronger flavor and (according to homeopaths) more powerful medicinal qualities, making it better suited for premium organic markets.

Here at the Rodale farm, we've done a lot of work trialing scab-resistant apple varieties over the past 30 years, and have found that most of them have terrific flavor, good appearance and acceptable storage qualities. What they lack is a familiar name that customers can identify, so selling them takes a bit more marketing effort. Having a combination of scab-resistant (but less familiar) and popular (but scab-susceptible) trees in the orchards gives us the best of both worlds: it limits our need to spray sulfur to prevent scab and gives us a mix of varieties to market.

Systemic acquired resistance: Do plants have immune systems? The ability of plants to respond to pests and diseases by acquiring systemic resistance when exposed to those pests and diseases has been widely studied (Casal, 2012; Slaughter et al., 2012). The term "systemic acquired resistance" refers to physiological changes that occur in plants in response to initial insect feeding or disease infection. These changes can help the plants stop the infection or slow insect reproduction rates. There's even evidence that crop plants under insect attack emit

volatile scent signals to protect themselves or to communicate with insect enemies of the attackers.

Plant immune responses may also increase crops' nutritional value. Researchers in California have found that unsprayed organic fruits produce higher levels of antioxidants—prized by health-conscious consumers—in response to insect and pathogen attacks.

BUILDING BIODIVERSITY

After choosing appropriate varieties and giving your crops the best growing conditions you can, the most effective way to minimize pest problems is by making your farm as biologically rich as possible. There are lots of ways to do this, from growing a wide range of crops to planting diverse hedgerows.

It may seem hard to believe that your field edges can have that big an effect on what insects show up in your field, but they do. When Bob and Ardie Rodale bought what's now the Rodale Institute farm back in 1971, it had been farmed pretty hard. Most of the trees and shrubs had been taken out, and the fields were plowed to within a few feet of the farm buildings. Since then, we've planted hundreds of trees, put in two ponds, established permanent grass waterways, and done substantial landscaping around the buildings. Not only do we have more beneficial insects and birds and other animals, it's also a more pleasant place to live and work.

Transitioning to an organic crop rotation, including three to five primary crops and two or more cover crops, will by itself do a lot to increase the biological diversity of your farm. As we discussed earlier, you can add diversity to your rotation by mixing varieties of a given crop within a single field, by undersowing a cover crop or a hay crop into vegetables or small grains, or by strip cropping and intercropping.

Some organic grain and livestock farmers have revived the old practice of growing "succotash" mixes of oats, barley, wheat, and/or field peas, reducing pest pressures and boosting yields while also producing better feed values. Studies (such as [Barkley and Peterson \(2008\) in Kansas](#)) have shown that mixed-variety wheat fields can outperform single-variety stands. The

FARMER-TO-FARMER

You know a revolution in pest management is happening when the pest-management specialist of a big Salinas Valley produce company shows a photo of a young, aphid-infested romaine lettuce plant and says, 'I don't worry about this anymore because I know the beneficial insects will catch up and eat them all.'

—Ramy Colfer
Salinas, CA

general rule seems to be the more, the merrier.

DEALING WITH LARGER PESTS

Larger pests such as birds and mammals can be as troublesome on organic farms as on non-organic farms. Problems with mammals—from rats to bears—are common; deer, in particular, can be devastating where pressure is high. There are no special organic solutions, except to note that many products are not approved for use.

In areas with intense deer pressure where hunting or special deer-control shooting permits are not an option, the best remedy is a 10-foot box-wire or plastic mesh fence, although some farmers, like Bob Muth in southern New Jersey, report success with a single strand of electrified wire with bundles of human hair (from a local barber shop) tied to it at intervals.

Many organic farmers use live traps to remove groundhogs. For bird damage to growing crops, a variety of “scare” products can be purchased, including plastic owls, scary-eye balloons, shiny streamers, and noisemakers that emit hawk calls. These need to be moved regularly for best effect.



Photo Credit: Cornell University

Deer damage can be severe even in commodity crops.

TIMING CROPS, DIVERTING PESTS

Once you understand the life cycles of your most serious pests, you may be able to adjust your planting schedule to avoid their seasons of peak activity. For example, early-season sweet corn can escape corn earworms; late-season potatoes are often less susceptible to Colorado potato beetles. Aphid problems can also sometimes be avoided by early-season planting. Other pest problems, like wireworms in root crops, can be minimized by early harvesting.

For vegetable growers, pests such as flea beetles and cucumber beetles can be effectively managed by using row covers to protect plants early in the season, when they’re small and vulnerable. Once the plants are well established (or have reached pollination stage), the covers are removed.

Trap cropping: An alternative strategy is to devote a small part of a field specifically to a crop that attracts pests as a way of enticing them away from your primary crop. Entomologist Forrest Mitchell in Texas has shown that using squash plants as a trap crop can almost completely eliminate squash bug damage in watermelon and cantaloupes. Potato plants can be used as trap crops for Colorado potato beetles in tomato and eggplant fields.

Trap crops are usually planted along field margins so that pests moving into fields encounter them first. For crops like alfalfa hay, a trap is created by leaving an unharvested strip when each field is cut, so that pests such as leafhoppers have a place to go instead of moving on to subsequent plantings.

A refinement on the trap cropping strategy is to destroy the “trapped” pests once you’ve attracted them. In California, some organic growers experimented with using vacuum machines to suck up lygus bugs from strawberries. Then researchers discovered that planting alfalfa as a trap crop every 16th row is so attractive to the lygus bug that vacuuming just the alfalfa rows gave better control of the lygus than entire-field vacuuming—and reduced vacuuming time by 75%. Infested trap crops can also be destroyed by flaming. Modification of trap crops can attract predators that can prey upon the pests potentially

eliminating the need for vacuuming. [Zinati G. and Smith A. \(2017\)](#) at Rodale Institute demonstrated that insectary strips, consisting of alfalfa as a base plant and oats as a nurse crop, mixed with a suite of herbs such as dill, basil, calendula, and lemon balm can provide a habitat for—and increase the populations of—beneficial insects such as ground beetles, wolf spiders, soldier beetles, lady bugs, bumble bees, cucumber beetle parasitoids, and braconid wasps. These beneficial insects have demonstrated a strong potential to control cucumber beetles—not only pests in cucumbers by themselves, but also vectors for a bacterium pathogen.

“FARMSCAPING” TO ATTRACT BENEFICIALS

Diversity shouldn't stop at the field margin—it should just be getting started there. The term “farmscaping” refers to the idea of looking at the entire farm landscape as a semi-wild ecological system that can be managed for overall farm productivity and health. Examples of good farmscaping strategies include:

- Leaving some standing dead trees and brush piles for wildlife habitat
- Eliminating plants that serve as overwintering habitat for specific pests (one example is blackberry, which is a host of the consperse stinkbug)
- Planting “living snow fences” to catch winter moisture and provide shelter for livestock
- Designing multistoried cropping systems, such as orchards with annual crops grown in between the rows, or tree nuts with grazing
- Establishing “beetle banks,” permanent grass strips that serve as habitat for beneficial ground beetles
- Sowing rows of flowering plants to provide food resources for beneficial insects
- Delaying field work to protect ground-nesting bird species

RESEARCH

Researchers at Montana State University report that farmers can protect crops from wheat stem sawfly by setting their cutter bars higher when they combine. Two parasitoids of the sawfly overwinter in standing wheat stems, but they can't do so if the stubble is left too short. The scientists recommend leaving at least one-third of the wheat stem standing at harvest and cutting even higher along field margins. Given sufficient habitat, the parasitoids can all but eliminate sawfly damage.

Read more: [A wealth of ways to manage pests without pesticides](#)

- Preserving or reestablishing native vegetation (prairie, woods, wetlands) on some portion of the farm
- Reducing and rotating tillage

Not all of these strategies will be possible on every farm. There can be a fine line between leaving undisturbed areas for wildlife habitat and keeping weeds from going to seed. In some cases, pest habitat will overlap with habitat for beneficials. You'll need to experiment to figure out what's practical for your conditions. When in doubt about a new management idea, start by managing a small area first.

ATTRACT BENEFICIALS WITH THE BASICS

Anybody who's kept bees—or worried about adequate crop pollination—knows the importance of having something in flower in the landscape all season long. Beneficial insect species like honeybees, lady beetles, and hoverflies rely on nectar and pollen resources for food at critical points in their life cycles. Because wild and weed species may not provide sufficient floral resources, many organic growers cultivate “[insectary](#)” plants to attract and retain beneficial insects.

Insectary plants work by supporting the adult, nectar-feeding stages of beneficial wasps and flies. The adults lay eggs on neighboring plants, and when the larvae emerge, they feed voraciously on aphids and other pests. For insectary plantings to be successful, specific

plant species that support predatory insects of your particular pests need to be included in the system, and the insectary plantings need to be close enough to the crop areas to have an effect. Depending on their size and how well they fly, beneficial insects may travel from a few yards to several miles to lay their eggs in crop fields. Insect specialists recommend you figure 50 to 400 yards in planning these beneficial interactions.

When choosing insectary plants, consider these criteria:

- Select plants for their attractiveness to beneficial insects
- Choose plants with an early and long bloom period
- Select plants with low potential to host crop viruses or attract pest species
- Choose plants with low potential to become weeds
- Consider low seed cost and easy establishment



This bee, *Osmia ribifloris* (on a barberry flower), is an effective pollinator of commercial blueberries.

Many members of the Umbelliferae (coriander, dill, Queen Anne’s lace), Compositae (goldenrod, yarrow, sunflower), Brassicaceae (sweet alyssum, wild mustard), and Leguminosae

(sweet clover, alfalfa) plant families offer good floral resources for beneficial insects.

Among California vegetable growers, a popular insectary plant mixture is sweet alyssum, coriander, buckwheat and a cereal grain. The cereal acts as a windbreak and as a host for alternate prey of the beneficials.

KEEP YOUR EYES OPEN

Walk your fields regularly at different times of the day and night and see how many insects you can identify. Look on the undersides of leaves, on the ground, and underneath the mulch. Try to familiarize yourself with the important beneficial species as well as the pests. Study field guides to learn about their life cycles and feeding habits.

Advanced scouting and monitoring involves being able to identify eggs, larvae, exoskeletons, and adults of pest species. Local and regional workshops, consultants, and websites are all good resources for this type of training. The insect world is vast, so don’t get discouraged. Even professional entomologists often find bugs they can’t identify right away.

Many larger organic growers hire consultants to monitor pests, since the initial stages of an outbreak can be easy to miss for untrained eyes. Local organic and integrated pest management (IPM) specialists sometimes establish thresholds and tolerance levels for different types of pest activity. Thresholds are generally lower if the pest is feeding on the marketable part of the crop.

Pheromone traps or sticky traps can detect insect population cycles and predict potential outbreaks. We use these in the Rodale Institute orchards, as do most fruit growers and some vegetable growers. Steve Groff, who grows no-till

FARMER-TO-FARMER

“Pest management in organic farming is all about paying attention to cycles—when a pest emerges, how much humidity or warmth it requires to hatch out, where it feeds and how quickly it reproduces. Once you understand the cycles, you can try to figure out ways to disrupt them.”

—Eric Strandberg
Tonasket, Washington

tomatoes in eastern Pennsylvania and sometimes has problems with slugs, puts a few boards or buckets out in the field to serve as slug monitoring stations.

Biological and physical controls can be essential in high-value crops. Use of Bt (*Bacillus thuringiensis*) in brassica crops, SurroundWP (kaolin clay) in cucurbit crops, and row covers for salad greens is standard practice among many organic growers. Many vegetables and fruits do require timely and judicious use of permitted insecticides, fungicides, and physical barriers.

Careful scouting to anticipate problems is critical. Time your first spraying with the initial emergence of pests. If the first population is controlled and not allowed to breed, the need for subsequent spraying declines dramatically.

MAKING USE OF APPROVED INPUTS

After all of the methods discussed so far have been tried or considered without success—crop rotations, planting adjustments, resistant varieties, encouragement of beneficials, sanitation, and exclusion, the organic rules permit you to resort to approved inputs.

A word of caution regarding pest management inputs: first, they tend to be expensive, so you want to use them sparingly. second, the weaker ones don't work all that well, and the strong ones work almost too well—which may result in harmful effects to beneficials and the possibility of developing resistance.

The best organic farmers try to use fewer pest-management materials every year. If you find yourself using more and more each year, you should probably step back and have a look at your whole system to see what else you can do to make things work better.

A short guide to organic pest-management materials: The major classes of organic pesticides are microbials, botanicals, synthetics, and minerals. For more detailed recommendations for specific crops and pests, consult the resources listed at the end of this chapter.

Microbial Insecticides

Microbial insecticides are derived from naturally occurring bacteria, fungi, algae, viruses, or protozoans. They suppress pests by producing

a toxin specific to the pest, causing a disease, preventing establishment of other microorganisms through competition, or other modes of action. The most commonly used microbial pesticide is *Bacillus thuringiensis*, or Bt.

As originally discovered, Bt is toxic to the caterpillars (larvae) of moths and butterflies. Several strains of Bt have been developed that control fly larvae and are used against mosquitoes and blackflies. Other major types of Bt are the Kurstaki strain for caterpillar pests (Dipel, Javelin, Thuricide, MVP and other brands) and the san diego or tenebrionis strain for potato beetle larvae (M-One, M-Trak, Beetle Beater, Novodor and others).

Other microbials are available that work as fungicides, such as Mycostop, a soil drench derived from *Streptomyces* fungus, and Gliogard, derived from *Gliocladium* fungus. Both these products are labeled to control root-rotting organisms that cause damping off and similar problems in young seedlings.

A new class of microbial-derived pesticides in organic farming are the spinosads, developed by Dow Chemical under the brand name Entrust. Organic fruit growers have rapidly adopted spinosads for control of pests such as codling moths.

Botanicals

Botanicals are plant-derived materials such as rotenone, pyrethrum, sabadilla, and ryania. Nicotine products, although natural, are not permitted in organic systems due to their high toxicity to animals. Botanicals are generally short-lived in the environment, breaking down rapidly in the presence of light and air. Thus, they provide pest control for only a day or two. Ryania and sabadilla may have some additional residual activity. Botanicals are generally broad-spectrum, so they kill beneficial insects as well.

Garlic and hot pepper extracts—used as repellents, not pesticides—are other botanicals commonly used for organic pest management.

Newer botanical insecticides include products made from extracts of the seeds of the neem tree, native to India. Neem has been used by Indian farmers for centuries. Azadirachtin, the active ingredient of neem extracts, has a very

low mammalian toxicity. It works by inhibiting development of immature stages of many insects and by deterring feeding by adults. Azatin and Align are labeled for many vegetable crops.

Another new botanical that's beginning to see some use in organic farming is orange peel extract.

Synthetics

Synthetic compounds for organic production include soaps and horticultural oil. Soaps are made from potassium salts formulated to act as either insecticides (M-Pede, Safer's Soap) or herbicides (Sharpshooter). Soaps and oils work by dissolving insects' cuticle of protective wax and by smothering soft-bodied insects like aphids and thrips. Application directly onto exposed insects is important. The soap-based insecticides and herbicides are not allowed by all certification groups, so be sure to check with your certifier. Soaps can be toxic to some crops and harmful to some beneficials.

Horticultural and other dormant oils can be petroleum-based but are permitted in organic systems for smothering scale and other insects. There is good evidence that horticultural oils in combination with bicarbonate salts (such as baking soda) can prevent powdery mildew on crops like cucurbits. Stylet oil is one of these. It is good for controlling virus transmissions and many insects.

Some of the best-performing cucurbit powdery mildew controls in our research have been milk sprays. Using milk hand washes is effective in preventing hand transmission of tobacco mosaic virus in tomatoes.

Insect pheromones are a synthetic biochemical product used in organic pest management. However, they are not a pesticide (they don't kill or weaken the insect). Pheromones are naturally occurring chemicals that insects use to locate mates. Synthetic pheromones are used to disrupt insect mating by creating false signals or by luring insects into traps. Pheromone-laced traps are also used to monitor insect populations.

Although disinfectants are not typically considered pesticides, they are important to horticultural production. The synthetic materials chlorine (bleach) and hydrogen peroxide are

allowed in organic systems as dilute solutions to disinfect greenhouse surfaces and tools. Iodine in a phosphoric acid solution can also be effective for bacteria control. This material is not caustic to human skin and is used as a disinfectant in organic dairy operations and in the organic ginger industry in Hawaii.

Minerals

Minerals such as sulfur and copper have long been organic mainstays against fungal and bacterial diseases. Some available formulations are Bordeaux mixture, tri-basic copper, copper hydroxide (Kocide), cupric oxide, copper sulfate, elemental sulfur, calcium polysulfide (lime sulfur), and copper-zinc mixtures. Use these products with caution because of potential phytotoxicity, especially at temperatures over 80°F. Copper is being phased out in European organic regulations, and this may be a harbinger for the United States.

Diatomaceous earth (DE) is made from tiny, single-celled organisms called diatoms, the "shells" of which act as a mineral dust that dries out certain soft-bodied insects. It is more widely used in post-harvest applications than in the field. DE can be effective for slug control, and when combined with Bt and applied to corn silk, gives good control of corn earworms.

So-called particle film products for coating plant foliage have been growing in popularity among organic farmers, especially fruit growers. Kaolin clays are the main particle film used in organics. These have been found effective in managing both insect pests and fungal disease. Surround WP is one common brand.

Again, keep in mind that organic standards require that preventive pest-management measures be used before resorting to inputs. And always check with your certifier—before you buy and apply—if you are uncertain about the permissibility of a particular input.

PLANT DISEASE BASICS

Broadly speaking, diseases are a minor problem for most organic grain farmers, a small to medium-size problem for organic vegetable growers and a medium to large problem for organic fruit growers. Organic farmers ranked pest and disease management fourth on a list

of research priorities in the Organic Farming Research Foundation's most recent national survey (2017). Farmers listed weed control, building soil health and fertility, and coping with water management during drought and flooding as major research priorities for US organic farmers.

The prevalence of plant diseases is determined by three factors, sometimes referred to as the "plant disease triangle:"

1. Plant susceptibility
2. Presence of pathogens
3. Environmental conditions favorable to disease development

As farmers, we can minimize disease by paying attention to all of these. We can provide good growing conditions to raise healthy plants that will be less susceptible to disease organisms in the environment. We can choose resistant varieties. We can implement crop rotations, remove diseased plant materials and practice other sanitation controls to limit pathogen populations. And we can alter environmental conditions to reduce disease transmission by using drip irrigation instead of sprinklers, for instance, adjusting planting dates or increasing crop row spacing to allow for better airflow.

Most infectious plant diseases are caused by fungi, bacteria, viruses, or nematodes. As with weeds and insects, not all of these kinds of microbes are bad—there are many species of beneficial nematodes, bacteria, and fungi that attack pest insects, and dozens if not hundreds of microorganisms that help break down plant materials in the soil and make nutrients available to crop plants.

RECOGNIZING DISEASE SYMPTOMS

Plant-disease symptoms include root rots, blights, rusts, smuts, wilting, leaf spots, mottling, and other types of necrosis or dying of plant tissue. Keep in mind that some "sick" plant conditions commonly referred to as diseases are in fact physiological responses to environmental factors such as nutrient deficiencies, waterlogging, or air pollution. An example is blossom-end rot in tomatoes and other crops, which is caused by calcium deficiency.

Again, as with weed and insect management, disease management in organic systems emphasizes prevention over rescue treatments. Choosing crops well-suited to your growing conditions, fostering balanced soil fertility, and scheduling planting to meet optimum soil temperatures for germination can all go a long way toward promoting crop health and avoiding disease. Some disease pathogens, including *Fusarium*, *Pythium*, and *Phytophthora*, benefit from excessive N, which can result from over-application of composts just as readily as from synthetic N sources.

Watch for Drift

Disease-like symptoms can also be caused by herbicide drift, which obviously can be a serious issue for organic growers. Drift of the herbicide 2,4-D can cause symptoms even at very low concentrations on sensitive crops such as grapes and soybeans. If you suspect that your crops have suffered from herbicide drift from a neighboring property, document what you've found by noting the date, taking photos and collecting leaf samples. Talk to your neighbor about what you see and to your certifier. If you're very concerned about drift potential, you should probably re-examine your buffer zones.

ROTATIONS, ROTATIONS, ROTATIONS

We have already talked a lot about the importance of diverse crop rotations in organic farming systems. Disease management is one of the major reasons why. For field crops especially, there's a large group of diseases often called "rotational diseases" because they overwinter in the soil and can readily infect subsequent crops if the rotations aren't long or diverse enough.

In general, rotations can be very effective in limiting diseases harbored in the soil or in crop residues, but are less effective in managing aerial and seedborne diseases. Depending on your local topography and what other types of farms are in your area, you may be able to use some fields as "isolation areas" for crops susceptible to windborne disease.

CHOOSE RESISTANT VARIETIES

Using resistant varieties is more important for disease management than for insect pest management, and more important in organic than in non-organic farming.

Study seed catalogs carefully to identify the traits most important to you. Talk to your fellow growers and make notes on your own experience with disease problems with different varieties. Plant pathologists make a distinction between “tolerance” (the ability of some plants to maintain yields in the presence of a pest or disease) and true “resistance” (the ability to successfully fight off a pest or disease, for instance through the production of special chemical compounds).

Both of these plant defenses work and should be a major consideration as you select the varieties you want to plant from year to year. Together, these kinds of inherited resistance are also referred to as “constitutive” resistance, as opposed to “acquired” or “induced” resistance, another set of mechanisms by which plants can fight off pests and pathogens. We talked about “systemic acquired resistance” briefly in the previous section of this chapter.

RESEARCH

Plant breeders talk about two types of resistance exhibited by plants: vertical and horizontal. Vertical resistance is relatively easy for breeders to work with because it usually involves a small number of genes. The downside is that because it relies on just a few genes, it can be overcome fairly easily by evolutionary change on the part of the pathogen. This is why breeders are constantly developing and releasing new crop varieties.

Horizontal resistance is conferred by multiple genes and is thus much more stable. It’s also more challenging to work with and has been largely ignored by mainstream breeding programs. (It’s also difficult to patent, making it much less commercially attractive.) Advocates of horizontal resistance consider that it is particularly well suited to organic farming systems.

KEEP IT CLEAN

The next major element of a successful organic disease-management program is sanitation. Sanitation can take many forms and is applicable to nearly every stage of the growing cycle, from seed to harvest. Organic farmers must be particularly careful to avoid disease-infested seed and seedlings, since organic seed and plant producers cannot use the standard chemicals to sanitize their stock. Check out your potential seed and transplant sources carefully, and consider using hot-water treatments to sanitize seed yourself. (Note: Follow specific directions for this practice, since hot water can damage seed viability.)

Sanitation is fundamentally a preventive strategy, although it can be part of rescue treatments as well. Other examples of good sanitation practices include:

- Pruning and destroying diseased plant parts
- Prevention and elimination of disease-hosting weeds
- Prevention of volunteers from previous crops that can carry diseases into subsequent seasons
- Cleaning and disinfecting tools and equipment, including seedling flats and tomato stakes
- Avoiding movement of soil or tools from diseased areas to disease-free areas on the farm
- Asking visitors to the farm to disinfect their boots or shoes
- Isolating new livestock downwind for a period of time before introducing them to the remainder of the farm
- Deep tillage to bury diseased crop residue (although this should be balanced against the value of leaving residues on the surface to protect soils from erosion)

GET AN IDENTIFICATION

When you do encounter a disease problem, obtaining a good diagnosis is the first step toward figuring out how to correct it. Keep in mind that

the symptoms of many diseases can look similar, so expert analysis is sometimes needed.

Once you have an identification, you can start to understand the pathogen's life cycle and then think about how to interrupt that cycle so as to minimize its impact on your crops. Organic disease management can come down to small, simple things like cutting broccoli heads off at an angle so that water won't collect on the stalk surface left behind or creating a place for brassica head rot bacteria to collect and reproduce. It is also essential to have well-trained employees who will follow good harvesting and other sanitation practices and who will keep an eye out for emerging symptoms while they are in the fields.

CULTURAL DISEASE MANAGEMENT

For fruit and vegetable crops, and to a lesser extent, field crops, managing your plant spacings and "crop architecture" to promote good airflow can go a long way toward minimizing disease. Growing soybeans in rows instead of a solid stand is a good example. It can also help to plant crop rows parallel to the direction of prevailing winds. Grapes and fruit trees that are well pruned and trained are usually less susceptible to diseases. Although it is labor-intensive, staking tomatoes and even eggplants and peppers can pay off in terms of reduced disease levels and harvesting efficiency.

Irrigation methods also play a major role in disease development and severity. Using drip irrigation instead of overhead sprinklers, or irrigating at night so foliage can dry off in the daytime will make your crops a less inviting environment for many diseases. Harvesting tomatoes later in the day, after the dew has dried off the foliage, is critical to preventing spread of diseases.

The effectiveness of straw mulches in reducing splash-borne diseases in potatoes and strawberries has been demonstrated by researchers. Many vegetable crop diseases thrive in wet conditions and can be minimized by planting on raised beds to improve drainage. Row covers can also be effective for limiting diseases, especially those spread by insect vectors, like cucumber beetle-induced bacterial wilt in

cucurbits.

Another positive development is the interaction taking place between organic farmers, researchers and integrated pest management. Although most IPM programs include occasional use of synthetic inputs off limits to organic producers, many extension services and consultants now offer recommendations specifically tailored to organic systems.

Tree fruit growers who have transitioned to organic are applying their knowledge of IPM monitoring techniques to organic systems, making organic materials more effective, for instance, by timing applications to the most vulnerable stages of pest and disease life cycles.



Photo Credit: Greg Endres

Planting soybeans in rows rather than a solid stand is one good way to minimize disease.

THE ROLE OF COMPOST

One reason why crop diseases seem to be less of a problem for organic farmers than for non-organic farmers has to do with the influence of compost. As discussed in the Soils chapter, compost is a living biological substance containing tens of thousands of microbes all feeding on one another and contributing to the complex soil food web. Because most organic farmers make regular use of composts of one type or another (along with other good soil-management practices like

crop rotations and green manures), organically managed soils are more likely to host a range of beneficial microorganisms that can help keep pathogens in check.

These effects are well documented by scientific studies. Soilborne root diseases, for example, have been shown to be less severe in organically grown crops than in non-organic ones. Composts have also been shown to promote “induced resistance” in crops to certain pathogens. In one experiment, composts applied to soils induced resistance to a fungal disease in plant foliage as well as root resistance to the soilborne disease Pythium.

There are a few diseases and pests, such as Rhizoctonia and symphylans, which enjoy the high soil organic matter levels promoted by organic management and can be difficult to manage. On the whole, though, organic farming will put you ahead on the disease front. Sometimes you just have to take the bad with the good.

Given the strong evidence that composts can keep some diseases at bay, it is not surprising that compost teas have attracted a lot of attention as a potential disease-management material. Compost teas are “brewed” by soaking compost in water, often in special aerated tanks and with additional ingredients such as dried molasses or fish oil.

RESEARCH

Rodale Institute conducted a two-year study of compost tea’s effectiveness in suppressing disease in grapes, pumpkins and potatoes. Results were mixed. The tea showed some ability to limit powdery mildew in grapes, but had no effect against diseases in pumpkins. The tea had a positive impact on plant health and yields in potatoes in one year, but not the other. Overall, we concluded that while compost teas alone do not make for an effective plant health program, they can complement other measures.

WEATHER MONITORING

Weather monitoring can be a critical part of an integrated pest-management program. New technologies make it possible to use small, computerized weather stations at different points on your farm to help anticipate pest and disease

pressures. By collecting temperature, humidity, wind, and leaf wetness data and then analyzing them with special software, such weather stations can project apple scab and fire-blight potential, for instance.

Doing your own weather monitoring is important because disease conditions in your orchard or on your farm can be different from those predicted by the local extension agent’s weather data.

SUMMARY

You, too, will gain entomology experience as you identify pests on your farm. Pay close attention to signs of pest activity in crops. Watch to see if they spread. Take action before the level of damage exceeds what you can tolerate for the markets you’re targeting.

Look for pest-resistant varieties. Focus on prevention and the use of cultural pest-management methods. If all else fails, consider the use of approved inputs.

Disease management begins with understanding plant disease basics. Remember, the prevalence of plant diseases is determined by the plant disease triangle: plant susceptibility, the presence of pathogens, and environmental conditions favorable to disease development. Learn to pay attention to all these factors. Select



Potato beetle

Photo Credit: Scott Bauer

disease-tolerant or resistant plant varieties when possible. Observe good sanitation practices.

Last but certainly not least, don't forget to fill out the pest and disease management sections of your Organic System Plan.

LESSON 5: WILDCRAFTING

OVERVIEW

Although it may seem logical to assume that any crop harvested in the wild should qualify as organic, in practice "wild" areas are highly variable and may be subject to contamination. For example, roadsides can be contaminated with heavy metals and soot from vehicle exhaust. Many railroad embankments and power line rights-of-way are sprayed with herbicides periodically. As a result, wildcrafted crops must meet organic regulations if they are to be sold as organic.

The list of crops for potential wildcrafting is long and varied. Some of the more common are mushrooms, tree nuts, and wild rice. Certain types of algae used in organic food processing are harvested from natural lakes in southern Oregon. Non-food crops like prairie plant seed can also be wildcrafted.

Strong markets exist for a wide variety of wildcrafted, native annual and perennial herbs.

WHAT THE STANDARDS SAY ABOUT WILDCRAFTING

The "Wild crop harvesting practice standard" (§205.207) is among the shortest sections in the federal organic regulation. It includes two key requirements. Crops must be harvested:

- "from a designated area that has had no prohibited substance ... applied to it for a period of three years immediately preceding the harvest of the wild crop;"

GLOSSARY TERMS

Prohibited substance: A substance the use of which in any aspect of organic production or handling is prohibited or not provided for in the Act or the regulations of this part. (*NOP definition*)

TO CERTIFY?

A key question for wildcrafters is whether organic status is necessary for a given market. In Missouri, for instance, a group called the Missouri Northern Pecan Growers obtained organic certification for its members' sustainably managed wild pecan groves. Ranging in size from two to 500 acres, the groves are self-sown but actively managed through thinning and pruning.

For these growers, certification has been key to market development—sales quadrupled in two years, and they've begun selling overseas. Some Native American wild rice harvesters in northern Minnesota, on the other hand, have chosen not to seek organic certification, focusing instead on fair trade and other types of authentication.

- "in a manner that ensures that such harvesting or gathering will not be destructive to the environment and will sustain the growth and production of the wild crop."

Organic crops harvested in the wild can thus come from land that is not itself technically certified, although it must meet the same basic requirements as certified acreage. Certifiers may ask for harvest locations, field management histories, descriptions of buffer zones, and/or affidavits of adjoining land use. They will want to know about your harvesting methods and crop handling practices.

If the land you are harvesting from is not your own, it is a good idea to obtain written permission from the landowner. Depending on the crop and the location, you may need to obtain other forms of documentation as well. For example, in some states, a permit is required to collect wild ginseng. Regulations like these exist to protect wild plant resources from over-harvesting.

RESEARCH YOUR MARKETS FIRST

Wildcrafting can be a terrific way to diversify your farm income. Think of it as a bonus for managing your farm in a way that protects and nurtures wild species. Or as an excuse to go for a

walk in the woods on a beautiful spring morning. Or as a way to share with your customers some of the best things about farming as a way of life, from finding mushrooms to making dandelion wine. Wild-harvesting can also play a role in neighborhood bartering networks.

But before you go gathering more than you and your family can immediately use, research your markets. Here on the East Coast, the company Herbalist & Alchemist purchases organically grown and ethically gathered plants for the production of whole plant extracts and other herbal products. The following is a short list of herb companies to contact for potential marketing of wildcrafted or homegrown herbs. Many other good companies exist as well.

AmeriHerb, Inc.: Bulk herbs and spices, 500+ organic and wildcrafted herbs. Phone: 800-267-6141, <http://www.ameriherb.com/>

Herbalist & Alchemist: Compound herbal formulas, single herb extracts, tea blends and bulk herbs, oils and ointments, educational materials. Phone: 908-689-9020, <http://www.Herbalist-chemist.com>

Jean's Greens: Organic and wildcrafted herbs, herbal teas, tinctures, and bulk essential oils. Phone: 888-845-TEAS (8327), <http://www.jeansgreens.com>

Mountain Rose Herbs: Bulk herbs, herbal oils, herbal extracts, and teas. Phone: 800-879-3337, <http://www.mountainroseherbs.com>

San Francisco Herb Co.: Quality herbs and green teas. <http://www.sfherb.com>

FARMER-TO-FARMER

"We have elderberry trees on our farm entirely by accident. Seeing the boughs loaded made me wonder how I might sell the berries. I've taken them to the farmers market in San Francisco, where the purple berries add a dash of novelty to our stall, and some chefs have purchased them to jazz up their menus. For me, the most fun has been inviting customers out to the farm to pick their own."

—Andy Griffin
Watsonville, CA

KNOW YOUR NATIVE ZONE

One reason there's a strong market for wild-harvested herbs is that many people believe wild herbs are purer and more potent than cultivated varieties. Rodale Institute wildcrafts many of the following species in the native woodlands that form part of our Pennsylvania farm. Use the resources listed at the end of this chapter to create a similar list for your area.

- Barberry (*Berberis vulgaris*)
- Bayberry (*Morella cerifera*)
- Blackberry (*Rubus fruticosus*)
- Black cohosh (*Cimicifuga racemosa*)
- Black haw (*Viburnum prunifolium*)
- Black walnut (*Juglans nigra*)
- Blue cohosh (*Caulophyllum thalictroides*)
- Blue vervain (*Verbena hastata*)
- Boneset (*Eupatorium perfoliatum*)
- Burdock root (*Arctium lappa*)
- Butternut (*Juglans cinerea*)
- Chickweed (*Stellaria media*)
- Dandelion (*Taraxacum officinale*)
- Elderberry, elderflower (*Sambucus nigra* subsp. *canadensis*)
- Ginkgo (*Ginkgo biloba*)
- Goldenseal (*Hydrastis canadensis*)
- Hawthorn (*Crataegus* spp.)
- Horsetail (*Equisetum arvense*)
- Juniper berry (*Juniperus communis*)
- Lobelia (*Lobelia inflata*)
- Mullein (*Verbascum thapsus*)
- Peppermint (*Mentha x piperita*)
- Raspberry (*Rubus idaeus*)
- Solomon's seal (*Polygonatum biflorum*)
- St. John's wort (*Hypericum perforatum*)
- Stinging nettle (*Urtica dioica*)

TEN RULES FOR WILDCRAFTING

1. Prepare by taking an herb (or mushroom or tree) identification course, studying guidebooks, or crafting with an

- experienced wildcrafter to become familiar with wild plants.
2. Keep a journal to record plants identified, the condition of the population, and precise locations, dates and amounts harvested. This is critical for certification and will also help you find the plants more easily the following year.
 3. Become familiar with the poisonous plants that grow in your area and be aware of look-alikes.
 4. Seek permission for collecting at a site. You may need a permit to harvest on public lands.
 5. Do not harvest endangered, protected, or sensitive-to-disturbance species. Check with the U.S. Fish and Wildlife Service, the Department of Agriculture, and/or the Native Plant Society to determine plants that are federally protected. When in doubt, leave the plants alone.
 6. A wildcrafter should never damage or deplete a plant community. Guidelines for sustainable harvesting recommend taking at most one in three or one in four individuals in a stand. Many crafters take only one in 10 in order to maintain the ecological and aesthetic balance of the site.
 7. Never harvest more than you can process promptly.
 8. Harvest only healthy specimens that are not contaminated in any way.

9. Consider your impact on the land before you harvest. Fill in any holes and clean up any debris—the area should be left in pristine condition. Minimize disturbance to insects, animals, and plant pollinators.
10. Process harvested plants as soon as possible after they have been gathered. Plant material must be fresh and unspoiled for the best-quality medicine or product.

SUMMARY

In the process of wildcrafting, be mindful of the fact that wild areas are highly variable and may be subject to significant potential contamination. If you harvest crops in the wild, make sure they meet organic regulations if you want to sell them as organic. Be aware that roadsides can be contaminated with herbicides, heavy metals, and soot from vehicle exhaust.

If you intend to seek organic certification for any wild-harvested crops, take some time now to fill out the relevant question in Section 5 of your Organic System Plan.

CONCLUSION

This concludes the Crops chapter. Plan your crop rotations carefully, making sure your rotation plan has the right crops that will give the right soil impact. Think about the economic viability of your crop rotation plan and your resources. Try to use rotations that suppress weeds. Think about delaying tillage to give seed predators more time to feast on weed seeds.

When you source seed, research and double-check seed packages or bags before purchasing. Make sure you source seed and planting stock in accordance with NOP regulations.

Brush up on your entomology skills as you identify pests on your farm. Give beneficials a chance to bring pests into balance, but take action before the level of damage exceeds what you can tolerate for the markets you are targeting for that crop.

Select pest-tolerant and disease-tolerant or resistant plant varieties when possible. Observe sanitation rules, and focus on prevention. Emphasize cultural pest- management methods. If

THE WILDCRAFTER'S ETHIC

The second part of the NOP wild- harvesting standard—the part about harvesting so as not to damage the wild population—is obviously open to interpretation. Fortunately, the wildcrafting community has developed its own set of guidelines congruent with the NOP Standards, and the ethics of wildcrafting are more or less commonsense once you start thinking along ecological lines. Mushroomers use mesh bags to bring their “crops” in from the fields, for example, so that spores from the mushrooms can disperse through the woods.

all else fails, consider the use of approved inputs.

You can use what you've been learning in this chapter to work on sections 2, 3, 4 and 6 of your Organic System Plan.

RESOURCES

Resources are free online unless otherwise noted.

GENERAL

[The New Organic Grower](#)

By Eliot Coleman

(Chelsea Green Publishing, 1989)

The new generation market gardener's bible.

Although some details have been improved upon by others, this sets the standard for meticulous, well-planned small-scale organic vegetable production.

\$24.95, 352 pp.

Includes sections on site selection, construction, environmental management, soil and crop management, pest management and marketing. Also features case studies of six different farmers using high tunnels. Free download, 75 pp.

[Four-Season Harvest](#)

By Eliot Coleman

(Chelsea Green Publishing, 1992)

A guide to raising winter vegetables at the 44th parallel, in tunnel greenhouses and cold-frames without supplementary heat.

(\$24.95, 236 pp.)

COVER CROPS AND CROP ROTATIONS

[Managing Cover Crops Profitably](#)

Edited by Greg Bowman

(Sustainable Agriculture Network, 1998)

Called "the most comprehensive book ever published on the use of cover crops to sustain cropping systems and build soil." Provides detailed information on top regional species, performance statistics, cultural traits, planting specifics, pros and cons of 18 different leguminous and non-legume cover crops. \$19.00, 212 pp.

[Guide to the Expert Farmers' DACUM Chart for Managing Crop Rotation Systems](#)

(Northeast Organic Network, 2002)

The NEON project gathered 12 experienced organic vegetable farmers, put them in a room and produced this stunning chart outlining real-life, practical 4- and 5-year crop rotation sequences with multiple variations. A real head-scratcher, in the best possible way. (free download, 4 pp. PDF format)

WEED MANAGEMENT

[Integrated Weed Management: "One Year's Seeding..."](#)

Edited by Adam Davis

(Michigan State University Extension Bulletin E-2931, 2005)

Probably the best extension publication on the topic. Combines farmer tips, cutting-edge research results and helpful illustrations. Also includes herbicide guidelines for organic and reduced input management and species profiles for a dozen problem weeds. \$13.75, 120 pp.

["Principles of Sustainable Weed Management for Croplands"](#)

By Preston Sullivan

(NCAT/ATTRA, 2003)

A bulletin discussing the basics of weed ecology, cropping system design to minimize weed pressure and alternative weed management methods such as flameweeding and weeder geese.

(Free download, 15 pp. PDF format)

[Vegetable Farmers and Their Weed Control Machines](#)

(University of Vermont Extension, n.d.)

A 75-minute video on cultivation and

SEEDS & PLANTS RESOURCES

[High Tunnels: Using Low-Cost Technology to Increase Yields, Improve Quality and Extend the Season](#)

By Ted Blomgren and Tracy Frisch

(University of Vermont Center for Sustainable Agriculture, 2007)

flameweeding equipment as used by nine farmers in three Northeast states.
(\$15 DVD, \$5 VHS)

PEST AND DISEASE MANAGEMENT

[ATTRA's Pest Management Resources Page](#)

Includes many valuable short publications on specific disease management issues, including "Organic Control of White Mold on Soybeans," "Notes on Compost Teas," "Use of Baking Soda as a Fungicide," "Downy Mildew Control in Cucurbits," and "Organic Alternatives for Late Blight Control on Potatoes." A longer, more general ATTRA publication is their resource on Biointensive Integrated Pest Management. (free downloads, PDF format)

[Manage Insects on Your Farm: A Guide to Ecological Strategies](#)

By Miguel A. Altieri and Clara I. Nicholls
with Marlene A. Fritz

(Sustainable Agriculture Network, 2005)

Contains a number of strategies for controlling pest insect populations through the management of beneficial predator populations, and stresses increasing above- and below-ground diversity, enhancing plants' natural defenses, and managing soil as means to this end. \$15.95, 128 pp., also available for free download, PDF format

WILD-CRAFTING

[The EchoHerbalists Fieldbook: Wild-crafting in the Mountain West.](#)

By Gregory Tilford

(Mountain Weed Publishers, 1993) \$24.50,
295 pp.

[The Encyclopedia of Edible Plants of North America](#)

By Francis Couplan

(Keats Publishing, 1998)

Details over 4,000 edible wild plant species, their distribution and general edibility; a truly encyclopedic resource in one handy

volume.
\$19.95, 570 pp.

[Identifying and Harvesting Edible and Medicinal Plants in Wild \(and Not So Wild\) Places](#)

By Steve Brill

(HarperCollins, 2002)

Features information on finding and using more than 500 different wild plants medicinally and for general health, and includes more than 260 detailed line drawings and over 30 different recipes.
\$23.00, 336 pp.

[Medicinal Wild Plants of the Prairie: An Ethnobotanical Guide](#)

By Kelly Kindscher

(University Press of Kansas, 1992)

[Planting the Future: Saving Our Medicinal Herbs](#)

By Rosemary Gladstar and Pamela Hirsch

(Healing Arts Press, 2000)