



# **Cover crops on the intensive market farm**

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# Cover crops on the organic market farm

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## Introduction

Crops that are grown solely to provide soil cover or for the purposes of increasing soil fertility are referred to as cover crops or green manures. In general, these crops are incorporated into the soil while green or just after flowering. Due to their ability to protect and enhance soils, cover crops are considered a fundamental aspect of any sustainable cropping system. However, the benefits of cover crops extend beyond soil quality. In particular, more and more growers are realizing the insect, disease and weed management benefits of cover crops.

This publication is meant to serve as a practical guide to using cover crops on small- to moderate-size fresh market vegetable operations. For more complete and thorough information on cover cropping principles, see the “Other recommended resources” section on page 15.

## The benefits of cover cropping

Cover crops bring a host of benefits to farms of all types. Due to the intensive nature and high fertility needs of fresh market produce farms, cover crops assume a vital role. By using rotations of both leguminous and nonleguminous cover crops, growers can begin to “close the nutrient loop” on their farms and rely less on purchased and imported fertilizers. The soil quality benefits of cover crops include:

- protection against soil erosion
- building and maintaining both active and stable organic matter
- improving soil structure and tilth
- improving the capillary action, or upward movement of water, within soils
- increasing the biological activity in soils
- the fracturing of hardpan by deeply rooting cover crops
- the addition of nitrogen to the soil by legume cover crops (peas, clovers, vetch, etc.)



*Cover crops at work: fall-planted rye on the left, spring-planted oats on the right*

On market farms using organic and other sustainable agricultural practices, cover crops also can play an extremely important role in managing weeds, insects and

diseases. One fundamental way to minimize the impact of pests is to ensure overall plant and crop health. By improving soil quality and fertility, cover crops contribute to a holistic pest management strategy. However, there are more direct benefits as well. Cover crops can:

- smother or suppress weeds
- break insect and disease cycles, and provide habitat, pollen and nectar for beneficial insects

Additional benefits of cover crops include:

- providing animal feed
- providing a source of mulch
- adding to farm aesthetics
- helping balance the stress of increased production with the satisfaction of soil building



*Oats and vetch are a great cover crop combination*

## Questions and challenges

The benefits of cover crops seem clear. But questions and challenges remain as vegetable growers at different scales of operation try to maximize those benefits, given the limitations of time and equipment. One challenge is the relationship between soil building and tillage. The most commonly employed implements on most market farms—namely the rototiller, moldboard plow and disc—can damage soil structure. It is easy to overwork the soil, especially when growing on a small scale and relying on a rototiller for field preparation.

Another challenge facing market growers is how to balance soil building and fertility management with the demands of succession planting and harvesting. The demands of making a living on the land may not always align with the needs of the soil. Furthermore, many market growers lack enough land to implement adequate cover crop rotations—especially longer term rotations involving season-long cover crops. Market growers who farm near urban areas with high land prices can be pressured into pushing the land to produce as much as possible.

Finally, how can growers maximize the pest management benefits of cover crops? There is both anecdotal and researched evidence about cover crops reducing weed, insect and disease pressure, but far more research and experimentation is needed in order to maximize and consistently replicate beneficial results.

## The market farmer's advantage

While market farmers face the real challenges of time availability, lack of necessary equipment, land availability and economic pressures, they have some advantages as well.

1. Short season vegetables allow for many cover cropping options.
2. Small fields are ideal for experimenting with a wide range of cover crop varieties.
3. Cover cropping can create interest and open doors with neighboring farmers.
4. Cover crops make a garden or market farm look lush and dynamic throughout the entire growing season.
5. Cover crops help keep growers' busy lives in balance by keeping them focused on long-term soil building in addition to the next day's produce delivery.

There is no shortage of creative, devoted market growers who are adept at finding new solutions to age-old problems. The rest of this publication is devoted to sharing ideas and information that will help both new and experienced vegetable growers make the best use of cover crops in their farming systems.

## Equipment needed to effectively manage cover crops

**Seeding:** A simple broadcast seeder can be used on a small (garden) scale with good success. A drag, harrow or cultipacker helps cover seeds and provides adequate seed to soil (seed to moisture) contact. Many market farms use old six-foot grain drills to plant cover crops. These can be found at auctions or used equipment dealerships for a reasonable price (\$100-400). The hand-pushed Earthway seeders that growers commonly use to plant vegetable seeds can also be used for drilling in cover crops on a small scale, or in narrow strips or beds. Compared to broadcast seeding, less seed is needed for drilling and more uniform stands can be achieved. Even with a drill, a cultipacker will hasten germination. Higher seeding rates are used for grasses and legumes grown as cover crops than for seed or forage production. Like all plants, cover crops need water to germinate. Timing a planting before rain is ideal. As a last resort, sometimes overhead irrigation is used in order to germinate a cover crop in a timely manner and get a jump start on any weed species present.

**Residue management:** A flail chopper (or stalk chopper) is the implement of choice for cutting or clipping cover crops before the residue is incorporated into the soil. A small (6') used flail chopper can be purchased for around \$300 to \$1,000. These



*A small seed drill works well for planting cover crops*



*A flail chopper works well for clipping cover crops*

require a tractor with sufficient horsepower: at least 30 to 40hp. Old sickle bar mowers are often less expensive, but they do not chop as finely and can leave a relatively thick mat of vegetation. Furthermore, a sickle bar mower often cannot handle a dense stand of vetch. Without tractor-mounted implements, it is wise to clip more often so as to avoid a tall, dense stand. A good tool for clipping at a small scale is a walk-behind sickle bar mower—although these can be expensive. Rotary mowers can also be used, especially for cover crops that become too tall or dense for a flail chopper. In a small market garden, it is best to stick with low-growing, “succulent” covers such as oats, peas and low-growing clovers. Avoid dense, matting cover crops such as hairy

vetch that are very difficult to manage with small scale equipment. Appendix A on page 16 includes cover crops that are best suited for smaller-scale growers.

Mowing at the flowering stage is the most effective way to kill a cover crop before incorporation (or if using the cover crop to produce a layer of mulch). Another option is to use a roller-crimper. This kills and lays down the cover crop to form a mulch residue. For more on this technique, see “No-till vegetables” on page 8.

***Tillage:*** Cover crops are most commonly incorporated with rototillers at smaller scales, and tractor-mounted rotovators at larger scales. Spaders, either walk behind or tractor mounted, can also be used. These do less damage to soil structure than rototillers. A more traditional approach is to turn under cover crops using a moldboard plow and then follow this with a series of cultivations using some combination of a disc, field digger and harrow. Turning the cover crop under, however, places it in an anaerobic, or oxygen deprived, environment—not the ideal condition for decomposition. Inverting the soil also brings weed seeds to the surface where they can germinate. Field diggers and power harrows are effective tools that are gentler on the soil. The following basic sequence, used by Dan Guenther at Common Harvest Farm in Wisconsin (2), will incorporate most cover crops and create a nice seed bed:

1. First, flail chop the cover crop.
2. At least 24 hours later, follow with a field digger with sweeps that operate at four to six inches deep.
3. Follow with a power harrow—such as a Lely Rotera—or a rotovator. The power harrow will stir the soil and lightly incorporate the residue without inverting the soil profile. The rotovator will chop and mix the cover crop into the soil.
4. Finally, use a chisel plow that operates at 12 to 18 inches deep to aerate the soil and lay out your beds.

Between stages 3 and 4, you can allow some weeds to germinate and use the harrow again to create a clean seed bed.

If a moldboard plow or disc are used—these tools move soil horizontally and can create a plow pan—it is recommended to alternate their use with tools that work vertically, like chisel plows and subsoilers.

At a small scale, rototillers or small spading tillers are about the only options (aside from hand digging). Because rototillers can damage soil structure—especially if they are overused—it is generally best to use them at shallower depths and at lower revolutions per minute (RPMs). Another option is to hire a neighboring farmer to till your soil with a tractor-mounted digger and/or chisel plow before using a rototiller for final seedbed preparation.

Regardless of the tools employed, keep them in working condition so that when the time comes to plant, clip or till, you can act quickly and efficiently. Timing is important, and you need to be ready to take advantage of relatively short windows of opportunity during various seasons and between rainstorms.

The vegetable crop that follows the cover crop often determines when the cover crop is killed and incorporated. However, early or delayed incorporation can have negative consequences. Researchers recommend tilling just before or at full bloom. This results in slower decomposition of the cover crop residue and a release of nutrients over a longer period of time. “Incorporating before bloom when foliage is green and succulent results in rapid increase in soil biological activity, rapid decomposition of the cover crop, and a quick release of nutrients into the soil” (5). If mowing and tillage occur after bloom, the cover crop may reseed itself. Furthermore, waiting too long also results in higher carbon to nitrogen ratios. This slows decomposition and delays nutrient availability. “In most cases, it is necessary to make tradeoffs between practices that maximize the growth of the cover crop and practices that maximize the marketable yield and profitability of the vegetable crop grown that season” (5).

Some growers leave cover crop residue on the surface as mulch and use no-till transplanting or strip tilling in order to reduce tillage and control weeds. For more on this, see the “No-till vegetables” section on page 8.



*A field digger and spike tooth harrow can be used to prepare the ground for seeding*

## Cover cropping sequences

There are several different windows of opportunity for planting cover crops and a variety of possible cropping sequences, based on the length of the cropping season. For example, in a field or section of a field that will be planted to early spring crops (peas, spinach, radishes, etc.), it is best to plant a cover crop the preceding fall that will winterkill, making it easy and quick to till and plant in the early spring. In an area that will be planted later with main season crops (such as tomatoes, peppers or squash), a perennial cover such as winter rye can work well. This strategy will prevent soil erosion and keep weeds in check until it is time to till and plant. There are many options for a full season of cover cropping. The following are sample sequences that market growers in the Upper Midwest have found useful and successful.

### Cover crop options

(Crops listed by season planted. Specific planting times are included in Appendix A.)

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<b>Spring</b>	<b>Summer</b>	<b>Fall</b>
Mow fall seeded rye/vetch	Rape	Rye
Oats and peas	Millets	Rye and vetch
Nitro alfalfa with oats	Sudangrass	Winter rape
Berseem clover	Oats and peas	Peas
	Buckwheat	Turnips
	Clovers	Oats
	Fallow cycle (for weed control)	

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#### *Cover cropping sequence notes:*

- A one- to three-week fallow cycle serves as a transition between each cover crop and garden crop. This fallow period is an opportunity to allow weeds to germinate. A shallow cultivation just after weeds germinate provides a stale seed bed for the coming garden crop. Over time, these fallow periods can be reduced as weed pressure diminishes.
- Garden crop foliage should be flail chopped shortly after harvest is complete in order to expedite cover crop seeding.
- Most cover crops (except buckwheat) can be clipped one to three times to encourage tillering. Tillers are shoots that sprout from the base of grass plants. Clipping also prevents the cover crop from going to seed and becoming a weed in the next garden crop. It also prevents the growth of a dense stand that makes cutting and incorporating difficult with smaller scale equipment. This is especially true for Sudangrass and millet.
- Buckwheat can become a weed if the seeds are allowed to mature. The challenge is to walk a fine line between providing flowers for pollinators and clipping the stand before it has set too much seed.

## Cover crop sequence options<sup>1</sup>

Full Fallow Season			
<b>Spring</b> Crop residue or cover crop from previous fall	<b>Summer</b> Buckwheat OR Sudangrass	<b>Fall</b> Oats and peas	<b>Spring</b> Spring vegetable crops
Crop residue from previous fall OR spring-sown oats and peas	Buckwheat	Winter rye	Plow rye 2-3 weeks before planting a vegetable crop Summer/fall vegetable crops
Oats and nitro alfalfa or oats and clover	Mow oats to prevent seed set	Overseed winter rye into nitro alfalfa, which will winterkill or leave clover to overwinter	Summer/fall vegetable crops
Clover or clover/grass mixture planted previous June or July	Mow, plow and fallow period to express and cultivate weeds	Rye/vetch OR oats and peas	Summer/fall vegetable crops OR spring vegetable crops
Early Spring Garden			
<b>Fall</b> Oats and peas that winterkill	<b>Spring</b> Early spring vegetable crops	<b>Summer</b> Buckwheat or Sudangrass or oats and peas	<b>Fall</b> Winter rye or rye/vetch mix or leave oats/peas to winterkill
Fall plowed field	Early spring vegetable crops	Buckwheat or Sudangrass or oats and peas	Winter rye or rye/vetch mix or leave oats/peas to winterkill
Main Season Garden			
<b>Fall</b> Winter rye or rye/vetch mix	<b>Spring</b> Plow rye 4-6 weeks before planting vegetable crop	<b>Summer</b> June-planted vegetable crops	<b>Fall</b> Winter rye or oats
Clover or clover grass mixture	Plow clover 3-4 weeks before planting vegetable crop	May and June-planted vegetable crops	Winter rye or oats
Oats and vetch planted in late August or early September	Plow vetch 3-4 weeks before planting vegetable crop	May and June-planted vegetable crops	Winter rye or oats
Fall Garden			
<b>Fall</b> Clover or rye	<b>Spring</b> Mow as needed to control weeds or manage cover crop	<b>Summer</b> Garden planted in July and August	<b>Fall</b> Leave crop residue or seed winter rye in crops harvested before early October

<sup>1</sup>Adapted from a handout created by Dan Guenther, Common Harvest Farm, Osceola, Wisconsin

- Winter rye is an aggressive plant that can regrow under moderately moist conditions. It is best to clip rye before it gets too tall. If this cover crop exceeds 10 to 12 inches tall before the first clipping, its regrowth potential diminishes.
- Annual rye (annual ryegrass) and winter rye ('cereal' or 'grain' rye) are different plants. Ryegrass is a tender annual. Winter rye is a hardy species that grows into the fall and early winter, and overwinters before growing vigorously the following



*Buckwheat can become a weed if the seeds are allowed to mature*

spring, flowering and going to seed. If your goal is weed suppression, winter rye can be allelopathic. Allelopathy refers to chemicals in some plants that inhibit the germination or growth of other plants. Unlike cereal rye, annual ryegrass has no allelopathic effect. Winter rye's allelopathic effect, which may suppress the germination of small-seeded vegetables, lasts four to six weeks after turning it under. Keep this in mind if you plan to seed a market crop behind it. The most commonly used cover crops on organic market farms in Wisconsin and Illinois are winter rye, clover, vetch and buckwheat (3).

### ***Relay planting***

Relay planting is the establishment of cover crops between rows of vegetables, usually during the summer or early fall. When the vegetable crop is harvested, the cover crop is already in place and poised to protect the soil during the winter. Growers and researchers have found success with using rye, vetch and red clover in relay systems with corn, beans, spinach and brassicas. With sweet corn, varieties that do not cast heavy shade are recommended.

Although relay planting is a bit more involved than seeding into bare ground, it can help ensure that a greater percentage of land is planted to cover crops in the fall. Relay planting also provides cover crops with additional time to grow before frost and decreasing day length terminate the growth of tender annuals, or limit the growth of hardy crops. Relay planting can potentially increase the amount of farmland protected by cover crops. In Wisconsin and Illinois, 45 percent of organic vegetable growers plant less than 50 percent of their land in vegetables to cover crops by season's end. Twenty-two percent plant 50 to 74 percent of their cropland to cover crops, and a third of these growers plant 75 to 100 percent of their cropland to cover crops in the fall (3).

### **No-till vegetables planted into cover crop mulch**

Given concerns about the impacts of tillage on soil health and erosion, growers and researchers have been developing various no-till vegetable systems. In addition to being good for the soil, no-till reduces weed pressure by leaving a layer of mulch on

the surface and not bringing weed seeds to the surface via tillage. The most prominent no-till system uses a combination of hardy winter cover crops, often winter rye with a legume such as hairy vetch. These cover crops are planted in the late summer or early fall and mowed or rolled after they begin to flower the following spring, usually in late May. This allows time to transplant a warm-season vegetable crop directly into the resulting layer of organic mulch. Crops such as tomatoes, peppers, eggplant, squash or cucumbers are planted with a no-till transplanter, while large-seeded crops such as sweet corn or beans are seeded directly using a no-till drill.



*Late spring is a good time to mow rye and vetch*

Experiments with a wider range of cover crop species for no-till vegetables planted in other seasons are yielding promising results (not necessarily tested in the Upper Midwest), according to researchers at the Rodale Institute (9). “Cool-season annuals like oats and fava beans can be planted in early spring, and then killed in mid summer for late plantings of cucumber, bean or summer squash. Summer annual (frost-tender) cover crops like millets, cowpeas or soybeans can be planted after the spring frost date, and then knocked down at the end of summer to plant fall brassicas or other fall crops. Finally, cover crops that are not winter hardy in a given location can be planted in mid to late summer and allowed to winterkill, forming a mulch for no-till spring vegetables” (9).

The timing of mowing or rolling is particularly important in no-till systems. For example, “if vetch is cut before the bud stage, it regrows and competes with the crop” (5). Roller crimpers are relatively expensive, so some growers are making them themselves.

Finally, it is worth noting that no-till does have potential drawbacks. First, undecomposed cover crop residues may produce allelopathic chemicals that interfere with the germination and growth of the following vegetable crop. Second, unincorporated residues yield less organic nitrogen in the rooting zone for the following cash crop. Organic no-till systems are still quite new and experimental.

### **Cover cropping for fertility management**

Different legume crops typically supply varying amounts of nitrogen to the following vegetable crop. Vetch produces high levels of nitrogen—as much as 100 to 150 lbs/acre. Clovers are also excellent nitrogen fixers, contributing about 80 to 100 lbs of nitrogen per acre while peas and beans often fix 40 to 80 lbs of nitrogen per acre



*Yellow blossom sweet clover is one of the best cover crops for warm-season nitrogen production*

(7, 8, 10). The amount of nitrogen produced will be greater if the legume is in place for the entire previous season. In the case of summer- and fall-planted legumes, the earlier the legume is planted and the better the stand, the more biomass and nitrogen that will be produced.

Not all of this nitrogen will be available to the following crop, and the timing of its availability can vary with decomposition rates and field and weather conditions. In many cases, additional nitrogen may need to be supplied with a fertilizer. Growing at least a portion of your own

nitrogen is still a good practice, and cover crops have other direct and indirect benefits such as pest, weed and disease control.

A cover crop combination of a grass and a legume usually results in more biomass production, enhanced weed suppression and higher levels of organic matter. Grass-legume mixtures also balance the carbon to nitrogen ratio. This results in a more gradual release of nitrogen for the following vegetable crop. In contrast, an all grass cover crop tends to tie up nitrogen because the residue is high in carbon. A stand-alone legume cover crop is prone to a rapid release of nitrogen, which can potentially leach into ground and surface water. Legumes and grasses affect other nutrients as well: legumes often increase the availability of phosphorus, while many grasses increase the availability of potassium (9).

### **Maximizing the pest management benefits of cover crops**

Research and experimentation on using cover crops to manage pests is increasing as both growers and researchers recognize the potential for biological and farming system approaches to address pest management challenges. Specific cover crops, as well as cover cropping sequences and practices have been identified that can help address disease, insect and weed problems. However, some weed, insect and disease suppression research results have proven difficult to replicate. Some information about pest management benefits is purely anecdotal. The following is a partial overview of what is known about using cover crops to manage pests, but growers may find it challenging to get the same results in all circumstances.

### **Cover cropping for weed management**

Cover crops suppress weeds by competing for light and nutrients or, in some cases, releasing compounds that inhibit the germination or growth of weeds through allelopathy. Weed suppression by cover crops varies by species, management (planting

dates, planting densities, tillage and residue management, etc.), existing weed populations and weather conditions. Particular cover crops and management approaches can suppress, have no effect on, or even stimulate weed growth. Accordingly, shifts in weed populations can occur when using cover crops in annual rotations. Because of this, it is best to match cover crops and management to the particular weed problems in a given situation (4).



*A swath of spring-sown oats and peas next to a recently plowed bed*

Cereal grains and grasses are excellent choices to suppress late fall and spring weeds because they establish themselves quickly in cooler temperatures, cover the soil, remain in place through winter and grow rapidly in the spring. Legumes grow too slowly to be effective, but they can be used in combination with grains and grasses to suppress weeds and fix nitrogen. Drilling, rather than broadcasting, is the recommended planting method because this hastens germination and results in a more even stand. Higher seeding rates (by as much as 50 percent) are also recommended (1, 4).

The tillage required to incorporate winter cover crops can bring new weed seeds to the surface, however. As noted above, some growers are experimenting with no-till systems that leave cover crop residues on the surface as mulch. This can create obvious challenges with direct-seeded crops (particularly those that require a fine seed bed) as well as transplanting. Summer weeds can be smothered with warm season annual cover crops such as buckwheat or Sudangrass, or with season-long cover crops.

As mentioned above, some cover crops have an allelopathic effect, cereal rye being the most notable. Rye and rye/vetch combinations are common winter covers that are tilled before transplanting or seeding large seeded crops such as beans. Another approach is to bale the rye and then use it for mulch. In addition to rye, oats and barley can inhibit germination and root growth (1). Simply incorporating large amounts of residue, especially if succulent, often causes a sharp increase in soil-borne pathogen populations, especially damping-off fungi, which attack seeds as they germinate. This may account for some of the reduced weed and crop germination rates observed shortly after killing and/or incorporating cover crops (4). Because of this effect, it is wise to wait three weeks or so after incorporation before planting direct-seeded crops.

Many new vegetable growers face enormous weed pressure as they convert old hay fields, pastures and lawns into vegetable gardens. Appendix B on page 20 contains several cover cropping scenarios to ease this transition.

### **Cover cropping for insect management**

Cover crops can affect a farm's insect community in several ways. They can attract both pests and beneficial insects by providing shelter and food, as well as making cash crops more difficult to locate. Management is complicated given that cover crops can act as a source and/or a sink for beneficial and pest insects (6). Given this complexity, careful observation, planning and timing are important.

The simplest strategy to achieve insect management benefits is to provide a diverse array of vegetation (6). Diversity in plant species and habitats contributes to overall farm diversity and helps ensure a balanced insect community, including beneficial predators. Increased diversity can be achieved by:

- selecting a diversity of cash crops
- utilizing a diversity of cover crops (such as planting both buckwheat and Sudangrass as summer cover crops since each has unique insect associations—see the chart on page 13)
- establishing permanent or semi-permanent hedgerows
- planning cover crop plantings and mowings to ensure that something is always in bloom (such as waiting until buckwheat has flowered before plowing a rye/vetch combination or mowing/plowing only portions of a stand at a time)
- strip cropping (the practice of growing crops in strips between adjacent stands of cover crops)



*A solid stand of rye and vetch is suitable for strip cropping*

Strip cropping can be a particularly useful strategy because it provides habitat for beneficial insects close to cash crops. For example, a solid stand of rye/vetch or clover can be mowed and plowed in strips, leaving habitat for ladybugs and other predators. The list of cover crops in Appendix A includes notes on whether various cover crops are suitable for strip cropping.

Planting special hedgerows to attract beneficial insects is another approach. Some seed companies (such as Johnny's Selected Seeds) offer mixtures that can be used to create borders or strips of beneficial habitat. Some growers have created

more permanent hedgerows that not only attract and harbor beneficials, but also yield a marketable crop such as curly willow or various types of perennial flowers and herbs. For example, members of the Umbelliferae family (such as caraway, dill and fennel) are attractive to parasitic wasps. Flowers in the Compositae family (sunflowers, asters, goldenrod, daisy, cone flower, etc.) attract insects such as ladybugs, pirate bugs and spined soldier bugs, can be maintained in permanent beds and are readily marketed as cut flowers (6).

The following table, published by Plotkin (6), lists insects (both pest and beneficial) attracted to common cover crop species.

### **Insects attracted to common cover crop species**

<b>Cover crop</b>	<b>Beneficial insects</b>	<b>Pest insects</b>
Buckwheat	Parasitic wasps, ladybugs, tachinid and hover flies, lacewings	Tarnished plant bugs and aphids (note: aphids can act as a food source for beneficials)
Clovers	Parasitic wasps, big eyed bugs, minute pirate bugs, ladybugs, tachinid flies, and aphid midges	Spider mites & flower thrips (note: flower thrips can prey on spider mites and provide food for several predatory insects)
Hairy vetch	Minute pirate bugs, ladybugs, predatory and parasitic wasps	Tarnished plant bugs
Cereals/grains	Ladybugs	Aphids

In addition to above-ground interactions, plants can impact soil-dwelling species. Oats, barley and sorghum-Sudangrass have been shown to reduce root-knot nematodes—a pest that can reduce carrot quality and affect other vegetable crops such as onions and potatoes. Research on various sorghum-Sudangrass hybrids and cultivars reveals that the leaves of these plants produce a nematicidal compound. To take advantage of this, sorghum-Sudangrass must be mowed and well-incorporated before first frost and while still green (1).

Other cover crops may actually increase detrimental species. Vetch can cause increases in root-knot nematodes as well as the soybean cyst nematode.

### **Cover cropping for disease management**

Cover crops can help reduce disease problems in vegetables in various ways. Most obviously, cover crop rotations break disease cycles in the soil. Other benefits can come from strip cropping or utilizing cover crops as mulches. Mulches can delay

the onset of early blight in tomatoes by reducing soil splash onto leaves. Preliminary research suggests that oats may help reduce vegetable crop diseases caused by *Rhizoctonia* (1). Because some cover crop species are related to cash crops (most notably field peas), it is wise to rotate cover crops. Pea diseases such as *Sclerotinia* can build up quickly if peas are planted in successive years in the same location (1).

## Seed sources

Some cover crop seed, such as oats and rye, can be bought from neighboring farmers. Other types, such as grain and field pea mixtures, clovers and sorghum-Sudangrass, are readily available at a local co-op elevator or feed store. More specialized seed, such as hairy vetch, rape, ryegrass, berseem clover, annual alfalfa and millet, is available from various seed companies throughout the Midwest and beyond. Sources for organic cover crop seed can be found by using the *Organic Resource Directory* published by the Midwest Organic and Sustainable Education Service (MOSES). This publication is free and is also available online at: [www.mosesorganic.org/resourcedirectory.html](http://www.mosesorganic.org/resourcedirectory.html).

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10. Sullivan, P. 2003. *Overview of Cover Crops and Green Manures*. USDA-ATTRA. Accessed 5/28/09. ([attra.ncat.org/attra-pub/PDF/covercrop.pdf](http://attra.ncat.org/attra-pub/PDF/covercrop.pdf))

### **Other recommended resources**

- Anne and Eric Nordell produced a 72-minute DVD and a 42-page booklet on cover cropping and tillage. The DVD costs \$15 plus \$3 shipping and handling; the booklet costs \$10 plus \$3 shipping and handling. Anne and Eric Nordell, 3410 Route 184, Trout Run, PA 17771.
- Appropriate Technology Transfer to Rural Areas (ATTRA). Call and ask for free information about cover crops and green manures. 1-800-346-9140.  
[www.attra.org](http://www.attra.org)
- University of California SAREP Cover Crop Database:  
[www.sarep.ucdavis.edu/cgi-bin/ccrop.exe](http://www.sarep.ucdavis.edu/cgi-bin/ccrop.exe)
- *Green Manuring: Principles and Practice*, 1989, Woods End Agricultural Institute.
- *Green Manuring: Principles and Practice*, 1927 (out of print and hard to find but worth the search).
- Cover Crop decision tool: Cornell website that identifies cover crop options for different situations.  
[www.nysaes.cornell.edu/hort/faculty/bjorkman/covercrops/decisiontool.php](http://www.nysaes.cornell.edu/hort/faculty/bjorkman/covercrops/decisiontool.php)
- Midwest Cover Crop Council: A multi-institutional website maintained by Michigan State University with many links and free resources. [www.mccc.msu.edu](http://www.mccc.msu.edu)
- *Vegetable Farmers and Their Innovative Cover Cropping Techniques*. [Video]. Vernon Grubinger. 2006. University of Vermont Extension. Available from:  
[www.uvm.edu/vtvegandberry/Videos/covercropvideo.html](http://www.uvm.edu/vtvegandberry/Videos/covercropvideo.html)
- *Vegetable Farmers and their Sustainable Tillage Practices*. [Video]. Vernon Grubinger. 2006. University of Vermont Extension. Available from:  
[www.uvm.edu/vtvegandberry/Videos/tillagevideo.html](http://www.uvm.edu/vtvegandberry/Videos/tillagevideo.html)

## Appendix A: Management Guide for Specific Cover Crop Species\*

Crop	Characteristics	Planting		Seeding rate:		Management and Comments	Suitable for small scale?
		Time	#/1000ft <sup>2</sup>	#/acre			
Alfalfa	Deep-rooted perennial legume. Excellent N fixer; drought tolerant; does not tolerate wet soils or flooding. Requires soil pH above 6 and moderate levels of P and K. Use alfalfa/clover inoculant.	Spring or late summer to early fall.	1/2 to 2	15 to 20	There are 2 kinds of alfalfa: dormant and non-dormant. Dormants stop growing in mid-autumn and are very winter hardy. Non-dormants (such as Nitro) grow faster but are less hardy. Excellent forage crop and soil-builder but not an ideal cover crop—unless a grower has haying equipment and use or market for hay. If grown, Nitro is the best choice for market growers.	No. Heavy equipment needed for incorporation.	
Clover (red and white)	Red (Medium, Mammoth, Alsike) and white (Dutch, New Zealand, Ladino) clovers are slow growing legumes. Whites are shorter and longer lasting. Tolerates soils too wet for alfalfa. Use alfalfa/clover inoculant.	Late winter (for frost seeding), spring or July/August (if moisture is adequate)	1/2 to 1	Red: 8 to 15 White: 5 to 15	Clovers grow slowly in the seeding year but rapidly the second year. Mow as needed to control weeds. Reds are the better N fixers, as is the New Zealand white. Clovers mixed with oats or annual ryegrass produce large amounts of biomass for soil improvement. Seed at lower rates if sown with grasses. White and red clovers can also be mixed. Well suited as cover crops.	Reds best incorporated by plows, chisels or heavy tillers; lower growing whites can be incorporated with rototillers.	
Yellow Blossom Sweet-clover	A biennial. Flowers and completes life cycle after overwintering. Deep taproot, drought tolerant, excellent nitrogen fixer, and adapted to all soils except wet. Use alfalfa/clover inoculant.	Late winter (for frost seeding), spring, summer, or fall (40 days before killing frost)	1/2 to 1	10 to 20	Mow as needed to control weeds and growth. Mow high; it is intolerant of low mowing. Plow under in fall if an early vegetable crop will follow in spring. If overwintering, plow before flowering; do not allow to set seed. Mature sweetclover is fibrous and breaks down slowly. Excellent choice for intercropping if planted before the veg. crop or 1-year soil building crop. Mix with oats for added biomass. Cheap and easy to plant.	No. Requires plowing to incorporate.	
Berseem Clover	Extremely vigorous, tall annual white clover. Tolerant of wet conditions. Excellent nitrogen fixer. Use alfalfa/clover inoculant.	Spring or late summer (if moisture is adequate)	1/2 to 2	15 to 25	Best if drilled but can be harrowed in. Makes excellent hay or heavy quantities of mulch. Cut when 7-20 inches. Don't mow close; leave 1-3 inches of stubble. Berseem leaves a friable seedbed so spring tillage requirements are minimal. Transplant directly into beds. Excellent weed suppressor. Good for interplanting because of slower summer growth. Mix with oats for biomass or 1-season soil building.	Yes. Can be controlled by mowing and no heavy tillage is needed.	

\* Adapted from information published by Charles Marr, Rhonda Janke and Paul Conway in "Cover Crops for Vegetables Growers" Kansas State University, 1998.

Crop	Characteristics	Planting		Seeding rate:		Management and Comments	Suitable for small scale?
		Time	#/1000ft <sup>2</sup>	#/acre	#/acre		
Soybean	Upright bushy legume. Must be planted in warm soil. Strong N fixer. Grows on most soils. Use soybean inoculant.	Late May through early August	2 to 4	50 to 150	Drill or harrow in. Excellent for planting after early vegetables; mowed residue leaves friable seeded next spring. Early plantings best incorporated by Sept. to maximize benefits. If field is new or weedy, plant a fast-growing cover crop first (buckwheat). Let beans grow 80-100 days to maximize biomass. Can be plowed, disked or mowed (leaving residue on the surface). Cost, availability, rapid growth and N fixing make it an excellent choice.	Yes.	
Field Peas	Grow like garden peas, only taller. Very cold tolerant and good N fixers (most N fixed before flowering). Use pea/vetch inoculant.	Spring	2 to 8	50 to 200	Drill or broadcast and harrow. For max. biomass, N, and weed suppression, seed heavily. Mow and disk to incorporate. Heavy stands will clog sickle bar mowers. Produces so much biomass that small seeded crops cannot be sown immed. following. Peas mix well with oats or barley. Pea, oat, and hairy vetch mixtures are excellent for soil building and available from some suppliers. Best use is on ground to be planted in June/July.	Yes. Mow to control peas. Tilling is easier if vines rot 1-2 weeks or are removed and used as mulch.	
Annual White Clover	Similar to yellow-blossom sweetclover. Deep taprooted and a strong N fixer. Use alfalfa/clover inoculant.	Spring or early fall	1 to 2	15 to 30	Drill or broadcast and harrow. Grows rapidly and can become woody when mature and difficult to incorporate. Mow as needed. Mix with oats for a nurse crop. Later plantings make good growth before being winterkilled. Seed is hard to find (most common variety is Hubam). As most clovers are biennial, make sure what you are getting is annual sweetclover.	Yes.	
Oats	Fast growing and frost-tolerant annual. Extensive, fibrous roots hold soil and produce biomass. Tolerant of wet soils and low pH. If allowed to mature, oats will reseed and new growth will winterkill.	Late winter (frost seeding) and spring or fall	2 to 4	100 to 140 (1-2 bushels) if mixed; up to 4 bushels if seeded alone.	"Feed" or "seed" oats are acceptable for cover crop use. Drill or broadcast and harrow. Oats produce mulch, mow when needed. Oat straw decomposes rapidly and acts like leaf mulch in the forest. Oats are a good trap crop; late summer plantings will hold N from manure applications. Oats provide good winter erosion control. Oats are excellent for mixing with legumes. Versatile, available and cheap.	Yes.	

Crop	Characteristics	Planting		Seeding rate:		Management and Comments	Suitable for small scale?
		Time	#/1000ft <sup>2</sup>	#/acre	#/acre		
Buck-wheat	Fast-growing, warm season annual (matures in 40-50 days). Not drought or frost tolerant.	Late spring to late summer	2 to 3	50 to 100	Drill or broadcast and harrow. Fast growth enables buckwheat to smother weeds and for several sequential plantings to be made in one season. Once mowed, residue decomposes rapidly and soil is friable; little tillage is necessary for next crop. Will reseed itself and can become a weed if flowers mature to seed. Buckwheat residue can be a good winter cover if late plantings are thick and growth is adequate.	Yes. Excellent choice to follow early vegetables or to help clean up a weedy field.	
Japanese Millet	Fast growing summer annual grass. Limited frost tolerance and will winterkill. Requires fertile soil for rapid growth. Tolerates frequent clippings and makes excellent forage/hay. Tolerant of both droughty and wet soils.	Late spring through August	1 to 1 1/2	25 to 30	Drill or broadcast and till shallow. Manure or fertilizer for best results. When intended as summer long trap crop, mowing is important. Clip before heading out (~60 days) and leave 3" of stubble. Not suitable for mixing but a good choice for a full season smother crop following early vegetables. Good choice for cleaning weedy fields or converting land to vegetable production. Also excellent if there is a need for mulch or feed.	Yes, but make sure soil is fertile enough to support multiple cuttings.	
Sorghum-Sudan-grass	Fast growing, drought tolerant annual grass. Will grow over 6' if left uncut. Grows on most soils but needs fertile soils for best results. Winterkills.	Late spring through July	1 to 2	15 to 40	Drill or broadcast and harrow. A good N trap crop and excellent smother crop that produces tremendous biomass (more than any other cover crop) even with mowing. Decomposes slowly; allow 1 month before planting next crop. Needs plentiful manure to reach full potential. If left too long it can become unmanageable.	No. Too rank in growth habit. Even large-scale farmers need heavy duty mowers to cut for hay or silage.	
Forage brassicas (cabbage family crops)	Most common types are turnips, rape and kale. Use readily available cheap varieties such as Purple Top Turnips. Will tolerate low fertility but do best under fertile conditions. Rape's long tap root loosens heavy soils.	Spring, summer or fall	1/4 for turnips 1/3 for rape or kale	5 to 7 for turnips 8 to 15 for rape or kale	Drill or broadcast with light incorporation. Not recommended if vegetable brassicas are grown nearby. Will tolerate mowing or grazing. Will trap N and other nutrients and provides ground cover after winterkill. Value as a cover crop is limited unless livestock forage is needed. Best used following early vegetables, mixed with summer legumes, or in mixes with peas, oats, vetch, etc. Can also be used under sweet corn.	Doesn't require heavy equipment but value is limited unless livestock forage is needed.	

Crop	Characteristics	Planting Time	Seeding rate:		Management and Comments	Suitable for small scale?
			#/1000ft <sup>2</sup>	#/acre		
Hairy Vetch	Cold tolerant viny legume. Excellent N fixer (100 lbs/acre). Needs pH of 6 or 7 for best results. Tolerates most soils but will not survive flooding. Drought tolerant once established. Tolerant of mowing but intolerant of shade. Use pea/vetch inoculant.	Spring, summer or fall (summer plantings generally less successful)	1 to 2	25 to 50	Best if drilled but can be harrowed in. Sow with a nurse crop of small grain in 1:1 or 1:2 ratio by volume (vetch to small grain). For overwintering, plant 3-4 weeks before a hard frost. A wet spring can delay incorporation and a mature small grain may hinder breakdown of the vetch following incorporation. Mow vetch/small grain mixtures if incorporation is delayed. Incorporate in April for a May-planted cash crop. Plow to incorporate or use heavy disk and chisel plow. Spring-sown vetch is easier to manage and can be left standing, tilled under or disked in the fall.	In general, no. It can be mowed until it dies, but other crops are easier to manage. Viney growth will quickly clog a rototiller.
Other Vetches	Less winter hardy than hairy vetch. All require pea/vetch inoculant.	Same as hairy vetch	Same as hairy vetch	Same as hairy vetch	Similar to hairy vetch but not as exacting. Seed prices are higher.	Yes.
Grain Rye (winter rye)	Very hardy small grain. Grows longer in fall than other grains and resumes growth earlier in spring. Grows on most soils. Extremely efficient nutrient scavenger, making it an excellent N trap crop. Dense, fibrous roots help build organic matter and make soil more friable.	Late summer to fall. Can be spring planted but will die before flowering and cheaper options exist.	2 to 5	50 if mixed with legume. 60-200 if seeded alone.	Can be broadcast and tilled but best if drilled. Can germinate on the surface if moisture is adequate. In spring, till when rye is 6-8" or wait until it flowers. Can be used as windbreak by leaving strips between beds. Often sown with hairy vetch but this mixture can get away from you unless soil is sandy or very well drained. Rye shows weed suppressing (allelopathic) abilities (include rye straw) and is useful to help clean weedy areas. Tremendous biomass production can create challenges for incorporation and problems with planting and germinating small seeded vegetables. Main challenge is having time for adequate incorporation between spring rains.	It can be managed without plows or heavy disks if incorporated early enough. Or let flower, mow, allow to decompose, and plant summer legume or fall cash crop.
Annual Ryegrass	Fast growing cool season grass. Tolerates most soils, including wet. Dense root system is excellent for trapping N, holding soil and loosening heavy soils. Growth habit compliments clovers. Not drought tolerant. Will self seed.	Spring or late summer to early fall	1 to 2	18 to 40	Best drilled but can be tilled in shallowly. Easy to establish and grows rapidly. Mowing is not necessary except to avoid setting seed. Unlike other mature small grains, annual ryegrass stays green and is easier to incorporate, although the dense root system can take time to decompose (small seeded vegetables are not recommended following ryegrass). Excellent choice as a nurse crop with legumes or for pathways.	Yes. Easily incorporated if tilled early in spring.

## **Appendix B: Bringing land into production and tackling persistent weeds**

Getting off to a good start is important in any new enterprise. Decisions made early in your planning process can have significant influence on the success of the farm for years to come. Rather than delve into the question of how to find land suitable for vegetable farming, this section assumes you already have a site selected.

The first question to answer is: *Has the land been in crop production in the preceding year?* If a row crop (corn or beans) or a small grain has been grown in the previous season, the tillage necessary to convert the land to vegetables will be considerably less than if you are following extensively rooted crops such as alfalfa, pasture or grass hay ground.

Many beginning market growers are forced to convert a deeply rooted sod into productive vegetable land. It is likely that this sod will contain Quackgrass and other rhizomes with well-established root structures. These grasses are difficult to control using organic methods. However, in the process of preparing your ground for intensive vegetable production, these same grasses can teach you about your soil structure, weed pressure and how water moves over and through your soil.

Here are some general guidelines for bringing fallow ground into production:

1. ***Start early.*** Plan on starting this process a full season before you intend to grow vegetables. Bringing new land into production in July or August of the preceding year allows time to cultivate the ground a number of times to dry up the rhizomes in the sod. By starting this process in mid-summer, you also avoid having too much exposed ground during the traditionally rainy months of May and June. Following a four- to six-week cultivating process, plant a fall-seeded cover crop of winter hardy rye or oats and peas.
2. ***Be careful not to overwork the ground.*** A heavily matted sod may require the use of a moldboard plow. If you do not own one, consider hiring a neighboring farmer to plow your field or garden for you. If you do plow, do so only to the depth of the root zone of the sod. In this process, the plow is used as an under cutter. The resulting action will turn the sod up to dry rather than burying it deep where it may not fully decay and may create a sponge-like mat that disrupts the capillarity of the soil. Many gardeners use rototillers to dice up this heavy sod structure. In doing so, they can spread the rhizomes rather than keeping them intact and

effectively drying them up. An excellent tool for working new ground is a 5-shank field cultivator with 16" sweeps. This tool undercuts the residue at a depth of four to six inches. This type of field cultivator can be used in conjunction with a power harrow or rotovator that stirs the soil and knocks off the roots of the sod residue.

3. **Observe and gather information.** By starting early to bring land into production, you will have an opportunity to learn about your soil. It is useful to know the cropping history of your farmland going back as far as possible. It is recommended to test your soil and correct the pH level, if necessary. One of the most important reasons for starting to prepare ground early is to gain a better understanding of the *variety and amount of weeds to anticipate your first season*. This window of time allows you an opportunity to express weeds and identify areas of your field that may be better suited for specific crops. Carrots and onions in particular benefit tremendously from being planted in areas with less weed pressure.

Starting a year ahead also allows ample time to measure or pace off a new field and mark row lengths and room necessary for headlands and roadways. Getting to know the texture, slope and general qualities of your soil a full season ahead will pay immediate dividends.

### **Tackling persistent weeds**

Even after a year of cover cropping, troublesome weeds may remain. Dealing with grassy areas—and Quackgrass in particular—can be a challenge, but there are cover-cropping methods that can greatly reduce, if not eliminate, these weeds. Here are several approaches that have worked for other growers:

- **Buckwheat – Buckwheat – Rye.**<sup>1</sup> This method will sacrifice growing a marketable crop for one season, but can be very effective. It also contributes nutrients and improves soil structure and tilth. Till the area in the spring as soon as the soil is dry enough. If the area is small, you can walk over it and remove exposed rhizomes and roots. When the weather turns warm and all danger of frost is past, plant the first crop of buckwheat. It will likely be necessary to till immediately before planting to eliminate grassy regrowth and early spring weeds that may have sprouted. Seed the buckwheat heavily (60-90 lbs/acre or 3 lbs per 1,000 square feet). The buckwheat must form a dense canopy in order to be effective. Till the buckwheat when it just begins to flower to prevent it from setting seed. Allow weeds to germinate and then till the area again and reseed buckwheat at the same heavy rate. This second crop should be tilled under in late summer or early fall, at least three weeks before first frost.

Let the area rest for one week before seeding winter rye at a rate of 90-120 lbs/acre or 3 lbs per 1,000 square feet. It will germinate and grow a few inches before going dormant for the winter. In early spring, the rye will green up with new growth. Till in the rye at least two weeks before planting vegetable crops. In any case, do not let the rye grow much beyond 12 inches tall as it will become very difficult to till down with small-scale equipment.

- ***Winter cover – Fallow – Winter cover.***<sup>2</sup> Anne and Eric Nordell in Pennsylvania grow back-to-back winter cover crops to manage weeds. A brief stint of aggressive summer tillage between the two cover crops keeps annual weeds from setting seed. First, yellow blossom sweet clover is overseeded at 20 to 24 lbs/acre into early crops such as onions or spring lettuce. Lettuce is overseeded a week or two after planting but before leaves open up to trap sweet clover seeds, while onions are overseeded near harvest. The Nordells walk up and down every other row with a hand-crank broadcast seeder. They harvest the cash crop, then let the clover grow through summer. Yellow blossom sweet clover (one of the best cover crop choices for warm-season nitrogen production) puts down a deep taproot before winter if seeded in June or July, observes Eric. Note: the clover alone will not suppress weeds. It works on their farm because of their successful management efforts over a decade to suppress overall weed pressure by crop rotation and varied cover crops.

The following spring, the sweet clover grows until it is about knee-high in mid-May. Then the Nordells clip it just before it buds. They let the regrowth bloom to attract pollinators and beneficial insects to the field, before clipping it again in July. In early- to mid-July, the Nordells moldboard plow the sweet clover to kill it. They then leave the ground in bare fallow, working it with a spring tooth harrow to hit perennial weeds at the weakest point of their life cycle. Harrowing every two to three weeks brings weed roots and rhizomes to the soil surface, where they bake in the summer sun. The harrowing also kills flushes of annual weeds before they can set seed.

After five years in this weed-killing rotation, the Nordells have been able to cut back on harrowing. In mid-August, the Nordells plant a second, overwintering cover crop. In this rotation, they seed a mix of rye and hairy vetch. They broadcast and lightly incorporate about 80 lbs rye and 30 lbs vetch per acre. The rye establishes quickly, putting on good growth both above and below the surface, while the vetch fixes nitrogen. Another combination is yellow, red and white clover in a 2:2:1 ratio by volume. Rye and vetch are a popular combination to manage nitrogen. The rye takes up excess N from the soil, preventing leaching. The vetch fixes additional nitrogen, which it releases after it is killed the following spring prior to planting the next cash crop. With the August seeding, the Nordells'

rye/vetch mixture produces most of its biomass in fall. The Nordells plow the rye/vetch mix after it greens up in late March to early April, working shallowly so as not to turn up as many weed seeds. They forego maximum biomass and N for earlier planting of their cash crop—tomatoes, peppers, summer broccoli or leeks—around the end of May.

- ***Spring fallow – Pumpkins – Fall/winter cover.*** This method lets you grow a marketable crop. First, allow weeds/Quackgrass to grow in the spring until six- to eight-inches tall. At this point, the Quackgrass begins transferring energy resources away from its roots and into producing a seed stalk and head. While it is vulnerable, moldboard plow and disk the area lightly. A series of cultivations with a spring tine harrow (field digger) will knock back regrowth, bring rhizomes up to the surface to dry out, and can also drag rhizomes to the edge of the field. Pumpkins are then transplanted into the field. Cultivate again as necessary before the pumpkins begin to vine. The pumpkin vines will quickly form a closed canopy and suppress weed growth. You may want to consider a closer spacing than normal (four to five feet between rows rather than six feet) to be assured of a quick-forming, dense canopy. As the pumpkin vines die back in the fall, a late fall cover crop (oats and peas, rye or rye and vetch) can be overseeded. This method requires a sufficiently long growing season to achieve a decent pumpkin harvest (the transplants may not go into the field as early given the series of cultivations prior to planting), but it has been used successfully in southern Wisconsin.

## **Mulching**

Another non-chemical means of removing weeds is mulching heavily for a year. Note: this method is more feasible and appropriate for smaller scale gardens. First, apply a thick layer of organic mulch (hay, leaves, even fresh manure). Then, top this with some kind of material that will block out light (black plastic, layered newspaper or old tin roofing). Leave this on for one full year. An exception is plastic. This should be removed before winter or else it will begin to break apart. After the spring thaw, remove the covering and pull back the mulch. Check to see if any roots or rhizomes survived their year of darkness. The soil should be ready for planting, but if not, cover the garden plot back up for another year.

## **Plan only a fall garden**

If you are unable to cultivate the ground during the preceding season, a garden is still possible, albeit more difficult. One consideration would be to not push for a spring crop. Rather, give yourself time to get the land adequately ready and plan for a summer or, better yet, a fall garden. On a small scale, almost anything is possible. One can plant into spring-plowed sod within three weeks. However, yields are usually compromised and weed pressure can be significant.

Check in with your county extension office to see if they have information on cover crops. And don't be afraid to ask neighboring farmers for advice. Many will offer it whether you ask for it or not! Remember to ***start small, be realistic and enjoy the work***. Good luck!

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<sup>1</sup> Adapted from *Weed Ending Secrets*, Rodale Press Inc., Emmaus, PA, 1994.

<sup>2</sup> Adapted from *Managing Cover Crops Profitably*, Second Edition, by the Sustainable Agriculture Network, reprinted 2000, SAN, Beltsville, MD, pp. 34-42. Complete text: [www.sare.org/handbook/mccp2/index.htm](http://www.sare.org/handbook/mccp2/index.htm). To order: <http://www.sare.org/htdocs/pubs/ToOrder.html>



