Methods for Successful Cover Crop Management in Your Home Garden

WASHINGTON STATE UNIVERSITY EXTENSION FACT SHEET • FS119E

This fact sheet is one of a three-part series on cover crops for home gardeners. It focuses on methods for managing garden cover crops, including planning, planting, managing nutrients, and terminating plants. This series also includes fact sheets on *Cover Crops for Home Gardens West of the Cascades* and *Cover Crops for Home Gardens East of the Cascades*.

Introduction

Cover crops are plants grown to both cover and improve the soil. They may be used as a living or dead mulch on the soil surface, or they can be tilled into the soil as a "green manure." Gardeners usually plant cover crops in the fall for winter cover, but some gardeners also use cover crops as part of a summer rotation. Cover crops can be any type of plant but are generally grasses (including cereal grains), legumes, or grass/legume mixtures. Some non-legume broadleaf plants can also be used.

Cover crops can be an effective way to maintain soil organic matter, supply and retain nitrogen (N), reduce soil erosion, and suppress weeds. However, successful cover cropping requires advanced planning, selecting the right cover crops, and planting and terminating them at the right time. Cover crops will provide the greatest benefit if they are treated as an integral part of garden planning and not just as an afterthought.

Cover crops require very little maintenance, and additional nutrients are seldom needed to support them since cover crops scavenge nutrients already present in the soil, and may even "fix" additional nitrogen from the atmosphere. Winter cover crops seldom need irrigation in areas west of the Cascades and only need irrigation for crop establishment in areas east of the Cascades. Cover crops do not require weeding since they will compete with, and even smother, surrounding weeds.

Planning for Cover Crops

Plan cover cropping in advance by selecting the best species for your garden conditions, and obtain seed early, so you can be ready to plant at the proper time. Gardeners plant and harvest different vegetable crops at different times. Planning ahead makes it easier to stagger the planting and termination of cover crops with the planting and harvest of vegetables in the garden.

Decide what vegetable crops you want to plant in the spring, so you can plan your winter cover crops accordingly. If you intend to plant early vegetables in March, plant a cereal cover crop, such as rye, oats, or wheat, the preceding fall. These cover crops can provide sufficient soil cover for the winter and significant growth before they need to be terminated to make room for vegetable planting. If you intend to plant vegetable crops in April or early May, a legume winter cover crop will have enough time to grow, so it can provide a nitrogen benefit. Legumes will provide even more nitrogen if the vegetable crop is not planted until late May or June.

Try to create niches in your garden for cover crops. You can reap the benefits of earlier fall-planted cover crops by using them in areas of the garden where the vegetable harvesting will be complete by August or early September. In garden areas where the vegetable crop is not harvested until October or later, choose a cover crop that is suitable (one that germinates at low soil temperatures) for later planting, such as rye, wheat, or fava beans. You can also relay seed cover crops into the garden while the vegetable crop is still growing. (See Advanced Cover Crop Techniques in this publication for more information on relay seeding.) This planting system is suitable for vegetable crops that remain in the garden until October, November, or even December. If you have vegetable crops that overwinter, such as kale, consider planting cover crops in the spring after harvest.

This fact sheet is part of the WSU Extension Home Garden Series.

Decide how you will terminate a cover crop when you are planning your garden. Crimson clover, for instance, is easier to incorporate (turn back into the soil) than hairy vetch, so it may be a better choice if you are terminating a large crop area with hand tools. If you will be transplanting vegetable seedlings or planting vegetable crops with large seeds, such as beans or corn, you may be able to leave the mowed cover crop on the surface as mulch, rather than incorporating it. (See Reduced Tillage below for details on using cover crops as mulches.)

Another issue to consider when planning for cover crops is how wet your soil becomes in the winter. Some cover crops can tolerate short periods of standing water, while others cannot. For example, hairy vetch will survive better in wet soils than crimson clover or winter peas, while annual ryegrass is more tolerant of wet soils than is winter wheat.

You can also plan for cover crops outside the normal winter season. See Cover Crop Niches below for ideas and guidance on summer- or "shoulder-season" (spring and fall) cover crops.

Planting Cover Crops

Cover crops are typically planted directly from seed. They can be seeded in spring, summer, or fall, depending on your gardening goals and vegetable rotations. Seeding cover crops during periods when environmental conditions are less favorable, such as cold soil or wet conditions, may require additional steps to improve seed germination and establishment. Each cover crop responds best to a certain seeding method, so using the proper method will improve crop establishment. While cover crops do not require much ground preparation or maintenance, crop establishment will be more uniform if the seedbed is evenly tilled and free of weeds and excessive plant residues.

Improving Crop Establishment Under Cool and Wet Conditions

- Select cover crop species that establish well under cool and wet conditions.
- Increase seeding rates to 1.5–2 times the usual rate.
- Observe seeding depth and make sure the seed has good soil contact.
- Keep birds from eating newly emerging crops.

Hand Seeding

The easiest way to plant a cover crop is by hand-seeding since this method requires no equipment (Figures 1 and 2). Spread seed evenly to ensure a uniform crop stand. One proven method of hand-seeding is to simply throw the seed out approximately 2 to 3 feet in front of you, in as wide a band as possible, as you walk through the seeding

Figure 1. Seeding a cover crop by hand.

Figure 2. Hand-seeded cover crops in raised beds.

area. This method distributes the seed more evenly before it makes contact with the soil surface. It is also useful to divide the total amount of seed required in half, spreading the first portion of the seed over the total soil area, and then going back and spreading the second half of the seed in areas that were missed (Cogger et al. 2014a). Mixing small seed, such as clover, with sand makes it easier to handle and can help improve seed distribution. It is also helpful to incorporate the seed into the soil to enhance germination.

Tools for Seeding

A variety of seed spreaders are sold in garden stores and catalogs. These spreaders distribute seed either by drop-spreading or broadcasting (scattering) the seed (Figure 3). Many of these spreaders have adjustable settings that control the seeding rate for a variety of seed sizes. Many spreaders broadcast seed over a wide area, so they may not be suitable for small gardens. Also, enough seed is needed to prime the spreader, which can be a problem if you are using only a small amount of seed.

Seeding Depth and Incorporation

Good seed-to-soil contact improves germination. When seeds get wet, they swell and the seed coat splits, but

Figure 3. This broadcast seeder scatters seed over a chosen area.

if a germinating seed dries out, the seedling is quickly destroyed. Good soil contact ensures that the seed will not be exposed to the drying effects of ambient air, and it provides the seed with the continued moisture it needs to complete the germination and emergence process.

It is best to rake or lightly till larger seeds into the soil to ensure good germination. Crops with large seeds, such as pea, vetch, oat, and cereal rye, can be planted fairly deep (½–1½ inches). The soil depth protects the seed from predation and provides more consistent moisture. Cover crops with small seeds, such as annual ryegrass and clover, must be kept closer to the surface (¼–¾ inch) because they do not have enough stored energy to reach the soil surface if planted too deep. Irrigation can sometimes carry small seeds deep enough into the soil to allow them to germinate well.

A seed roller can also provide good seed-to-soil contact and improve emergence of crops that have either large or small seeds. Once the seed gets wet, be sure to keep the soil moist. When germination begins, a young seedling can easily dry out, especially in warm, late-summer or fall weather. If seeds are planted in dry soil, they will remain dormant until the first fall rains trigger the germination process.

Terminating Cover Crops

Terminate a cover crop at a time that meets your gardening needs. However, keep in mind that large amounts of cover crop vegetation will take 4 to 6 weeks to break down—so good planning is essential. Incorporating the terminated cover crop allows for more rapid breakdown and nutrient release. Termination and incorporation do not necessarily need to be done in two separate steps; it is often easier to terminate and then incorporate at the same time.

Some gardeners do not incorporate cover crops, but terminate them and leave them on the soil surface as mulch. See Reduced Tillage, below, for more information on cover crops as mulches.

Timing of Termination

The growth stage of a cover crop affects its biomass (volume of living plant matter) and its quality. Biomass increases up to the time of flowering, but quality declines as cover crops move from vegetative to flowering states and beyond. When cereal cover crops are terminated at flowering or later, their residues become fibrous and will immobilize or "tie-up" nitrogen in the soil as they decompose, reducing the nitrogen available to the next crop. Earlier termination reduces this problem, as does growing cereal cover crops together with legumes.

Residues from freshly terminated cover crops can inhibit seed germination, including germination of desirable vegetable seed. Waiting to plant vegetable crops for 3 to 4 weeks after terminating cover crops often improves their establishment.

Tools for Termination

The scythe has been used to cut crops for millennia because it can easily cut through large amounts of plant material (Figure 4). Scythes require some physical strength and good technique. Choose a scythe that feels comfortable, and keep the blade sharp, so it cuts through crops easily. Slice a narrow strip of cover crop with each stroke, rather than trying to cut individual plants. Practice will help you keep the blade close to the ground without hitting soil and dulling the blade.

Figure 4. Scythe next to cut cover crop.

Smaller hand tools, such as a grass whip, can function much like a scythe (Figure 5). It cannot work as quickly as a scythe in larger gardens, but it is economical and easy to use in smaller and tighter spaces more typical of home gardens.

A string trimmer is a mechanized version of a scythe, and it can quickly terminate a cover crop. However, if you try to cut too much plant material at once, plant stems can wrap around the trimmer head. String trimmers also tend to scatter plant material into unwanted areas.

A typical rotary lawn mower can cut down a cover crop (Figure 6), but the wheels should be adjusted as high as

Figure 5. A grass whip for terminating cover crops in home gardens.

Figure 6. Walk-behind rotary mower.

possible for the first pass through the crop. Rotary mowers tend to cut the plant at the height of the blade without chopping up the plant material. Heavier walk-behind brush mowers have rotary blades that can handle larger cover crops in one pass. Some lawn mowers have mulch attachments, but these tend to clog when mowing tall cover crops. Flail mowers have chisel-like blades that swing from a rotating bar (Figure 7). They can cut down thick cover crops, while simultaneously chopping the residue into fine mulch.

Incorporating Cover Crops

A rototiller can incorporate a cover crop, while simultaneously preparing a planting bed for seeding or transplanting (Figure 8). Small, fine-leaved cover crops can be terminated and incorporated at the same time, but larger and coarser cover crops often need to be terminated and perhaps chopped with a mower or similar piece of equipment. They can also be allowed to simply wilt for a week or two before being incorporated.

If a rototiller is not available, you can incorporate cover crops using a shovel or garden fork. Incorporating a cover

Figure 7. Flail mower used to terminate cover crops.

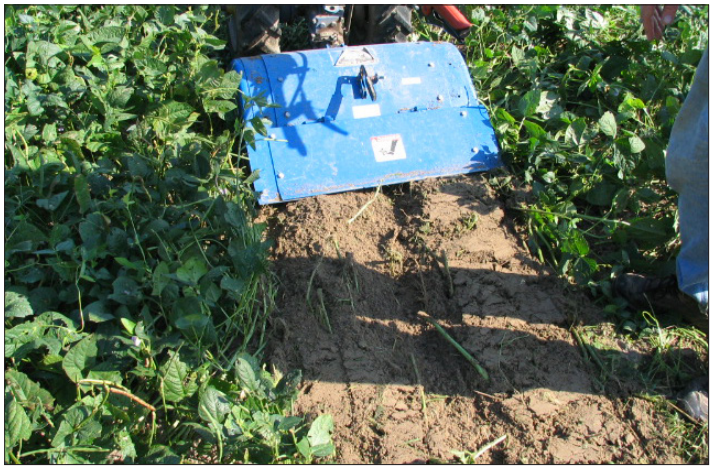

Figure 8. Incorporating cover crops with a rototiller.

crop by hand takes more effort than turning bare soil, but it is effective in raised beds and in small- to medium-sized gardens.

Nitrogen from Cover Crops

Cover crops can be an integral part of maintaining soil fertility. Legume cover crops fix atmospheric nitrogen through a symbiotic relationship with soil bacteria (*Rhizobia* spp.), which infects crop roots. Incorporating the legume cover crop into the soil releases plant-held nitrogen for the next crop (Collins et al. 2013). Cereals and other non-legumes do not fix nitrogen, but they can rapidly take up soil nitrogen as they grow. If they are planted early enough to establish well in the fall, they can take up nitrogen left behind at the end of the growing season, which prevents it from being leached by winter rains.

The amount of nitrogen supplied by a cover crop depends on the nitrogen content and biomass of the crop. Cover crop residue is decomposed by soil microorganisms. If a cover crop has a low nitrogen content, such as cereal cover crops, the microbes will experience a nitrogen deficiency as they decompose the crop residue. This deficiency leads to nitrogen tie-up in the soil, which converts the nitrogen from a plant-available form into a form that can be taken up and used by soil microorganisms. This

is called immobilization (Figure 9). If a cover crop has a high nitrogen content, the microbes will release surplus nitrogen in plant-available mineral form as they consume the residue. This is called mineralization. In cover crop tissue, the "break-even" point between mineralization and immobilization is about 2% nitrogen.

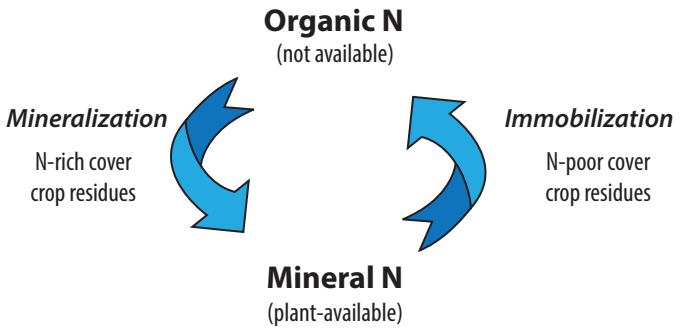

Figure 9. Cycle of mineralization and immobilization of nitrogen from decomposing cover crop residues.

Legume cover crops can contain 2% to 4% nitrogen, and non-legumes typically contain 1% to 2% nitrogen. The nitrogen content of both types of cover crops drops to the lower end of their ranges as they mature and go to seed. To optimize the nitrogen contribution from your cover crop, the best time to incorporate it is during the late-vegetative and early flowering stages. This is the "sweet spot" for nitrogen supply; that is, the point at which there is the maximum amount of plant material, but before the plant material's nitrogen content declines. Even relatively small amounts of legume in a cover crop stand can reduce the risk of nitrogen immobilization after incorporation.

Table 1 compares the potential plant-available nitrogen (PAN) contribution from legume vs. non-legume plants vs. a mix of the two. These amounts should be lowered if you have a thin stand of cover crop or if you incorporate the cover crop early.

Table 1. Comparison of potential plant-available nitrogen content between types of plants: legume crops vs. non-legume crops.

Cover crop	Pounds (lb) of PAN per 1000 ft^2
Pure legume	1 to 2
Legume 50% and non-legume 50%	0.7 to 1.4
Pure non-legume	-1 to 0

For more accurate estimates, you can harvest cover crops from a measured area of your garden (e.g., 4 ft^2), then weigh the crop, and submit a sample to a soil laboratory for nitrogen percent and dry-matter analysis. The Organic Fertilizer and Cover Crop Calculator, available online at http://smallfarms.oregonstate.edu/calculator, is also able to estimate a cover crop's PAN contribution.

Advanced Cover Cropping Techniques

Effective planning, timing, and techniques all contribute to successful cover cropping.

Hairy Vetch Relay Seeded into Fall Carrots

Hairy vetch relay seeded between carrot rows. Carrots were planted in August, hairy vetch was seeded in early October, and photo was taken in late October.

Hairy vetch was seeded between carrot rows. Carrots were harvested in December, and photo was taken in early April.

These photos show a plot of late-planted carrots with a relay-seeded hairy vetch cover crop. Carrots were planted in August, and the hairy vetch was planted between the carrot rows in early October. The top photo shows the hairy vetch becoming well established by late October, approximately 4 weeks after planting. The carrots were not harvested until early December, well beyond the recommended planting time for a fall cover crop. Carrots were loosened using a digging fork and harvested by hand with minimal damage to the hairy vetch, despite foot traffic in the rows. The bottom photo was taken in early April, just as the hairy vetch began its rapid spring growth. Relay seeding produced a healthy stand of hairy vetch going into the spring, although complete ground cover was not achieved.

Relay Seeding

Good timing is critical when seeding, particularly for fall-planted cover crops, so good crop establishment and growth can be achieved. Many summer vegetables, such as tomatoes and sweet corn, can keep producing until the first hard frost, and vegetables, such as brassicas and carrots,

Cover Crops Relay Seeded into Plantings of Peppers and Eggplant

Cover crops can be seeded successfully into summer vegetables, such as peppers and eggplant. For cover crops with larger seeds, broadcast the seed into the vegetable crop just before the last weed cultivation. For cover crops with smaller seeds, broadcast the seed into the vegetable crop just after the last weed cultivation. In both cases, seeding should occur 1 to 2 weeks before the vegetable crop canopy shades the soil surface. Depending on the season and the type of crop, this can be from mid-July to late August. Provide at least one or two irrigations after seeding the cover crop to ensure the seedlings are well established. When a cover crop is seeded early enough, it can become well established before a vegetable crop crowds it out. It can also provide a good winter groundcover and a robust cover crop the following spring. Winter oats, cereal rye, and annual ryegrass are well suited to relay seeding. Common vetch and crimson clover are suitable legumes for relay seeding in mild winter areas.

Broadcasting cover crops into eggplant crop.

Common vetch in November after the eggplant is winter-killed.

Oats in November after the eggplant crop is winter-killed.

may be left in the garden well into the winter months. However, cover crops planted this late frequently do not establish well or provide adequate soil protection. To avoid this problem, plant the cover crop among (or alongside) an established vegetable crop while it is still growing. This method is variously known as relay seeding, overseeding, interseeding, or undersowing.

Relay seeding allows for timely cover crop establishment in late-season vegetable crops and can also eliminate the need for fall tillage. Note that relay seeding results in establishment of a second crop within a garden bed.

For relay seeding, try to create a seedbed that does not contain too much plant residue, such as from large weeds. Cover crops that have been planted by relay seeding in the summer months usually need supplemental irrigation to get established; remember, you are watering drought-sensitive seedlings. Additionally, they do better with overhead irrigation as opposed to drip irrigation because overhead sprinklers irrigate the entire cover crop seedbed, while drip irrigation only targets the plant root zone.

The timing of relay seeding depends on the type of vegetable crop being grown, as well as the planting window for the cover crop. If relay-seeded cover crops are planted too early, they can compete with the vegetable crop for space and resources. If they are planted too late, they are less likely to become established before winter.

For fall vegetable crops, such as spinach, carrots, or broccoli, it is best to relay seed cover crops after the vegetable crop has become well established, usually between mid-August and late September. If you relay seed a cover crop into sweet corn, you will likely be planting in June or July, when the corn plants are about 6 to 12 inches tall. Some cover crops, such as crimson clover and hairy vetch, are less winter hardy if planted during these months. You may need to experiment with your vegetable plantings (those harvested in November or later) to see which cover crop and planting window works best at balancing cover crop growth with vegetable-crop competition.

Cover Crop Niches

While most cover crops are planted in the fall and allowed to overwinter, they can be planted at other times as well. Cover crops can benefit a garden even when grown for short durations. Home gardeners often grow many different vegetable crops each season, so bare soil may be

Figure 10. Mustard planted in the summer effectively smothers warm-season annual weeds. The mustard shown is ready to flower and ready for immediate termination.

available at different times in different parts of the garden. Proper use of these "niches" or windows of opportunity can benefit your garden in various ways, such as reducing summer weed pressure (Figure 10) and breaking disease and insect cycles (Clark 2007).

Warm-season niche strategies

Many cold-sensitive cover crops can be planted, established, and terminated in less than two months during the warm season. The cover crops, listed below, do well with warm soil and air temperatures and longer day lengths. You can plant them as a cover for fallow summer garden spaces, or as a cover between spring and fall vegetable crops (Figure 11). Cover crops will need some irrigation when grown in the summer under dry environmental conditions.

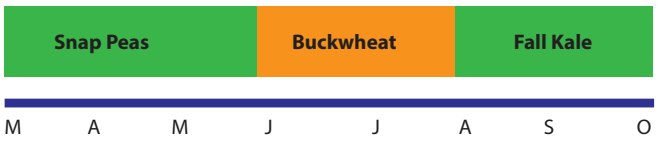

Figure 11. Calendar schedule for growing a buckwheat cover crop between spring peas and fall kale.

The following list contains examples of cold-sensitive crops that do well in warm-season niches.

- *Buckwheat* (seeding rate of 1 cup per 100 ft^2) is quick to establish, which enables it to compete with weeds. Buckwheat attracts beneficial insects and pollinators and can reduce weed emergence after being incorporated back into the soil (Figure 12). This cover crop can germinate in cool soil temperatures, but it is not cold hardy. Plan to terminate this crop after 40 days or less to prevent seed production. Buckwheat is easy to incorporate and will reliably winter-kill.
- *Vetches* (seeding rate of ½ cup per 100 ft^2) grow slowly in cool weather, but under warmer air temperatures they quickly accumulate biomass and can out-compete weeds.

Figure 12. Buckwheat grows rapidly, attracts pollinators, and smothers weeds.

- *Mustards* (seeding rate of 1/8 cup per 100 ft^2) can attract beneficial insects and pollinators, smother in-season weeds, and reduce weed emergence after being incorporated. They do best in warmer soils. Do not let mustard plants go to seed because they can become troublesome weeds themselves. Terminate this cover crop within 60 days of summer planting to avoid shedding seeds. Cross-pollination between flowering mustards and brassica crops can threaten commercial brassica-seed production. (Brassica seed is grown in parts of northwest Washington, as well as Oregon's Willamette Valley, and parts of central Washington and central and eastern Oregon.) See the companion publications in this series, *Cover Crops for Home Gardens West of the Cascades* and *Cover Crops for Home Gardens East of the Cascades*, for details (Cogger 2014 a,b).
- *Sorghum-Sudangrass* (seeding rate of 1/8 cup per 100 ft^2) is a hybrid that can develop large amounts of biomass, smother weeds, and deposit organic matter back into the soil. Sorghum-Sudangrass needs warm soil and air temperatures to thrive. This cover crop can be terminated as early as 40 days after planting and still provide significant weed suppression, or it can be grown for longer periods (up to 100 days) for maximum biomass accumulation. Sorghum-Sudangrass can be difficult to kill in the summer. It is killed by the first hard frost, at which time it collapses, providing mulch over the winter and easier incorporation in the spring.

Cool-season niche strategies

Some cold-tolerant cover crops can be grown in early spring to cover bare soil after the harvest of overwintering vegetables, such as winter brassicas and field-stored carrots or parsnips (Figure 13). Cover crops that establish quickly and can tolerate cold soil temperatures, frosts, and wet conditions fit into this category. These cover crops can also be used to break pest cycles and protect soil quality, thus increasing the productivity of your garden. It is

Figure 13. Example of a cool-season cover crop with rye planted after fall-planted kale and before summer-planted winter squash.

helpful to use higher seeding rates (a rate of 50% greater than normal) with these cover crops to improve crop establishment.

The following list contains examples of cold-tolerant crops that do well in cool-season niches.

- *Barley* (seeding rate of 1½ cups per 100 ft^2) can germinate in temperatures from 35°F to 40°F and withstand cooler temperatures during growth. Seed is inexpensive, and its large seed size allows for quick establishment.
- *Winter wheat* (seeding rate of 1½ cups per 100 ft^2) can germinate when the soil temperature is above 40°F to 45°F, and it is cold tolerant. Seed is readily available and inexpensive.
- *Cereal rye* (seeding rate of 1½ cups per 100 ft^2) is extremely cold hardy even during early stages of growth and can germinate at temperatures as low as 35°F to 40°F.
- *Oats* (seeding rate of 2½ cups per 100 ft^2) can germinate at temperatures from 40°F to 45°F and establishes quickly.

Cover Crops Aid in the Breakdown of Disease and Insect Cycles

Many plant pathogens require a susceptible host to survive, and some cover crops can act as a carryover host, sometimes called a "green bridge," for soilborne plant diseases, increasing the risk or severity of some diseases. However, if a non-host cover crop species is planted in a garden with a history of disease pressure, it may break the disease lifecycle because you are depriving the pathogen of a suitable host. It is important to correctly identify the plant disease and know its lifecycle, as well as its alternative hosts before choosing cover crops to include in your management program. Check with your local Extension office for assistance in identifying plant diseases. Cover crops can also help break insect lifecycles. Planting a non-host cover crop will help reduce the survival of many insect pests in your garden, although some insects can feed on a variety of plants, including cover crops.

Reduced Tillage

Tillage is used to prepare a seedbed and break down plant material. However, eliminating or reducing tillage can improve overall soil health (Luna et al. 2012). Integrating reduced-tillage strategies when growing cover crops in a garden requires careful planning. Planning should include strategies such as creating a thick mulch to control weeds by mowing or crimping cover crops and then simply tilling or opening a narrow strip of soil for planting vegetable crops. Reduced-tillage strategies are well suited for use with vegetable crops that have large seeds and with vegetable transplants (Figure 14). Vegetable crops with smaller seeds can be planted in strip-tilled areas.

Figure 14. Winter squash transplanted into incorporated hairy vetch (A) and mowed and mulched hairy vetch (B). In both cases, no weeding was done.

Mowing or crimping to create mulch

A cover crop can be cut down with a scythe or mowed, as previously described, and then left in place as mulch without incorporation. If the mulch is unevenly distributed in the garden bed, spread it more evenly by using a rake. It is also possible to terminate cereal cover crops by physically damaging them using a roller/crimper just after pollination. This timing is important for preventing the cover crop from growing back or creating viable seed. Gardeners can simulate the action of a roller/crimper on a smaller scale by using a flat-edged shovel or by stepping forcefully on a piece of wood and crimping stems about every eight inches. However, crimping with a shovel or piece of wood is more work than cutting or mowing cover crops. Crimping is not an effective method for terminating legume cover crops. These crops should be mowed or cut with a scythe, grass whip, or string trimmer.

Strip tillage

This tillage method involves mowing or crimping and mulching, then tilling planting strips into the cover crop. Strip tillage creates a planting bed suitable for a wide range of seed sizes. It also allows for planting in warmer soils and provides for easier access when weeding young vegetable plants. If a narrow tiller is not available, a planting strip can be opened up with a pick-like digging tool, such as a mattock.

Advantages and disadvantages of cover crop mulches

The mulch created when a cover crop residue is left on the soil surface works to suppress weeds, reduce the impact of rain, and retain water for the vegetable crop. However, this plant residue can also increase the slug population and its attendant damage. Furthermore, soil is likely to be cooler and wetter in the spring because the cover crop shades the soil surface beneath it and its canopy holds moisture. A lower soil temperature, as well as wet soil can slow vegetable crop growth and maturity, which can be problematic in mild maritime summers. Also, cover crops are less available as a source of plant nutrition when they are used as mulch, rather than being incorporated back into the soil. However, strip tillage can reduce these disadvantages.

References

Andrews, N., D. Sullivan, J. Julian, and K. Pool. 2010. Organic Fertilizer and Cover Crop Calculator. *Oregon State University Extension*. http://smallfarms.oregonstate.edu/calculator.

Clark, A., ed. 2007. *Managing Cover Crops Profitably*, 3rd edition. Sustainable Agriculture Network. http://www.sare.org/content/download/29733/413984/ManagingCoverCropsProfitably_0812.pdf?inlinedownload=1.

Cogger, C., C. Benedict, N. Andrews, and A. McGuire. 2014a. Cover Crops for Home Gardens West of the Cascades. *Washington State University Extension Publication* FS11E. https://pubs.wsu.edu/ListItems.aspx?Keyword=fs111e.

Cogger, C., C. Benedict, N. Andrews, S. Fransen, and A. McGuire. 2014b. Cover Crops for Home Gardens East of the Cascades. *Washington State University Extension Publication* FS117E. https://pubs.wsu.edu/ListItems.aspx?Keyword=fs117e.

Collins, D., C. Miles, C. Cogger, and R. Koenig. 2013. Soil Fertility in Organic Systems: A Guide for Gardeners and Small Acreage Farmers. *Washington State University Extensions Publication* PNW646. http://cru.cahe.wsu.edu/CEPublications/PNW646/PNW646.pdf.

Luna, J.M., J.P. Mitchell, and A. Shrestha. 2012. Conservation Tillage for Organic Agriculture: Evolution toward Hybrid Systems in the Western USA. *Renewable Agriculture and Food Systems* 27: 21–30. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=8484919.

Sattell, R., ed. 1998. Using Cover Crops in Oregon. *Oregon State University Extension Publication* EM8704. http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/24506/EMNO8704.pdf?sequence=1.

Smith, R., R.L. Bugg, and M. Gaskell. 2011. Cover Cropping for Vegetable Production. *University of California Agriculture and Natural Resources Publication* 3517. http://anrcatalog.ucdavis.edu/AgriculturalProduction/3517.aspx.

WASHINGTON STATE UNIVERSITY EXTENSION

By **Chris Benedict**, Regional Extension Specialist, WSU Whatcom County Extension; **Craig Cogger**, Extension Soil Specialist, WSU Puyallup Research and Extension Center; **Nick Andrews**, Metro-Area Small Farms Extension Agent, OSU North Willamette Research and Extension Center.

Issued by Washington State University Extension and the U.S. Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, sex, religion, age, color, creed, and national or ethnic origin; physical, mental, or sensory disability; marital status or sexual orientation; and status as a Vietnam-era or disabled veteran. Evidence of noncompliance may be reported through your local WSU Extension office. Trade names have been used to simplify information; no endorsement is intended. Published February 2014. *This publication replaces EB1842*.

FS119E