United States Department of Agriculture

Conservation Crop Rotation (328) in Organic Systems

Oregon Implementation Guide

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Oregon Tilth
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Contents

Figure 2. Crops at Goodfoot Farm, Philomath, Oregon

ACKNOWLEDGMENTS

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Photos Oregon Tilth unless otherwise noted

Figure 1. (on front cover) Rows of crops a Goodfoot Farm in Philomath, Oregon (Oregon Tilth)

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Purpose

The purpose of this document is to provide guidance for implementing the NRCS Conservation Crop Rotation (328) practice in organic systems in Oregon. Crop rotation refers to a planned sequence of crops grown on the same ground over time (i.e., the rotation cycle). Crop rotation can be used to achieve several conservation goals and is required for organically managed systems. This guide discusses considerations for designing a crop rotation based on an organic grower's conservation goals. The steps for planning and implementing crop rotation in organic systems, and examples from different Oregon cropping systems, are discussed. This guide can be used to support NRCS conservation planners and partners in meeting the criteria of the Conservation Crop Rotation (328) practice standard, while also complying with USDA National Organic Program regulations.

Crop Rotation in Organic Systems

The purposes of crop rotation in organic systems do not differ from those in conventionally managed systems; however, the role of crop rotation in supporting soil health and reducing pest and weed pressure takes on greater importance in organic systems because the use of synthetic chemical fertilizers and pesticides is generally prohibited. Crop rotation is also essential on organic operations to meet National Organic Program (NOP) requirements to maintain or improve soil organic matter content, provide for pest management in annual and perennial crops, manage deficient or excess plant nutrients, and provide erosion control (see regulatory text on Page 4).

Producers and planners may implement crop rotations to address a variety of purposes on a particular operation. The purpose will impact design and implementation of the practice.

The following purposes are recognized by the NRCS Conservation Crop Rotation (328) practice standard:

- Reduce sheet, rill, and wind erosion;
- Maintain or increase soil health and organic matter content;
- Reduce water quality degradation due to excess nutrients;
- Improve soil moisture efficiency;
- Reduce the concentration of salts and other chemicals from saline seeps;
- Reduce plant pest pressures;
- Provide feed and forage for domestic livestock; and
- Provide food and cover habitat for wildlife, including pollinator forage, and nesting.

The NRCS Conservation Crop Rotation (328) practice standard notes that a crop rotation must include a minimum of two different crops, which can include a cover crop. Wheat-fallow rotations are not considered compliant with the NRCS practice standard, or the NOP organic regulations when continuous wheat-bare-ground fallow is used.

Relevant National Organic Program (NOP) Regulations

The entire NOP regulations, as well as lists of approved and prohibited materials and other information can be found at the NOP website: www.ams.usda.gov/AMSv1.0/nop

§ 205.203 Soil fertility and crop nutrient management practice standard. (Abbreviated)
(a) The producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion.
(b) The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials.
(c) The producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances.

§ 205.204 Seeds and planting stock practice standard. (Abbreviated)
(a) The producer must use organically grown seeds, annual seedlings, and planting stock: *Except,* That,
(1) Nonorganically produced, untreated seeds and planting stock may be used to produce an organic crop when an equivalent organically produced variety is not commercially available;
(2) Nonorganically produced seeds and planting stock that have been treated with a substance included on the National List of synthetic substances allowed for use in organic crop production may be used to produce an organic crop when an equivalent organically produced or untreated variety is not commercially available*;
(3) Seeds, annual seedlings, and planting stock treated with prohibited substances may be used to produce an organic crop when the application of the materials is a requirement of Federal or State phytosanitary regulations.

§ 205.205 Crop Rotation Practice Standard
The producer must implement a crop rotation including but not limited to sod, cover crops, green manure crops, and catch crops that provide the following functions that are applicable to the operation:
(a) Maintain or improve soil organic matter content;
(b) Provide for pest management in annual and perennial crops;
(c) Manage deficient or excess plant nutrients; and
(d) Provide erosion control.

§ 205.206 Crop pest, weed, and disease management practice standard. (Abbreviated)
(a) The producer must use management practices to prevent crop pests, weeds, and diseases including but not limited to:
(1) Crop rotation and soil and crop nutrient management practices, as provided for in §§ 205.203 and 205.205;

* Commercially Available: The ability to obtain a production input in an appropriate form, quality, or quantity to fulfill an essential function in a system of organic production or handling, as determined by the certifying agent in the course of reviewing the organic plan. (Sec. 205.2).

Designing a Crop Rotation Sequence

When planning a crop rotation sequence, each crop and variety's distinct characteristics should be considered, including crop species, nutrient requirements, residue load, pest and disease vulnerability, and growth patterns such as rooting depth, canopy cover, and growth speed. A first step in planning a crop rotation should be identifying the objectives of the rotation with the producer. Possible functions of the rotation can be discussed to help identify some of these objectives, and then specific practices can be selected based on these objectives.

Crop rotations on organic farms can be more diverse and longer than conventional operations (Barbieri et al., 2017). Because rotations are critical nutrient, weed, and pest management strategies on organic farms, a more diversified and longer rotation sequence allows for maximum benefit to the operation. Delate et al. (2015) conducted a review of long-term organic farming trials across the U.S. under varying climatic conditions. Outcomes reviewed included greater soil organic carbon, available nitrogen, and nitrogen mineralization potential, and reduced weed pressure and required manure applications for optimal yields amongst longer crop rotations as compared to conventional systems and shorter rotations on organic operations (Delate et al., 2015).

When planning a crop rotation with a wide mix of crops, try grouping crops into categories according to plant family, timing (for example, early season and late season crops), perennial versus annual, type of crop (root, fruit, leaf, etc.), nutrient needs, or similar cultural practices. Consider incorporating both warm and cool season crops into a rotation sequence for increased crop diversity. Perennials can provide organic matter and soil aggregation benefits when included in a rotation.

Bare-ground fallow periods should be minimized, with cover crops incorporated into the rotation when the climate and soils allow for it. The organic regulations allow for fallow periods for the purpose of field preparation and weed control that do not result in erosion or other issues of concern.

Additionally, a producer's management and labor capacity, equipment, and economic and market pressures should all be carefully considered when planning a crop rotation. Variations in field characteristics and the acreage of each crop, as well as shifting business priorities can result in numerous rotations being planned for one farm. A fixed schedule for every field across the operation, with every crop rotating field to field throughout the rotation sequence and around the farm may be unrealistic. Consider both time and space when planning a rotation—where physical space is being created between fields of the same crop, and where time is separating plantings of the same crop.

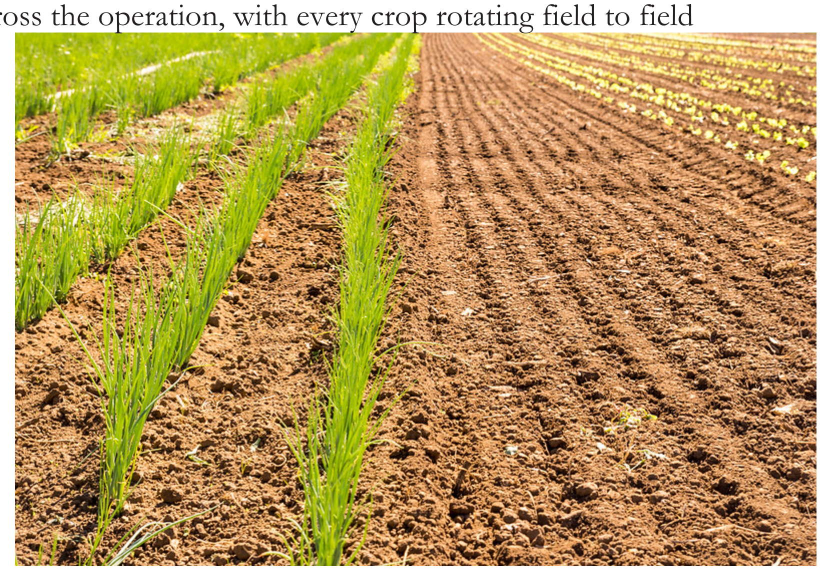

Figure 3. Gathering Together Farm, a certified organic, diversified vegetable and fruit farm in Philomath, Oregon.

Nutrient Management

Managing nutrient supplies is a crucial consideration of crop rotation. Producers must ensure there are enough available nutrients for crop growth, while avoiding the accumulation of excess nutrients in the soil that can lead to nutrient leaching and water quality concerns. Organic producers manage fertility through crop rotations, incorporation of crop residues, growing cover crops, and additions of organic soil amendments.

When designing a crop rotation, it is important to consider the nutrient requirements of each crop in the sequence, and how each one will contribute to or deplete nutrient pools. Physically grouping crops together that have similar nutrient needs can assist with nutrient planning and management, as the group's nutrient needs can be managed as a single entity.

Legume cover crops and some high-residue cash crops may also help meet nitrogen demands of subsequent crops; a legume may be followed by a high nitrogen-demanding crop in the sequence (see Table 1 for examples of low, medium, and high nitrogen-demanding crops). A lower nitrogen-demanding crop may then follow. The incorporation of annual or perennial legumes in a rotation can be useful when high levels of soil phosphorus or potassium exist due to manure applications. Legumes should be inoculated (and NRCS may require inoculation), but organic producers will need to ensure they are using an inoculant that is allowed in organic production and receive approval from their certifier before use of a new input. A majority of the plant available nitrogen is normally released from legume cover crops in the first 3-5 weeks after termination. A slow release of nitrogen can also be provided by crop residues, while minimizing the risk of nitrogen leaching.

Table 1. Nitrogen requirement of vegetable crops based on seasonal nitrogen uptake

Low Total N Need <120 lb/acre	Medium Total N Need <120-200 lb/acre	High Total N Need >200 lb/acre
Baby greens	Carrot	Broccoli
Beans	Corn, Sweet	Cabbage
Cucumbers	Garlic	Cauliflower
Radish	Lettuce	Celery
Spinach	Melons	Potato
Squashes	Onion	
	Peppers	
	Tomatoes	

***Note*: Adapted from "Soil Fertility Management for Organic Crops," by Gaskell et al., 2007.**

When an objective of the crop rotation plan is the removal of excess nutrients from the field, crops should be chosen that germinate and form root systems quickly, and root deep enough to reach nutrients in the soil that were not removed by the preceding crop. The crop must be able to readily utilize the soil's excess nutrients (in other words, it should not be a very low nutrient-demanding crop). Shallow-rooted cover crops can allow for deep moisture and nutrient storage for subsequent crops. See Table 2 for example crop rooting depths. Be mindful that crop rooting depth can vary based on variety, soil and environmental conditions, nutrients, and plant and root health. When planning for the removal of excess nutrients, all nutrient sources should be considered, including nitrogen credits from legumes and previous applications of plant and animal materials. End-of-season cover crops, for example cereals or cereal mixes, may reduce the risk of nitrate leaching, but will need good stand establishment to take up residual nitrogen.

Soil testing to determine soil nutrient content can inform nutrient management decisions, and it is recommended to follow land grant university guidelines on soil sampling procedures, as well as guidelines for fertilizer application rates if available.

Table 2. Crop root depths in a deep, uniform, well-drained soil profile	
Crop	**Root Depth (ft)**
Alfalfa	4-6
Asparagus	6
Beet (table)	1-1.5
Berries	3-5
Broccoli	2
Cabbage	2
Carrot	1.5-2
Corn (grain and silage)	2-3
Corn (sweet)	1.5-2
Cucumber	1.5-2
Lettuce	0.5-1.5
Onion	1
Pea	1.5-2
Radish	1
Tomato	2-4
Turnip (white)	1.5-2.5
Wheat	2.5-3.5

***Note*. Adapted from Chapter 11, "Sprinkler Irrigation," Section 15, United States Department of Agriculture National Engineering Handbook, 2008.**

Figure 4. Crop rotation can support soil health and soil organic matter objectives.

Improvement of Soil Health and Organic Matter Content

Increasing an operation's biodiversity through crop rotation can increase the diversity in types of organic matter, supporting soil-building organisms and helping to address many soil quality-related objectives.

When building soil health and organic matter is an objective of a crop rotation, include crops that will maintain or increase soil organic matter content, as determined by the Soil Conditioning Index. Bare-ground fallow periods should be reduced as much as possible, as a reduction in organic matter can occur while additions of biomass are not being made, but organic matter decomposition continues (Baldwin, 2009).

Considerations When Using Erosion Prediction Tools in Organic Systems

The Soil Conditioning Index (SCI) is a quantitative value that indicates how cropping systems and tillage practices impact soil organic matter. It enables a rapid assessment of organic matter dynamics in a cropping system, which is important since organic matter is a critical component of soil health. Surface residues shield soil from erosion. Decaying residues feed microbes, improve soil structure and water infiltration, all of which work to reduce runoff. In organic cropping systems, the SCI can be an especially informative way to evaluate the consequences of using large levels of organic inputs and varying amounts of tillage. There are three main components of the SCI:

1. Soil Organic Matter accounts for quantity of organic material returned to the soil.
2. Field Operations accounts for the effect of field operations that stimulate organic matter breakdown, including tillage, planting, fertilizer application, spraying and harvesting.
3. Erosion accounts for the effect of removal and/or sorting of surface soil material by the sheet, rill, and/or wind erosion processes which are predicted by water and wind erosion models.

The SCI provides a rating based on these components. A negative rating indicates the cropping system is leading to a decline in soil organic matter, while a positive rating indicates improvements in organic matter. Conservation planners can use SCI to plan and design cropping systems and residue management practices to address soil organic matter depletion resource concerns. There are several ways organic producers can modify their management practices to improve their SCI scores, including:

1. Include high residue producing crops in their crop rotations
2. Integrate cover crops into the cropping system
3. Use compost or mulch to add organic matter to the soil
4. Limit the number and intensity of tillage operations
5. Monitor irrigation application to minimize water erosion.

Organic cropping systems can be evaluated in the Integrated Erosion Tool (IET), using the Revised Universal Soil Loss Equation Version 2 (RUSLE2) and Wind Erosion Prediction Systems (WEPS) to calculate SCI.

When selecting a Crop Management Zone (CMZ) management template for use in RUSLE2 or WEPS, be mindful of NOP regulations and adjust the template accordingly.

Crop residues are another important consideration for improving soil health and organic matter, providing protection from erosion by covering the surface of the soil, and allowing for a slow release of nutrients. If improvement of soil health and organic matter content is an objective of the crop rotation, low residue loads over the course of a rotation sequence may lead to producers' conservation goals not being met. Crop residues also influence soil moisture and temperature, and it is important to consider how this will influence crop performance. A crop rotation plan can be used in combination with the NRCS Conservation Practice Standards Residue and Tillage Management (329 and 345) to enhance the type of residues, as well as amount and distribution based on the types of crops and varieties selected, plant density, cover crop use, and row spacing.

Vegetable crops and other plants that typically produce low residues can be rotated with crops producing higher residues, such as cover crops, in support of meeting residue goals. Producers should ensure they have the proper equipment to manage high residue loads before planting for high residues. The NRCS

Conservation Practice Standard for Conservation Crop Rotation (328) specifies that when an objective of the rotation is to improve soil health, at least one-third of the sequence (in terms of time) should include high-biomass annual or perennial crops. For rotations that are typically dominated by low-residue crops, one-half of the sequence should be comprised of cover crops and high-residue production crops.

When soil stability is a concern, consider incorporating perennial crops with deep or extensive root systems in the rotation to help build organic matter throughout the soil profile, penetrate compacted soil layers, and support soil aggregation. For example, alfalfa produces a strong, deep tap root that can push through hard soil layers.

Insect and Disease Management

Crop rotation is a key prevention and avoidance strategy for organic producers in supporting the reduction of insect and disease pressures without the use of synthetic materials prohibited in organic production. Crop rotation can support these objectives on a farm when the sequence is designed to alternate host and non-host crops to interrupt the lifecycle of the pest or pathogen of concern. Alternating susceptible and less-susceptible crops can be an additional strategy to minimize damage.

Time and distance are crucial factors in planning a crop rotation for insect and disease management objectives. The basic strategy is to make it hard for pests and pathogens to find their desired host plant. To accomplish this, planners and farmers need to understand the lifecycle and plant preferences of the target pest or pathogen. The ability of a crop rotation to control insects or disease depends on the lifecycle of the organism. Pests that are less mobile, such as soil-dwelling nematodes, and those that feed on a specific type of host plant are generally easier to control. Foliar-feeding insects with high mobility and wind-borne disease can be particularly challenging to control on smaller farms, when physical distance in the crop rotation can be hard to achieve.

Table 3. Common Plant Families of Crops

Plant Family	Example Crops in Plant Family
Grasses	Corn, sorghum, millet (warm-season), barley, wheat, oats, spelt, rye (cool-season)
Legumes	Peas, beans, vetch, clover, alfalfa
Mustards/Brassicas	Broccoli, cauliflower, Brussels sprouts, collards, kale, cabbage, turnips, mustard greens, canola, radish, sweet alyssum, arugula
Alliums	Garlic, leeks, onions, chives, shallots
Cucurbits	Squash, pumpkin, cucumbers, gourds, melons
Solanaceae/Nightshade	Tomato, potato, eggplant, peppers
Lettuce/Asteraceae	Lettuce, endive, artichokes, sunflower
Beets/Chenopodiaceae	Beets, spinach, chard
Carrot/Apiaceae	Carrot, celery, cilantro, dill, fennel, parsley, parsnip
Rosacea	Strawberries

***Note*. Adapted from "Tipsheet: Crop Rotation in Organic Farming Systems" by R. Dufour, 2015.**

Rotating crops from different plant families can help to break pest and pathogen lifecycles and maximize above and below-ground diversity. Table 3 shows common plant families of crops with examples. Longer rotations with multiple years of perennial cover, incorporating crops from at least three different plant families and allowing at least three years between plantings within the same family can all support reducing pest and disease pressures. Pathogen-susceptible weeds must also be excluded from the field. For disease management, longer rotations combined with other strategies such as solarization and the planting of disease-resistant varieties can be successful. As a general principal, it is recommended to avoid following one crop with another closely related species.

Biological pest control can also be supported by incorporating flowering plants that provide food and habitat for beneficial insects or natural enemies of the pest of concern. Plant families such as mustards can also suppress fungi and nematode populations in the soil (Mohler & Johnson, 2020). When feasible, retaining bolting or flowering crops can also provide food for beneficial insects.

Weed Management

Weed control products permitted for use in organic production systems are often more expensive and less effective than their conventional counterparts. Therefore, weed management can be a top challenge for organic farmers, and crop rotation is a powerful weed management strategy. Sequences that include varied planting and maturation dates, allelopathic and competitive traits, and management practices such as mowing can provide weeds with an inhospitable environment. Competitive characteristics such as rapid germination and biomass accumulation can give a crop a competitive advantage over weeds. Rotating between spring, summer, and fall-planted crops can interrupt the lifecycles of weed species with preferred germination seasons. Shorter rotations such as a two-year rotation between two different crops can result in increasing weed populations over time, compared to longer rotations with varied crops and opportunities for weed control through different mechanisms (Gallandt & Weiner, 2015). Generally, the more complex and diverse a crop rotation is, the more effective it will be in controlling weed growth over time (Melander et al., 2017).

Crops that reduce the quantity or quality of light beneath their canopy can also shade out weeds. Competitive cash crops and cover crops such as wheat, buckwheat, barley, oats, rye, sorghum, and sudan grass can aid in the control of weeds by competing for nutrients and water, and producing a thick canopy. Crops that do not grow a canopy, such as onions, can be rotated with crops that do grow dense canopies, such as potatoes, to reduce weed pressure. Some crops like carrots and parsnips grow a thick canopy but germinate slowly, and may be very susceptible to weed competition. High crop density, if tolerated by the crop, may support earlier leaf canopy closure. Alternating crops in which different weed control tactics are used (for example, flame weeding versus hilling) can also reduce the abundance of weed species.

Alternating the length of the crop growing period can also be a critical weed management strategy, as weeds may have the opportunity go to seed in long-season crops like field corn and winter squash, but not in a short-cycle crop like lettuce or mustard greens.

Residue management can be another weed control strategy when residues are left on the soil surface as mulch (such as those from crimson clover, hairy vetch, and other legumes), as residues can shade the soil surface, limiting weed seed germination.

Combining several of these rotation considerations for weed control may ultimately deplete weed seed banks and result in reduced weed pressures over time.

Crop Rotation in Perennial Systems

It is a National Organic Program requirement that certified organic producers of perennial crops must introduce biodiversity in lieu of the organic crop rotation requirement, using cover crops, intercropping, and other methods. Although NRCS financial assistance for Conservation Practice Standard 328: Conservation Crop Rotation does not apply to perennial cropping systems due to the minimum requirement for two different crops in the rotation, NRCS can provide technical assistance in this area. Many NRCS practices be supportive of introducing biodiversity, such as Conservation Cover (327), Cover Crop (340), Alley Cropping (311), Field Border (386), Hedgerow (422), and more. Please confirm the conservation practice is available for contracting in your region (i.e., the practice is a component of an existing Conservation Implementation Strategy).

An example of introducing biodiversity in organic perennial production is the use of cover crops in orchard systems to attract beneficial insects, to provide nitrogen (if legumes), and to suppress weed growth in the tree row or alleys. Many perennial crop producers will choose to incorporate perennial cover crops, rather than annuals, in their operations. However, annual cover crops can also provide many of the same benefits in perennial systems.

When choosing to implement cover crops or otherwise introduce biodiversity in organic perennial systems, planners and producers should consider competition for moisture and/or nutrients, harvesting requirements of the cash crop, creation of habitat for beneficials, natural predators or pests, and avoiding pollinator competition when flowering non-crop plants may be more desirable to pollinators than flowering crops.

Figure 5. Paz Blueberries, Eugene, Oregon

Example Rotations from Oregon Producers

<table>
<tr><th colspan="2">Eric Nelson, Nelson Grade Organics, Pendleton, Oregon</th></tr>
<tr><td><u>Previous 11-year rotation:</u></td><td rowspan="7">Eric Nelson is a certified organic producer farming 880 acres near Pendleton, Oregon. The 10 to 12 inches of annual precipitation present challenges for Nelson and other growers in the region, with seventy percent of this precipitation coming in the winter months. Nelson follows an 11-year crop rotation, dividing his land into 11 fields of approximate equal size. Despite increasing his workload, Nelson finds this rotation minimizes risk on his operation.

Shown here are two rotations: Nelson's previous rotation with alfalfa, grown to build soil nitrogen, break up compact soil layers, and reduce weed pressure, and</td></tr>
<tr><td>Year 1: Establishing Alfalfa</td></tr>
<tr><td>Years 2-3: Alfalfa</td></tr>
<tr><td>Year 4: Summer Fallow</td></tr>
<tr><td>Year 5: Winter Wheat</td></tr>
<tr><td>Year 6: Summer Fallow</td></tr>
<tr><td>Year 7: Winter Wheat</td></tr>
</table>

Eric Nelson, Nelson Grade Organics, Pendleton, Oregon (Continued)

Year 8: Cover Crop (Spring)

Year 9: Spring Crop (such as spring soft white wheat, yellow or brown mustard, cover crops)

Year 10: Cover Crop (Spring)

Year 11: Spring Crop

Current 11-year rotation:

Year 1: Cover Crop + Compost

Year 2: Summer Fallow

Year 3: Winter Wheat

Year 4: Cover Crop (Spring)

Year 5: Spring Crop

Year 6: Cover Crop + Compost

Year 7: Summer Fallow

Year 8: Winter Wheat

Year 9: Cover Crop (Spring)

Year 10: Spring Crop

Year 11: Spring Crop

his current rotation. Ultimately, Nelson found the alfalfa challenging to establish due to the lack of moisture. His new rotation adds compost during cover crops prior to winter crops, and adds a spring rotation to help with weed pressure, fertility, and soil water management, in addition to temporally spacing out his winter wheat crops.

His rotation is not set in stone—Nelson frequently experiments with different crops, timing, and management practices to maximize his yields and the benefits that the rotation provides.

Figure 6. Eric Nelson, Nelson Grade Organics, Pendleton, Oregon

Kris Woolhouse, Ruby & Amber's Organic Oasis, Dorena, OR

Kris Woolhouse of Ruby & Amber’s Organic Oasis never plants two of the same plant family in succession on her mixed vegetable farm. Her main objectives in rotating crops are to control disease, add nutrients to the soil, and maintain overall soil health.

Woolhouse’s rotation is largely dependent on weather conditions—if conditions are just right, a two or three-year rotation will be used. However, recent season unpredictability and climate extremes have posed a challenge for planning and implementing a routine crop rotation, and particularly with planting cover crops.

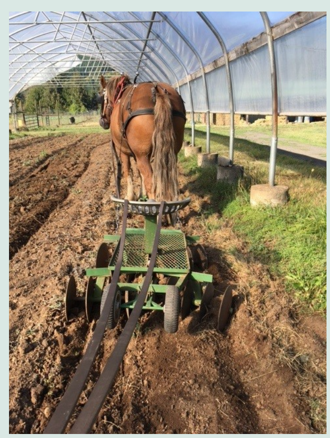

Figure 7. Bed preparation in a hoop house at Ruby & Amber's Organic Oasis, Dorena, OR (Kris Woolhouse)

Kris Woolhouse, Ruby & Amber's Organic Oasis, Dorena, OR (Continued)

As an example, Woolhouse shares that in one section of her field in 2021, she followed a pea-oat cover crop with winter brassicas, planted in August. A quick oat green manure crop followed the brassicas, and then sweet corn was planted in late June, 2022. A cover crop was planned to follow the sweet corn, but weather conditions ended up being too wet for this particular sequence. Woolhouse finds planting cover crops to be easier in her hoop houses, because soil moisture can be more adequately controlled.

Elizabeth Miller, Minto Island Growers, Salem, Oregon: Perennial Production

Minto Island Growers is a certified organic farm in Salem, Oregon growing several varieties of annual vegetables, plant starts, and perennial crops, including tea and multiple berries. Elizabeth Miller works to maintain and introduce biodiversity within and surrounding her perennial crops. Her tea plants are surrounded by native plantings that were at one time managed as crops—willow beds, dogwood beds, spirea, and more. Miller notes that adequate planning for weed control is essential when establishing organic perennial crops—something she learned by trial and error when she found mechanical weed control to be impossible in raised blueberry beds without a weed barrier. With an interest in intercropping, Miller at one time planted alfalfa in the pathways between the blueberry rows, with the idea of mowing and blowing the alfalfa cuttings into the row. This strategy proved difficult for weed control, as there was not enough organic material being generated to effectively control weeds in the rows.

For her strawberries, Miller rotates between plantings of June-bearing and everbearing varieties, with clover in the pathways to prevent erosion and attract pollinators. The clover has proven challenging to maintain, however, particularly with regards to mowing along edges of rows, and she has found border plantings of clover easier to maintain than those in the aisles.

Miller has integrated longer season flowering species such as anise hyssop, wild fennel, marigolds, and dwarf sunflowers to attract native predators and support pest management in her annual plantings; she has not felt the need to establish these flowering species for pest management in her perennial crops. She has also considered incorporating longer-term rotations with raspberries, annual vegetables, and cover crops.

Figure 8. Minto Island Growers Tea and Elizabeth Miller, Salem, Oregon

Cover Crop Considerations

Please refer to Cover Crop in Organic Systems implementation guides (including state-specific guides, as available) for more information on implementing the NRCS Cover Crop (340) conservation practice on organic operations.

Selection

The primary consideration for the selection of cover crops is identifying objectives for their use. Other factors may include seed availability, cost, and equipment available for seeding and termination. See Table 1 in the Cover Crop (340) in Organic Systems implementation guide for a list of example purposes for cover crop use (such as weed management, organic matter contribution, etc.), and cover crop types and related practices to help achieve these objectives.

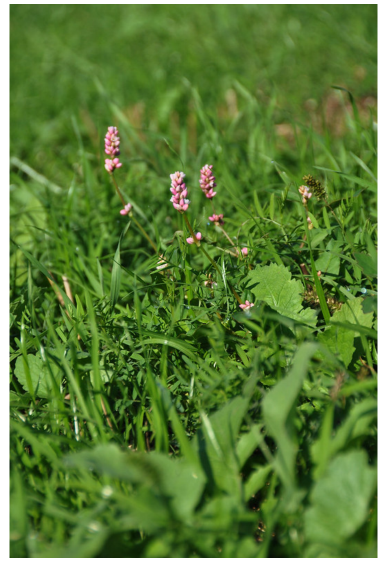

Figure 9. A Multi-species, fall-planted cover crop mixture including legumes, cereals, and forbs.

The NRCS Pacific Northwest Cover Crop Selection Tool is intended to help growers and conservation planners in Idaho, Oregon, and Washington select cover crop species that are well-suited to climate, soils, and objectives of planting the cover crop.

Including cover crops in a crop rotation may prevent the buildup of pathogens and populations of parasitic nematodes in the soil. Rhizobial seed inoculants are recommended for use with legumes, but producers will need to ensure the inoculant is not genetically modified and confirm with their certifier as needed before applying a new input on their operation. The correct inoculant should be used for each legume, and NRCS may require the use of inoculants if the purpose of the cover crop is to provide nitrogen fixation.

Site Preparation

Field preparation is an important first step in the successful establishment of a cover crop. Soil should be worked to break up clods and allow for good seed-to-soil contact, and weed pressure should be reduced to a tolerable level before seeding. Appropriate moisture levels are also required. Once the soil condition is sufficient, cover crop seeds should be planted as soon as possible, to reduce competition and infestation of germinating weeds.

Seeding

Organic producers must use organic seeds, except when not commercially available. Producers should ensure they are meeting their certifier’s requirements for organic seed searches and documentation.

The timing of cover crop planting is dependent on the species or mix, purpose, and seeding equipment. A cover crop can sometimes also be relay seeded (planted into a growing cash crop) to allow for reduced weed pressure, quicker canopy cover, and erosion control.

Organic farms typically use higher seeding rates to ensure a dense, weed-suppressing canopy is produced by the cover crop. Increasing seeding rates by 1.5 to 3 times when weed pressure is high or fertility, seed quality, or planting dates are less than optimal may be worthwhile (Schonbeck, 2020).

A correct seeding depth is essential for good stand establishment. While planting methods may vary depending on the purpose of the cover crop, the recommended seed depth for each cover crop species should be used.

Termination

Selection of an appropriate termination method for cover crops is dependent on equipment available and the objectives of the cover crop's use. Cover crops can be terminated in organic systems by frost, mowing, tillage/disking, roller-crimping, or a combination of mowing and tillage. They cannot be burned. If NRCS cost-share assistance is provided, termination by harvest or grazing may be restricted. Check with your NRCS state office.

The timing of termination will depend on the type(s) of cover crops planted and their purpose. Termination before seed set is important to prevent cover crop species from becoming volunteer weeds. A few examples of termination timing considerations are included here. Refer to the Cover Crop (340) in Organic Systems implementation guide for more examples.

- When a legume cover crop is used alone, termination at the budding growth stage allows for maximum PAN (Plant Available Nitrogen).

- If a mix with 25% or less legume biomass is grown, N immobilization should be avoided by terminating the cover crop before the cereals reach boot stage (Sullivan et al., 2020).

- When an objective of the cover crop is providing beneficial insect habitat, it should be terminated after reaching maximum flowering, but before setting viable seed.

If cover crop residues are being incorporated, producers may need to wait four to five weeks before planting a subsequent crop, to allow for sufficient decomposition of the cover crop residue. Too much residue may attract seed maggots and reduce cash crop germination.

Appendix A: References

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Resources

NRCS Practice Standard Conservation Crop Rotation (328)
The NRCS Conservation Practice Standard for Conservation Crop Rotation (Code 328)

NRCS Natural Resource Concern List and Planning Criteria
The official list of NRCS resource concerns and planning criteria that are used to determine resource treatment levels using the conservation planning process

Cover Crop in Organic Systems: Oregon Implementation Guide
This page links to the downloadable implementation guide for implementing cover crop (NRCS conservation practice 340) in organic systems, specific to Oregon.

ATTRA Tipsheet: Crop Rotation in Organic Farming Systems
A publication from Appropriate Technology Transfer for Rural Areas (ATTRA) identifying general principles to guide a crop rotation, organic regulations that relate to crop rotation, and suggested planning steps

Pacific Northwest Extension: Organic Small Grain Production in the Inland Pacific Northwest: A Collection of Case Studies
A series of case studies featuring organic small grain farmers in Washington, Oregon, and Idaho and their production practices, including crop rotation

SARE: Crop Rotation on Organic Farms, A Planning Manual
An in-depth planning manual for implementing crop rotation on organic farms from Sustainable Agriculture Research and Education (SARE), including rotation strategies for various field conditions and crops.

SARE: Manage Weeds on Your Farm
A guide of ecological weed management strategies from SARE, including crop rotation practices. Not specific to organic production.

NRCS Conservation Webinars: Crop Rotations on Diversified Farms
A webinar from NRCS' Science and Technology Training Library on using crop rotation as a multi-functional management technique, with speaker Charles Mohler, Ph.D.

Oregon State University: Organic Fertilizer and Cover Crop Calculators
Online tools from Oregon State University to estimate nitrogen supplied by organic fertilizers and cover crops.

eOrganic
An Extension resource featuring articles, webinars, and videos on various organic topics.