Organic Production:
Using NRCS Practice Standards to Support Organic Growers

Practice Fact Sheets

Crop Rotation

Introduction

Organic farmers face the same soil resource concerns as non-organic farmers. Heavy reliance on tillage leads to loss of organic matter, soil compaction, and excessive soil erosion, resulting in poor soil quality. Using a conservation crop rotation can help mitigate the negative effects of tillage. A conservation crop rotation is more than just growing different crops. It is a well planned sequence of crops where benefits are gained from the previous crop and provided to the following one. It can include a combination of perennial and annual crops, as well as intermingling cover crops for soil protection during the rotation. Organic growers rely heavily on the benefits of crop rotations to achieve growth and production from their crops.

> A well thought out crop rotation is worth 75% of everything else that might be done to raise a crop, including fertilization, tillage, and pest control.
>
> --Attributed to Dr. Firman Bear, Rutgers University

Comparison of NRCS and National Organic Program Practice Standards for Crop Rotation

NRCS Conservation Crop Rotation (practice code 328) is defined as "growing crops in a recurring sequence on the same field" in the Agency's Field Office Technical Guide. The practice may be applied as part of a conservation management system to support one or more of the following purposes:

- reduce sheet and rill erosion
- reduce soil erosion from wind
- maintain or improve soil organic matter content
- manage the balance of plant nutrients
- improve water use efficiency
- manage saline seeps
- manage plant pests (weeds, insects, diseases)
- provide food for domestic livestock
- provide food and cover for wildlife

General criteria applying to all purposes are:

- crops shall be grown in a planned recurring sequence
- crops shall be adapted to the climate, region, soil resources and the goals of the producer
- a conservation crop rotation may include crops planted for cover or nutrient enhancement
- crops are selected to produce enough biomass to reduce erosion; in the instances where this is not possible cover crops or other conservation practice will be used

Additional criteria for specific resource concerns are also included. For example, crops should be selected to produce plant biomass that will maintain or improve soil organic matter content as indicated by the Soil Conditioning Index. This index determines trends in potential soil organic matter accumulation under different management scenarios. However, some crops have insufficient biomass (thus producing low residue) and must be offset by including a cover crop that contains a

Legume plants provide nitrogen for the next crop.

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high biomass mixture of grasses and legumes. Further improvements in organic matter can be achieved by terminating the growth of cover crops using mechanical means, e.g. roller crimpers. Crop rotations are designed to sequence nitrogen-fixing crops prior to crops that deplete nitrogen. Rotations may also include crops with rooting depths or nutrient requirements that will use excess nutrients in the soil. Pest management can be achieved by planting resistant crop varieties and/or alternating crops to break pest cycles.

National Organic Program (NOP) Crop Rotation

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

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:

- 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

What are the Differences and Similarities?

There are many similarities between the NRCS and NOP standard definitions and purposes including erosion control, pest management, nutrient management, and improved soil organic matter. The differences are principally in the extent of practice adoption and how the criteria are used to determine compliance with the applicable standard (table 1).

NRCS - To meet the NRCS standard, a producer must address and meet one of the intended purposes. Tools, such as RUSLE2 and the Soil Conditioning Index, are used to evaluate system effects on erosion rates and organic matter. Nutrient balance is measured using an approved procedure that documents the nutrient needs of the crop(s) and the estimated nutrients that are available to it.

NOP - The NOP standard requires that all functions applicable to the operation be addressed. Criteria to judge compliance with the standard are subjective. No technical measurement tools are required to evaluate the effectiveness of a rotation for building organic matter or controlling erosion. Certifying agencies look for:

- at least three different crops planted over five consecutive years in annual cropping systems.
- a leguminous green manure crop planted at least one time in the five year period to improve soil
- diversity in plant species or families so that crop species or crops within the same family are not grown repeatedly without interruption on the same field
- inclusion of crops with different rooting systems and pest pressures to assist with building soil quality and reduced pest management activities
- use of green manure and cover crops
- crop rotations (as opposed to a double crop system, e.g. growing a continuous vegetable crop with a wheat cover crop)

Planning a Crop Rotation

For the NRCS Conservation Crop Rotation practice standard to meet the NOP Crop Rotation practice standard, it is necessary to meet all of the criteria in the standard: reduce soil erosion, maintain or improve soil organic matter content, manage the balance of plant nutrients and manage plant pests (weeds, insects, diseases). NRCS does not dictate what crops can be grown, but rather recommends how the producer can manage their operation in a way that meets the standard and also achieves their individual goals.

Crop Rotation Considerations

A successful crop rotation requires an understanding of the following key considerations.

Botanical Family - There are different botanical families in which vegetable crops can be grouped (table 2). Plants in the same family often have the same soil and temperature needs and similar pest problems. In general, crops in the same family should not follow one another in a rotation. Understanding how plant families interact can help producers gain benefits from the preceding crop while setting the stage for pest control and nutrient management for following crops. Another useful grouping is gardening categories. Rather than using botanical characteristics to create the group, crops can be grouped based on similar cultural requirements and time of harvest.

Space - While not necessary, it might be more desirable for smaller operations to have equally sized fields or plots, which allow for greater flexibility and choice in the crops grown. Crops like sweet corn require a larger area to grow enough produce for market needs, while onions, beets, and celery require smaller areas. Soil loss should be calculated on the entire field rather than on individual plots unless there are differences in soils or rotation.

Growing season: cool vs. warm - Knowing what time of year a plant grows and matures to produce a crop is important for developing a conservation

Table 1. Comparison of the NRCS and National Organic Program Standards

NRCS Standard	National Organic Program Standard
Similarities	
Reduce erosion	Provide erosion control
Maintain or improve soil organic matter content • Use cover and green manure crops to increase organic matter • Grazing of cover and green manure crops is allowed	Maintain or improve soil organic matter content • Use sod, cover and green manure crops to increase organic matter
Manage the balance of plant nutrients • Use legumes prior to nitrogen depleting crops • Use crops or cover crops with rooting depths that use excess nutrients	Manage deficient or excess plant nutrients • Use legume cover prior to nitrogen depleting crops • Use catch crops to trap nutrients in the soil profile
Manage plant pests (weeds, insects, diseases) • Crops are alternated to break pest cycles • Resistant varieties are used	Provide for pest management in annual and perennial crops • Crops are alternated to break pest cycles • Resistant varieties are used
Differences	

Primary goal is to protect the soil resource base
• Soil loss must meet tolerable levels for both wind (WEQ) and water (RUSLE2)
• Supporting practices (contouring, strip-cropping) are used if rotation alone will not meet tolerable soil loss levels
• A positive Soil Conditioning Index (SCI) must be achieved
• Crop selection and sequence is based on nutrient balance procedure
• Must meet one of the intended purposes of a crop rotation to meet the standard
	Primary goal is food quality, ensuring that farm products are raised using no prohibited substances
	• No technical measurement tools are used to evaluate:
	  • Soil loss
	  • Improvements in organic matter
	  • Nutrient needs and availability
	• Must address all four functions of a crop rotation, if applicable to the organic operation, to meet the standard

crop rotation. Cool-season crops require cool soil and air temperatures, tend to be shallow rooted, are susceptible to drought, and are grown for their leaves or roots. They are grown in spring or autumn. Warm-season crops require warm soil and air temperatures to germinate, grow, and mature. They are deep rooted, resistant to drought, and are grown for their seed or fruit. Alternating cool and warm-season crops allows a producer to include a cover crop, or raise multiple crops during the same growing season. For example, a cool-season pea crop could be followed by a buckwheat cover crop in summer, and then a fall planting of onions or radishes.

Rooting depth - The rooting depth of plants is variable and should be taken advantage of in a crop rotation. Following deep-rooted plants with shallow-rooted plants allows for more complete use of nutrients available throughout the entire soil profile. An example of this principle is following spinach (shallow-rooted) with potatoes (deep-rooted) or a rye cover crop.

Nutrient demands - Plant nutrient requirements are important when planning a crop rotation. Having two nutrient depleting ("heavy feeding") crops follow each other robs the soil and can result in poor yields. Heavy feeding crops should be sequenced with light-feeders or a soil building cover crop like hairy vetch.

Rotation length - Flexibility can be built into longer rotations. For example, rotation periods of several years may be required to suppress soil borne pathogens. Longer rotations also allow the addition of perennial crops, such as grass or legume hay, resulting in healthier soil by building organic matter and improving soil aggregation.

Tillage practices - Weed control consistently ranks as the number one problem for organic producers as there are few herbicides approved for use in organic farming. As a result, various tillage operations are used to combat weeds and some plant diseases. NOP rules require incorporation of manures into soil when applied within the allowed time frame prior to harvest of certain crops. Tillage is the primary means for incorporating manure into the soil. The frequency and magnitude of tillage is also the primary influence on sheet and rill erosion, as well as the amount and accumulation of soil organic matter. A well planned crop rotation will minimize the length of time that soil is left bare, exposed to the elements, and thus susceptible to erosion. Planting cover crops immediately after final harvest reduces this risk and replenishes biomass lost through tillage. Cover crops also conserve plant available nutrients that could otherwise be lost in runoff. Maximum protection of soil loss can be achieved by including crops that can be successfully no-tilled into cover crops. The key to minimizing the negative effects of tillage on soil is maximizing the use of cover crops in the rotation.

Table 2. Common vegetables grouped by botanical family

Botanical Family	Family Name	Common Vegetables
Alliaceae	Onion/Lily	Onion, garlic, leek, shallot, chive
Apiaceae	Carrot	Carrot, parsnip, celery
Asteraceae	Aster	Lettuce, endive
Brassicaceae	Mustard	Cabbage, broccoli, turnip, radish, collards
Chenopodiaceae	Goosefoot	Beet, spinach
Convolvulaceae	Bindweed/Morning glory	Sweet potato
Cucurbitaceae	Cucumber/Gourd	Cucumber, muskmelon, watermelon, squash, pumpkin, gourd
Fabaceae	Pea	Garden pea, snap bean, lima bean, soybean
Malvaceae	Mallow	Okra
Poaceae	Grass	Sweet Corn, popcorn, field corn
Solanaceae	Nightshade	Tomato, pepper, eggplant, potato

Cover Crops - Cover crops are often overlooked when planning a crop rotation as the focus is typically on harvestable crops. Selecting the right cover crop(s) is/are critical to maximize the benefits of including them in the crop rotation. The key to selecting the right cover crop is matching it to the next harvested crop, watching the weather, and timing termination to minimize negative impacts on soil moisture and temperature.

Manure Application - Manure is a critical part of an organic grower's nutrient management program, and it is important to consider when manure can be applied in the rotation. NOP rules restrict manure application prior to crop harvest, requiring incorporation of manure into the soil 90 to 120 days before harvest, depending on the crop. Planning a rotation to accommodate this requirement is challenging especially if the producer is trying to minimize tillage to control erosion. Adequate windows of time for manure application must be part of the crop rotation plan. Including a cover crop to trap and hold manure nutrients over the winter provides nourishment for spring crops. Also, some crops respond better to manure that is applied in the first year (squash, corn, or peas), while others respond better if manure is applied a year in advance (cabbage, tomatoes, or root crops).

Crop Rotation Examples

Examples of four-year crop rotations that meet the definition, purposes, and criteria of both the NRCS and NOP practice standards are presented in Tables 3 and 4. The examples show diversity in crop species and family, space, growing season, rooting depth, and nutrient requirement, along with details for managing tillage, cover crops, and manure application to develop a system that builds soil organic matter and improves soil quality.

Table 3. Crop rotation example for the northern U.S.

	Year 1	Year 2	Year 3	Year 4
Crop	Potatoes	Spring wheat/Oats	Clover/Timothy	Clover/Timothy
Botanical family	Solanaceae (Tomato Family)	Poaceae (Grain Family)	Legume	Legume
Space	Medium (need room to spread)	Small (entire field or portions of field could be planted)	Small (entire field or portions of field could be planted)	Small (entire field or portions of field could be planted)
Growing season	Cool-season	Cool-season	Cool-season	Cool-season
Rooting depth	Shallow rooted <18"	Shallow rooted < 24"	Moderate rooted > 24"	Moderate rooted > 24"
Nutrient needs	Heavy (will benefit from legume)	Moderate	Light	Light
Tillage practices	Heavy tillage will be required prior to planting	Level field prior to planting	Seed in fall after second year harvest	Plow down as green manure prior to potatoes
Cover crop	None	None	None	None
Manure	No, apply 1 year before	Apply after harvest		
Impact on soil quality	Negative impact – excessive tillage during planting and harvesting	Positive impact – sod forming root mass, good soil builder	Positive impact – builds organic matter, provides nutrients	Positive impact – builds organic matter provides nutrients

Table 4. Four-year crop rotation that relies on cover crops to control erosion, provide nutrients and build organic matter. It also includes a "rest year" after two heavy feeder crops.

	Year 1	Year 2	Year 3	Year 4
Crop	Summer squash	Potatoes	Rye and vetch	Mixed vegetables (lettuce, spinach, radish)
Botanical family	Cucurbitaceae (Cucumber Family)	Solanaceae (Tomato Family)	Grass – Legume	Asteraceae or Brassicaceae
Space	High (sprawling vines require a lot of room)	Medium (need room to spread)	Entire field planted	High producing crops need smaller areas to meet marketing needs, divide field according to anticipated demand
Growing season	Summer	Spring – Fall	Fall – Spring	Cool-season
Rooting depth	Shallow rooted <18"	Shallow rooted <18"	Moderate rooted > 24"	Moderate rooted > 24"
Nutrient needs	Heavy – will benefit following a legume	Heavy – will benefit following a legume	Light	Moderate – will not use all of the nutrients provide by previous year cover crops
Tillage practices	Heavy tillage will be required prior to planting to incorporate manure and terminate cover crop	Heavy tillage will be required prior to planting, harvesting disturbs soil	Seed in fall after potato harvest	Heavy tillage will be used prepare seedbed, incorporate green manure
Cover crop	Yes – rye and vetch cover crop, control erosion, adds organic matter, provides Nitrogen, traps nutrients	Yes – rye and vetch cover crop, control erosion, adds organic matter, provides Nitrogen, traps nutrients	Yes – plant summer cover crop like sudangrass to trap nutrients, build soil quality, fall cover crop of oats and peas will provide additional benefits	Yes – rye and vetch cover crop should be planted to begin the rotation again
Manure	Apply in fall or early spring before planting, follow NOP rules for incorporation	Apply manure 1 year prior to planting	Manure should be applied in fall for next years crop	None
Impact on soil quality	Negative impact – excessive tillage prior to planting to incorporate manure, prepare seed bed	Negative impact – excessive tillage to plant and harvest	Positive Impact – builds organic matter, provides nutrients	Negative impact – heavy tillage prior to planting

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