1.6 Selecting and Using Cover Crops

Introduction: Selecting and Using Cover Crops

OVERVIEW

Cover crops can be a key soil and pest management tool for organic growers. This unit introduces students to the role and selection of cover crops for organic farming and gardening systems. The lecture addresses the influence of cover crops on soil's physical and chemical properties, the role cover crops play in pest management, and the factors to consider when selecting a cover crop for a farm or garden. The resources section includes an annotated list of print and electronic references that students may use in selecting cover crop species or mixes for specific agricultural applications.

MODES OF INSTRUCTION

> LECTURE (1.5 HOURS)

A lecture covers the advantages and disadvantages of using cover crops and the three-step process of choosing a cover crop based on the agricultural system's needs.

> ASSESSMENT QUESTIONS (0.5 HOUR)

Assessment questions reinforce key unit concepts and skills.

LEARNING OBJECTIVES

CONCEPTS

- The influence of cover crops on the physical and chemical properties of agricultural soils
- The role cover crops play in pest and disease management
- The factors to consider when selecting a cover crop for farm or garden use

SKILLS

- How to access cover crop information

Lecture Outline: Selecting and Using Cover Crops

for the instructor

A. Pre-Assessment Questions

1. What benefits can be derived from the regular use of cover crops in a farming system?
2. What role do cover crops play in the management of soil fertility in organic farms and gardens?
3. How can cover crops be used to ensure adequate soil nutrient levels/nutrient budgeting?
4. How can cover crops improve the physical properties of agricultural soils?
5. What role can cover crops play in pest management?
6. What are the factors to consider when selecting a cover crop for your farm or garden?

B. Why Use Cover Crops?

1. The role of cover crops in organic farming systems: Benefits and disadvantages
2. Cover crop, "green manure," and "catch crop" defined
   a) Cover crop: Mainly used to prevent soil erosion by covering soil with living plants
   b) Green manure: Crop grown mainly to be turned under for soil improvement
   c) Catch crop: Used to "catch" nutrients left after harvest of a cash crop and prevent leaching
   d) Most cover crops serve multiple functions

C. How to Choose a Cover Crop

1. Three steps in selecting a cover crop
   a) Step 1: Identify what you want the cover crop to do
      i. Defining primary function of cover crop based on needs of system
         - Provide nitrogen
         - Increase soil organic matter (SOM) and improve nutrient availability
         - Scavenge nutrients
         - Prevent soil erosion
         - Improve soil structure
         - Improve drainage
         - Protect water quality
         - Provide mulch to conserve soil moisture and/or suppress weeds
         - Provide habitat for beneficial insects and spiders
         - Suppress weeds
         - Suppress soil borne pests and diseases
   b) Step 2: Identify planting niche
      i. Defining where the cover crop fits in your crop rotation
      ii. Examples of cool weather and warm weather cover crops
   c) Step 3: Select cover crop species or mix to meet the goals and requirements from steps 1 and 2. Once you have set the priorities for what cover crop effects you are looking for, and you have identified when the cover crop can be grown, the final step is to match the potential candidates identified in step 2 with the required characteristics identified in step 1.

i. Additional considerations

- Consider the characteristics you don't want as well as those you are looking for
- Consider the cost and availability of seed
- Consider the number and types of field operations required for the different options in order to make a sound economic assessment of the alternatives

D. How to Roughly Estimate N Contribution from a Cover Crop

1. Calculate above-ground weight for a given area as follows:
   a) Take a number of samples from the field (clip at ground level, and use a yardstick or frame to measure area to be sampled)
   b) Dry for a few days in sun, greenhouse or oven (140°F) until "crunchy" or brittle
   c) Calculate the dry weight produced in pounds/acre (lbs/ac) as follows:

$$\text{Dry wt (lbs/ac)} = \frac{\text{weight of samples}}{\text{\# of sq. ft sampled}} \times \text{43,560 sq.ft}$$

2. Multiply dry wt by the % N content of the biomass (see below) to give total N in cover crop in lbs/ac:

$$\text{Total N (lb/ac)} = \text{dry weight} \times \frac{\%N}{100}$$

3. To estimate how much of the N will be available to the crop that season:
   If conventionally tilled divide total N by 2
   If left on surface divide by 2 in warmer climates, by 4 in cooler climates
4. Typical % N contents for cover crop types
   Before flowering:
   Annual legumes 3.5–4%
   Perennial legumes: 2.5–3%
   Grasses, brassicas: 2–3%
   When flowering:
   Annual legumes: 3–3.5%
   Perennial legumes: 2–2.5%
   Grasses, brassicas: 1.5–2.5%

From: *Managing Cover Crops Profitably, 2nd Edition,* published by the Sustainable Agriculture Network (see Resources section). Used by permission.

Detailed Lecture Outline: Selecting and Using Cover Crops

for students

A. Pre-Assessment Questions

1. What benefits can be derived from the regular use of cover crops in a farming system?
2. What role do cover crops play in the management of soil fertility in organic farms and gardens?
3. How can cover crops be used to ensure adequate soil nutrient levels/nutrient budgeting?
4. How can cover crops improve the physical properties of agricultural soils?
5. What role can cover crops play in pest management?
6. What are the factors to consider when selecting a cover crop for your farm or garden?

B. Why Use Cover Crops?

1. The role of cover crops in organic farming systems

   Cover crops are one of the primary fertility and soil management tools available to the organic farmer, and are an important strategy for preventing nutrient and soil loss from a field. They are crops grown primarily for soil or ecosystem improvement rather than cash, and can provide a variety of services, from increased nitrogen (N) input, to soil protection, to weed and disease suppression. However, they can also have negative consequences if they are managed incorrectly or the wrong species are chosen. These issues are covered in Unit 1.1, Soil Fertility Management.

2. Cover crop, "green manure," and "catch crop" defined

   Though the terms are used interchangeably, cover crop, green manure, and catch crop refer to different primary functions of the crops planted

   a) Cover crop: Mainly used to prevent soil erosion by covering soil with living plants
   b) Green manure: Crop grown mainly to be turned under for soil improvement
   c) Catch crop: Used to "catch" nutrients left after harvest of a cash crop and prevent leaching

      These are not mutually exclusive functions. For example, a fall-planted cereal + legume crop that is incorporated the following spring can serve as a cover crop, green manure, and catch crop. However, different species and mixes may perform one function better than another.

C. How to Choose a Cover Crop

1. Deciding whether it is desirable or feasible to include a cover crop in a given production system, and which cover crop to use, involves the following three steps

   a) Step 1: Identify what you want the cover crop to do

      The first step is to identify your goals by prioritizing the main effects you want the cover crop to have in your system. This will depend on what you think are the most important factors limiting the productivity and sustainability of your production system. For example, is it low fertility, poor soil structure, weed or pest populations? Deciding this is critical before choosing which cover crop to use.

      i. Defining primary function of cover crop based on needs of system

- *Provide nitrogen.* Here the best choice would be a legume that is well adapted to your area. It is important to ensure that sufficient rhizobia bacteria are present in the soil to give good root nodule formation, and hence N_2 fixation. If it is the first time a legume cover crop has been grown in a field it is recommended that you purchase the appropriate rhizobium inoculant for the species being planted. A rough guide to estimating the N contribution from a cover crop is shown on page 10 (excerpted from *Managing Cover Crops Profitably, 2nd Edition,* published by the Sustainable Agriculture Network).
- *Increase soil organic matter (SOM) and improve nutrient availability by increasing soil biological activity.* To build SOM you would look for a high biomass-producing cover crop. Possible options include non-legumes such as annual rye grass, cereal rye, triticale, or sorghum/sudan if a summer niche is identified. High-biomass legumes such as sub-clover or woollypod vetch would also work and provide N, as would a mix of cereals and legumes.
- *Scavenge nutrients left in the soil after the cash crop and prevent loss by leaching.* To maximize nutrient scavenging the cover crop should have an extensive root system that develops quickly after planting. Non-legumes such as small grains, cereal rye, triticale, rapeseed, annual rye grass, oilseed radish, and mustards work well, but some legumes are also suitable.
- *Prevent soil erosion.* Here the key is to choose a species that rapidly covers the soil surface. Many of the species that are good nutrient scavengers also provide excellent ground cover. However, while annual rye grass is a good nutrient scavenger, it has fine leaves and is slow to cover the soil surface.
- *Improve soil structure.* Increasing SOM is the key to improving soil structure, and similar species can be used. It may be beneficial to include a non-legume to provide organic material that breaks down more slowly than a legume alone.
- *Improve drainage.* Some deep-rooted species can help to break through compacted layers in the soil and improve drainage. The roots of soil-penetrating cover crops also create channels through which water can move as the root systems decompose after death or incorporation. Recommended species include bell beans and clovers . In addition, many grass species with extensive, fibrous root systems add large quantities of organic matter to the soil by sloughing off roots. Such organic matter additions stimulate biological activity and the formation of soil aggregates, which improve soil's drainage. Recommended species include annual rye , perennial rye, and oats.
- *Protect water quality.* This is achieved by selecting species that both prevent soil erosion and scavenge nutrients during periods of high rainfall. It is also important to avoid turning in high N cover crops when the soils will be vulnerable to leaching, e.g., when there is little or no crop cover and high rainfall.
- *Provide mulch to conserve soil moisture and/or suppress weeds.* A combination of high above-ground biomass and moderate or high C:N ratio residues is desirable. Most legume residues with their high nitrogen content will decompose too rapidly to be effective.
- *Provide habitat for beneficial insects and spiders.* This aspect of cover crop ecology has not been well studied for annual systems, and there may be more potential than has been recognized. From work in orchards and vineyards it is clear that cover crops provide good habitat for beneficials, especially when species with food sources such as extrafloral nectaries (e.g., vetch) or flowers are used. The key in annual systems is to make sure that when the cover crop is turned in there are alternative habitats for the beneficials to move to.

- *Suppress weeds.* Cover crops can reduce weed populations either by outcompeting weeds by more vigorous growth and dense canopy cover, or by releasing allelopathic compounds that inhibit weed seed germination and growth. Some good options include cereal rye, triticales, sorghum/sudan and other cereals, as well as brassicas such as rapeseed and oilseed radish, and high biomass or allelopathic legumes. A well-balanced mix can also work, providing the canopy closes quickly. It is also important to remember that certain cover crops can themselves become weeds if they have persistent or hard seed. Finally, just as crop rotation is important, it is advisable to avoid using the same cover crop every year, particularly a single species. Otherwise populations of weeds that are most competitive with that species will build up, as will pests and disease organisms that also attack that species.
- *Suppress soil borne pests and diseases.* Certain species are known to suppress particular disease or pest organisms. Similarly others are known to be excellent hosts to certain pests and diseases. If your field is known to have a history of bad pest or disease problems this will affect your choice of cover crop. For example, cereal rye, sorghum/sudan, selected rapeseed varieties (e.g., c.v. humus), oilseed radish, and white mustard are known to suppress root knot nematodes, and soil-borne diseases such as rhizoctonia and verticilllium wilt. Conversely many legumes are excellent hosts for nematodes and populations will increase rapidly in the soil with their use unless the crop is turned in before the nematodes complete their life cycle. If the timing is correct the legume may actually reduce nematode populations by stimulating the nematodes' emergence but killing them when the crop is turned in and the infected roots die before their life cycle is complete.

b) Step 2: Identify the cover crop planting niche

Where can the cover crop fit in your crop rotation? What are the climatic and soil conditions at that time? Once these two questions are answered, then you can select the best species or mix to plant.

i. Defining where the cover crop fits in your crop rotation

To choose when to plant cover crops, timing of field operations to avoid interfering with cash crop production is critical. Once the niche or window for cover crop growth and incorporation is identified then the species selection will depend on the climatic and soil conditions during the window. The publications and web sites in the Resources section of this unit provide information on climatic and soil requirements for many cover crops and will enable you to identify potential species to consider.

- Define timing of critical field operations for cash crop production. Field operations and labor needs for cash crop production will take precedence over cover crop management, so it is important to minimize these conflicts.

ii. Examples of cool weather and warm weather cover crops

- Winter cover crops. Most cover crops are planted in the fall to provide cover over the winter months. Examples include: Vetches, fava/bell beans, peas, annual and perennial clovers, rape seed and oilseed radish, and grasses such as oats, annual and perennial rye grass, or barley.
- Summer cover crops. When temperatures are high during the summer and providing water is available, fast-growing species such as sorghum/sudan grass, cowpeas, buckwheat, lab lab, Crotolaria (sun hemp), Sesbania, and others can provide a good biomass return in a short growth period.

c) Step 3: Select cover crop species or mix to meet the goals and requirements from steps 1 and 2

Once you've set the priorities for what cover crop effects you are looking for, and you've identified when the cover crop can be grown, the final step is to match the potential candidates identified in step 2 with the required characteristics identified in step 1

i. Additional considerations:

- Consider the characteristics you don't want as well as those you are looking for. It is rare that the "perfect" cover crop will exist and trade-offs will need to be made amongst different goals.
- Consider the cost and availability of seed
- Consider the number and types of field operations required for the different options to make a sound economic assessment of the alternatives

D. How to Roughly Estimate N Contribution from a Cover Crop

1. Calculate above-ground weight for a given area as follows*:
   a) Take a number of samples from the field (clip at ground level, and use a yardstick or frame to measure area to be sampled)
   b) Dry for a few days in sun, greenhouse, or oven (140°F) until "crunchy" or brittle
   c) Calculate the dry weight produced in pounds/acre (lbs/ac) as follows:

   $$\text{Dry wt (lb/ac)} = \frac{\text{weight of samples}}{\text{\# of sq. ft. sampled}} \times \text{43,560 square feet}$$

2. Multiply dry wt by the % N content of the biomass (see below) to give total N in cover crop in lbs/ac:

   $$\text{Total N (lb/ac)} = \text{dry wt} \times \frac{\%N}{100}$$

3. To estimate how much of the N will be available to the crop that season

   If conventionally tilled, divide total N by 2

   If left on surface, divide by 2 in warmer climates, by 4 in cooler climates

4. Typical % N contents for cover crop types

   Before flowering:

   Annual legumes: 3.5–4%

   Perennial legumes: 2.5–3%

   Grasses, brassicas: 2–3%

   When flowering:

   Annual legumes: 3–3.5%

   Perennial legumes: 2–2.5%

   Grasses, brassicas: 1.5–2.5%

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Assessment Questions

1) Define the following terms:
   Cover crop Green manure Catch crop

2) In what ways do cover crops serve to improve or maintain the nutrient availability of agricultural soils?

3) In what ways do cover crops serve to improve or maintain the physical properties of agricultural soils?

4) In what ways do cover crops play a preventive pest management role in agricultural systems?

5) What are the factors to consider when selecting a cover crop for your farm or garden?

Assessment Questions Key

1) Define the following terms:
   - *Cover crop = Mainly used to prevent soil erosion by covering soil with living plants*
   - *Green manure = Crop grown mainly to be turned under for soil improvement*
   - *Catch crop = Used to "catch" nutrients left after harvest of a cash crop and prevent leaching*

2) In what ways do cover crops serve to improve or maintain the nutrient availability of agricultural soils?
   - *Legume cover crops are able to "fix" atmospheric nitrogen (N_2) and convert it into a plant-useable form. Up to 200 lbs/acre of actual N can be fixed by certain species of cover crops. This can be a significant contribution to the N budget of a cash crop. Grains and cereal cover crops with extensive root systems that develop quickly after planting are also able to"scavenge" water-soluble nutrients left in the soil after the cash crop and prevent loss through leaching. Deep-rooted fabaceous cover crops are also able to access normally unavailable nutrients (e.g., phosphorous) from lower soil horizons and bring them to the surface through the distribution of the nutrients through their tissues. Such nutrients are then made available to cash crops when cover crops are tilled into the soil.*

3) In what ways do cover crops serve to improve or maintain the physical properties of agricultural soils?
   - *Cover crops help prevent soil erosion. When tilled in, cover crops cycle organic matter through agricultural soils. This cycling of organic matter provides energy (carbohydrates) and nutrients (nitrogen) that increase soil biological activity. Through the process of decomposition, soil organisms bind soil particles together forming stable (erosion-resistant) soil aggregates that improve and maintain desirable soil structure.*
   - *Cover crops improve drainage. Some deep-rooted cover crop species can help to break through compacted layers in the soil and improve drainage.*

4) In what ways do cover crops play a preventive pest management role in agricultural systems?
   - *Provide habitat for beneficial insects and spiders: Though not well studied in annual cropping systems, it is clear from research in orchards and vineyards that cover crops provide good habitat for beneficial insects especially when species with food sources such as extrafloral nectaries (e.g., vetch) or flowers are used*
   - *Certain cover crops suppress soil borne pests and diseases: Certain species are known to suppress particular disease or pest organisms through allelopathy*
   - *Cover crops suppress weeds: Cover crops can reduce weed populations either by outcompeting weeds by more vigorous growth and dense canopy cover, or by releasing allelopathic compounds that inhibit weed seed germination*

5) What are the factors to consider when selecting a cover crop for your farm or garden?
   - *Step 1: Identify what you want the cover crop to do.*
   - *Step 2: Identify where the cover crop can fit in your crop rotation and what the climatic and soil conditions are at that time.*
   - *Step 3: Select cover crop species or mix to meet the goals and requirements from steps 1 and 2, considering the characteristics you don't want as well as those you are looking for. Consider the cost and availability of seed and the number and types of field operations required to manage the cover crop.*

Resources

PRINT RESOURCES

Chaney, David, and Ann Mayse, eds. 1997. *Cover Crops: Resources for Education and Extension.* Davis, CA: UC Sustainable Agriculture Research and Education Program (UC SAREP), UC Division of Agriculture and Natural Resources.

A collection of materials that educators will find useful in conveying information about cover crops to farmers and ranchers. The packet includes a variety of materials that may be used in short courses, seminars, workshops, etc. Includes web resources, print publications and articles, cover crop profiles, listings of video and slide sets, and a directory of expertise. Order from the UC SAREP web site, www.sarep.ucdavis.edu.

Sustainable Agriculture Network. 1998. *Managing Cover Crops Profitably, Second Edition.* Handbook Series Book 3. Sustainable Agriculture Network. Beltsville, MD: National Agricultural Library.

Very useful information on the characteristics, costs, seeding rate, and management of different cover crop species. Contains a good intro-duction to the potential advantages and disadvantages of using cover crops, and how to manage them effectively to minimize unwanted effects. It also provides comprehensive information on the major species used in the U.S. Though geared primarily toward large-acreage cropping systems, the information is readily adapted for smaller-scale systems. Available from www.sare.org.

Miller, P. R., W. L. Graves, et al. 1989. *Cover Crops for California Agriculture.* Leaflet 21471. Oakland, CA: University of California Division of Agriculture and Natural Resources.

A concise overview of the common cover crops used in California agriculture. Addresses annual and perennial cropping systems

Sarrantonio, M. 1994. *Northeast Cover Crop Handbook*. Emmaus, PA: Rodale Institute.

Practical information on the selection and management of cover crop species for northeast agriculture.

WEB RESOURCES

International Development Research Centre (IRDC)

www.idrc.ca/cover_crop/

The International Development Research Centre is a public corporation created by the Canadian government to help communities in the developing world find solutions to social, economic, and environmental problems through research. This site contains research on cover crops for sustainable agriculture in the tropics.

Management of Organic Inputs in Soils of the Tropics (M.O.I.S.T.)

ppathw3.cals.cornell.edu/mba_project/

This interdisciplinary group based at Cornell University investigates and exchanges information on cover crops, green manures, managed fallows, and mulches in tropical farming systems. Their goal is to improve and sustain evolving agriculture systems in Asia, Africa, and Latin America.

UC Sustainable Agriculture Research and Education Program (UC SAREP) Cover Crop Data Base

www.sarep.ucdavis.edu

Contains a thorough cover crop database, with quantitative information on specific cover crops, and two slide shows covering the use of cover crops for annual and perennial farming systems. The database includes valuable cover crop information such as pounds of nitrogen fixed, seeding rates, suggested timing for seeding, etc. Focuses on California and other similar climatic situations. Includes photographs.

VIDEOS

Creative Cover Cropping in Annual Farming Systems. By Robert L. Bugg. University of California Communications Services. UC Davis: UC DANR (27 minutes).

Creative Cover Cropping in Perennial Farming Systems. By Robert L. Bugg. University of California Communications Services. UC Davis: UC DANR (24 minutes).

Videos discuss how to use cover crops to protect and enhance soil fertility, enhance pest control, and provide other benefits. A wide array of plant materials is presented, along with creative management options.