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Cover Crops and Green Manures

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A cover crop is any living ground cover planted to protect the soil from erosion. It may be planted into or after a main crop and is killed before the next crop is planted. Though the primary benefit of cover crops is the reduction of water runoff and soil erosion, they provide many other services, including weed, insect and disease suppression; enhanced soil structural stability; water conservation; increased microbial populations; and preservation of soil nutrients. Because of their many services, cover crops can be used to fill multiple niches within a farming system.

Cover Crops and Their Uses

Cover crops have multiple uses, providing several opportunities for inclusion in crop rotation. Cover crops may be used as green manures, living mulches, residue mulches, catch crops and forages.

- Green Manures

Green manures, as the name implies, are used primarily for the addition of nutrients and organic matter to the soil, protecting and improving soil quality. Green manure crops are typically grown for a specified period during a rotation when a field is not in use, and are then plowed under and incorporated into the soil before the succeeding crop is established.

- Living Mulches

Living mulches are cover crops planted for living ground cover throughout the growing season. Living mulches are established between rows of the main crop to suppress weeds by blocking sunlight and competing for water and nutrients and to reduce erosion. A concern with living mulches is competition with the main crop. It is therefore important that living mulches complement the cash crop; typically, the living mulch should be shade-tolerant and low-growing. Mechanical suppression, such as mowing, may be necessary throughout the growing season to help manage the living mulch.

Annual ryegrass living mulch in broccoli.

- Residue Mulches

High-residue cover crop mulches are well-adapted for use in conservation tillage programs. Killed cover crop residue is left on top of the soil surface as mulch. The crop residue limits weed seed germination by intercepting sunlight,

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preventing it from reaching the soil surface. Cover crop residue also enhances methods of biological control, such as weed seed predation by insects.

- Catch Crop

Typically grown for a short time, catch crops are established after the cash crop is harvested to reduce leaching by holding nutrients in the soil rootzone. Catch crops have been shown to have the most marked effects on the availability and loss of soil inorganic nitrogen and sulfur. Buckwheat is the only known catch crop that is able to mobilize phosphorus. No catch crops have been shown to increase potassium availability and uptake by succeeding crops.

Buckwheat is an excellent short-season, summer cover crop that catches phosphorous, making it available to subsequent crops, and attracts beneficial insects and pollinators.

- Forage

Forage crops are those grown for grazing by livestock. Forages function as cover crops when they are used for haying or pasturing, and as a green manure when eventually killed or tilled in. Many of the grasses and legumes selected as forages are typically used as cover crops.

Benefits of Cover Crops and Green Manures

- Organic Matter & Soil Structure

The addition of cover crops in a production system furnishes organic matter that helps to boost soil quality. During the breakdown of organic matter by microorganisms, compounds are formed that help bind soil particles together into aggregates of various sizes. Soil aggregates are clumps of soil particles held together by clay, plant roots, bacteria and fungi, and the byproducts of decomposition. Soil aggregation creates spaces, or pores, within the soil that are essential for storing air and water. Organic matter additions increase the number of larger-sized aggregates in the soil, enhancing overall porosity. Soil structure has a major influence on soil quality; a well-aggregated soil tills easily, is well-aerated, has a high water infiltration rate and supports biological activity. All of these aid in root growth and seedling emergence. Well-aggregated soil is said to have good "tilth." Approximately 2 tons/acre/year of crop residue are considered adequate to maintain soil organic matter at constant levels in continuously cropped soils.

- Legumes & Nitrogen Production

The addition of leguminous crops, which are able to fix their own nitrogen (N) from the atmosphere, will provide N for succeeding crops when plant residues are

Purple vetch is a cool season, leguminous cover crop that does well in Tennessee.

incorporated into the soil. If conservation tillage is used, the N will also slowly become available but will be tied up in the decaying residue. Planting legume cover crops, as pure stands or bi-cultures, can be used as a replacement or supplement for inorganic nitrogen fertilizers. Nitrogen supplied by legume crops can be held in the soil for extended periods and be available for plant uptake, unlike highly soluble N fertilizers, which have a significant potential to leach out of the plant root zone.

Nitrogen accumulation by leguminous crops ranges from 50-200 lbs N/acre depending on the species of legume grown, the total amount of biomass produced and the percentage of N in the plant tissue. The portion of green manure N available to the following crop is usually 40-60 percent of the total amount contained in the legume. Forty percent can be expected in the first year following a cover crop that is killed and used as mulch. Sixty percent can be expected when the cover crop is incorporated as a green manure. Lesser amounts are available in following years, but increased yields are apparent for 2-3 growing seasons.

Conditions that encourage good N production include good crop stand, optimum soil nutrient levels and soil pH, good nodulation and adequate soil moisture and temperature.

- Nutrient Enrichment

The inclusion of cover crops into rotation plans can cut fertilizer costs by contributing N and scavenging for nutrients below the cash crop rooting zone. In addition to N supplied by legumes, cover crops help recycle nitrogen, phosphorous, potassium, calcium, magnesium and sulfur. These nutrients are held by the cover crop until it is incorporated into the soil, when they are made available through decomposition. The breakdown of green manures in the soil also produces organic acids, which are formed as a byproduct of microbial activity. The organic acids react with insoluble mineral rocks, releasing nutrients that are available to the crop.

- Soil Microbial Activity

Cover crop residues furnish a carbon or food source to microorganisms. When a green manure crop is incorporated into the soil, microbes multiply to break down the fresh plant material, resulting in a rapid increase of microorganisms. Microbial populations may be enhanced 2-6 fold. As populations grow and plant matter is decomposed, soil microorganisms enhance soil structure through the production of compounds that aid in soil aggregation.

Factors that influence the breakdown of organic matter include soil temperature, soil moisture and the C:N ratio of plant material. The C:N ratio reflects the type and age of plant material. Microorganisms use nitrogen as an energy source and carbon to build their cell structure. Higher C:N ratios can result in N being tied up by soil microbes to break down carbon-rich residues, while lower C:N ratios will provide more N release into the soil for immediate use by plants. The optimum C:N ratio for soil is between 15:1 to 25:1.

- Water Conservation

Using cover crops impacts soil water conservation and availability. In early spring, soil water is removed when cover crop growth and transpiration is at its highest. In many Southern soils, which are too wet in spring, this may allow for earlier tillage and planting. During the growing season, cover crop residue mulches retain soil moisture when crop transpiration rates are greatest and rainfall is seasonally at its lowest. Mulches that result from killed cover crops increase water infiltration and reduce water evaporation from the soil surface in no-till planting, allowing conservation tillage systems to provide moisture that would otherwise be lost through evaporation. Covering the soil, whether with living mulches or crop residue, reduces crusting and subsequent surface water runoff. Cover crops protect water quality by slowing erosion and runoff, reducing pollution caused by sediments, nutrients and chemicals.

- Weed Suppression

The use of cover crops can reduce the need for herbicides by suppressing weeds. The presence of winter annuals and living mulches helps control escaped weeds and may prevent or slow the invasion of new weeds. Cover crops suppress weeds by out-competing for water and nutrients. Cover crops above the weed canopy intercept light, shading the soil and reducing soil surface temperatures, making it difficult for weeds to establish. Some cover crops, such as small grains like rye and summer annual forages related to sorghum and sudangrass, exhibit allelopathy. Allelopathic cover crops inhibit or slow the growth of other nearby plants by releasing natural toxins. The mulch that results from mowing or killing these crops can provide significant weed control in no-till cropping systems.

- Pest Management

Cover crops can also reduce the need for pesticides by increasing the diversity of plants, arthropods, mammals, birds and microorganisms in the farm system. Diversified natural systems are more stable, and serious pest outbreaks are rare because natural controls exist to counteract pest population explosions, keeping pest populations in balance.

Cover crops provide pollen, nectar and habitat for beneficial organisms such as predators while they are searching for pests. Once a main crop is growing, the beneficial organisms from the cover crop move onto it. Cover crops also host beneficial microbes that discourage disease by creating competition below the soil surface with soilborne pathogens.

Managing Cover Crops

- Establishment

When planted solely for soil conservation, cover crops should provide a high percentage of ground cover as quickly as possible. Sowing a mix of grassy and leguminous-type crops will increase ground coverage, act as insurance if one crop does not establish as well as the other and provide more benefits than planting a single cover crop.

Crop selection depends upon the niche, or need to be met, and establishment guidelines will vary by crop. For information on crops and seeding information, see the UT Extension factsheet Forage and Field Crop Seeding Guide For Tennessee (PB 378), available online at: http://utextension.tennessee.edu/publications/Documents/pb378.pdf

- Killing

In traditional systems, cover crops are often killed with herbicides. However, in organic systems, approved pesticides are expensive and only marginally effective in killing the cover crop. In organic systems, mechanical methods are most commonly used to suppress or kill cover crops, such as mowing, rolling and tilling. Timing is a key factor when mechanically killing cover crops. Management is most effective during seed formation, when the plants are beginning to dry down.

Flail mowers contain many small doubled-edged knives that uniformly distribute finely cut residue on the soil surface. Flail mowers generally produce more uniformly

The flail mower finely chops and uniformly distributes plant residue on the soil surface.

distributed mulch than rotary cutters, which tend to windrow crop residue. The roller-crimper is a water-filled drum with horizontal blades (angle iron) that rolls and crimps the stems, killing cover crops while leaving the plant intact. When cover crops are rolled, a dense stand of mature crop is laid uniformly on the ground. It may take from a few days to several weeks for crops to completely die. Rolling facilitates more efficient use of no-till equipment when the subsequent crop is planted in the same direction as the cover crop was rolled, and cover crop persistence and weed suppression are better as compared to mowing.

The roller crimper, with angle iron blades, crimps the stems and lays the intact plant uniformly on the ground.

Planting cover crops known to winter-kill is another non-chemical means of management. Cover crops should be fall-planted early enough to accumulate adequate top growth before being killed by freezing temperatures. Instead of living cover, they provide a dead mulch through the winter months.

Selecting the Best Cover

First, decide the need or use the crop will fulfill. Common goals are often to provide nitrogen, add organic matter, reduce soil erosion, provide weed control, manage nutrients and supply a killed mulch. Next, identify an available niche in your cropping system by determining when the cover crop should be used to meet your need, or identify uncropped periods throughout the seasonal work schedule where cover crops could be used. Lastly, determine which crop(s) best meets your needs based not only on ideal planting dates, but the crop characteristics. It is important to consider how and when the crop will be seeded, where the seed will come from and what it will cost, weather and temperature patterns during the planting period, which weather extremes the crop is able to tolerate throughout its lifecycle, the amount and kind of growth expected, how vigorous or aggressive the crop is, how it will be killed and what equipment will be necessary. Determine the risks involved with incorporating the crop into your seasonal rotation. What will happen if the crop does not establish or die on schedule? It is important to evaluate cover crop impact similar to any other crop, balancing costs against returns.

The inclusion of cover crops in farm planning offers significant benefits to organic systems by providing nitrogen and organic matter; encouraging diversity; and fostering natural disease, insect and weed control. Cover crops enhance soil quality over time, boosting crop yields, reducing the need for outside inputs and increasing profits.

For more information on cover crops, visit 'Grower Resources' at: http://organics.tennessee.edu. Access "Managing Cover Crops Profitably" online at http://www.sare.org/publications/covercrops.htm or request a print copy, available from SARE.

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