Increasing Soil Organic Matter with High Residue Cover Crops in Residue Management Practices

Introduction

Soils in the southeastern United States are generally less fertile and have lower organic matter (OM) compared to those in other regions of the U.S. Here in the Southeast we have further degraded these delicate soils by continuous row cropping and tillage. When the land was first cleared and plowed from forests and native prairie grasses, the soil OM content near the surface was around 4%. Currently the OM content of these soils range from 0.5 – 1% as a result of continuous cropping. Organic matter improves soil aggregate stability and soil structure, water infiltration, water holding capacity, cation exchange capacity, breakdown of pesticides, reduces erosion potential, acts as a storehouse for slow release of nutrients and provides substrate to be used by soil fauna including the wide array of microbes and earthworms. Soil OM also enables soils to better absorb the weight of tillage and harvest equipment, which results in less compaction.

The amount of OM in soil is the result of the combined influences of climate, inherent soil characteristics, land cover and use, and management practices. Soil formed under warm, arid climates is usually lowest in organic matter mostly due to low amounts of biomass production. When rainfall or irrigation is sufficient, the amount of vegetation (biomass) increases with warmer temperatures, but OM accumulation is generally slow because the decomposition rate of the biomass also increases with warmer, moist conditions. Organic matter tends to increase at the highest rate per year where rainfall is high enough to promote plant growth, but cooler soil temperatures slow decomposition. Soil texture is another influence on organic matter. Clayey soils generally have higher levels of OM than sandier soils. These are several reasons why Florida sandy soils have low OM levels. In contrast, Florida soils with drainage limitations due to landscape position or a slowly permeable layer will generally accumulate more OM as a result of slower decomposition from the anaerobic conditions that limit microbial activity, than more freely drained, aerobic soils. High OM content is the main reason soils in the Everglades Agricultural Area are experiencing subsidence; this area is losing several inches per year due to the fields not being in a flooded condition as they were when they were in native vegetation and undrained. This is a good demonstration that humans are a factor in influencing the amount of OM through the selection of management practices.

Agronomic inputs like adding manure or fertilizers increase vegetative growth (above and below ground), thus increases soil OM. Crop diversity, cover and green manure crops, reduced tillage, and rotations with pasture or hay will promote accumulation of surface residue and will generally increase soil OM in the surface layer. The opposite is also true with management systems that require intensive tillage (i.e., plows, chisels, disks) and low residue crops or cropping systems without residue producing cover crops during high erosion periods. These will result in losses of
soil OM. Additionally, when intensive tillage is performed soil aggregates and large pores are disrupted when left unprotected from the impact of raindrops. This reduces water infiltration and increases runoff and erosion.

All forms of tillage decrease OM to some extent; therefore, it is difficult to maintain soil OM levels when tillage is practiced. Adding organic materials, such as manure, may help maintain or increase the level of organic matter. However, research has shown that even with several years of adding organic materials the residual OM levels had not increased mainly due to tillage practices that were still being performed. The use of cover and green manure crops between cropping seasons, in minimum tillage crops and between rows in orchards proves to be a feasible practice to accomplish soil OM increase.

**Cover crops used in Florida**

Sorghum-sudangrass hybrids (Sorghum bicolor), also known just as sorghum sudan, has been used as a cover crop throughout Florida at one time or another, and it is still used by some growers during the fallow summer period in south Florida. Sorghum-sudangrass usually produces 5 to 7 tons dry mass per acre. Since 0.92 percent of this material is nitrogen, the amount of nitrogen potentially available to the subsequent crop ranges from about 90 to 130 pounds per acre. It also suppresses weeds and some parasitic nematodes, and the seed is inexpensive ($1.00 to 1.50 per pound of seed). Sorghum-sudangrass falls short as a good cover crop for Florida for several reasons. This plant grows poorly in many Florida soils, having been developed for the finer textured soils in the Midwest and Southwest. It grows quite tall, requiring mowing to prepare the crop for green manuring, which adds cost to the crop. Its large fibrous stems have a high carbon: nitrogen ratio (C: N), which slows decomposition and may immobilize nitrogen from the soil during decomposition. Sorghum-sudangrass attracts armyworms and corn silk flies, which maybe detrimental to subsequent vegetable crops.

Sunn hemp (Crotalaria juncea) is another cover crop that has been used in Florida, which has a number of advantages compared to sorghum-sudan as a cover crop. This plant is an annual tropical legume that has a fast, 60- to 80-day production cycle, during which the plant may exceed 6 feet in height. It is a short-day plant that is quite drought-tolerant, grows well in both high and low pH soils, and is also resistant to root-knot nematode. Sunn hemp produces 6 to 8.5 tons of dry mass per acre. Since 2.85 percent of this material is nitrogen, the amounts of nitrogen potentially available to the following crop range from about 340 to 450 pounds per acre. However, sunn hemp does have several limitations. Seeds are rather high-priced ($1.50 to $4.00 per pound) due to import costs and limited seed availability. Seeds require rhizobium inoculation before planting. In some fields, sunn hemp stands maybe reduced due to damping off from Pythium or a form of Fusarium. Even with these possible limitations, sunn hemp was among the best of the tested cover crops in southern Florida conditions.
Velvetbean (Mucuna pruriens var. utilis) is also an annual tropical legume that produces a large amount of biomass, is drought-tolerant, suppresses parasitic nematodes, and grows well in both high and low pH soils. Velvetbean may produce 5 to 7 tons per acre of dry biomass consisting of 2.6 percent nitrogen, which may provide from 260 to 360 pounds of nitrogen to the following crop. But its large seed requires a special planter, and volunteer plants may persist into the next crop, requiring weed control. There is a small seeded cultivar called, ‘Georgia Bush’, that can be seeded with some conventional seeders. Another draw back is that velvetbean maybe potentially allelopathic to some vegetable crops.

Cowpea (Vigna unguiculata) is a legume that grows well in a variety of soils, is resistant to root-knot nematodes, and has a short growing season of 40 to 50 days. Cowpea may produce 3 to 5 tons per acre of biomass consisting of 2 percent nitrogen, which may provide from 120 to 200 pounds of nitrogen to the subsequent cash crop. However, cowpea is not tolerant to flooding, and in southern Florida conditions, biomass production is low.

Aeschynomene or joint vetch (Aeschynomene americana) is a warm-season forage legume that grows well on acidic and calcareous soils in southern Florida. It is resistant to root-knot nematodes. Its single disadvantage is relatively low biomass production, producing only about 2 to 3 tons per acre of biomass.

Sesbania (Sesbania exalta), like aechynomene and cowpea, is a warm-season legume forage legume that is well adapted to Florida conditions. However, it is more susceptible to root-knot nematodes, and does not quickly form a closed canopy, competing rather poorly with some persistent weeds.

German millet (Setaria italic) grows well in southern Florida and has been proven to be resistant to root-knot nematodes, but it produces low biomass.

Pearl millet (Pennisetum americanum) is a warm season grass that is used as a forage crop. It is fast growing, resistant to nematodes, drought tolerant, grows with low fertility and low pH.

Hairy vetch (Vigna villosa) is a cool season legume, which is very cold tolerant. It has high nitrogen fixing capability and is shade and drought tolerant.

Crimson clover (Trifolium incarnatum) is a cool season legume, which is very cold tolerant, and grows well in North Florida. It has nitrogen fixing capability and is shade tolerant. It is also has moderate drought tolerance.

Rye (Secale cereale) is a cool season grass. It is moderately cold, shade, and drought tolerant. Can be used as a forage crop for spring hay and is quick to establish. One draw back is that it can volunteer readily and may become a weed problem.
Black oat (Avena strigosa) is a cool season grass widely used as a cover crop in South America. It is allelopathic to weeds and resistant to root-knot nematode. It can be used as a forage and cycles nitrogen more effectively than rye. Two cons to its use are susceptibility to *Helminthosporium avenae* and there is only one cultivar, SoilSaver, available in the US.

**Benefits of Cover Crops**

In low residue crops, increases in soil OM with either no-till or strip-till conservation systems would not be expected without the addition of cover crops. Cover crops can be beneficial in several soil quality factors including the following:

1. Erosion - Cover crops increase vegetative and residue cover during periods when erosion energy is high, especially when main crops do not furnish adequate cover.
2. Deposition of sediment - Increase of cover reduces upland erosion, which in turn reduces sediment from floodwaters and wind.
3. Compaction – Increased biomass, when decomposed, increases organic matter promoting increased microbial activity and aggregation of soil particles. This increases soil porosity and reduces bulk density.
4. Soil aggregation at the surface – Aggregate stability is increased with the addition of and the decomposition of organic material by microorganisms.
5. Infiltration – Surface cover reduces erosion and run-off. Cover crop root channels and animal activities, such as earthworms, form macropores that increase aggregate stability and improve infiltration.
6. Soil Crusting – Cover crops will provide cover prior to planting the main crop. Increases of OM, improved infiltration, and increased aggregate stability reduce soil crusting.
7. Nutrient loss or imbalance – Decomposition of increased biomass provides a slow release of nutrients to the root zone.
8. Pesticide carryover – Cover crops reduce run-off resulting in reduced nutrient and pesticide losses from surface runoff and erosion. Increased organic matter improves the environment for soil biological activity that will increase the breakdown of pesticides.
9. Organic Matter – Decomposition of increased biomass results in more organic matter. Research shows cover crops killed 2 -3 weeks prior to planting the main crop, results in adequate biomass and reduces the risk of crop losses from soil moisture depletion and tie up of nutrients.
10. Cover and green manure crops increase the available food supply for microorganisms resulting in increased biological activity.
11. Weeds and Pathogens – Increased cover will reduce weeds. Cover crops have shown some allelopathic effects on weeds reducing weed populations in conservation tillage.
12. Excessive Wetness – Cover and green manure crops may remove excess moisture from wet soils, resulting in reduction of “waterlogging” in poorly drained soils.
Reduced tillage options

Some of the benefits of adopting a no-till practice, instead of intensive tillage, are erosion control, fuel, labor and time savings. Research has also found another benefit of no till, which is that it increases soil OM in the surface three inches of the soil. No-till is considered the most effective system for improving soil OM, because no soil is disturbed. This characteristic of no-till is extremely beneficial, because decomposition is slowed due to reduced oxidation. As a result, OM gains are maximized, which promotes improvements in soil quality parameters and soil tilth.

Another option for conservation tillage systems is strip-till. This system is a modified version of no-till that is used to improve seedbed conditions in cold and poorly drained soils. The level of disturbance to soil and crop residue with this system is greater than with no-till. A narrow tilled zone is created in the fall or spring to promote soil warming and water evaporation in the seedbed while leaving undisturbed areas between rows.

Research is now being conducted by UF/IFAS on an intensive crop rotation that includes cover crops after row crops and a two year rotation of bahiagrass as a permanent cover. The rotation is: year 1 bahiagrass is planted with a oats cover for winter grazing, year 2 is bahiagrass, year 3 is peanuts strip-tilled into the killed bahiagrass with oats cover for winter grazing, and year 4 is cotton strip-tilled into the oat cover crop. Some of the findings from this research are improved soil physical properties and water infiltration. Increased earthworm population and improved soil health. Increase soil OM and improve soil water content. Improved crop root growth in both cotton and peanut. Reduced disease and insect damage in row crops. Increased yield, especially peanut yield.

References
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5. USDA-NRCS, (1996), Effects of Residue Management and No-Till on Soil Quality, USDA-NRCS Soil Quality Institute, Soil Quality – Agronomy Technical Note No. 3.