



# Soil Quality - Agronomy

Technical Note

No. 3

## Effects of Residue Management, No-Till on Soil Quality

Compared to water or air quality, Soil Quality is a relatively new concept and relies on indicators, like organic matter, bulk density, nutrient status, and biomass for measurement. Of this, organic matter is probably the most vital in maintaining a quality soil resource. It improves aggregate stability and soil structure, reduces erosion potential, provides energy for microorganisms, is important to nutrient cycling, and improves infiltration, water holding capacity, cation exchange capacity and the breakdown of pesticides. The best ways to manage organic matter in a cropping sequence is to reduce tillage and use cover crops and crop rotations to increase organic inputs as root biomass. This technical note focuses on tillage and residue management, as the practices that most influence organic matter levels. Residue Management includes no-till that is the method of preparing a narrow slit or strip for a seedbed and leaving surrounding residue cover on the surface undisturbed. Other forms of residue management are mulch till, ridge till and seasonal residue management. Conventional tillage usually includes a moldboard, disk or chisel plowing and secondary tillage that disturbs the soil surface for seed preparation. This note focuses on the least disruptive form of conservation tillage, no-till. Local soil and climate conditions may dictate other forms of conservation tillage be used in order to maintain economic sustainability.

### Factors Influencing Organic Matter Levels

The amount of organic matter in soil is the result of the combined influences of climate, inherent soil characteristics, land cover and use, and management practices. When rainfall or irrigation is sufficient, the amount of vegetation (biomass) increases with warmer temperatures, but rates of decomposition of the biomass also increase dramatically. Generally, organic matter increases with higher rainfall and cooler temperatures. Conversely, soil formed under warm, arid climates is usually low in organic matter mostly due to low amounts of biomass production. Soil texture is another influence on organic matter. Clayey soils generally have higher levels of organic matter than sandier soils. Soils with drainage limitations due to landscape position or a slowly permeable layer will generally accumulate more organic matter as a result of slower decomposition from the anaerobic conditions that limit microbial activity, than more freely drained, aerobic soils. Humans influence organic matter through the selection of management practices. Agronomic inputs like adding manure, or applying fertilizers increase vegetative growth (above and below ground), and thus increases soil organic matter. 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 organic matter in the surface layer. Conversely, management systems that require intensive tillage and low residue crops result in greater losses of soil organic matter. In the 1850s, the moldboard plow became the standard for primary tillage. The plow turned the soil over and buried most of the residue of the native vegetation or the previous crop residue. The stirring and turning of soil stimulated microbial



United States  
Department of  
Agriculture

Natural  
Resources  
Conservation  
Service

Soil Quality Institute  
2150 Pammel Dr.  
Ames, IA 50011  
515-294-4592

Technical  
Note No. 3



Oct., 1996

*This is the third  
Agronomy fact  
sheet in a series on  
on soil quality. This  
fact sheet is  
general. For specific  
information, contact  
NRCS State  
Agronomist.*

activity and increased the rates of residual organic matter break down. For example, the Morrow research plots in Urbana, Illinois, established in 1876, had a 23% decline in organic carbon due to tillage (Odell et al., 1982). Soil aggregates and large pores are disrupted when left unprotected from the impact of rain drops. This reduces water infiltration and increases runoff and erosion. In more arid climates, the unprotected soil surface becomes smooth, making it vulnerable to wind erosion until crusting occurs. Unfortunately, all forms of tillage decrease organic matter to some extent. Therefore, it is difficult to maintain soil organic matter levels when tillage is practiced. Adding organic materials, such as manure, may help maintain or increase the level of organic matter. However, research at Pendleton, Oregon showed that even after 40 years of adding manure at rates over 10 tons per acre per year, residual organic matter levels had not increased mainly due to tillage and summer fallow practices (Rasmussen et al., 1989). Reicosky and Lindstrom 1993, measured carbon dioxide released from soil 19 days after wheat stubble had been plowed. The moldboard plow caused as much carbon to be oxidized as had been photosynthesized in the roots and residue during the whole growing season. This rate was 5 times greater than the untilled plots. In summary, research has shown that it is practically impossible to increase organic matter when the entire land surface is tilled.

### **Tillage Effects on Organic Matter**

Adoption of no-till has increased in acreage from approximately 14 million acres to nearly 41 million acres from 1989 through 1995 (Conservation Technology Information Center, 1996). Some of the benefits of no-till is erosion control, fuel, labor and time savings. Some research has shown that no-till increases soil organic matter in the surface three inches (Ishmal et al., 1994; Mahboubi et al., 1993). However, the residue cover from no-till protects the soil surface from erosion and preserves the continuity of water conducting pores. The best way to increase organic matter throughout the surface is through the use of cover crops or sod rotations in conjunction with no-till (See Technical notes No. 1 and No. 2). Reicosky et al., (1995), summarized 9 long term no-till studies, all of which showed that organic matter increased an average of 986 pounds per acre per year, or about 0.1 percent per year.

Locations of these studies were in the states of Minnesota, Nebraska, Illinois, Ohio, Kentucky, Georgia, and Alabama. Research ranged from 5 to 11 years, and rates of increase ranged from 80 pounds to 2,000 pounds of average annual residual soil organic matter. These increases were the result of no-till, crop rotations with grain crops and cover crops. Increases would not be expected in low residue crops without rotations of grain crops and the addition of cover crops. Increases in organic matter such as this will affect properties such as cation exchange capacity, aggregate stability, available water holding capacity.

### **Impacts on Aggregate Stability/Soil Structure**

Residues left on the surface help increase aggregate stability. Soil aggregates in no-till systems are more stable than in conventional tillage soils due to the added strength provided by products from the decomposition of soil organic matter and presence of bacteria and fungal hyphae. The hyphal material acts like strings that bind or tie smaller aggregates and soil particles together. A demonstration was recently conducted in the Central Valley of California compared cover crops in an orchard tilled annually, to permanent cover crops. To illustrate the benefits of a permanent cover, the researchers placed one clump of soil in a glass of water from the untilled site that had accumulated surface organic matter, and one from the tilled site that had not. The tilled sample began to disperse immediately and the water became very cloudy. The untilled sample with increased surface organic matter was stable and the water remained clear. Surface residues in no-till systems help protect aggregate stability and maintain the continuity of soil pores, resulting in increased infiltration rates and reduced soil erosion.

### **Impacts on Biological Activity**

It is generally acknowledged that residues have several positive effects on the microbial populations in agricultural systems. Residue accumulations in the surface 3 inches provides a cooler and moister environment than conventional tillage systems. Surface residues provide more substrates or food for nitrifying and denitrifying microbes. The increased residues with high carbon to nitrogen ratio slow the rate of mineralization over a longer period of

United States  
Department of  
Agriculture

Natural  
Resources  
Conservation  
Service

Soil Quality Institute  
2150 Pammel Dr.  
Ames, IA 50011  
515-294-4592

Technical  
Note No. 3

Oct., 1996

time (Coleman and Crossley, 1996). Soil invertebrate populations such as microarthropods and earthworms increase with less tillage as a result of increased populations of litter-decomposing fungi and help's increase nitrogen availability for plant growth. Research comparing 22 components of no-till and conventional tillage (House, et al. 1984), Shown that no-till systems had greater resilience, greater invertebrate species richness, greater soil organic matter and nitrogen turnover time. The following table highlights some of the 22 components compared between no-till and conventional tillage.

<u>Component</u>	<u>No-Till vs. Conventional</u>
Crop Yields	NT=CT (except during drought)
Weed Biomass	NT>CT
Residue Decomposition Rates	CT>NT
Surface Crop & Weed Residues	NT>CT
Surface Litter (%N)	NT>CT
Nitrification Activity	NT>CT in upper soil layer
Total Soil N	NT>CT in upper soil layer
Organic Matter	NT>CT
Soil Moisture	NT>CT
Foliage Arthropods	CT=NT
Arthropods Species Diversity	NT>CT

High residual organic matter levels increase the general fertility and productive capacity of soil (Moldenhauer et al 1995). Residual organic matter and a slow decomposition rate provide crops with a limited but continuing source of nutrients. Residual organic matter also promotes deeper rooting by improving infiltration and water holding capacity.

### Management Concerns

Soil compaction may become a problem with no-till. Limited deep tillage and strip tillage may be useful in breaking up compacted areas without disrupting the entire surface area. Also, no-till crop production in the beginning, may require more chemical weed control, but over time the residue cover increases to the point weed seeds cannot germinate because they are not brought to the surface by tillage. Vines and other perennial weeds can become more prevalent in no-till monoculture systems, because certain weeds may not be controlled by

the herbicides nor is there tillage for weed control. Crop rotations along with no-till systems may alleviate some pest and compaction problems. In agricultural soils that have been degraded, it may take 3 to 5 years to see benefits from no-till. However, no-till used in combination with crop rotations and cover crops can be a valuable tool for improving the soil resource.

### Summary

Organic matter is one of the most important indicators of soil quality. Some of the beneficial effects of soil organic matter includes better aggregation and aggregate stability, longer cycling of nutrients, higher microbial activity

United States  
Department of  
Agriculture

Natural  
Resources  
Conservation  
Service

Soil Quality Institute  
2150 Pammel Dr.  
Ames, IA 50011  
515-294-4592

Technical  
No. 3  
Oct., 1996