

CONSERVATION TILLAGE

Soil Organic Matter Levels in the Central Great Plains

FACTS

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The Fact: Soil organic matter enhances soil productivity and sustainability

Why Soil Organic Matter is Important

With a renewed interest in soil quality and long-term sustainability, the soil organic matter (SOM) status has taken on new significance. This is because SOM correlates so well with a number of important soil physical, chemical, and microbiological properties. As SOM content increases, soil nutrients such as available nitrogen (N), phosphorus (P), and sulfur (S) increase; other nutrients like calcium (Ca), magnesium (Mg), potassium (K), and nutrients required in small amounts like zinc (Zn), iron (Fe), copper (Cu), manganese (Mn) also increase. Additionally, SOM binds soil particles together to form stable aggregates (clumps) that are resistant to erosion, and at the same time, permit water to infiltrate easily, thereby reducing runoff. In adequate quantities, SOM reduces soil crusting and soil bulk density (hardness), and helps to maintain a stable soil pH. In short, SOM improves soil structure and soil tilth, and helps to provide a favorable medium for crop growth.

Factors Controlling SOM

Generally, SOM content is controlled by the kind of parent materials (texture primarily), climate, slope, and management practices that exist. Rocks (minerals) that have not lost its nutrients from excessive rainfall (leaching), and areas where temperature and water are adequate will have high SOM. Management practices that affect crop biomass (yield and straw) production (water, fertilizer, variety), residue maintenance (equipment, harvest), and litter (wind) will also affect SOM content. Thus, as dry matter production increases, SOM increases. However, only that which remains after harvest along with root biomass will influence long-term SOM content.

What is SOM and How is It Measured

Soil organic matter is broadly defined as all living organisms (microorganisms, earthworms, etc), fresh residues (old plant roots, crop residues, recently added manures), and well-decomposed residues (humus). The SOM content of agricultural topsoil is usually in the range of 1 to 6%. This amount is the result of all additions and losses of SOM that have occurred over the years.

Since SOM is usually measured in the laboratory as organic carbon, one needs to understand the relationships between the two. Soil organic matter is estimated to contain 58% organic carbon (varies from 40 to 58%) with the rest of the SOM comprising of other elements (eg, 5% N, 0.5% P and 0.5% S). A conversion to SOM from a given organic carbon analysis requires that the organic carbon content be multiplied by a factor of 1.72 (1.00/0.58). Thus, 2% SOM is about 1.2% organic carbon. Because of potential differences in conversion factors, research data across

sites and regions are best compared as organic carbon. SOM content can also vary with the amount of litter and small residue or roots introduced into the soil sample.

When the soil contains lime (calcium carbonate with pH above 7.7), methods that measure release of carbon dioxide gas from SOM can overestimate the SOM if lime which produces the same gas is not neutralized before analysis. If a gas release test (acid on lime produce CO_2) was not done on the soil sample, sometimes a high C/N ratio or higher values for 3 to 6 inch depth than 0 to 3 inch depth could indicate a potential problem. Even though a bit tedious and somewhat suspect environmentally because of the use of the heavy metal chromium in the analysis, the classic Walkley-Black method for SOM is not affected by the presence of lime, and does not require expensive instrumentation. At this time, most soil testing laboratories still use the Walkley-Black method, while researchers are slowly converting to the gas release method with a Carbon-Nitrogen gas analyzer. It is advisable that the SOM at the tillage depth be determined every three to five years to assess direction of SOM change and potentially available nitrates.

Since variability in SOM across a field can easily exceed cropping treatment effects, it is important that consistency be practiced relative to sampling depths and sample preparation, analytical procedures and analysts, and in the case of changes with time, closeness to the original sampling site.

How SOM is Lost

While SOM additions have been discussed in terms of dry matter inputs (residue, manures), SOM losses fall under two major categories: losses from erosion and from decomposition. Erosion represents the physical loss of SOM when clay and silt are removed from the field by wind and water. Decomposition is a chemical loss of SOM as carbon dioxide (CO_2) when microbes use SOM as food for energy and growth. Inversion or leaching of SOM could also represent a loss when SOM is assessed in the surface soil only. It should be noted that even if no erosion or decomposition had occurred, the conversion from native sod to wheat-fallow, could result in a lowering of SOM when SOM inputs to the soil under WF are lower than SOM inputs under continuous grass.

Figure 1 shows a typical curve for SOM loss (both from decomposition and erosion) with time under a clean-till dryland winter wheat-fallow system. Note that losses from decomposition is about 15 to 20% after 20 years, and about the same or slighter larger for erosion, for a total of about 40 to 45% loss. The bulk of the erosion in the Central Great Plains in the traditional wheat-fallow system is due to wind even though erosion by water could have more devastating localized effects. While earlier data had suggested large losses of SOM in cultivated soils (50 to 60% in 20 years), current assessments where soil bulk density (looseness or compaction of soil) is measured, suggest much smaller SOM losses.

SOM in Cropping Systems

Under steady-state conditions (just as much SOM decomposes as is added), residue additions of 800 lb and 2000 lb/ac/y are required for maintaining 2% SOM (Fig. 2) with decomposition rates of 2%, and 5%, respectively. Since it is estimated that about 100 lb of residue is produced for every bushel of wheat, a 40 bushel

harvest would return about 4000 lb, or about 2000 lb residue/acre/year for a WF rotation. From this 2000 lb, 100 lb would be lost to decomposition (5%), but another 2000 lb would be added for the next cycle and so on until the 2% SOM is reached. Thus, to go from 1% SOM to 2% SOM would require about 13 years. This scenario, however, assumes no loss of residue from wind or loss of SOM from erosion.

A contribution of about 20 to 40 lb of N in the form of nitrates is added to the soil for every 1% SOM in the tillage depth depending upon the decomposition rate (a function of temperature, water, residue type and fineness, and residue contact with soil). Under our dryland conditions, soils with less than 1.3% SOM may result in sulfur deficiency for oil crops, and zinc deficiency in corn.

SOM typically found in Central Great Plains Soils

Generally, for the Central Great Plains, SOM content in the top six inches ranges between 1 and 2% for cultivated soils, and about 1.5 to 3.0% for native grasslands (Table 1). This percentage, obviously, is related to topography, and to temperature and water differences that produce native SOM across the Great Plains, and to the type of management practices in cultivated areas. Generally, the organic C to organic N ratio (C/N) is about 10 to 1 (SOM/N ratio about 17 to 1). Over the long term, this C/N ratio reflects well the decomposition/residue input status of the soil where lower ratios reflect greater tillage and longer fallow periods, and higher ratios greater cropping intensity and production of residue. Table 1 also shows clay content of selected Central Great Plains soils. Clay is highly correlated with both organic C and N, and offers some physical protection against SOM decomposition. Soil reaction (pH) is also important in SOM studies, but mostly as it affects nutrient availability and plant growth. Both SOM and pH could be important in affecting the residual activity of certain herbicides.

Table 1. Soil organic matter content and other properties for some native soils across the Central Great Plains. (0-6 inches).

Soil Series	% SOM	% N	% Clay	pH
Ascalon sandy loam	1.6	0.095	10	6.6
Haverson loam	1.9	0.110	23	7.9
Keith loam	1.9	0.110	20	6.7
Nunn loam	2.3	0.120	24	7.2
Platner loam	2.0	0.110	20	6.7
Rago silt loam	2.3	0.125	25	6.6
Weld silt loam	2.2	0.120	23	6.9
Valent sand	0.7	0.040	6	6.7
Vona sandy loam	1.2	0.060	9	6.5

Data from other parts of the country have shown that yield potential may be sustained with about 2.0% SOM. Also data for western soils show a steep increase in stable aggregates as SOM increased from 1 to 2%. Thus, a soil with 2% SOM provides not only important soil nutrients, but also good physical conditions for water

infiltration and use, and erosion control. Again while a 2% SOM content may be high for a sandy soil, a soil with high clay content will require greater than 2% SOM content to maintain good tilth.

How to Maintain or Increase SOM

With adequate residue and water conservation, and with proper N and P fertilization, (lime, sulfur and zinc where appropriate) we increase yields. With minimum tillage, we conserve the residue, reduce erosion, and maintain (minimal loss from erosion) or build SOM especially when long summer fallow periods are reduced. This trend has been documented by our research here at the Central Great Plains from our long-term tillage plots and from our 5-year intensive cropping rotations. This increase in SOM, however, is primarily in the top 2 inches. Even though the SOM content in the top six inches may not differ appreciably among tillage systems and cropping intensities over the short term, high residue and SOM in the top two inches decrease crusting, increase water infiltration, and reduce erosion.

Conclusions

As we strive to improve the long-term sustainability of our soils, and start to rethink the advantages and disadvantages of the clean-till winter wheat summer fallow, this effort becomes possible only within a context of economic viability and environmental stability. The precepts of increasing yields and maintaining and increasing SOM are not inconsistent with good stewardship. Research has to provide the options in terms of cropping sequencings based upon soil and water conditions, pest infestations, right varieties, proper fertilization, and sound knowledge about risk assessments based upon current and projected economic realities.

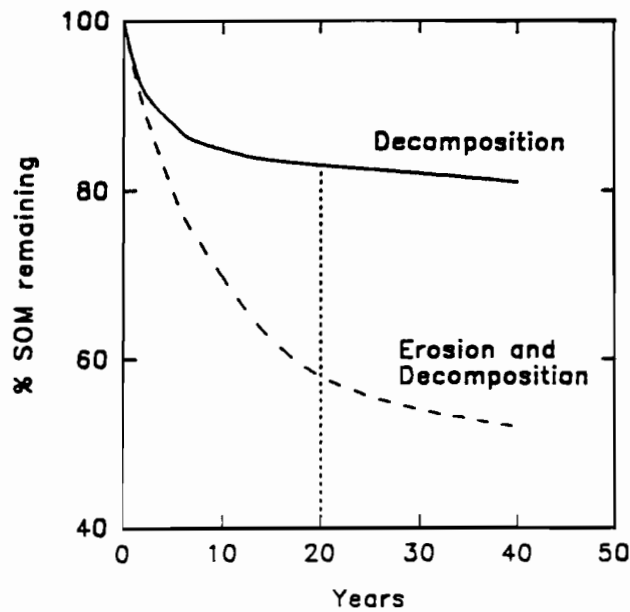


Fig. 1. Loss of SOM in clean-till WF with time.

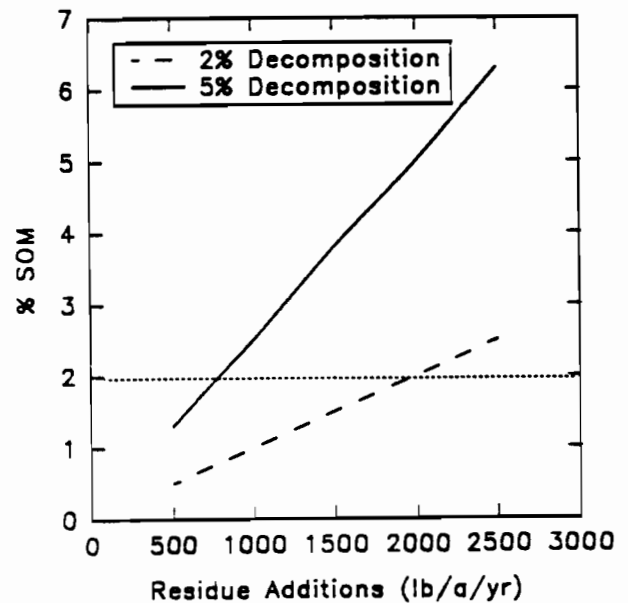


Fig. 2. Estimated SOM at steady-state at two different decomposition rates.