HOW TO BUILD SOIL ORGANIC MATTER

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One of the simplest and most comprehensive measurements of soil health is soil organic matter (SOM). Soil organic matter is connected to the ability of the soil to provide nutrients, retain water, and improve yields. As farmers seek to increase the SOM in their fields, it is important to reflect on the management practices that will lead to increases in SOM, the long-term nature of the gain in SOM, and inherent soil factors that dictate the ability of farmers to increase (or decrease) their SOM rapidly. Soil OM is measured as loss on ignition, which requires burning the soil and measuring what remains. Soil OM is typically about 50% carbon. Most scientific studies measure and report SOM in terms of soil organic carbon (SOC). The SOC can be multiplied by two to estimate SOM percentage.

Soil Management – Adding Carbon

There are two ways to build SOM in soil: (1) increase the amount of carbon inputs into the soil and (2) reduce the amount of carbon loss from the soil. Increasing the amount of carbon inputs can come from crop residues, manure, or cover crops. Changing crop rotations to increase biomass return lead to SOM gains. For example, changing from a corn-soybean rotation to continuous corn rotation in Iowa increased SOC by 22% over 14 years (Poffenberger et al., 2017). However, there are certain economic and agronomic advantages to rotation corn with soybeans (i.e., increased corn yields and reduction in N fertilizer). Frequent manure additions to the soil can lead to increases in SOM over time. For example, 17 years of liquid dairy manure applications to a silt loam soil in British Columbia, Canada led to greater SOM in the upper 8 inches (Maillard et al., 2015). Long-term use of cover crops, however, typically show only modest increases in SOM (Poeplau and Don, 2015). However, for both manure and cover cropping, there is much variation in the results of different research studies. The ultimate effect of how an increase in carbon input will lead to increases in SOM will be dependent on tillage and soil properties.

Soil Management – Protecting Carbon

Reduction in tillage is the management practice that will increase carbon storage in soil. Tilling soil breaks apart soil aggregates, exposing “protected” SOM to the

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environment, allowing it to be mineralized (i.e., consumed and converted to CO_2) by soil bacteria. The fundamental concept here is that SOM is protected when an aggregate is formed. Soil aggregates (soil pieces between 0.05 and 2 mm) are "organo-mineral complexes" – meaning they are a creation of clay and silt tightly bound with decayed plant material or dead bacterial cells. This new structure (the aggregate) is the foundation of carbon storage in soil. Over time and with less soil disturbance, the soil forms a greater amount of aggregates and thus sequesters more carbon. It is this process that allows SOM to be built when carbon inputs are increased into soil. There is still a debate whether no-till alone increase SOM in soil, or if it is just changes where the SOM is stored (at the surface or at the depth of tillage).

Soil Properties

There are two key soil properties that will dictate your ability to build SOM: texture and drainage class. Texture is connected to the ability to form aggregates. Soils with greater clay content have a great ability to bind with organic material, form aggregates, and build SOM in the soil as compared with soils with greater sand content. Drainage class influences SOM in two ways. First, it indicates the historic, pre-agricultural SOM levels in the soil. Soils that are more poorly drained (and wetter) may have greater SOM than well drained soils (think about how much SOM are in wetlands and peatlands). If a poorly drained soil was recently tile drained, then this will cause a slow decline in SOM over a long period of time; implementing management practices to increase SOM may only serve to slow the decline in SOM. Second, if a soil is less well drained, crop yields may be lower compared to well drained soils, resulting in less carbon return (via crop residues) to the soil. In addition, these soils may require tillage to optimize yield and use of cover crops may be limited. The ability to build SOM on different fields will be dependent on these properties and expectations for SOM building should be different for different fields.

Time and Expectations

One of the biggest issues concerning soil organic matter building is the time required to see measurable increases. Building SOM takes time. Land managers should consider this a long-term investment in the soil. In addition, increasing carbon inputs and reducing tillage come with additional agronomic considerations. There will be challenges to overcome. It is also important that expectations be realistic. If farmers are managing on poorly drained soils or sandy soils, there may be less ability to increase the SOM compared to a well-drained silt loam. Another important consideration is historic soil management. For example, if a field had been historically managed in a corn-alfalfa rotation that received manure and then recently converted to a grain-based rotation not receiving manure, we would expect that SOM may decline over

time. In this case, we would be starting from a condition of relatively high SOM. Even if farmers are using as much conservation management as possible for a grain-based cropping system, we would not be able to maintain as much SOM as compared to a perennial rotation that has three key aspects of SOM building (reduction in tillage, large inputs of crop residue, and frequent manure application).

References

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