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Questions of Organic Matter

FOR IMMEDIATE RELEASE: Soil organic matter is one of the oddest components of soil. Although it comprises a small percentage of total soil volume and weight, it completely changes the color, nutrient transfers, cation exchange capacity and water holding capacity.

What is soil organic matter?
In simple terms organic matter is complex matrix that is 50% carbon that forms long twisted chains connected to oxygen, hydrogen, phosphorus, nitrogen, sulfur, and other nutrient elements that comprise the other 50%. Organic matter is very light and fluffy which allows it to hold lots of water and gives it plenty of edges in which to hold cations. It can hold onto some anions like nitrates as well. For water holding capacity, organic matter can hold 10 times its weight in water and every 1% increase in organic matter, increases water holding capacity by ½ gallon per foot. That's over 20,000 gallons per acre. Every year 3 to 5% of total organic matter decomposes, and every 1% organic matter in the soil releases 20 lbs of nitrogen and a couple pounds of phosphorus. Besides the more well-known effects of increasing water percolation, holding capacity, and releasing nutrients, it also has more subtle effects like acting as a chelate for micro metals, increasing their availability to plant roots.
One question that many people ask is how much material or stover does it take to make organic matter. In a very general since, it takes ten pounds of material to make one pound of organic matter. Calculated out that means it takes 100 tons field stover per acre to increase organic matter 1%. The increase of organic matter is a long process. It takes years of intensive conservation practices to truly change the percentage of organic matter. Over the years as an extension agent I've heard of organic matter building "compounds" or "microorganism solutions" but there isn't a lot of science to their benefit. The natural biome of the soil has plenty enough microbes to break down field stover. The only help soil microbes really ever need is the occasional extra nitrogen to decrease the carbon to nitrogen ratio of high carbon material like wheat straw.

Is all organic matter the same?

Organic matter is divided into a number of pools and there a few different ways in which organic matter can be classified, but in general, most are based largely on how easily it is to break down. Some organic matter only last a couple of years while some is so tightly bound that microbes can't get to it and can last centuries.

Plant Residue – This first pool isn't really so much soil organic matter as it is field stover composed of stalks, leaves, and anything left behind after harvest. Most of it is broken down in a few weeks to a couple of years.

"Active" organic matter – Active organic matter is that which in transition and will be decomposed in a few years' time. Some of it the plant sugars and cellulose, some of it the decomposing plant material, while some of it the living and dead microorganisms.

Humus – This pool is what we think of when we think organic matter. It is old carbon that could be decade to centuries old and gives soil its dark brown and black colors.

Recalcitrant organic matter – Really this is just "advanced" humus that is very difficult to break down and could be around for centuries.

While humus is the organic matter we want because it will stick around for a long time, it takes lots of "active" organic matter to get there. This is also why testing for a change in organic matter right after a change in farming practices won't tell you anything. "True" organic matter humus takes years to make.

What field stover makes organic matter?

The first pool, plant residue, can be very diverse and what makes up that residue can affect the processes it goes through down the organic matter chain. In general, material high in lignin is harder for microbes to break down and it more likely to create lasting organic matter. To break down lignin, microbes need some seriously strong attack methods that involve creating strong acids to break the bonds that hold lignin together. Usually it's the funguses in the microbial world that specialize in the lignin breakdown. Hemicelluslose is the next level and is slightly easier for microbes to break down while cellulose is the easiest to for microbes to consume. Field stover like corn and soybean stalks and wheat straw are fairly high in lignin and wood pulp is nearly all lignin. Basically, if it makes good cattle forage, it probably doesn't have much lignin.

How is organic matter formed?

The lignin theory – Lignin theory is the concept that organic matter is created mainly from microbes' inability to break down lignin. While some parts of lignin get chewed on, microbes are never quite able to break the whole thing down before it gets bound into a complex. By this understanding only lignin is able to create organic matter while cellulose is completely broken down. This is of course not entirely accurate as organic matter can be formed without any lignin. A fair share of organic matter likely comes from not what dead plants fell onto the soil surface but from the sugars that living plants are pumping down through their roots to feed the soil microorganisms that benefit them.

The polyphenol theory – The polyphenol theory is the understanding organic matter is the by-product of microbes and plants, where simpler carbon chains, the polyphenols, bind together in large chains to form large organic matter complexes. This would allow nearly any kind of plant material to make organic matter. Likely is a combination of both the lignin and polyphenol theory that forms organic matter.

No matter what it is or how it's made, organic matter has a unique and dramatic role within the soil. Any effort to build organic matter will need to be a long term plan but the added benefits are diverse, large and lasting. You can't change your soil's texture or its location, the only part that can be change is how much organic matter it has. To increase organic matter it needs to be treated like any other living organism by being feed consistently (cover crops and diverse rotations) and treated nicely (reduced tillage and soil conservation).

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