Understanding soil microbes and nutrient recycling

Jim Hoorman in a Sustainable Agriculture fact sheet discusses new information on how soil microbes recycle soil nutrients to plants. "Soil microorganisms exist in large numbers in the soil as long as there is a carbon source for energy. Bacteria, actinomycetes, and protozoa tolerate soil disturbance and dominate in tilled soils. Fungal and nematode populations tend to dominate no-till soils with live plants. There are more microbes in a teaspoon of soil than there are people on the earth.

Microbes need regular supplies of soil organic matter (SOM) or carbon in the soil to survive. Long-term no-tilled soils or soil with continuous live plants have significantly higher levels of microbes, more active carbon (sugars), more SOM, and more stored carbon than conventional tilled soils. A majority of the microbes in the soil exist under starvation conditions and thus they tend to live in a dormant state, especially in tilled soils. Active roots supply 25-45% of their total root carbohydrates to feed the microbes. There are 1,000-2,000 times higher microbial population near active live roots than in the rest of the soil. Plants do this because the microbes are beneficial for their survival.

Bacteria are the first microbes to digest new organic plant and animal residues in the soil. Bacteria typically have low carbon and high nitrogen content in their cells (3:1 C:N ratio, 10-30% N). Under the right conditions of heat, moisture, and a food source, they can reproduce very quickly (in 30 minutes). Bacteria are generally less efficient at converting organic carbon to new cells, leaving behind many waste carbon compounds, some of which may be toxic.

Fungus generally captures more energy from the SOM as they decompose it, assimilating 40-55% carbon, releasing less carbon dioxide into the atmosphere. Most fungi consume cellulose and lignin, which is slower to decompose. The lignin content of most plant residues may be of greater importance in predicting how fast SOM will decompose than the carbon to nitrogen (C:N) ratio.

Mycorrhizal fungi live in the soil on the surface of or within plant roots. Mycorrhizal fungus are 1/10 the size of a root hair and can explore up to 20% of the soil volume compared to only 1% of the soil volume for a root hair. Fungi have a large surface area and help in the transport of mineral nutrients and water to the plants. Mycorrhizal fungus may transport 150-210% more water back to the plant than plant hair roots.

The fungus life cycle is more complex and longer than bacteria. Fungi are not as hardy as bacteria, requiring a more constant source of food. Fungi population levels tend to decline with conventional tillage and high fertilizer usage. Fungi have a higher carbon to nitrogen ratio (10:1 C:N ratio, 10% nitrogen) but are much more efficient at converting carbon to SOM. With high C:N organic residues, bacteria and fungus will take nitrogen out of the soil. The rule of thumb is that soil microbes feed first, then excess nitrogen is used to decompose organic residues, and the plant feeds last. In the future, we may directly fertilize or feed the microbes rather than the corn because it is more efficient.

Protozoa and nematodes consume other microbes. Protozoa can reproduce in 6–8 hours while nematodes take from 3 days to 3 years (average of 30 days) to reproduce. After the protozoa and nematodes consume microbes (which are high in nitrogen), they release excess nitrogen in the form of ammonia. Ammonia (NH_4^+) and soil nitrates (NO_3^-) are easily converted back and forth in the soil. Plants absorb ammonia and soil nitrates for food with the help of the fungi mycorrhizal network. The C:N ratio of most soils is 10-12:1 indicating the release of nitrogen back to the plants.

Adding a living cover crop to a no-till field increases active SOM (sugars and proteins) for the soil microbes to consume and thus increases microbial populations by providing two crop roots to feed on instead of one crop per year. Healthy microbial populations thrive with no-till and cover crops. As soil microbes decompose organic residues, they slowly release nutrients back into the soil for the cover crops or the following crop. Cover crops prevent the nutrients from being lost through soil erosion, leaching, volatilization, or denitrification." Hoorman, 2010) Microbes in the soil have been described as soluble bags of fertilizer, so healthy microbial populations increase our crop productivity. For more information, Google the following fact sheet: Understanding Soil Microbes and Nutrient Recycling, SAG-16-10 on Ohioline.