PEACE COUNTRY BEEF & FORAGE ASSOCIATION

The Soil Food Web

Basics for Beginners

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Forage Facts

What is the Soil Food Web and Where do they all Hang Out?

In recent years, molecular sciences have dramatically increased our understanding of the rhizosphere, which is the area immediately surrounding plant roots and more importantly, the interaction of this zone with the larger soil microbial community—the Soil Food Web! The rhizosphere is quite small—it extends only a couple of millimeters out from around a plant's root tips. The soil microbial community, on the other hand, is enormous! In a teaspoon of very healthy, active soil, there can be a billion bacteria, several meters of invisible fungal hyphae (kind of like roots, only they belong to microscopic fungi instead of to a plant), thousands of protozoa (you know, the amoebas and paramecium from high school science) and up to a dozen nematodes (tiny worms). In fact, a healthy soil under an electron microscope kind of looks like a alien-zombie horror story. Everybody is eating everybody else and there is no escape (see fig. 1).

Fortunately, this is a horror show that plants just love to see over and over again. It turns out that a lot of the energy that plants get from photosynthesis is used to produce chemicals that they secrete through their roots—kind of like we sweat. These are called plant root exudates and are mostly carbohydrates and sugars. Young seedlings will actually exude 30-40% of their fixed carbon as soil organic carbon (SOC). What would possess any self-respecting plant trying to establish itself to give up that much energy? Well, these exudates initiate mutually beneficial relationships with a variety of soil microbes and give a 'kick start' to the soil food web. In fact, it's these plant exudates that get the whole messy show going and there is increasing evidence that plants design their own soil food web by releasing specific compounds that will attract the right microbe at the right time who is going to deliver the right nutrient or the right defense mechanism that the plant needs. It's an amazing system of chemical communication taking place right below our feet.

Fig. 1 Can you spot the nematode, the bacteria and the fungi in this photograph?

Here is how it works: the plant puts out the exudate to attract and grow specific bacteria and fungi. These microbes live off the exudates and cellular material sloughed off as the root tips grow. Nematodes and protozoa eat the fungi and bacteria. Anything that is not needed by these secondary consumers is excreted as wastes and plant roots take those wastes up as nutrients, which are maintained and held in the rhizosphere, right where the plant needs them! As long as there is an active and healthy soil food web, nutrients get recycled over and over again and never actually leave the system. Instead of draining down to a water table and being flushed away with infiltrating water, nutrients are tied up in living organisms that reliably bring them back to the rhizosphere where they're needed. Every time a microbe dies (and remember—these guys are dying **constantly**!), nutrients become readily available to the plant. I can't emphasize enough the aspect of all this that amazes me the most: the plants control it! They are constantly responding to and then altering their immediate environment to their own benefit.

Other Benefits to the Soil

The soil life makes plant-available nutrients, but it also creates soil structure. Bacteria and fungi produce slimes which bind soil particles together. Other soil inhabitants such as worms, insect larvae and arthropods (gross things with hard shells) create pathways as they move through the soil. These pathways help aerate the soil and also increase water infiltration. The soil life also controls disease. Sometimes beneficial microbes will attack and consume unwanted critters (fig. 2). More often, the great diversity of organisms in a healthy soil compete with disease organisms and pests for nutrients, keeping the populations of these undesirable species from going too crazy. Fungi and bacteria and their slimes often act as barriers to root invasion and also produce inhibitory compounds that will kill or deter nastier members of the soil food web. Microbes can even be important on the phyllosphere (the leaf surface) of plants—by acting as a physical barrier to infectious disease causing organisms or by excreting off-putting compounds.

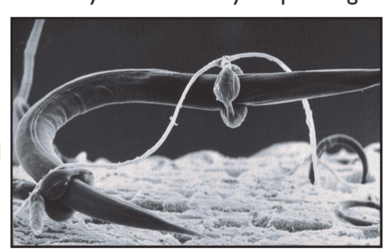

Fig. 2 Fungus traps unwanted nematode

EVENTS

February

Water Works Series #1

February 5-7th
Fairview, Manning, Demmit

Craig Sponholtz of Dryland Solutions, INC is an internationally renowned expert and teacher in watershed restoration. His workshops will develop the skill sets you need to restore degraded watersheds and bring water back to your land in a way that complements—and improves—your production system!

Call Karlah at 780-523-4033 for more details or to register!

DON'T FORGET!

It's our AGM February 8th! Start the night off right at 4pm at Dunvegan Motor Inn in Fairview. Network with fellow producers, update your membership, vote in your new board of directors and enjoy some quality entertainment! Hey wait!! Did I mention a delicious meal?

Call Morgan at 780-835-6799 for more details or to register!

Mycorrhizal Fungi—What's all the Fuss?

Mycorrhizal fungi are a special group of fungi that form mutually beneficial relationships with plant roots. In fact, they cannot live without this relationship with plants. There are two types of mycorrhizal fungi. Ectomycorrhizal fungi grow very close to plant roots and tend to associate with conifers and other hardwoods. Endomycorrhizal fungi (also known as arbuscular mycorrhizal fungi) actually grow inside plant roots and tend to associate with grasses, vegetables, annuals, shrubs, perennials and softwood trees. These fungi increase the surface area of plant roots tremendously and can pull nutrients and water from a long ways away. Their hyphae extend well outside the "nutrient depletion zone" that can form around roots. They break down organic matter and absorb needed nutrients and bring them to the plant. In the case of endomycorrhizal fungi, they deliver these goodies right to exchange sites located inside the plant's roots. In return, the plant gives them carbon captured through photosynthesis.

Fungi can't get their own carbon—it's their nature to latch onto something that will get it for them. In the case of mycorrhizal fungi, it turns out that this relationship is a pretty good deal for the plants. For example, phosphorous is one mineral that is often locked up tight in a form plants cannot access. Mycorrhizal fungi metabolize this mineral and deliver it in a plant-available form. In one study, 80% of a plant's phosphorous was supplied through a fungal relationship. These fungi also improve nitrogen fixation rates and can deliver additional nitrogen from organic in-soil sources. No wonder a seedling is so eager to give up its carbon! These mycorrhizal fungi form associations with 95% of all plants, including most agriculturally important species. These associations can also free up copper, calcium, magnesium, zinc and iron. Fungi form intricate webs in the soil and often carry water and nutrients to a bunch of different plants, not just the one they started growing with.

Endomycorrhizal fungi contribute a lot to soil structure. Glomalin is the name of a carbon-holding super glue that coats their hyphae and it is the most important ingredient in soil humus. It binds soil particles together and creates soil aggregates. Soil aggregates creates tiny soil pores which can hold even more soil microbes and their associated nutrients and most importantly, water. These are the 'water holding soil particles' that keep soil from going dry. Without soil structure, water just runs off land and the process of desertification begins.

Agronomic Applications?

Nitrogen is in different forms once organic materials start to decay. In the nitrogen cycle, nitrogen typically first becomes available as ammonium (NH_4^+) but bacteria change the ammonium to nitrate (NO_3^-). It turns out that some plants like their nitrogen as nitrates and that these plants typically do well in bacterially dominated soils. These plants include annuals, grasses and vegetables. Other plants prefer their nitrogen as ammonium and prefer to grow in fungal-dominated soils. These plants include perennials, trees and shrubs.

Some producers are getting excited about making and using compost teas. These teas are intended to increase the microbial population in a soil by first breeding the microbes and then placing them in association with agricultural plants—either on the soil or as a top dressing on plant leaves. While brewing compost tea, the brewer can add fungal foods to the mix and get a fungal-dominated tea or add bacterial foods and get a bacterial-dominated tea. It depends on what the soil currently contains and which direction it needs to go for the anticipated crop. Ideally, introducing an appropriate microbial community will, over time, deliver all the added benefits of improved nutrient availability, improved soil structure and even protection against diseases.

Another topic that has arisen in scientific literature concerning the soil food web is the treatment of invasive plant communities. The soils that support invasive plant communities typically have a fungal population that is greatly reduced in both numbers and in diversity. It has been postulated that invasive plants become invasive in their non-native habitats because they have not co-evolved with the existing microbial community. One theory suggests they wipe out soil microbes through exuding chemicals that are toxic, rather than tasty. Another suggests that they cannot provide an appropriate carbon source for the indigenous microbial community which declines in the area surrounding the point of infestation. As the microbial community recedes from an area of infestation, so too does the indigenous plant life. The invasive species then spreads as it is the only plant there that can stand it's own exudates! Some people have postulated that applying an appropriate microbial community can help halt the spread of invasive species.

The jury is out on how this emerging science can play a role in agronomic systems. Many of our agricultural tools, including tillage and the application of commercial fertilizers and fungicides actually hurt the soil food web. We may not know for certain, but it seems there are definite potentials for this science to play a role in agricultural landscapes that incorporate perennial systems. Smart partnerships with microbes could very well be a key to feeding both our plants and our pocketbooks.

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