The previous plantstones article (page 7) detailed exciting Australian research into the carbon storage capabilities of some of our grass crops. This article looks at US research into glomalin and potential carbon sequestration.

Glomalin: What is it... and what does it do?

By Don Comis, Agricultural Research Service, USDA

Glomalin is a glycoprotein, a sugar-protein compound that might trigger the formation of soil. In a study at two North Dakota locations in the US, Kristine Nichols, a microbiologist with the ARS Northern Great Plains Research Laboratory, found that soils under native grasses have higher levels of glomalin than soils planted to nonnative grasses.

"The more glomalin in a particular soil, the better that soil probably is," Kristine says.

Native grasses, more glomalin

In 2004, Kristine collected soil under monoculture grass plots established between 1987 and 2002. She found that the amount of glomalin in the soil increased as the degree of interdependence increased between plants and arbuscular mycorrhizal fungi.

These fungi produce glomalin and live inside plant roots and in the surrounding soil. The fungi have hairlike filaments called 'hyphae' that extend the reach of plant roots. The plant-fungus interdependence is greatest in warm-season native grasses, such as switchgrass, blue grama, big bluestem, and indiangrass.

Further evidence that soils under native grasses are higher in glomalin came from another study on rangeland areas at Mandan and near Platte, South Dakota. This study also showed that shifting cattle to other pastures before they could overgraze an area helped raise glomalin levels in soils.

In an earlier study, Kristine analysed samples from undisturbed soils under native vegetation in Maryland, Georgia, and Colorado. According to her analysis, glomalin stored an average of 15 per cent of the carbon found in those soils and contributed greatly to soil fertility. The highest amount of stored carbon, 30 per cent, was found in a Colorado soil and the lowest amount, nine per cent, in a Georgia soil. These amounts are similar to those from other soil samples taken around the world.

Vault for soil carbon

Glomalin may also provide a secure vault for soil carbon. By helping to form and stabilise small soil particles called "aggregates," glomalin reduces the decomposition of the labile (unstable) organic carbon compounds within the aggregates. For this reason, the carbon within the glomalin molecule may resist decomposition for up to 100 years.

The larger amounts of glomalin and stored carbon observed under grasses such as switchgrass add to the grasses' value as potential sources of cellulosic ethanol.

A sticky string bag

Kristine began her career with ARS working with soil scientist Sara Wright, who discovered and named glomalin in 1996. Sara has since retired.

Kristine explains how glomalin may actually make soil.

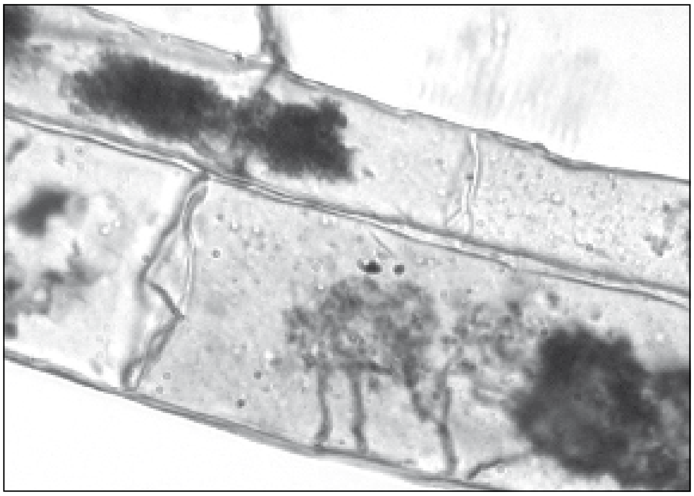
"Before the discovery of glomalin, other researchers described the hyphae of mycorrhizal fungi as forming a sticky string bag, with the hyphae acting as the string and some other substance on the hyphae sticking sand, silt, and clay particles, plant debris, and other organic matter to the hyphae – like little gobs of chewing gum. Photographs of glomalin on hyphae indicate that glomalin might be these 'gobs of chewing gum.' The sticky string bag starts aggregate formation, which is a major part of what makes soil.

"Aggregates provide structure to soil for better water infiltration, water-holding capacity, and gas exchange, and increase soil fertility by providing organic carbon (that is, food) to soil organisms, which use this food as energy to release plant nutrients from the soil," Kristine says.

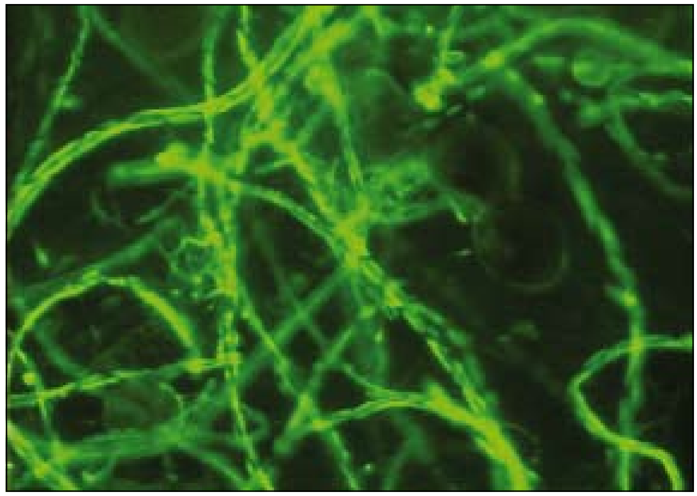
"On the surface of soil aggregates, glomalin no longer acts like bits of chewing gum, but instead forms a latticelike waxy coating to keep water from flowing rapidly into the soil aggregate and causing the aggregate to rupture. When an aggregate ruptures, everything within it – plant debris, organic matter, microbes, glomalin, fungal hyphae, and sand, silt, and clay particles – may be washed or blown off the soil with the erosive forces of wind and water," Kristine explains.

The waxy nature of glomalin also serves as a protective coating on fungal hyphae, keeping water and nutrients from being lost before they reach the plant host and

Physical science technician Gary Brucker (right) and former biological aid Crystal Jundt collect soil samples under Russian wildrye in Mandan, North Dakota. Glomalin concentration and water-stable aggregation levels were measured on these soil samples and compared to measurements from soil samples under other non-native and native grasses. (Photo by Kristine Nichols)



Arbuscules inside corn root cells. The arbuscule is the finely branched mycorrhizal structure where the exchange of soil nutrients for carbon occurs. This is one mechanism by which carbon dioxide from the air is sequestered in the soil. The carbon is used to form more and longer hyphal strands and to produce glomalin. (Photo by Kristine Nichols)



Thin, threadlike strands of mycorrhizal hyphae from pot cultures have an abundant amount of glomalin – seen on their surface as bright green spots here after a laboratory procedure. Glomalin is also present on mycorrhizal hyphae found on the roots of native and non-native grasses and crops in rangeland and cropland studies. (Photo by Kristine Nichols)

protecting hyphae from decomposition and microbial attack. It may also be what gives hyphae the rigidity needed to span air spaces between soil particles and extend beyond plant roots for greater access to more plant nutrients present in the soil.

Kristine uses glomalin measurements as a quick guide to evaluate how soil friendly farming or rangeland practices actually are. The amount of glomalin present is also a measure of how much carbon is being stored under various practices, so quantifying glomalin could be used in conjunction with carbon-credit-trading programs.

Kristine has done studies on cropland as well as on rangeland. On cropland, she found that both tillage and fallowing – as is common in arid regions such as those in the Northern Plains – lower glomalin levels by destroying living hyphal networks. The networks are physically torn by tillage or broken down due to starvation during fallowing.

The more glomalin, the better soil's feel

The higher a soil's glomalin level, the better its tilth, or feel and structure, the less its susceptibility to erosion by either wind or water, and the better it is for the growing plants.

As the builder of the formation bag for soil, glomalin is vital everywhere to soil building, productivity, and sustainability – as well as to carbon storage.

All this makes glomalin both the farmer's – and Earth's – best friend.

Kristine Nichols is in the Natural Resource Management Research Unit, USDA-ARS Northern Great Plains Research Laboratory, North Dakota. Ph: (701) 667-3008; Fax: (701) 667-3054. ■