Harvesting carbon from the air

Raylene Nickel, Successful Farming Magazine

Carbon is as precious as gold to plants. Working with water and sunlight, carbon makes plants grow. Plants assimilate carbon in the form of carbon dioxide, extracting it from the air to make roots, shoots, and leaves. With the help of soil microbes, the plants then transfer the carbon to the soil through roots and decomposing residue.

The stable storage of this carbon below ground not only builds soil organic matter and improves future crops but also, like a pressure valve, relieves the atmospheric carbon buildup.

CARBON BENEFITS

The benefits of this plant-driven harvesting of carbon from the air extend far beyond the farm and ranch gate.

"If we were able to increase the carbon in the soils of the world by sequestering 3.6 gigaton of carbon per year [1 gigaton equals 1 billion tons], we could offset or negate the additional effects of climate change that will be caused by future increases in carbon dioxide released by the fossil fuel use of a growing world population," says Rattan Lal. Lal directs the Carbon Management and Sequestration Center at Ohio State University.

"It is this assumption that was the basis of the 4 per Thousand program initiated at the Climate Summit in Paris in December 2015," he says. "The strategy of this program is to sequester carbon in soils of the world at the rate of 0.4% per year in the top 16 inches of soil. Implementing such a program would require appropriate policies to encourage farmers to adopt the recommended management practices.

"Globally, the release of carbon into the atmosphere from fossil fuel use is 10 gigaton, and it goes up annually," says Lal. "The U.S. accounts for about 18% to 20% of that amount. In the U.S., the per-capita rate of release of carbon into the atmosphere is going down but rising globally. Global warming has resulted from the increasing levels of carbon in the atmosphere. This is causing an increased frequency and intensity of extreme weather events such as floods, droughts, and hurricanes.

"Estimates of the total potential of carbon sequestration in world soils vary widely, and this potential is finite in capacity and time," says Lal. "Nonetheless, soil carbon sequestration buys us time over the next 20 to 50 years until the low-carbon or no-carbon alternatives to fossil fuel take effect."

The capacity for soil to sequester carbon is finite, because it's limited to the soil's original capacity to store carbon. Agricultural use over time has caused soil to lose carbon. Restoring soils to their original states accounts for the global potential for carbon sequestration.

"The potential soil carbon sink capacity of managed ecosystems approximately equals the cumulative historic carbon loss estimated at 55 to 78 gigaton," says Lal. "Some recent estimates indicate the historic loss as high as 130 gigaton. Restoring carbon stock in world soils by 130 gigaton would be equivalent to a drawdown of atmospheric carbon dioxide by about 65 parts per million. Such an achievement could happen in 50 to 100 years."

LOST CARBON

For some U.S. croplands, the historic carbon loss translates into a loss of more than half of soil's original carbon content.

"Within the Great Plains, a historical evaluation from Texas to Montana found relative soil organic carbon losses to range from 39% to 59%," says Mark Liebig, soil scientist at the USDA-ARS Northern Great Plains Research Laboratory at Mandan, North Dakota.

“Losses of soil organic carbon were due to cropping practices that relied on the use of intensive tillage and fallow for the production of corn and small grains.”

Restoring carbon in the soil results from a matrix of management practices that reduce soil disturbance, conserve root and plant residues, improve soil structure, and enhance soil biology and nutrient cycling growing diverse crop rotations including cover crops and perennials. These processes tend to increase populations of fungi, microbes, and other beneficial soil life critical to restoring soil health and sequestering soil carbon.

CARBON SEQUESTRATION RESPONSES

Measured carbon sequestration responses to specific practices include the following:

• Spring wheat grown by conventional tillage. A study at the Northern Great Plains Research Laboratory showed how differences in cropping systems affect soil structure and, ultimately, soil carbon. In the conventionally tilled spring wheat, the soil had 14% water-stable aggregates, and the carbon in the top 3 inches of soil measured 6.6 tons per acre.

• No-till continuous cropping of spring wheat/winter wheat/sunflowers. The same study found no-till soil had 47% water-stable aggregates, and the carbon measured 9.6 tons per acre.

• Pasture managed under moderate but continuous grazing. In this third treatment of the study, the soil had 93% water-stable aggregates, and the carbon measured 12.8 tons per acre.

• Switchgrass production. A five-year on-farm study by the Agricultural Research Service evaluated switchgrass for ethanol production. The study encompassed 10 on-farm fields in Nebraska, South Dakota, and North Dakota. The fields were located in marginal land areas that would have qualified for the CRP.

“Within the top 12 inches of soil, soil organic carbon increased across all sites at a rate of 980 pounds per acre per year,” says Liebig. “In Nebraska, where four sites were sampled to a depth of 48 inches, carbon increased at an average rate of 2,590 pounds per acre per year.”

The changes in soil organic carbon were variable among sites, ranging from a decrease of 540 pounds per acre per year to an increase of more than 3,800 pounds per acre per year.

The study underscores the potential of perennial grasses to sequester significant amounts of carbon in the soil. These deep-rooted perennials are more effective than the more shallow-rooted annual crops at storing carbon at depths where it’s less likely to be released back into the atmosphere due to possible soil disturbance.

Yet the study also shows the variability in carbon-accrual rates of a single practice played out in different settings. Geography, climate, production practices, and other variables play a role in accrual rates.

A process for measuring the rate at which carbon accrues in soils is presently not readily available to farmers and ranchers.

However, rough estimates of carbon pools in soil may be drawn from levels of soil organic matter.

“Organic matter is about 50% carbon,” says Lal. “If organic matter is increasing over time – such as by no-till farming with a cover crop – it is possible to increase soil carbon stock at a rate of 500 to 2,000 pounds per acre per year. By the use of petroleum-based production inputs – such as fertilizers, herbicides, and farm operations – some carbon is also being used in order to sequester carbon. So there’s a gross carbon-accrual rate and a net rate.”

VALUE BEYOND THE FARM

Beyond enabling farmers and ranchers to reap the on-farm production and aesthetic benefits of improving soil quality, sequestering carbon in the soil offers a societal value.

Soil scientist Rattan Lal advocates nationally and internationally for farmers and ranchers to receive federal financial incentives for sequestering carbon.

“Farmers in the U.S. who sequester about 500 pounds of carbon per acre in the soil annually should receive an annual payment of $16 an acre,” he says. “There’s a close link between soil carbon sequestration and world food security on the one hand and climate change on the other.”