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What Helps Organic Soils Store More Carbon?

New research suggests that a chemical group known as phenolics may help soils on organic farms retain more carbon

By Tiffany Stecker and ClimateWire | Tuesday, June 11, 2013 | 3 comments

Phil Robertson may be on the cusp of solving a long-standing mystery.

Why does organic farming store more CO2? Phil Robertson thinks he may have found the answer.
Image: Flickr/Charles Knowles

Boosters of organic food often say the practice, which rejects synthetic fertilizers and pesticides, is a good method for curbing climate change because it stores more carbon in the soil. But aside from anecdotal observations, no one could really explain the dynamics behind why organic fields keep more carbon underground than conventional ones.

Robertson, a researcher at Michigan State University's Kellogg Biological Station, thinks he might have an answer: a chemical group called phenolics, a class of complex compounds that also protect plants from disease and pests.

"It's only by elimination that we're left with the chemical explanation," Robertson said. He believes phenolic compounds enter the soil when farmers plant cover crops like beans and legumes that enrich the soil with nitrogen before planting. These compounds create a barrier around the carbon in the soil, protecting the carbon from microbes that process it into carbon dioxide gas. While organic farmers are not the only growers who use cover crops, they rely on them much more than conventional growers.

In understanding the role phenolics play, Robertson's findings could lead to a better understanding of how to cut emissions from the global agriculture sector.

The idea that organic agriculture keeps more carbon underground is not a novel one, Robertson said. But the fact that legumes may produce a disproportionate amount of phenolic compounds may be unique. Robertson plans to publish the findings in the coming year.

Carbon accumulates in the soil when more carbon is absorbed into the ground than is released as carbon dioxide. As growers mix in compost, dead plant matter and other amendments to keep the soil healthy, tiny soil microbes begin to eat away at the matter. The end product is carbon dioxide, which is released into the air and, in large quantities, will contribute to climate change.

Researchers at the Kellogg Biological Station's Long-Term Ecological Research site tested corn, wheat and soybean fields that had not been treated with any synthetic chemicals and fields that used the standard amount of synthetic fertilizers and pesticides, as well as plots that used one-third of the inputs of a conventional system. They've observed the plots over the last 20 years.

In some soils, like no-till soils that are barely plowed in order to minimize disturbance, the bigger chunks of dirt create a barrier against escaping carbon dioxide. But in Robertson's experiments, the organic plot was plowed.

"We know it's very unlikely to be a physical protection," he said.

'A lot of gray areas'

There's another reason why the high carbon levels in the organic plot were surprising. Organic agriculture tends to be less productive than conventional agriculture, so when plants die, there is less decaying matter entering the soil.

Robertson compared the dynamic to carbon-rich forest dirt where lignin, the chemical compound found in tree leaves, twigs and branches that makes plants rigid, also keeps carbon from escaping. In agricultural fields, there is much less lignin, but Robertson thinks phenolics play a similar role.

"The phenolics maintain a microclimate that's very uninviting for microbes," Robertson said.

Agriculture is responsible for 13.5 percent of greenhouse gas emissions, primarily carbon dioxide, nitrous oxide and methane. Soils store one-third of the carbon on Earth, so efforts to keep that carbon underground could yield big benefits for slowing the pace of climate change.

Cynthia Cambardella, a soil scientist with the federal Agricultural Research Service, recently published a decadelong study on carbon storage that shows organic farming significantly improves the storage of carbon in the top 15 centimeters of soil. But the reason eludes her.

"There's a lot of gray areas where we have incomplete knowledge here, and it's not because of lack of research," she said. "We need to develop a more complete understanding of how the soil microbial community is functioning and the processes that control and drive whether or not carbon is stored."

On Wednesday, Agriculture Secretary Tom Vilsack spoke of the importance of cover crops to maintain fertile soil, control erosion, hold moisture and store carbon. Although farmers recognize the importance of cover crops, many are reluctant to use them because of concerns that growing them might conflict with crop insurance rules. Vilsack announced the rollout of new cover crop guidelines to encourage farmers to use them.

Storing carbon in soils could also help farmers cash in on carbon credits, providing an extra income for growers who take care to maintain carbon in the ground. Last year the Verified Carbon Standard approved the first soil offset program for a World Bank-run effort in Africa. In Oklahoma, the state's conservation commission runs a carbon program that pays farmers up to $3.50 per ton of carbon sequestered.

But without the lure of additional income, keeping soil rich with carbon is not a priority for most growers.

"The incentive is for the farmers to strip mine the soil; that's the cheapest, fastest way to get a buck," said Daniella Malin, project manager of the Cool Farm Institute, a program on agriculture and climate under the Sustainable Food Laboratory. Malin works to finds ways to monetize low-carbon agriculture through the use of carbon markets.

Organic agriculture doesn't lower N2O emissions

Malin says she does not favor organic agriculture over conventional when it comes to choosing the best method for curbing climate change. But the practices that enrich soils with carbon tend to be adapted more heartily by organic farmers. Compost, or the decayed remains of plants that are used to amend the soil, tends to add a more stable source of carbon, for example.

Nevertheless, there are reasons why organic agriculture can be a worse option than conventional growing for keeping carbon dioxide out of the atmosphere. Yields tend to be lower for organics, meaning one needs more land to grow the same amount of food.

Overall, the information on how to quantify carbon has been lacking. "The carbon footprint has been guessed at the farming level," Malin explained.

But although organic practices may be winning in the race for low-carbon agriculture, they seem to fare no better than conventional crops for another, more nefarious greenhouse gas: nitrous oxide.

Nitrous oxide (N_2O), or laughing gas, has a global warming potential 200 times that of carbon dioxide. About 80 percent of nitrous oxide emissions come from agriculture, as nitrogen-based fertilizer bonds with oxygen and is released as a gas.

As it turns out, organic fields, enriched with cover crops, emit just as much nitrous oxide as conventional crops that rely on pungent ammonia-based industrial fertilizer.

"The microbes producing it don't care where the nitrogen comes from, a fertilizer factory in the Gulf Coast versus a legume that has fixed the nitrogen last spring," Robertson said. "All they care about is what's there, and they'll go to town regardless."

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