Soil Carbon Loss Proportional to Tillage Intensity

Soil scientist Don Reicosky says the more soil you disturb in tillage, the more CO2 is released. In addition, he says tillage is detrimental to fungi-to-bacteria ratios that are vital to carbon and nitrogen storage.

By Dan Crummett, Contributing Writer

RETIRED USDA-Agricultural Research Service (ARS) soil scientist Don Reicosky of Minnesota admits he's prejudiced against conventional farming and the moldboard plow because of their effects on soil organic matter (SOM), but he says research supports his bias, noting a quote from a colleague that says: "Soil is lost not because we farm, it's lost because of how we farm."

"That wisdom from David Montgomery is borne out by work we did in Minnesota that suggests carbon dioxide emissions related to tillage are proportional to the volume of soil disturbed," Reicosky told his audience at the 2019 National No-Tillage Conference in Indianapolis.

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Don Reicosky

The career agronomist says a cloud of CO2 rises behind any tillage tool and he explains that the invisible gas is indicative of organic matter loss in the soil, a loss that negatively affects soil fertility, water infiltration, soil biology and overall soil structure.

"Long-term studies from the late 19th century to about 2000 in Illinois and Missouri show, regardless of cropping systems, land on research plots farmed continuously over more than a century have shown steady declines in SOM," he says.

Why Carbon Loss? Reicosky says he thinks tillage is the prime suspect in the carbon loss shown in the Illinois and Missouri studies, along with similar findings at other land-grant universities, because significantly less carbon is lost in the systems with the least tillage.

"In a field crop, one-third of the carbon is fixed in the grain, one-third is fixed in the upper part of the plant and the remaining third is fixed in the root zone in the form of exudates and roots," he says.

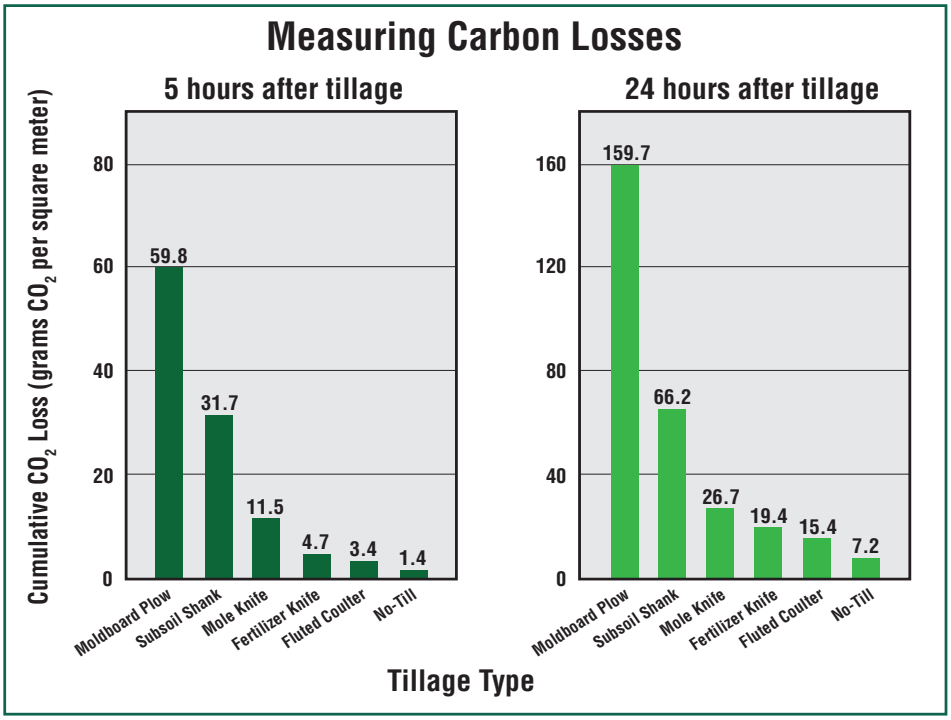
He goes on to explain that in addition to removing a third of the available carbon at harvest to feed ourselves and our animals, we've also changed from growing perennial species that put 60-90% of their biomass below ground to annual species that put only 15-20% of their biomass below ground, so we have less carbon being returned to the soil.

On top of that, using a moldboard plow or disk harrow further exacerbates carbon loss by disturbing the soil and the biological activity that enables carbon and nutrient cycling synergies. Other traditional farming techniques add to the problem.

"As the use of synthetic fertilizer increases, we're adding more nitrogen to the soil, which increases the mineralization or breakdown of SOM. And, in the case of the upper Midwest, tile drainage allows more oxygen into the deeper soil profiles, and it's possible that extra oxygen can oxidize more organic matter," he says.

Empirical Data. During his work with the ARS, Reicosky helped develop a portable chamber technique which measures CO2 released from the soil behind a variety of tillage tools.

"We would drop the chamber over the soil behind the tillage tool and measure CO2 and water loss," he explains. "We sampled once a second for 60 seconds initially. Then we'd repeat the measurement every 3, 4 or 5 minutes depending upon how close the plots were together."



LASTING EFFECT. Don Reicosky's portable chamber measured the amount of CO2 released from soil based on different types of tillage. While the bulk of CO2 release came immediately after the tillage tool passed through the soil, it continued to be released for many hours afterward.

Reicosky's experiments compared five tillage practices to the use of a no-till treatment, which included only a tractor pass through the plot to provide the same compaction that the other treatments would get with the tractor along with a series of other ground-engaging tools.

Tillage treatments included:

✗ A fluted coulter with a 3-by 6-inch wide track

✗ A fertilizer knife that produced about a 6-inch V-shaped disturbance

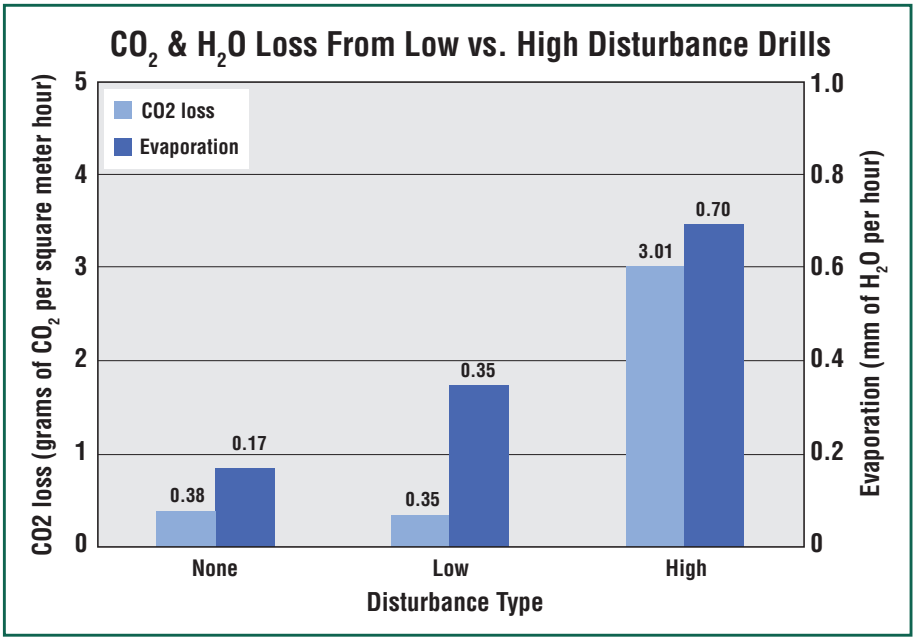
✗ A mole knife that produced about a 6-inch U-shaped disturbance

✗ A subsoil shank that ran about 14 inches deep

✗ A moldboard plow that ran about 10 inches deep across the entire 30-inch row.

"We'd make a pass with the tillage tools and then carry on and make measurements with the portable chamber," he explained. "We also measured these treatments 5 hours after tillage and again at 24 hours after tillage."

The results show a significant portion of the CO2 loss came immediately after tillage and was proportional to the volume of soil disturbed.



DRILL TYPE MATTERS. Don Reicosky's research shines a light on CO2 and water loss based on the type of no-till drill used. A low-disturbance disc released considerably less than did the high-disturbance hoe-type drill.

"On top of these carbon releases, consider how much diesel you'd be burning if you were driving a tractor pulling a 10-bottom plow at 10 inches deep," the scientist says. "Intensive tillage with a deeply-engaged tillage tool is a double negative from a carbon footprint standpoint, with more diesel exhaust entering the atmosphere and more CO2 from the burp of CO2 escaping from the soil."

Further Study. In keeping with his studies of tillage intensity on soil carbon loss, Reicosky also compared a pair of no-till drills — one a hoe-type drill (high disturbance) and the other a disk drill (low disturbance) — at a field day. As with the experiment mentioned above, he followed these drills with the portable chamber to measure CO2 and water loss.

"Where there was no disturbance in a no-till treatment, we measured 0.3 g per hour for CO2 and 0.174 mm per hour for water loss.

"With the low-disturbance disc drill we didn't get much CO2 off but we did get a little more water, and in the case of the high-disturbance hoe-type drill, both the CO2 and the water were higher," he says.

Reicosky says the field-day study shows making very small changes can have measurable effects.

"This is important when we consider other management techniques that rip a lot of soil and force tractors to work much harder," he says.

Caring for Fungi. While Reicosky can show the benefits of managing for minimum soil disturbance as a tool to maintain SOM, he says he's learning the fungi-to-bacteria ratio of soils is also vital to soil carbon management.

"Because the carbon and nitrogen storage depend upon the ratio of various fungi to bacteria in the soil, and the fungi are much more susceptible to tillage damage, if we want to store more carbon and nitrogen for subsequent crops, we must try to maximize this ratio.

"Any type of tillage will damage the fragile hyphae filaments on soil fungi and that works against optimum ratios," he explains.

Another soil ingredient that thrives in the presence of soil fungi, and by being left alone, is glomalin, a glue-like carbohydrate that helps bind soil particles together to form larger — beneficial — aggregates, which allow water and oxygen infiltration around roots, he says.

"Research by soil scientist Sara Wright shows no-till management allowed glomalin to more than double in 3 years of no soil disturbance," he explains. "In an adjacent buffer strip, which had not been disturbed for 15 years, glomalin content was four times as great.

"This tells me we have to do something to protect soil fungi, and right now the best thing we can do is reduce soil disturbance."