Manure and Fertilizer Effects on Carbon Balance and Losses for Irrigated Corn

Soils are a vital cog in the global carbon budget mechanism because they store more than three-quarters of the earth's terrestrial C, over four times that in vegetation. Thus, any agricultural management practice that causes even a relatively minor change in terrestrial C processes can produce large environmental mass transfers of C, owing to the multiplying effect of the change across millions of acres. An increase in soil respiration, for example, increases the release of the greenhouse gas CO_2 into the atmosphere and may exacerbate global warming. Our understanding of carbon cycling in cropping systems is limited. While much research has examined individual components of the annual C budget for agricultural soils, few studies have evaluated the entire carbon budget for any single system, and even fewer have determined manure effects on the carbon budget of irrigated row-crop systems.

In a new study published in the May–June 2014 issue of the *Soil Science Society of America Journal*, southern Idaho researchers determined the complete carbon budget of a furrow-irrigated corn field fertilized with inorganic or organic fertilizers and quantified the relative size of transfers among the atmosphere, crop, and soil pools. In each year of the two-year study, the authors treated a calcareous silt loam with either inorganic nitrogen fertilizer, stockpiled dairy manure, or no amendment. Carbon inputs from amendments were determined. During each irrigation, researchers measured and sampled water volumes entering field plots and exiting in runoff and percolation, and determined inorganic and organic carbon concentrations for both dissolved and particulate components. They also determined atmospheric carbon inputs to the system, which were incorporated into crop biomass; carbon outputs from the system as harvested crop tissue and gaseous soil emissions; and changes in soil C by difference.

Runoff from manure and fertilizer plots contained similar dissolved organic C (DOC) concentrations, suggesting that DOC derived from manure was either leached or metabolized shortly after application, or its influence (signal) was swamped in a year where inflow DOC concentrations were elevated. Dissolved organic C in runoff from manure plots exceeded that from non-amended plots only in a year with low inflow DOC concentrations. Overall, runoff losses of DOC from plots increased as inflow concentrations increased, implying that these losses were linked to the region-wide production of organic C in soils, possibly in response to climatic conditions, and that *in situ* DOC production plays an important role in the transfer of this carbon to irrigation runoff. Interestingly, the behavior of DOC in runoff was similar to that of its organic counterpart.

Runoff particulate organic carbon concentrations were sensitive to processes that concentrated clay in the runoff water rather than total sediment. Thus, indirect effects of manure, which often acted to inhibit erosion, and fertilizer, which tended to disperse fine soil particles in runoff, substantially influenced runoff particulate organic C concentrations. On the other hand, particulate inorganic carbon concentrations closely paralleled sediment responses irrespective of amendments throughout the experiment. This evidence supports the concept that particulate inorganic C is present in soil as free particles of varying sizes or precipitated on soil particles without regard to particle size; whereas particulate organic C, in addition to occurring as

continued on page 19

Field plots (clockwise from upper left) showing: the insulated cap covering the tensiometer used to measure soil matric potential at each subsurface percolation water sampler; outflow measurement flume; Imhoff cones in stands for determining and sampling runoff sediment concentration; and insulated structures housing vacuum flasks to collect percolation water.

Manure and Fertilizer Effects on C

continued from page 14

free colloids (Dalzell et al., 2011), is preferentially bound to soil clays.

Manure application added 1.5 times more total C each year to corn plots than did control or fertilizer treatments, while total C outputs for the three treatments were similar. Hence, the manure plots acted as a short-term C sink by ending each growing season with an average net gain of 3.3 Mg C ha^{-1} while the non-manure treatments acted as a C source by finishing the season with a net C loss of about -1.5 Mg C ha^{-1} yr^{-1}. Given manure's substantial organic C additions, carbon losses from manure plots were less than expected because (i) the resultant increases in gaseous C emissions and runoff DOC losses were disproportionately small; (ii) total particulate C in runoff and dissolved organic C in percolate were less than in non-manure plots; and (iii) atmospheric C incorporated into root biomass was greater in manure than fertilizer plots.

References

Dalzell, B.J., J.Y. King, D.J. Mulla, J.C. Finlay, and G.R. Sands. 2011. Influence of subsurface drainage on quantity and quality of dissolved organic matter export from agricultural landscapes. J. Geophys. Res. 116:1–13.

Adapted from Lentz, R.D., and G.A. Lehrsch. 2014. Manure and fertilizer effects on carbon balance and organic and inorganic carbon losses for an irrigated corn field. Soil Sci. Soc. Am. J. 78(3). View online at www.soils.org/publications/sssaj/tocs/78/3 (journal subscribers) or https://dl.sciencesocieties.org/publications/sssaj/tocs/78/3 (Digital Library)

doi:10.2134/csa2014-59-7-4

CO_2 Enrichment *continued from page 15*

mon beans, the stimulation in yield caused by increasing the carbon dioxide concentration by 180 mmol mol^{-1} above that of the ambient outside air was much less when the addition of carbon dioxide was stopped at night than when carbon dioxide was added continuously. A similar result has been reported for soybeans, but there are no reports for other crop species grown under field conditions. Despite the effects on yield, no effects of carbon dioxide concentration at night on daytime leaf photosynthesis or stomatal conductance occurred in the bean study.

In both cultivars of common bean, the area of individual leaves was increased when carbon dioxide was added continuously but was not increased when carbon dioxide was added only during the daytime. In one of the cultivars, elevation of carbon dioxide only at night increased yield as much as did elevation of carbon dioxide only in the daytime because of an increase in leaf size in response to elevated carbon dioxide at night.

Prior experiments on seedlings of several species indicated that effects of elevated concentrations of carbon dioxide at night had effects on growth that varied from positive to negative, depending upon species, the difference in temperature between day and night, and the daytime carbon dioxide concentration. Thus, there is no reason to believe that elevation of carbon dioxide concentration during the night as well as during the day would further increase crop yields in all cases. Nevertheless, it may be important to simulate both future day and night carbon dioxide concentrations when the goal is to assess crop yield responses to rising atmospheric carbon dioxide concentrations.

Adapted from Bunce, J.A., 2014. CO_2 enrichment at night affects the growth and yield of common beans. Crop Sci. 54(4). View the full article online at www.crops.org/publications/cs/tocs/54/4 (journal subscribers) or https://dl.sciencesocieties.org/publications/cs/tocs/54/4 (Digital Library)

Soil Mineralogy *continued from page 16*

Chunmei Chen, a doctoral student in the Department of Plant and Soil Sciences at the University of Delaware, focused her research on the Christina River Basin Critical Zone Observatory (CRB-CZO), specifically reporting on the interaction of soil organic matter with soil minerals at the molecular scale along landscape redox gradients. Her research is designed to lead to better soil management strategies to maintain and enhance levels of soil organic matter.

These four students and their research represent the future of soil mineralogy and the continuing legacy of Dr. Dixon to the field. SSSA members are all well aware of the watchword—"Soils Sustain Life"—and indeed they do. But they can only fulfill that mission when soil management strategies ensure that the necessary mineral nutrients that are essential to agriculture are available when and where plants need them. In turn, these vital minerals are an interconnected part of the other components of soils—one of the basic ingredients in the earth's ecosystem.

And as contemporary video artist Bill Viola has said, "… there's a feeling that life is interconnected, that there's life in stones and rocks and trees and dirt, like there is in us." You can be part of that connection by supporting the Joe B. Dixon Soil Mineralogy Program Excellence Fund or one of the many other volunteer or giving opportunities offered by the Agronomic Science Foundation. To find out more about options that might interest you, call me at 608-273-8095 or email me at abarton@sciencesocieties.org. To make a monetary donation online, visit www.a-s-f.org.

Crops, Soils, Agronomy

csa news

July 2014

Your Societies. *Your* Magazine.

Crop Science Society of America | Soil Science Society of America | American Society of Agronomy

Enhancing food security in the Northeast