Change and the Heartland

How Climate Change Will Affect the Midwest

Big issues, bite-sized lessons

Can Conventional Farming Sequester Carbon?

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Beginning in the 1950s, the agricultural landscape of Illinois shifted from the traditional family farm, with legume-based rotations and integrated animal production, toward intensive cash-grain cropping of corn and soybeans. This shift was made possible by a postwar expansion in the availability of commercial nitrogen fertilizers that boosted corn yields with improved hybrids. The past five decades have seen a remarkable increase in corn yield and also in the consumption of fertilizer nitrogen, often overapplied as a means to ensure high yields.

Unfortunately, the input-intensive approach used in achieving this yield increase has been decidedly negative in its consequences for soil carbon, a key component of fertility and an important means of storing carbon that would otherwise be contributing to climate change as atmospheric carbon dioxide (CO_2).

Key Term

Carbon Sink

A carbon sink is a natural or humanmade reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period. People usually refer to carbon sinks as places to store atmospheric (CO_2) that would otherwise contribute to global warming. The largest natural carbon sinks are the oceans and soil. The largest humanmade carbon sinks are landfills and, potentially, underground reservoirs where excess CO_2 could be piped.

Agricultural soil has significant potential to remove CO_2 from the atmosphere. Farming practices such as nitrogen fertilizer application and tillage affect the amount soil can store. When stored in soil, carbon has a number of functions. It can improve soil stability, prevents nutrient leaching, and can stabilize pH. Generally, farmers who store more carbon in their soil are both combatting climate change and improving the productivity of their soil.

Nitrogen Fertilization Increases Organic Carbon Inputs But Not Storage

Long-term experiments at the Morrow Plots at the University of Illinois show that applying nitrogen fertilizer reduces stored soil carbon even as it increases the amount of residue carbon left in fields. Historical yield records for the Morrow Plots reveal impressive gains in corn production since the shift to commercial fertilization in 1955. Five decades later, the cumulative result has been a massive input of residue carbon (91 to 124 tons per acre), yet the only significant changes in soil organic carbon were net losses, and these tended to be more extensive for the subsurface soil than for the plow layer.

In effect, nothing remained from the residue carbon incorporated in the past 51 years, and a decline had usually occurred in native soil organic carbon. This decline contributed directly to increasing atmospheric levels of carbon dioxide. To ascertain whether the Morrow Plots are unique in documenting a detrimental effect of synthetic nitrogen fertilization on soil storage of organic carbon, extensive effort was made to compile baseline changes from 48 published field trials with synthetic nitrogen.

The resulting database, representing a wide range of soil and climatic conditions, cropping systems, and management practices, confirms the effectiveness of nitrogen/phosphorus/potassium fertilization for increasing biomass production but not for sequestering soil carbon. On the contrary, the usual finding has been

Soil Carbon and Nitrogen Fertilizer

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a decrease over time in organic carbon levels. If nitrogen fertilization increases the input of carbon into the soil without increasing carbon storage, there must be more extensive microbial decomposition of residue carbon to CO_2.

Soil Carbon Losses Increased by Removing Above-Ground Residues or Overapplying Nitrogen

The adverse impact of nitrogen fertilization in promoting the loss of soil organic matter will be exacerbated by removing above-ground residues, which act as a buffer to reduce microbial attack on native soil carbon. Before the 1950s, this practice promoted soil degradation in the Corn Belt by depleting soil carbon and several major nutrients (notably nitrogen, phosphorus, and sulfur) while enhancing erosion and compaction.

With heavy usage of synthetic nitrogen, the impact would be far worse today, so caution is warranted with the current trend toward using crop residues for bioenergy production. The long-term consequences of removing above-ground residues are readily apparent from the developing world, where soils have been depleted by many centuries of residue removal to provide animal feed and fuel for the kitchen. In the Midwest, residues would be used as a flex fuel subsidized at public expense.

To minimize further loss of soil organic carbon, reducing fertilization beyond the crop's nitrogen requirement should be emphasized. One option would be to account for the soil's indigenous nitrogen-supplying power using the Illinois Soil Nitrogen Test (ISNT), in which case application rates can be adjusted specific to each site.

Nitrogen inputs can be further reduced if fertilization is postponed to better coincide with crop nitrogen need, ideally by a sidedress application in late spring. This strategy will help producers cut their cost of production while moderating the detrimental effects of overfertilization on air, water, and soil resources.

Conventional Cropping Practices Cause Decline in Soil Organic Carbon

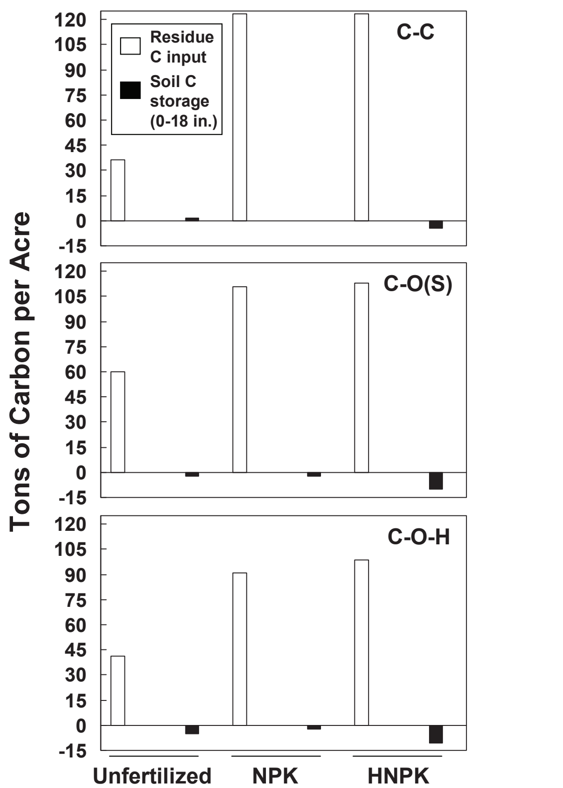


Fig. 1. Cumulative input and storage of carbon between 1955 and 2005 with and without NPK or HNPK fertilization of Morrow Plots cropped to continuous corn [C-C], a corn-oats (before 1967) or corn-soybean (since 1967) rotation [C-O(S)], or a corn-oats-alfalfa hay rotation [C-O-H].

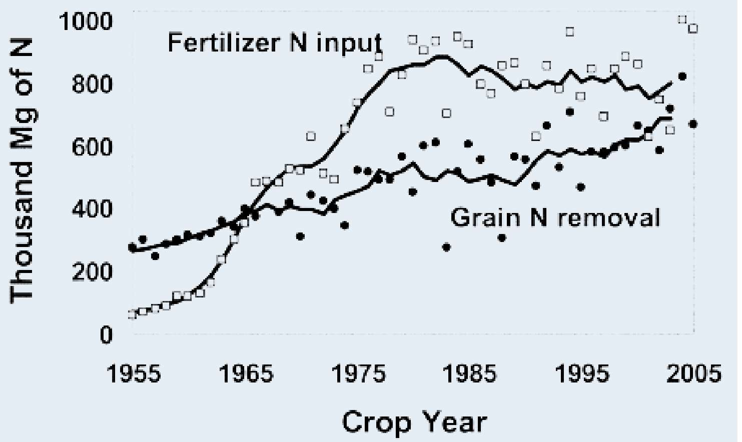
Illinois Soil Nitrogen Test

ISNT
ILLINOIS SOIL NITROGEN TEST

The Illinois Soil Nitrogen Test (illinoissoilntest.nres.uiuc.edu/about.html) lets farmers estimate how much nitrogen their soil can provide to crops, giving them a better idea of how much fertilizer they should apply.

The tool helps farmers maximize the return on their fertilizer investment, while minimizing the adverse environmental effects of overfertilization.

N Fertilizer Commonly Overapplied



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