The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Reducing Fossil Energy Use on the Farm

Posted by Gail the Actuary on April 20, 2010 - 10:25am
Topic: Environment/Sustainability
Tags: agriculture, alternative farming, energy inputs, fertilizer, james giese [list all tags]

This is a guest post by James Giese, Director, Science Communications, American Society of Agronomy.

Conventional production agriculture relies heavily on fossil fuels, particularly in its ability to provide high yields at low labor costs. However, the uncertain future of fossil fuel availability and prices point to a need to explore energy efficiencies of alternative cropping systems. Although more labor intensive, low-input cropping could substantially reduce dependence on fossil fuels while maintaining comparable yields.

Most of the U.S. Corn Belt relies on a 2-year rotation of corn and soybean with heavy inputs of fertilizer, herbicides and pesticides derived from fossil fuels to achieve high yields while keeping costs low.

To better understand energy inputs in all cropping systems, Matt Liebman, Michael Cruse, and their colleagues at Iowa State University conducted a six-year study to compare energy use of a conventionally managed corn–soybean system (a two-year rotation) with two low input cropping systems that used more diverse rotations and manure, but substantially lower quantities of nitrogen fertilizer and herbicides. The study will be published in May-June issue of Agronomy Journal, published by the American Society of Agronomy.

The two low-input systems, which use lower levels of purchased inputs such as fertilizer and fuel, consisted of a three-year rotation of corn–soybean–small grain/red clover and a four-year rotation of corn–soybean–small grain/alfalfa–alfalfa.

Did the replacement of fertilizer with manure decrease the fossil fuel energy costs? Manure prices are dependent on local economic conditions, and depending on how fossil energy costs were assigned to manure, the two low input systems used between 23 and 56% less fossil energy than did the conventional system.

During the course of the study from 2003 to 2008, nitrogen fertilizer inputs were reduced 66% in the three-year rotation system and 78% in the four-year rotation system compared with the two-year system. Herbicide use was reduced by an average of 80% in the three-year system and 85% in the four-year system.

Despite the fossil fuel reductions, corn and soybean yields in the low-input three- and four-year systems matched or exceeded levels obtained from the conventionally managed two-year system. Crop yields in all of the experimental systems were similar to, or greater than, mean yields of commercial farms in the surrounding county in all years of the experiment.

According to Liebman, the two-year corn-soybean rotation is typical of cash grain systems in the region of Iowa that was studied. The three- and four-year rotations are representative of low input cropping systems in the region that are integrated with cattle production through the feeding of crops to livestock and the application of manure to crop fields.

“Iowa has a long history of mixed crop and livestock farming, although these operations do require more management and labor,” said Liebman. “If fossil energy costs rise steeply, we may see more of them again.”

The researchers used two approaches for evaluating the energy and economic costs of manure. In one approach, manure was considered a waste product of a livestock operation and its only energy cost was the energy used for its application. Similarly, for a low economic cost scenario, manure was regarded as free except for application costs (labor, tractor fuel, and machinery depreciation).

The second approach included both the energy costs of manure application and the energy costs of manure nutrients assessed as if they required the same amounts of energy used to produce commercial fertilizers. Similarly, for a high economic cost scenario, the cost of manure was set as the application costs plus the cost of nutrients within the manure set at commercial fertilizer prices.

The researchers noted that the real energy and economic costs are likely to lie between the low and high extremes they analyzed, and will vary depending on market conditions and the configuration and management of the livestock operation generating the manure.

When considering manure as a low-cost economic input, the researchers found that the monetary return to land and management was similar for all systems, averaging $249 per acre. Using commercial fertilizer prices for manure nutrients reduced returns by $38 per acre for the three-year rotation and $28 per acre for the four-year rotation.

Most of the fossil energy input for all systems was from grain drying and handling. Conditions in northern latitudes, where farmers have limited time to allow grain to dry in the field, make it difficult to reduce this cost. The researchers point out, however, that growing corn less frequently in a rotation sequence can reduce the need for grain drying with fossil energy.

A major trade off is that the low-fossil energy input systems require more labor.

Efficiency ratios, including crop energy output and economic return per unit of fossil energy invested, were significantly higher in the low input four-year rotation than in the conventional system. Most of the variability observed among systems in energy use efficiency was due to differences in fossil energy input values, not in outputs from the systems, since productivity of the systems was essentially equal. Incorporating alfalfa into the four-year rotation was important: in all economic analyses, the four-year rotation was significantly more efficient in energy use than the two-year rotation, while the three-year rotation was not.

In this study, labor inputs followed an opposite trend to that seen for fossil energy inputs, with the four-year rotation having the largest labor inputs and the two-year rotation having the smallest. As compared with the two-year rotation, which required 41 minutes per acre per year, the three-year rotation required 54% more labor, while the four-year rotation required 91% more labor. However, the incorporation of small grain crops (triticale and oat) and alfalfa into the low-input rotation systems placed much of the extra time investment into parts of the year that did not overlap with peak activities associated with corn and soybean production.

The researchers suggest that historically low energy prices during the 20th century, along with relatively high wages in the United States, have contributed to widespread adoption of energy-intensive farming practices. The team says that their analysis shows that the conventional two-year rotation system widely used in the central U.S. (corn-soybean) relies on fossil energy to reduce labor requirements while allowing net economic returns to remain constant. This provides greater wage rates for the producer. However, the researchers claim, diversified low-input systems can provide greater returns per unit of fossil energy invested, even though overall returns from the land are similar to the conventional system.

In coming years, the market prices from cash grains will play a big role in what cropping systems will gain favor in the U.S. If demands from ethanol plants or overseas markets increase the price of corn grain faster than input costs rise or if commercial-scale production of biofuels from corn stover becomes economically viable, Midwestern cropping systems might become less diverse and more focused on corn. Alternatively, if fossil energy prices rise significantly without simultaneous increases in crop value, diversified low-input cropping systems, such as those described in this study, may become preferable to conventional cropping systems and used more widely.

“It’s hard to predict the exact details of what the future will bring us,” said Liebman. “But results of this study show that we do have options for maintaining high farm productivity and profitability while substantially reducing our dependence on fossil energy.”

The research team, funded by the Leopold Center for Sustainable Agriculture and the U.S. Department of Agriculture, is expanding its activities with measurements of effects of the different cropping systems on water quality, greenhouse gas emissions, and soil carbon and nitrogen dynamics. They will also investigate the economic consequences of integrating crop and livestock production in different ways.

Material adapted by James Giese, Director, Science Communications, American Society of Agronomy (URL: https://www.agronomy.org/), from:

Fossil Energy Use in Conventional and Low-External-Input Cropping Systems
Michael J. Cruse, Matt Liebman,* D. Raj Raman, and Mary H. Wiedenhoeft
DOI: 102:934-941
Published online 24 Mar. 2010 in Agronomy Journal (URL: https://www.agronomy.org/publications)