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FOR SUSTAINABLE AGRICULTURE

Long-term study shows many benefits of longer rotations

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AMES, Iowa – What would you think if a farmer could grow corn and soybeans with lower costs, fewer chemicals, less environmental impact, all while increasing yields and making a profit?

A new study shows that it's possible, and it's not a scene from the future.

Analysis of data collected since 2003 at Iowa State University research plots comparing two-year corn-soybean rotations with longer-term rotations reveals many advantages, including higher yields, lower energy use and effective weed and pest management with far fewer chemicals, while providing comparable economic returns.

Project findings were published October 10 in the peer-reviewed online journal *PLOS ONE*. The journal article, "Increasing cropping system diversity balances productivity, profitability and environmental health," was written by Adam Davis, USDA-ARS weed ecologist in Urbana, Illinois; Iowa State University agronomist Matt Liebman, who leads the research project; Jason Hill, an environmental scientist at the University of Minnesota; Craig Chase, economist and interim program leader at the Leopold Center for Sustainable Agriculture; and ISU Extension economist Ann Johanns.

The authors write, "Substantial improvements in the environmental sustainability of agriculture are achievable now, without sacrificing food production or farmer livelihoods." The key to the success can be summed in one word: diversity.

"More diverse cropping systems can use small amounts of synthetic agrichemical inputs as powerful tools with which to tune, rather than drive, agroecosystem performance, while meeting or exceeding the performance of less diverse systems," the authors note in the journal. They call it "synergizing effects of cropping system diversification."

The project consists of 36 replicated research plots at the ISU Marsden Farm west of Ames that compare three crop production systems:

- Two-year conventional corn-soybean rotation,
- Three-year rotation of corn, soybean and small grain/red clover (during startup, triticale was the small grain; oats have been used as the small grain since 2006), and a
- Four-year rotation of corn, soybean, small grain/alfalfa and a fourth year of alfalfa.

The diverse rotations received clover and alfalfa residues and composted cattle manure, so 80 to 86 percent less synthetic nitrogen was applied than in the conventional system during 2003-2011. The diverse rotations also reduced herbicide use during the corn and soybean years by application in 15-inch bands rather than broadcast spraying, and cultivation between rows. The two-year system required more than twice the fossil energy inputs of other rotations, primarily due to increased herbicide and fertilizer usage.

These differences contributed to a healthy bottom line for the diverse rotations. Although there were no statistically significant differences in profitability among the different systems, the three-year rotation came out numerically on top, netting $194 an acre in returns to management, compared to $187 for the two-year system and $171 for the four-year rotation. The longer rotations also had higher yields – an average of 4 percent greater for corn in the three- and four-year rotations than in the two-year rotation, and 9 percent greater for soybean during the nine years of the study.

But the biggest difference over time among the three systems was in weed management.

Weeds were suppressed as effectively in the longer rotations as in the two-year rotation, with declining soil seedbanks and negligible weed biomass, yet herbicide inputs in the longer rotation plots were 6 to 10 times lower. During the startup phase of the project (first three years), there was only a two-fold difference between the two-year system and the longer rotations in potential toxicity to freshwater organisms, based on analyses evaluating 8 of the 10 active chemical ingredients applied. However, during the past six years, 2006-2011, potential aquatic toxicity was 200 times less in the longer rotations than in the two-year system.

In the paper, the authors address the criticism that longer rotations are impractical because fewer acres are devoted to corn and soybean production. They note that although corn and soybean are grown less frequently in longer, more diverse rotations, “this will not compromise the ability of such systems to contribute to the global food supply, given the relatively low contribution of corn and soybean production to direct human consumption and the ability of livestock to consume small grains and forages.”

The paper is available on the *PLOS ONE* website at: http://dx.plos.org/10.1371/journal.pone.0047149

Liebman, Chase and Johanns prepared an analysis of energy use and economic returns for the project that covers 2006-2011. The analysis, *Energy and Economic Returns by Crop Rotation*, is available on the Ag DecisionMaker website, www.extension.iastate.edu/agdm, and on the Leopold Center website, www.leopold.iastate.edu/pubs/alpha (listed by title).

The Leopold Center provided a competitive grant to set up the research plots in 2003 and has continued to support this project. Additional support comes from the ISU College of Agriculture and Life Sciences, with funding leveraged from the U.S. Department of Agriculture National Research Initiative, Iowa Soybean Association and the Organic Center.

The Leopold Center, established by the 1987 Iowa Groundwater Protection Act, supports the development of profitable farming systems that conserve natural resources. The Center is named after Iowa-born conservationist Aldo Leopold and is located at Iowa State University.

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