AGRI-VIEW

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Rotations: More diversity, lower inputs equal greater resiliency

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What if you could grow corn and soybeans with lower costs, fewer chemicals and less environmental impact, while at the same time increase yields, sustainability and even slightly, profitability? Newly reported long-term research by Iowa State University and others shows it's possible simply by diversifying the corn-soybean rotation. In the aftermath of the 2012 drought, now might be a good time to be thinking about making changes to increase an operation's resiliency.

Newly reported data, collected since 2003, compares the two-year corn/soy rotation with longer-term, more diversified ones. This work reveals lots of advantages – higher yields, lower energy use, effective weed and pest management with far fewer chemicals, and comparable economic returns.

The findings were published last month in the peer-reviewed, online open-access journal, PLOS ONE (http://bit.ly/RD94b1). The summary was written by ISU agronomist Matt Liebman (project lead); Adam Davis, a USDA Agriculture Research Service weed ecologist in Illinois; Jason Hill, University of Minnesota environmental scientist; Craig Chase, an economist with the Leopold Center for Sustainable Agriculture at ISU; and ISU economist Ann Johanns.

The team concludes that "substantial improvements in the environmental sustainability of agriculture are achievable now – without sacrificing food production or farmer livelihoods." The key can be summed up 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 – agro-ecosystem performance, while meeting or exceeding the performance of less diverse systems," the authors report in this journal article. They call it "synergizing effects of cropping system diversification."

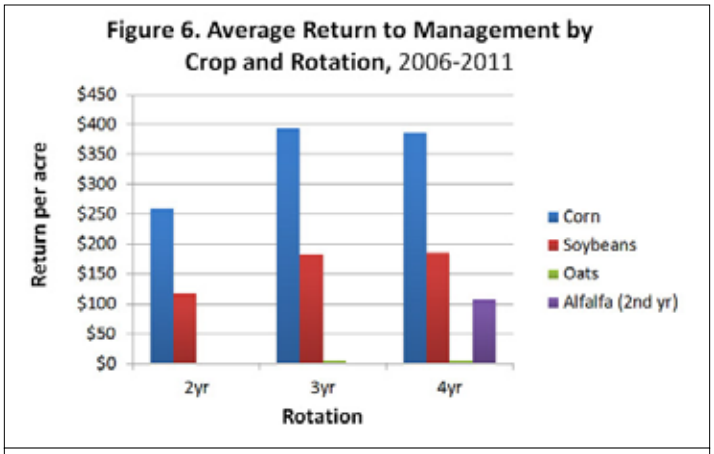
The project consisted of 36 replicated research plots west of Ames, Iowa that compare three cropping systems: A two-year conventional corn-and-soybean rotation; a three-year rotation of corn, soybeans and small grain/red clover; and a four-year rotation of corn, soybeans, small grain/alfalfa and fourth year of alfalfa. (In the three-year rotation, triticale had been the small grain, with oats used since 2006.)

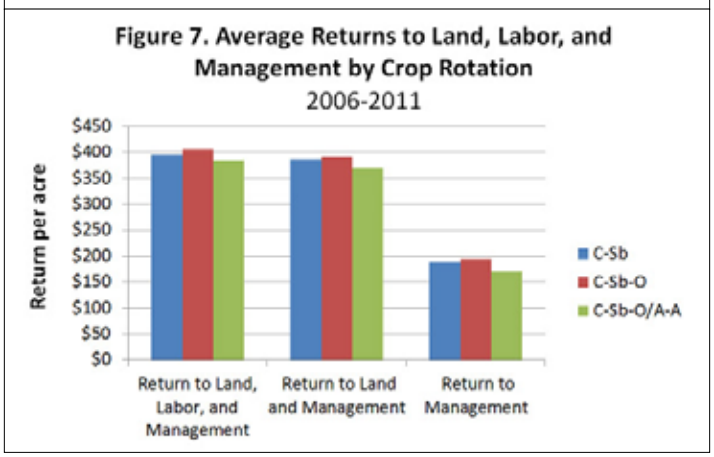
The more-diverse rotations took into account clover and alfalfa residue and utilized composted manure from cattle; dramatically less purchased nitrogen was applied than to the corn/soy plots from 2003-2011. Purchased N use was 80 percent lower in the three-year rotation and 86 percent lower in the four-year rotation, compared to the two-year corn-soybean rotation.

Herbicide use during the corn and soybean years was also reduced in the more-diverse rotations by applying chemical in 15-inch bands (in the corn and soybean years) versus broadcast spraying. Inter-row areas were cultivated as well.

The two-year system also required more than twice the fossil energy inputs of other rotations, primarily due to greater herbicide and fertilizer use.

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 soybeans during the nine years of the study.

The greatest difference, however, over time among the three systems was weed management. Weeds were suppressed as effectively in the longer rotations as in the two-year rotation, with declining soil seed banks and negligible weed biomass, yet herbicide inputs in the longer rotation plots were 6 to 10 times lower.

According to the Leopold Center, "Diverse rotations received an average of 88 percent less herbicide compared to the conventional system." Small grains and forage legumes required no herbicides. Actually, as noted, weed seed banks decreased in all three cropping systems, and reduced herbicide rates didn't lead to weed problems.

There are also major environmental benefits from a longer, more diverse rotation. During this project's 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 six years from 2006-2011, potential aquatic toxicity was a whopping 200 times less in the longer rotations than in the two-year system.

The authors address common criticism that longer rotations are impractical (because fewer acres are devoted to corn and soybean production). They note that although corn and soybeans are, in fact, 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 Leopold Center at ISU emphasizes the similar profits. Diverse rotations produced similar profits compared to the conventional corn-soybean system – during both the transition years (2003-2005) and established years (2006-2011). The net returns to land and management reported earlier were calculated assuming that diverse rotations received, as noted, manure from either on-farm or a neighbor's livestock (and incurred costs for labor and machinery for spreading manure, but not for the manure itself).

Researchers report that "diverse rotations are less vulnerable to changing input costs, and may become more profitable if fossil fuel costs rise substantially relative to crop prices."

Does crop variety really matter? The researchers compared genetically engineered (GE) and non-GE corn hybrids and soybean varieties in the different systems. Results indicate that genetically engineered crops offer higher net returns if used in conventional corn-soybean systems. However, the Leopold Center reports that "with diverse rotations, farmers can choose between GE and non-GE without jeopardizing net returns."

Diverse rotations "outperformed conventional in yield – regardless of the crop variety," the center cropping experts emphasize.

The Leopold Center at ISU also highlights that Sudden Death Syndrome (SDS), a disease of soybeans caused by a soilborne fungus, severely impacted ISU's soybeans in the conventional system in 2010 – infecting 97 percent of non-GE plants and 27 percent of the GE plants. By contrast, less than 9 percent of the soybean plants in the two diverse rotations were impacted by SDS. Those plants also had significantly less defoliation, resulting in higher yields that year.

How do more diverse crop rotations improve sustainability? Adding small grains and perennial legumes minimizes the need for purchased inputs – fertilizer, herbicide and fuel. Diverse rotations also enrich the soil with plant-available nitrogen and organic carbon. They help break disease and weed cycles and diminish erosion by putting living roots and cover on the ground. Further, the Leopold Center points out that "they protect nearby waterways from pollutions and reduce the risk of creating herbicide resistant weeds."

"These environmental benefits improve over time," the center staff maintains. "After nine years, herbicide inputs in the diverse rotations were 7 to 10 times lower, and herbicide-related freshwater toxicity 200 times lower, compared to the conventional system. Diverse rotations used 48 to 51 percent less energy per acre per year compared to the conventional system. Most of the energy was consumed in fertilizers, propane for drying grain and fuel for farm equipment."

While growers can appreciate those benefits, they still have to make a living on the land. Here are yields across the study: Two-year rotation – 194 bushels of corn, 51 bushels of soybeans; three-year rotation – 202 bushels of corn, 55 of soybeans; and four-year rotation – 204 bushels of corn, 57 of soybeans. Returns to land and management were as following: Corn-soybean rotation – $318 per acre per year; three-year rotation – $315; and four-year rotation – $308.

The complete paper is on the PLOS ONE website. Liebman, Chase and Johanns have also prepared an analysis of energy use and economic returns for the project that covers 2006-2011. Growers can read the latter on this ISU website www.extension.iastate.edu/agdm. There's also more information on the Leopold Center at http://bit.ly/QiGxJe.

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 USDA's National Research Initiative, the Iowa Soybean Association and the Organic Center. The Leopold Center, established by the 1987 Iowa Groundwater Protection Act, supports development of profitable farming systems that conserve natural resources. The center is named after Iowa-born conservationist Aldo Leopold.