Understanding the continuous corn yield penalty

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As escalating corn prices have encouraged many farmers to switch to growing corn continuously, they wonder why they have been seeing unusually high yield reductions over the past several years. The University of Illinois conducted a six-year study that identified three key factors affecting yield in continuous corn (CC) systems.

"Prior to this study, the most common management recommendations for continuous corn production were to apply an additional 45 pounds of nitrogen per acre and reserve your best crop land for it," said U of I soil scientist and lead author Laura Gentry. "Very little was known about the agents or mechanisms causing reduced yields in continuous corn systems."

Although corn can be cropped continuously, it is widely accepted that there is a yield reduction compared to corn rotated with soybean (CS). This difference is referred to as the continuous corn yield penalty (CCYP), which is generally in the range of 20 to 30 bushels per acre. The 2012 growing season marked the third consecutive year of unusually high CCYP values in the U.S. Midwest, often with corn yields that were 30 to 50 bushels per acre less than corn following soybean.

The researchers conducted the experiment from 2005 to 2010 in east-central Illinois, beginning with corn produced in a third-year CC system or a CS rotation, at six N fertilizer rates. The study investigated: 1) how the yield penalty changed with time in CC, 2) under what conditions increasing the nitrogen (N) fertilizer rate reduced the penalty, and 3)

what causes the penalty?

Each year, they determined an "agronomically optimum N rate" and corresponding yield value for each rotation (CC and CS). On average, corn yield at the agronomically optimum N rate for CC was 167 bushels, compared to 192 bushels per acre for CS – a CCYP of 25 bushels per acre. CCYP values ranged yearly from 9 to 42 bushels per acre.

Matias Ruffo, a co-author of the paper and Worldwide Agronomy Manager at The Mosaic Co., said, "To explore the causes of the CCYP, we tested a number of different weather- and yield-related measurements for their relationships with the CCYP. We found that with just three predictors, we could estimate the CCYP with almost 100 percent accuracy." The predictors were: 1) unfertilized CC yield, 2) years in CC, and 3) the difference between CC and CS delta yields.

The researchers found that the best predictor of the CCYP was unfertilized CC yield. In years when unfertilized CC yields were relatively high, the yield penalty was low, and vice versa. Unfertilized CC yield is an indicator of how much N the soil is supplying to the corn crop, either from residual fertilizer N or from decomposition of previous crop residues and other organic matter (N mineralization).

The second predictor of the CCYP, years in CC, was also strongly correlated with the CCYP. CCYP got worse with each additional year in the CC system through the seventh year, when the study was terminated.

This conclusion is at odds with the claims of many Corn Belt farmers who argue that corn yields in CC eventually attain the same level as CS rotations. On average, the CCYP in this study increased by 186 percent from third-year CC to fifth-year CC and 268 percent from third-year CC to seventh-year CC.

"Yield reductions resulting from additional years of continuous corn production mirror the effects of residue accumulation when corn is cropped continuously," said U of I crop physiologist Fred Below, another co-author. "It is well documented that corn residues introduce a host of physical, chemical, and biological effects that negatively influence corn yields."

Effects of accumulated corn residues include reduced soil temperature, increased soil moisture, reduced N fertilizer availability, and production of autotoxic chemicals, all of which can negatively affect growth and future corn crop development.

The final predictor of the CCYP, difference in CC and CS delta yields (the difference between the yield where no N was applied and the maximum yield under non-N limiting conditions), is probably a function of weather conditions, particularly during critical growth periods such as ovule determination and grain fill. Drought and heat can disproportionately reduce yields of the CC system relative to the CS system. This principle was demonstrated during the 2012 drought, when farmers reported yield reductions as large as 50 bushels per acre for CC systems compared to CS.

Based on this study, the authors concluded that the CCYP persists for at least seven years. However, during very favorable growing seasons, increased N rates can overcome the CCYP. Unfortunately, higher N rates do not eliminate the CCYP during average or poor growing seasons. This study concluded that the primary causes of the CCYP are: N availability, corn stover accumulation, and unfavorable weather.

"Given that weather cannot be controlled, and the optimum N fertilizer rate can be determined only after crop harvest, managing corn stover has the greatest potential for reducing the CCYP," said Gentry. The same research team is collaborating on a follow-up study investigating the

effect of stover removal and tillage on the CCYP.

More information: "Identifying Factors Controlling the Continuous Corn Yield Penalty" was published in the January 2013 issue of *Agronomy Journal* (105:295-303). It is an open-access article available at: www.crops.org/publications/aj/articles/105/2/295

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