Increasing the frequency of corn in crop sequences: Grain yield and response to nitrogen -- a research update

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Abstract
Several Iowa long-term experiments are studying rotation and N fertilization effects on corn yield (see Nitrogen fertilization for corn following corn). A unique piece of information provided by an experiment conducted since 1979 at the Iowa State University Northeast Research and Demonstration Farm near Nashua is the evaluation of yield and response to N of corn grown continuously and one, two, or three times after soybean among other rotations. The N rates for corn have been 0, 80, 160, and 240 lb N/acre/year as granulated urea applied and incorporated in the spring.

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Soils

Increasing the frequency of corn in crop sequences: Grain yield and response to nitrogen—a research update
by Antonio P. Mallarino, Department of Agronomy, and Ken Pecinovsky, Iowa State University Extension

The expected increase in the acreage of corn after corn in Iowa calls for a careful look at available research on long-term effects of crop rotation on corn grain yield and response to nitrogen (N) fertilization. Rotating corn with legumes often reduces N fertilizer needs compared to continuous corn because of increased soil N availability after the legume crops. Also, yield of corn in rotation often is higher than for continuous corn, even at high N rates, due to other poorly understood beneficial rotation effects.

Several Iowa long-term experiments are studying rotation and N fertilization effects on corn yield (see “Nitrogen fertilization for corn following corn” on pages 27–28). A unique piece of information provided by an experiment conducted since 1979 at the Iowa State University Northeast Research and Demonstration Farm near Nashua is the evaluation of yield and response to N of corn grown continuously and one, two, or three times after soybean among other rotations. The N rates for corn have been 0, 80, 160, and 240 lb N/acre/year as granulated urea applied and incorporated in the spring.

Figure 1 shows the 26-year average yields and response to N for seven corn crops as determined by the crop sequences. There are two distinct and tight groupings of sequences for both yield level and response to N. Corn after soybean (C-s, C-c-s, and C-c-c-s) had the highest yield and lowest response to N compared with corn after corn. The yield level and response to N did not differ among continuous corn, second-year corn (c-C-s and c-C-c-s), or third-year corn (c-c-C-s) after soybean. Data in the figure and response equations (not shown) indicated that 160 lb N/acre maximized long-term average yield of corn after soybean and that the highest N rate used (240 lb N/acre) maximized average yield of corn after corn. Yield of non-fertilized corn after corn did not yield as much as corn after soybean in part because the highest rate used was not high enough, but the small curvature of the response curve suggests other unknown rotation effects. This yield difference was 16 bu/acre for the N rate that maximized yield for each group. The same corn hybrids (Bt in recent years) and insecticide management for root insects have been used for all sequences. Increasing the frequency of corn has increased soybean yield slightly (4 to 5 bu/acre).

Figure 2 shows yields and response to N over time for the two groupings of corn sequences. In spite of large yield variation over time due to drought or excessive rainfall, the data and regression analyses indicate some clear trends. Yield of nonfertilized corn after corn declined 1.4 bu/acre/year on average (due to decreasing soil N supply), was flat for the 80-lb N rate, and increased 1.0 and 1.3 bu/acre/year with rates of 160 and 240 lb/acre, respectively. Yield of nonfertilized corn after soybean declined 0.6 bu/acre/year and increased 1.1, 2.0, and 2.3 bu/acre/year with rates of 80, 160, and 240 lb N/acre, respectively. Adequate N allowed for better expression of genetic or management improvements.

The yield advantage of corn after soybean, which on average was 16 bu/acre, ranged from 0 to 40 bu/acre over time. The difference for early, middle, and recent periods was 15, 14, and 26 bu/acre, respectively. A larger difference in recent years is explained by a greater rate of yield level increase for corn after soybean than for corn after corn. This result could be explained by insufficiently high N rate for corn after corn in some years or undetermined effects of the monoculture. Although the yield difference between fertilized and nonfertilized plots became larger with time, the N rate
Figure 1. Rotation and N rate effects on average corn yield from 1979 to 2004. An upper case letter in the rotation code indicates the sequence in the rotation for the corn crop to which the graphed yield refers. For example, c-c-C-s indicates third-year corn of the corn-corn-corn-soybean rotation.

Figure 2. Rotation and N fertilization effects on corn yield over time (averages for two groups of sequences shown in Figure 1).
that produced statistically maximum yield of corn did not change consistently over time. Analyses of yields in Figure 2 indicated that rates of 80, 160, and 240 lb N/acre resulted in statistically maximum yield of corn after corn 25, 67, and 8 percent of the years. Cumulative effects of small, nonstatistically significant responses determined that the 240-lb rate maximized yield for long-term averages. With corn after soybean, rates of 80 and 160 lb N/acre resulted in maximum yield 58 and 33 percent of the years, respectively, while 240 lb N/acre never increased yield further, and there was no response to applied N in 9 percent of the years.

The corn responses to N rates shown in this article must be interpreted with caution; although the responses reflect many years of cropping, the data come from a single location. Results of other studies evaluating the response of continuous corn and first-year corn after soybean using more N rates may better reflect the most likely economic optimum N rates for these rotations. For example, see the article “Nitrogen fertilization for corn following corn” on pages 27–28 and the Corn Nitrogen Rate Calculator Web tool (http://extension.agron.iastate.edu/soilfertility/nrate.aspx).

In many years, unknown rotation effects resulted in higher yield for corn after soybean than for corn after corn even with the highest N rate used. This difference became larger in recent years. First-year corn after soybean needed significantly lower N rates than corn after corn. Continuous corn and second- or third-year corn after soybean had statistically similar yield and N fertilizer requirements. Producers thinking of planting two or three corn crops after soybean should be aware that N fertilizer rates for these crops are likely as high as for continuous corn.

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