

University/Pioneer Research¹ Update: A New Look at Corn and Soybean Rotation Options

by Tom Doerge, Agronomy Research Scientist

Key Findings of CMRA¹ Research Project

- Escalating corn prices have induced growers to consider deviating from a traditional 50-50 corn-soybean (CS) rotation to either a corn-corn-soybean (CCS) or a continuous corn (CC) cropping sequence.
- Field studies at six widely contrasting locations in Illinois were conducted in 2004-2006 to measure the effect of CC, CCS and CS rotations on the yield of corn and soybean.
- Averaged across all sites and years, the yield penalty for CC compared to corn following soybean was 17 bu/acre or about 9%. In contrast, the yield loss for second-year corn in the CCS rotation was only 10 bu/acre or 5%.
- There was also a slight benefit for soybean grown in the CCS vs. the CS rotation. The additional year in corn raised soybean grain yield by an average of 2 bu/acre or 4%.
- Yield effects of the three rotations differed only slightly across environments, despite the wide range of productivity levels characterizing the six experimental locations.
- Neither hybrid/variety type (“high yield” vs. “defensive”) demonstrated a consistent advantage across environments.
- Based on this study, the predicted order of profitability for these three long-term crop rotations is CC > CCS > CS.

Introduction

The large demand for corn to produce ethanol coupled with high worldwide demand is increasing corn prices relative to soybean prices. Because much of the corn and soybean in Illinois and the Corn Belt are grown in a 2-year, 50/50 rotation, the increasing demand for corn will mean more corn acres and fewer soybean acres. This will require that more corn be grown following corn, rather than following soybean.

Two likely ways that the increase in corn acreage will occur is through adoption of a corn-corn-soybean rotation (CCS) and through growing corn continuously. It is believed that the 3-year rotation might be better suited to less-productive land, and continuous corn (CC) to more-productive fields. However, it is not known how yields of both crops respond to a corn-corn-soybean rotation, nor is it known what management factors might alleviate some of the yield penalty for corn when it follows corn, either in the first year or when grown continuously.



Figure 1. Crop rotation study at the University of Illinois’s Orr Center near Perry in 2005.

Primary Research Objectives

The primary objectives of this study were 1) to measure differences in yield of corn and soybean in CS, CC, and CCS rotations in six different soil-climate zones of Illinois, and 2) to see whether or not offensive versus defensive corn hybrids and soybean varieties respond differently within these rotations. Dr. Emerson Nafziger of the University of Illinois led this study.

Study Description

Locations and Crop Rotations- This study was established beginning in 2002 at the University of Illinois Crop Sciences research centers at DeKalb, Monmouth, Urbana, Perry, Brownstown, and Dixon Springs, covering major soil-climate zones of the state. The three rotations established included: continuous corn; soybean-corn; and soybean-corn-corn. Each entry point (crop) in each rotation was present each year, for a total of six main plots. Main plots were about 40 ft. wide and 60 ft. long (Figure 1), and were laid out in a Randomized Complete Block design with four replications.

Hybrid Selection- Starting in 2003, two Pioneer brand corn hybrids or soybean varieties were assigned to subplots within each main plot, with the hybrids and varieties chosen to represent “defensive” and “high-yielding” types. These types were assigned to the same subplots each year. Corn hybrids

chosen to represent “high yield” and “defensive” types were 34B24 and 34H32, respectively, at DeKalb and Monmouth. These were changed to 34A18 and 34H39 in 2006. The hybrids 33P67 (“high yield”) and 32P76 (“defensive”) were used at Urbana, Perry, Brownstown, and Dixon Springs in 2004 and 2005, and were changed in 2006 to 31G96 and 33P70 at Brownstown and Dixon Springs, and to 33D37 and 33K42 at Perry and Urbana.

Variety Selection- Soybean varieties chosen to represent the high yield and defensive categories were 92M91 and 92M92 at DeKalb (variety 92B95 was used instead of 92M92 in 2004), 93M11 and 93M10 at Monmouth (93B47 and 93B67 were used in 2004), and 93B82 and 93B86 at Urbana, Perry, and Brownstown; the variety 93M60 was substituted for 93B82 in 2006 at Brownstown, and the varieties 93M11 and 93M10 were used at Perry in 2006. At Dixon Springs, 94B73 was used each year, and 94B74 in 2004, changed to 94M70 in the last two years. While it is clear that the terms “high yield” and “defensive” do not fully describe these cultivars, these designations will be used for convenience in the following discussion (Figure 2).



Figure 2. Contrasting soybean varieties (foreground) used in the crop rotation study near Monmouth, IL in 2006.

Crop Management- All crops were managed according to usual local practices. Primary tillage in the fall was done using a chisel plow, and secondary tillage with a field cultivator before planting. Corn was planted in mid-April to early May, at planting rates per acre from the high 20,000s to the mid-30,000s, depending on soil productivity. Soybean planting was completed by mid-May, at seeding rates of 160,000 to 180,000 per acre, in 30-inch rows. Weeds were controlled by herbicides and row cultivation. Nitrogen rates of 200 lb/acre were used for corn following soybean in the four northern locations, and 140 lb/acre at Brownstown and Dixon Springs. Corn following corn received an additional 40 lb N per acre, and P and K were applied according to soil test levels. Corn rootworm were controlled by using a full-rate of a soil-applied insecticide as needed by location.

Data Analysis- Plots were combine harvested and yields were calculated at a 15% moisture basis for corn and 13% for soybean. Data were analyzed over three years (2004-2006) at each location, using a conservative analysis. Using this type of analysis, variation in treatment response from year to year reduces the likelihood of significant rotation differences.

Results

1. Did crop rotation affect corn yields?

Yes. Continuous corn yielded less than corn following soybean at four of the locations, but differences among rotations were not significant at Perry and Urbana (Figure 3).

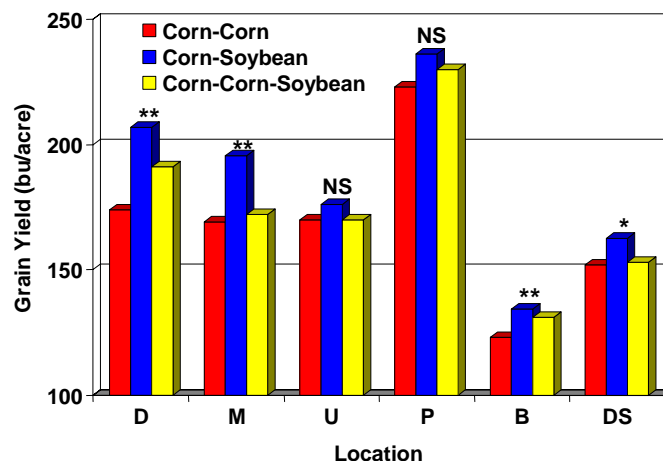


Figure 3. Corn yields obtained at six Illinois locations between 2004-2006 using three corn and soybean rotations.

(D=DeKalb, M=Monmouth, U=Urbana, P=Perry, B=Brownstown and DS=Dixon Springs). *, **, NS = Significant at 10% and 5% level and Not Significant at the 10% level, respectively.

The site at Perry is a very productive bottomland soil, and yields were very high regardless of rotation. Yields at Urbana were only average, and while yields of corn following soybean were numerically higher than those of corn following corn, the difference was small (only about 3 percent) and not consistent over years. These two sites had the same set of corn hybrids, which might have affected the rotation effect.

Continuous corn yielded about the same as second-year corn (in CCS) and corn following soybean yielded about the same in the CS and CCS rotations at Monmouth and Dixon Springs, on very different soils at very different yield levels (Figure 3). Corn following corn yielded about 13% less than corn following soybean at Monmouth, and about 6% less at Dixon Springs.

At DeKalb and Brownstown, again on very different soils with different yield levels, second-year corn in CCS yielded more than continuous corn, but less than corn following soybean (Figure 3). This was unexpected, since most previous results have shown that second-year corn yields the

same as continuous corn. It is not known how a year of soybean might affect the yield of the (second) corn crop two years later.

2. How did crop rotation affect soybean yields?

At four of the six locations, there was no significant yield advantage for soybean following two years of corn compared to soybean following one year of corn. However at both DeKalb and Monmouth, soybean following two years of corn yielded 3 and 5 bu, or about 5 and 9 percent, more than soybean following only one year of corn. Because two years of corn should help reduce soybean diseases and cyst nematode pressure, it was expected that two years of corn would routinely increase soybean yield. It is not known why this did not happen at all locations, unless it was due to limitations on soybean yield not related to soybean diseases. Nevertheless, soybean in the CCS rotation did numerically out-yield the CS crop at five of six locations (Figure 4).

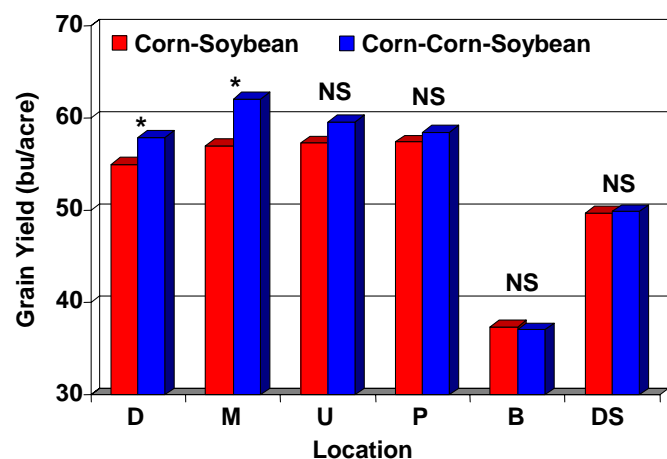


Figure 4. Soybean yields obtained at six Illinois locations between 2004-2006 using two corn and soybean rotations.

(D=DeKalb, M=Monmouth, U=Urbana, P=Perry, B=Brownstown and DS=Dixon Springs). *, NS = Significant and Not Significant at the 10% level, respectively.

3. Which rotation is likely to be the most profitable?

Averaged across all years and locations, continuous corn yielded 17 bu, or 9%, less than corn following soybean. In contrast, second-year corn in the CCS rotation yielded only 10 bu, or 5%, less than first-year corn. Soybean following two years of corn yielded 2 bu, or 4%, more than soybean following one year of corn. The corn price is currently about one-half the price of soybean, compared to the more typical one-third in recent years, and corn production costs, though they have increased more than soybean production costs, have risen moderately. Thus it is predicted that the profitability of the three crop rotations is as follows: CC > CCS > CS. Yield differences might be greater or less in other fields, but inherent productivity (yield) differences among

locations did not have much effect on the yield differences among the rotations.

4. Did hybrid or variety "type" make a difference?

No. In some individual years the defensive or high-yield type yielded more, but neither type consistently demonstrated an advantage across environments (Tables 1 and 2). Perhaps this is because yields are limited by different factors over years and locations. Some may assume that more "defensive" corn hybrids would perform better in less-productive fields and under more corn-intensive rotations. However, this was not observed in the study, even over the wide range of productivity and yield levels represented at these six experimental locations.

Location	Corn Hybrid Type		Significance
	Defensive	High-yield	
	----- bu/acre -----		
DeKalb	192	197	NS
Monmouth	185	181	NS
Urbana	173	173	NS
Perry	231	231	NS
Brownstown	137	134	NS
Dixon Springs	160	155	NS

Table 1. Corn yields obtained at six Illinois locations between 2004-2006 using two corn hybrid types. NS = not statistically different at the 10% level.

Location	Soybean Variety Type		Significance
	Defensive	High-yield	
	----- bu/acre -----		
DeKalb	57.0	55.8	NS
Monmouth	63.1	56.0	NS
Urbana	59.3	57.6	NS
Perry	57.1	58.7	NS
Brownstown	37.1	38.0	NS
Dixon Springs	51.5	48.1	NS

Table 2. Soybean yields obtained at six Illinois locations between 2004-2006 using two soybean variety types. NS = not statistically different at the 10% level.

¹The Pioneer Crop Management Research Awards (CMRA) Program provides funds for agronomic and precision farming studies by university and USDA cooperators throughout North America. The awards normally extend for three years and address crop management information needs of Pioneer agronomists, sales professionals and customers.