MAKING THE BEST OF CORN-CORN MONOCULTURE IN THE EASTERN CORN BELT

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Introduction

Most of the growing demand for the nation's ethanol production, at least in the short term, will be met by utilizing more grain corn as the preferred raw material. The increased demand for corn will not be met from higher yields alone, regardless of how optimistic corn growers might be about their potential yield gains over time. Indiana farmers, like those in other Corn Belt states, will likely respond to the anticipated market demand signals by planting more corn after corn.

Livestock farmers have often had corn-dominant rotations to meet the feed needs of their animals. Those same farmers have also benefited (from both nutrient and soil structure perspectives) from the manure returned to their fields. But the considerations now being given to more corn on corn by cash-crop farmers are relatively new. Total Indiana corn acreage may return to levels not seen since the decade from 1976-1985, when harvested corn area exceeded 6 million acres for 9 of those 10 years (USDA-NASS). Harvested soybean acreage during that same period averaged only 4.26 million acres (USDA-NASS).

Some cash-crop farmers simply intend to convert some of their acreage (e.g., fields with highest corn yield history) to a rotation of two years corn, one year in soybean while keeping most of their acreage in the traditional corn-soybean rotation. Other farmers are considering switching all of their fields into a two-year corn, one-year soybean rotation. Still other Corn Belt farmers are interested in adopting continuous corn production, and a few yield-contest winning farmers are already growing continuous corn (defined as more than five years of corn in succession) because they do not believe there is a yield loss associated with continuous corn on their best fields.

There are significant compromises and consequences associated with switching from the traditional corn-soybean rotation of the past two decades to a corn-corn system. Growing corn after corn requires more management than the traditional corn-soybean rotation, involves more risk, results in some negative environmental consequences, and is not necessarily more profitable than the corn-soybean rotation even when relative commodity prices point to a preference for corn over soybean. A recent economic modeling analysis for a well-managed 3,000 acre Indiana farm found that continuous corn yields would have to be 20% higher than those for corn after soybean in rotation to economically justify continuous corn at a typical soybean to corn price ratio of 2.4-2.5 (Robertson, 2006). At least three consequences and three compromises from an agronomic perspective should be considered before expanding corn on corn in Indiana.

Consequences

1. **Yield loss.** The rotation yield advantage one assumes for corn after soybean is perhaps the key factor in making the economic decisions about rotation changes. Does the historical assumption of a 10% yield reduction for corn after corn still apply with today's hybrids and production practices? Our long-term rotation and tillage experiments (Tables 1 and 2) confirm that the yield advantage for rotation corn is still valid, but varies from 4 to 18% depending on the tillage system and soil type that is being assumed. The yield advantage for the simple two-year rotation of corn-soybean seems to have declined somewhat during the past decade of our 32-year study in chisel and moldboard plow situations (Table 1). However, the rotation advantage is fairly consistent over a wide range of yield levels from year to year within a location; review of our historic records indicates that the rotation yield advantage when corn yields are over 200 bushels per acre is just as evident as it is for corn yielding less than 150 bushels per acre (Vyn, 2004).
2. **Additional tillage requirement.** The information in Tables 1 and 2 clearly emphasize that more tillage is needed when corn follows corn than when corn follows soybean. In fact, other than the economic cost of reduced yield, the biggest economic loss associated with corn after corn is that it virtually rules out a no-till system. Moldboard plowing seems to result in the best performance for corn after corn on the dark prairie soils with high clay and organic matter contents (Table 1). Intensive tillage seems to be required to minimize the yield reduction with continuous corn, though fall strip tillage can result in yields comparable to the chisel plow system on medium-textured soils (Table 2).

3. **Additional nitrogen fertilizer requirement.** Current recommendations are that nitrogen needs are at least 30-50 pounds per acre higher for corn after corn than for corn after soybean. These general recommendations are being revisited with a multitude of new farm and research station trials organized by Purdue University specialists such as Jim Camberato and Bob Nielsen. Nevertheless, this additional nitrogen requirement comes at a cost per unit that is much higher now than 20 to 30 years ago when corn after corn was also common in Indiana.

Table 1. Corn Yield Responses* to Tillage and Rotation from 1975 to 2006 in West Lafayette, Indiana (Chalmers silty clay loam)

Tillage System	1975-2006		1997-2006		Yield Gain for Rotation (%)	
	Corn/Soy	Cont. Corn	Corn/Soy	Cont. Corn	1975-2006	1997-2006
	Yield (bu./A)					
Moldboard Plow	179.8	172.4	190.0	184.3	4	3
Chisel Plow	180.1	167.7	189.7	180.6	7	5
No-till	175.2	148.8	186.6	158.7	18	18

*Yield data from a cooperative project involving T. J. Vyn, T.D. West and G. Steinhardt of the Agronomy Department at Purdue University. Nitrogen rate for corn was equal in both rotations, and was high enough (total application of at least 230 lbs. of nitrogen per acre) that nitrogen should not have limited the yield response of corn following corn). Corn plant populations have increased over time to over 30,000 plants per acre, and are generally not significantly affected by tillage or rotation.

Table 2. Corn Yield Responses* to Tillage and Rotation from 1997 to 2006 in Wanatah, Indiana (Sebewa loam)

	1997-2006		2001-2006		Yield Gain for Rotation (%)	
Tillage System	Corn/Soy	Cont. Corn	Corn/Soy	Cont. Corn	1997-2006	2001-2006
	----------------------Yield (bu./acre)----------------------					
Fall chisel	193.5	181.9	198.0	186.7	6	6
Fall disk	197.4	178.3	204.3	186.5	11	10
Strip tillage	NA±	NA	203.2	186.6	NA	9
No-till	189.7	167.2	197.1	175.6	13	12

*Yield data from a cooperative project involving T. J. Vyn, T.D. West and G. Steinhardt of the Agronomy Department. Nitrogen rate for corn was equal in both rotations, and was high enough (total application of 225 to 275 lbs. of nitrogen per acre) that nitrogen should not have limited the yield response of corn following corn). Corn plant populations have increased over time to over 30,000 plants per acre, and were generally not significantly affected by tillage or rotation.
± NA means not applicable since these plots were originally in a modified no-till system.

Compromises

1. **Soil erosion.** If farmers adopt more intensive tillage as their answer to corn residue management, soil erosion rates will increase and the long-term productivity of our soil resource base will diminish. Moldboard plowing may become more commonplace in the Corn Belt simply because it results in highest yields for corn after corn on fine-textured and high organic matter, and poorly drained soils. Chisel plowing is not much better; it still leaves just 20 to 25% surface residue cover after planting for corn after corn.

2. **Air and water quality.** Corn production involves more risks to the quality of air and water resources than soybean production, especially if more intensive tillage systems are used, simply because of the typical application of more fertilizer (nitrogen and phosphorus) and pesticides. Water quality can be impeded by water and soil runoff from the surface soil, as well as from the tile drains, to surface and groundwater sources. Nitrous oxide emissions from the soil surface will be much higher in continuous corn than in rotation corn because continuous corn receives N fertilizer annually, and because higher N rates are typically applied to continuous corn. Most farmers are environmentally concious and will continue to adopt best management practices insofar as possible. In fact, Indiana farmers have adopted conservation tillage sytems much faster than farmers in states west of Indiana. However, there are more challenges to retain conservation tillage systems and maintain environmental quality when corn follows corn than when corn follows other crops.

3. **Pest incidence.** Monoculture production systems (whether soybean, corn, or another crop) invariably increase production and grain quality risks associated with weeds, insects and diseases. Corn hybrids generally have more stress tolerance now than those of 20 to 30 years ago and, unlike even a decade ago, we now have the advantage of a wide range of transgenic hybirds with specific resistances to certain insects. But hybrid selection for corn after corn situations must still consider susceptiblity to certain foliar diseases that can increase in corn after corn. Weed resistance will also be a greater concern without crop rotation.

There are many other agronomic issues involved in management decisions for corn after corn versus corn in rotation. These include the expected wider range in planting dates, hybrid maturity selection, stalk lodging, plant population management, fertilizer timing, ear rot factors, and differences with two-year versus 10-year plus continuous corn. Extension tools are available to help make some of the important management decisions for corn following corn (Nielsen et al., 2006). But before Corn Belt farmers concern themselves with the details, they should consider the major costs of switching to a more corn-dominant rotation.

Multiple-year Corn Options and Management Implications

Sometimes our long-term yield comparisons of continuous corn versus the standard corn-soybean rotation (Tables 1 and 2) are questioned because many Corn Belt farmers are more likely to grow monoculture corn for shorter periods of perhaps two or three years after a single year of soybean. Yet, most of the evidence from rotation experiments in other states is that second or third-year corn behaves very much like continuous corn (i.e., 5-30) years when N fertilizer is not limiting. Corn yields for any situation of corn after corn are generally the same regardless of whether it is year two or year 20 (for evidence see Mallarino and Ortiz-Torres, 2006 ; and Janovicek and Deen, 2006). These results, and many others, show that continuous corn yields do not get any better with time, and that long-term corn after corn requires much higher rates of nitrogen fertilizer than corn after a legume like soybean. Stranger and Lauer (2006) observed that second and third year corn yields were higher than those for continuous corn in extended rotations that involved two or more years of forage crops (alfalfa) in a five-year rotation system. Generally continuous corn tends to deplete soil N levels over time, and either high rates of N fertilizer, or the combination of leguminous crops and N fertilizer are required to maintain soil N status and corn yield potential in stress years (like those with excessive rain or drought).

Summary

Growing more corn after corn in response to ethanol industry needs will not be an entirely new phenomenon because Indiana already grew more corn than soybean from 1976 to 1985. However, there are potentially negative consequences and compromises associated with corn on corn that need to be given serious consideration by corn farmers, and in appropriate applied research involving various corn after corn situations. Ultimately, growing more corn for the expanding ethanol industry to will be economically sustainable and environmentally sustainable for farmers and society only if we are able to achieve the joint goals of financial viability and resource protection simultaneously. We know less about how to do so in continuous corn than we do for rotation corn, and there is now a strong impetus to prepare as best we can before abandoning even more of the already short-term two-year rotations of corn-soybean on Indiana's cropland area. The latter will take considerably more analysis and research than has been invested to date.

References and Resources

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