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P Starters Bump Yields In Corn/Soybean Rotations

Researchers stress that optimum placement of phosphorus (P) is essential in reduced-till systems, especially in soils testing low in P.

Summary: *On the low P-testing site, tillage did not affect corn yields in 2001, the five-year average, or the 1998 to 2001 soybean yields. Starters increased corn yield by 35 bu/A in 2001 and by 45 bu/A/yr across the five-year period, while soybean yields were increased by 20 bu/A in 2001 and 14 bu/A/yr across the four-year period due to the residual effects of the starter. Corn and soybean yields at the 100-lb/A P_2O_5 rate (broadcast) were generally greater than the 50-lb/A starter P_2O_5 rate and deep-band P treatments, suggesting that band applications at a half rate are usually not sufficient in low to very low P-testing soils. Highest yields were generally found with the chisel plow system, followed by the one-pass and strip-till systems. Lowest yields were usually found with no-till. The data from these studies suggest that P management strategies are more important than tillage systems for optimizing yields on low P-testing soils. However, on high P-testing soils, tillage has a greater effect on yield than does P management.*

Row-crop agriculture in the Mississippi River Basin is under intense pressure to reduce sediment and nutrient losses by practicing less tillage, as well as more precise application and placement of nutrients (N and P). No-till, strip-till, and one-pass secondary tillage systems are being proposed as reduced-till alternatives to conventional-till.

No-till corn production, however, has provided serious challenges to corn growers in the northern portions of the Corn Belt and has not been economically competitive with conventional-till systems. This is especially true on the highly productive but poorly drained clay loam soils of northern Iowa and southern Minnesota, where approximately eight million acres are in corn production annually. Retarded plant growth, delayed silking, greater moisture at harvest, and reduced corn yields are often associated with no-till systems that have high amounts of surface residue and cooler soil temperatures.

Table 1. Corn yield in a corn/soybean rotation on a low P testing soil as affected by tillage and P management strategies in 2001 and the 5-year avg.

Tillage	P mgt.	P_2O_5 lbs/A	Yield bu/A 2001	Yield bu/A 1997-2001 avg.
No-till	Check	0	107	103
	Starter	50	133	139
Field cult.	Check	0	101	103
	Starter	50	140	151
	Fall band	50	142	144
	Spring b'cast	100	152	162
Strip-till	Check	0	98	102
	Starter	50	139	149
	Fall band (f)	50	140	146
	Fall band (r)	50	135	139
	Fall band (f)	100*	146	
Chisel	Check	0	106	104
	Starter	50	141	152
	Fall b'cast	100	149	163

(f) = fixed in same position each year
(r) = random and band moved 8 inches laterally each year prior to planting corn
* This treatment first applied in fall, 1999.

Table 2. Soybean yield in a corn/soybean rotation on a low P testing soil as affected by tillage and P management strategies for corn in 2001 and the **4-year avg.**

Tillage Corn	Tillage Soybean	P mgt.	P_2O_5 lbs/A	Yield bu/A 2001	Yield bu/A 1998-01 avg.
No-till	No-till	Check	0	29.1	34.8
		Starter	50	51.7	47.7
Field cult.	Spr. disk	Check	0	31.2	36.0
		Starter	50	51.1	48.2
		Fall band	50	49.2	48.0
		Spr. b'cast	100	53.6	52.5
Strip-till	No-till	Check	0	36.7	37.9
		Starter	50	50.2	49.1
		Fall band (f)	50	47.0	47.8
		Fall band (r)	50	42.2	43.5
		Fall band (f)	100*	49.3	
Chisel	Chisel	Check	0	28.5	32.4
		Starter	50	52.0	50.8
		Fall b'cast	100	52.4	53.7

(f) = fixed in same position each year prior to planting corn
(r) = random and band moved 8 inches laterally each year prior to planting corn
* This treatment first applied in fall 1999 for the 2000 corn crop.

Table 3. Corn yield in a corn/soybean rotation on high P- testing soil as affected by tillage and P management strategies in 2001 and the 5-year avg.

Tillage	P mgt.	P_2O_5 lbs/A	Yield bu/A 2001	Yield bu/A 1997-2001 avg.
No-till	Check	0	134	155
	Starter	40	143	156
Field cult.	Check	0	135	161
	Starter	40	142	165
	Fall band	40	146	161
	Spring b'cast	80	157	171
Strip-till	Check	0	147	161
	Starter	40	147	165
	Fall band (f)	40	148	160
	Fall band (r)	40	149	165
	Fall band (f)	80*	152	
Chisel	Check	0	153	167
	Starter	40	153	168
	Fall b'cast	80	153	171

(f) = fixed in same position each year
(r) = random and band moved 8 inches laterally each year prior to planting corn
* This treatment first applied in fall, 1999.

Strip-till or zone-till is suggested as an alternative to no-till in these northern climates where soils are cold at the time of planting and are slow to warm. This fall tillage method disturbs the soil to a 7- to 8-inch depth and creates a 4- to 6-inch wide by 1- to 2-inch high mound of soil that is free of residue. Corn can be planted early and directly into the strip area that is warmer and drier. One-pass, secondary tillage systems consist of no fall primary tillage and either field cultivation or a disking operation in the spring. This system is now quite popular for corn following soybeans in the Corn Belt.

Use of conservation-till practices limits the opportunity for incorporation of P-containing fertilizers that are broadcast on the soil surface. Therefore, optimum placement of P is essential in reduced-till systems, especially in soils testing low in P. Thus, one purpose of this long-term study is to determine the effect of P placement on corn and soybean yields in three reduced-till systems and one conventional-till system for corn/soybean rotations.

LOW-TESTING SOILS

Corn yields in 2001 were lower than expected due primarily to very wet conditions from April 5 to June 15 (16.5 inches of rain) followed by below normal rainfall from June 16 to August 15 (4.9 inches) and very hot temperatures (18 days greater than 90^o F). Under these stress conditions, large yield responses to P were obtained on this low-testing soil with all four tillage systems (Table 1). Averaged across similar P management strategies (no P and starter P) yields were not significantly different among tillage systems. The yield response to starters averaged 35 bu/A across the four tillage systems with no tillage by starter interaction. Corn yields were 8 to 12 bu/A greater for the broadcast P (100 lbs/A of P_2O_5) com-

Table 4. Soybean yield in a corn/soybean rotation on a high P-testing soil as affected by tillage and P management strategies for corn in 2001 and the 4-year avg.

Tillage Corn	Tillage Soybean	P mgt.	P_2O_5 lbs/A	Yield bu/A 2001	Yield bu/A 1998-01 avg.
No-till	No-till	Check	0	45.0	51.2
		Starter	40	49.5	52.5
Field cult.	Spr. disk	Check	0	52.7	54.8
		Starter	40	52.7	55.0
		Fall band	40	53.5	54.5
		Spr. b'cast	80	55.7	55.1
Strip-till	No-till	Check	0	51.2	52.9
		Starter	40	47.7	51.8
		Fall band (f)	40	52.7	53.8
		Fall band (r)	40	48.4	53.0
		Fall band (f)	80*	51.8	
Chisel	Chisel	Check	0	42.0	52.5
		Starter	40	50.0	54.6
		Fall b'cast	80	54.4	55.9

(f) = fixed in same position each year prior to planting corn
(r) = random and band moved 8 inches laterally each year prior to planting corn.
* This treatment first applied in fall 1999 for the 2000 corn crop.

pared to the starter P (50 lbs/A of P_2O_5).

Averaged across five years (1997 to 2001), corn yield was not affected significantly when tillage systems were compared across similar P management strategies (Table 1). A 45-bu/A yield response was obtained with starters when averaged across tillage systems. No interaction existed between tillage and starters. Similar to the 2001 data, corn yields with the 100-lb/A of P_2O_5 broadcast rate were 11 to 18 bu/A greater than with the 50-lb/A starter rate. These data suggest that band applications of P at the half rate on very low-testing soils are not sufficient to optimize corn yields compared to broadcast applications of P at a full rate.

Soybean yields were quite good in 2001 even on this low-testing soil when adequate P was used (Table 2). Averaged across similar P management strategies (no P and starter P), yields were not statistically different among the four tillage systems. Yield response to starters averaged 19.8 bu/A when averaged across tillage systems with no starter by tillage interaction. When tillage systems using starters were compared, yields were not different and ranged from 52.0 bu/A with the chisel system to 50.2 bu/A with the strip-till/no-till systems. Soybean yields were 0.4 to 2.4 bu/A greater for the broadcast P treatments (100 lbs/A of P_2O_5) compared to the starter and band P treatments (50 lbs/A of P_2O_5), but this difference was not statistically significant.

Averaged across four years (1998 to 2001), soybean yield was not affected significantly when tillage systems were compared across similar P management strategies (Table 2). A 13.7 bu/A response was obtained from the residual effect of starter when averaged across tillage systems. No interaction was found between tillage system and starter. When tillage systems using starter were compared, yields were highest for the chisel system and slightly lower for the strip-till, one-pass, and no-till systems. These yields were not statistically different. Soybean yields were 2.9 to 4.3 bu/A greater for the broadcast P treatments (100 lbs/A of P_2O_5) compared to the starter and band P treatments (50 lbs/A of P_2O_5). This difference was statistically significant. These data again suggest that band applications of P at a half rate to low-testing soils for corn are not sufficient to optimize soybean yields in the following year compared to broadcast application of P at a full rate.

HIGH-TESTING SOILS

Corn yields in 2001 were significantly different among tillage systems when averaged across P management strategies (Table 3). Yields were greatest with the chisel and strip-till systems and lowest for one-pass and no-till systems. Corn yields were not increased with starters and there was no interaction between tillage and starters. Yields were not different between the starter P (40 lbs/A of P_2O_5) and broadcast P (80 lbs/A of P_2O_5) treatments for the chisel system but were 15 bu/A greater with the one-pass system.

Averaged across five years (1997 to 2001), corn yield was affected significantly when tillage systems were compared across similar P management strategies (Table 3). Yields were greatest with the chisel, one-pass, and strip-till systems and lowest for no-till. Starters did not increase yields significantly, and no interaction was found between tillage and starter. Yields were not different between starter P and broadcast P treatments in the chisel system, but were different in the one-pass, field cultivate system.

Soybean yields in 2001 were quite good but were extremely variable (Table 4). The variability occurred primarily in the control plots for each tillage system. Soil test P levels in some of these plots are declining to the point where yields are becoming limited while in other plots within the same treatments yields are not being limited by P. When averaged across similar P management strategies, yields among the four tillage systems were not statistically significant. Soybeans did not respond to the residual effect of the starter when averaged across tillage systems. A tillage-by-starter interaction was not found. A statistically significant yield difference was not found between the 80-lb/A broadcast rate of P_2O_5 and the 40-lb/A rate that was applied either as a starter or as deep band below the corn row, but yields were consistently 3 to 5 bu/A higher with the broadcast treatment.

Averaged across four years (1998 to 2001), soybean yield was affected significantly when tillage systems were compared across similar P management strategies (Table 4). Highest yields were obtained with one-pass and chisel systems, with somewhat lower yields for strip-till and no-till. Soybean yield did not respond to the residual effect of starter when averaged across tillage systems, and a tillage-by-starter interaction did not occur. A yield difference was not found between the 80-lb/A broadcast rate of P_2O_5 and the 40-lb/A rate, applied either as a starter or as a deep band below the corn row.

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