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Don't Overlook Effect of Variables on P Use in Corn-Soybean Rotations

Tillage systems, P placement, P levels in soils, and applied P rate can affect yields and economic return Minnesota studies show.

Summary: *On low P-testing sites, starter fertilizer increased corn yield by 71 bu/A in 2002 and by 49 bu/A across the six years of the study. Soybean yields were increased by 18 bu/A in year 2002 and by 15 bu/A across five years of the study, due to the residual effects of the starter. Corn and soybean yields were generally increased over the 50-lb/A starter P and deep-band P treatments by the 100-lb/A broadcast P treatments, suggesting that band applications at a half rate are usually not sufficient in low to very low P-testing soils. On high P-testing sites, tillage did not affect corn yields in 2002 but did affect the six-year and five-year corn and soybean averages. Highest yields were generally found with the chisel plow system followed by one-pass and strip-till systems. Lowest yields were usually found with no tillage. Both corn and soybean yields were affected by the P treatments in 2002 because soil test P had declined to yield limiting levels in the control plots in the third year of the corn-soybean cycle. Economic return to fertilizer P averaged almost $100/A/yr on the low P- testing site with virtually no return to fertilizer P on the high P-testing site. On the low P-testing site, returns were greatest with the 100-lb/A broadcast treatment and lowest for the 50-lb/A "deep" band treatment.*

No-till corn production 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 8 million acres are in corn production annually.

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 disking in the spring. This system is now quite popular for corn following soybeans in the Corn Belt.

Use of conservation-till limits the opportunity for incorporation of P fertilizers that are broadcast. Optimum placement of P is therefore essential in reduced-till, especially in soils testing low in P. In this study, starter P was placed with the corn seed and the deep-banded P was placed 4 to 5 inches directly below the corn seed.

Purposes of the portion of the study as reported here were to determine effect of P placement and rate on corn and soybean yield and economic return in one conventional-till and three reduced-till systems.

Low P-testing Sites

Corn yields in 2002 were excellent due primarily to above-average rainfall (May through September 20.2 inches), coupled with warmer-than-normal temperatures from June through September. Growing degree units for the growing season were 6 percent above normal. Under these favorable conditions, large yield responses to P were obtained on low P-testing soils with all four tillage systems (Table 1). Yields averaged 144, 164, 165, and 165 bu/A for the no-till, one-pass field cultivate, strip-till and chisel systems, respectively, when starter P was applied. The yield response to starter fertilizer averaged 71 bu/A across the four tillage systems with no tillage by starter fertilizer interaction. Corn yields were 15 to 32 bu/A greater for broadcast P (100 lbs/A of P_2O_5) compared to starter P (50 lbs/A of P_2O_5).

Yields averaged 140, 153, 152, and 154 bu/A when starter P was applied for no-till, one-pass, strip-till and chisel + field cultivate systems, respectively, when averaged across the 6 years (1997 to 2002). A 49 bu/A yield response (101 vs 150 bu/A) was obtained with starter fertilizer when averaged across the tillage systems. No interaction existed between tillage and starter fertilizer. Corn yields with 100 lbs/A of P_2O_5 broadcast were 12 to 13 bu/A greater than with the 50-lb/A starter rate. These data suggest that band applications of P at a half rate on low to 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 2002, even on this low-testing soil when adequate P was used (Table 2). Yields averaged 49.1, 52.3, 51.8, and 48.6 bu/A for the no-till, one-pass spring disk, strip-till and chisel systems, respectively, when tillage systems using starter fertilizer were compared. The yield response to residual P from the starter applied for corn averaged 17.8 bu/A (32.6 vs 50.4 bu/A) when averaged across tillage systems with no starter fertilizer by tillage interaction.

When averaged across 5 years (1998 to 2002), yields averaged 48.0, 49.1, 49.7 and 50.4 bu/A for the no-till, one-pass spring disk, strip-till, and chisel systems, respectively, that received starter P for corn. A 14.6 bu/A yield response (34.7 vs 49.3 bu/A) was obtained via the residual effect of starter fertilizer when averaged across tillage systems. No interaction was found between tillage system and starter fertilizer. Soybean yields were 2.6 to 3.5 bu/A greater for the broadcast P treatments (100 lbs/A of P_2O_5) compared to starter and deep-banded P treatments (50 lbs/A of P_2O_5). 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.

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

Tillage	Placement*	P_2O_5 lbs/A	Grain yield 2002 (bu/A)	Grain yield '97-'02 Avg. (bu/A)
No-till		0	68	97
No-till	Starter	50	144	140
Field cult		0	92	102
Field cult	Starter	50	164	153
Field cult	Fall band	50	157	146
Field cult	Spr. bdct.	100	189	166
Strip-till		0	92	101
Strip-till	Starter	50	165	152
Strip-till	Fall band (f)	50	160	148
Strip-till	Fall band (r)	50	154	141
Strip-till	Fall band (f)	100**	176	
Chisel fc		0	101	103
Chisel fc	Starter	50	165	154
Chisel fc	Fall bdct	100	180	166

* Fall Band (f) = fixed in same position each year. Fall Band (r) = random and band moved 8 inches laterally each year prior to planting corn.

** This 100 lb/A P 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.

Tillage: Corn	Tillage: Soybean	Placement*	P_2O_5 lbs/A	Yield 2002 (bu/A)	Yield '98-'02 Avg. (bu/A)
No-till	No-till		0	33.6	34.5
No-till	No-till	Starter	50	49.1	48.0
Field cult	Spr disk		0	35.2	35.9
Field cult	Spr disk	Starter	50	52.3	49.1
Field cult	Spr disk	Fall band	50	53.5	49.1
Field cult	Spr disk	Spr bdct	100	52.7	52.6
Strip-till	No-till		0	33.5	37.0
Strip-till	No-till	Starter	50	51.8	49.7
Strip-till	No-till	Fall band (f)	50	48.1	47.9
Strip-till	No-till	Fall band (r)	50	45.6	43.9
Strip-till	No-till	Fall band (f)	100**	48.5	
Chisel fc	Chisel fc		0	28.0	31.5
Chisel fc	Chisel fc	Starter	50	48.6	50.4
Chisel fc	Chisel fc	Fall bdct	100	50.5	53.0

* Fall Band (f) = fixed in same position each year prior to planting corn. Fall band (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.

High P-testing Sites

Corn yields in 2002 were not significantly different among tillage systems (Table 3) when averaged across P management strategies (no P and starter P). Corn yields increased 19 bu/A with starter fertilizer when averaged across all tillage systems largely due to soil test P declining from when the study was started. Thus, during the 6 years soil test P became limiting in some plots on this high P-testing site. There was no interaction between tillage and starter fertilizer.

Averaged across 6 years (1997 to 2002), corn yield was significantly affected when tillage systems were compared across similar P management strategies (Table 3). Yields were greatest with chisel, one-pass, and strip-till systems and lowest for no-till. Starter fertilizer increased yields significantly but no interaction occurred between tillage and starter.

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

Tillage	Placement*	P_2O_5 lbs/A	Grain yield 2002 (bu/A)	Grain yield '97-'02 Avg. (bu/A)
No-till		0	157	156
No-till	Starter	40	182	160
Field cult		0	160	161
Field cult	Starter	40	186	168
Field cult	Fall band	40	187	165
Field cult	Spr Bdct	80	206	176
Strip-till		0	181	164
Strip-till	Starter	40	184	168
Strip-till	Fall band (f)	40	187	165
Strip-till	Fall band (r)	40	175	166
Strip-till	Fall band (f)	80**	189	
Chisel fc		0	155	165
Chisel fc	Starter	40	180	170
Chisel fc	Fall bdct	80	202	176

* Fall Band (f) = fixed in same position each year. Fall Band (r) = random and band moved 8 inches laterally each year prior to planting corn.

** This 80-lb/A P treatment first applied in fall, 1999.

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.

Tillage: Corn	Tillage: Soybean	Placement*	P_2O_5 lbs/A	Yield 2002 (bu/A)	Yield '98-'02 Avg. (bu/A)
No-till	No-till		0	48.0	50.5
No-till	No-till	Starter	40	51.9	52.4
Field cult	Spr disk		0	50.9	54.0
Field cult	Spr disk	Starter	40	53.0	54.6
Field cult	Spr disk	Fall band	40	52.8	54.1
Field cult	Spr disk	Spr bdct	80	54.1	54.9
Strip-till	No-till		0	51.3	52.6
Strip-till	No-till	Starter	40	51.8	51.8
Strip-till	No-till	Fall band (f)	40	52.0	53.8
Strip-till	No-till	Fall band (r)	40	50.4	52.5
Strip-till	No-till	Fall band (f)	80**	50.0	
Chisel fc	Chisel fc		0	50.6	52.1
Chisel fc	Chisel fc	Starter	40	54.6	54.6
Chisel fc	Chisel fc	Fall bdct	80	52.3	55.2

* Fall Band (f) = fixed in same position each year prior to planting corn. Fall band (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.

Soybeans. When averaged across similar P management strategies, yields among the four tillage systems in 2002 were not statistically significant (Table 4). Yield averaged 50.2 bu/A on plots that had not received starter and 52.8 bu/A on plots that had. A tillage by starter fertilizer interaction was not found.

Soybean yields were significantly affected by the tillage system when averaged across 5 years (1998 to 2002). Highest yields occurred with the one-pass and chisel systems with somewhat lower yields for the strip-till and no-till systems (Table 4). Yield did not respond to residual starter effect when averaged across tillage systems. A tillage by starter interaction did not occur.

Economic Return

Corn. Substantial economic return was obtained at the low P-testing site. Return was greatest with broadcast P (100 lbs/A of P_2O_5) at $120/A/yr, intermediate with in-row starter (50 lbs/A of P_2O_5) at $95/A/yr, and least for "deep" banding (50 lbs/A of P_2O_5) at $88/A/yr.

Economic return to fertilizer P on high P-testing site was virtually negligible.

Soybeans. On the low P-testing site, economic return to the residual P ranged from $57 to $113/A/yr. Economic return was greatest for broadcast P at $100/A/yr, intermediate for in-row starter at $76/A/yr, and least for "deep" banding at $63/A/yr.

Similar to the corn phase of the rotation, economic return to fertilizer P on high P-testing soil was negligible.

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