MINNESOTA

Soybean Response to Residual Phosphorus for Various Placements and Tillage Practices

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Row-crop agriculture in the Mississippi River Basin is under intense pressure to reduce sediment and nutrient losses by practicing less tillage and more precise application and placement of nutrients, especially nitrogen (N) and P. By keeping more crop residue at the soil surface, reduced tillage systems can limit sediment losses. The tillage system keeping the most residue at the surface is no-till. However, in the northern portions of the Corn Belt, corn yields are generally lower in no-till systems because of wetter and cooler soils at the time of planting. Other tillage systems are being investigated to find solutions offering adequate surface cover while providing good growing conditions. Currently used conservation tillage alternatives are strip tillage (strip-till) and one-pass secondary tillage.

Under very low soil test phosphorus (P) levels, significant soybean yield responses to residual P were observed for all placements in a Minnesota study. Banded applications at half the recommended broadcast rate were not sufficient to optimize soybean yields.

When soil tests are low, substantial soybean yield increases may result from residual P applied either broadcast or in bands the previous year for corn.

Strip tillage, or zone tillage, disturbs the soil to a depth of 7 to 8 in. and creates a 4 to 6 in. wide by 1 to 2 in. high mound of soil that is free of residue. The tilled area is warmer and drier at planting time. One-pass secondary tillage systems consist of no primary tillage in the fall and either field cultivation or a disking operation in the spring.

In the corn growing areas of Minnesota, soybeans frequently follow corn in crop rotations. The effects of surface residue on temperature and moisture are not considered as important for soybeans, which can be planted later when soils are drier and warmer. Therefore, strip-till is not normally performed for the soybean crop. Instead, where strip-till was used in the previous corn year, most producers revert to no-till for the subsequent soybean crop.

Most producers do not apply fertilizer prior to planting soybeans. They generally rely on the residual effects of fertilizer, primarily P and potassium (K), applied for the

TABLE 1. Soybean yields associated with each tillage practice, averaged across years (1998-2000) and similar P management practices.

Tillage	Soybean yield, bu/A	
	High P site	Low P site
No-till	53.4	41.5
One-pass	55.6	42.5
Strip-till (c); no-till (s)	53.7	43.5
Chisel	56.1	42.1

prior corn crop. Previous research in Minnesota has shown that under conventional tillage, soybeans generally respond best to broadcast applications of P. However, in reduced tillage systems, less soil disturbance limits the opportunity for incorporation of broadcast P fertilizers. Therefore, banded applications, as with starters or deep banding, serve as viable alternatives to broadcast applications and are commonly used for corn. Application of P below the soil as bands serves two purposes: 1) It places P in the soil volume where it is easily accessible by roots and 2) concentrated zones of P can decrease fixation, making P more readily available for plant uptake. For these reasons, the University of Minnesota recommends that rates of banded P be reduced to half the recommended broadcast rate at Bray P-1 greater than 5 parts per million (ppm). We tested this recommendation to understand how P management for corn affected soybean response in the subsequent growing season.

A study was begun in the fall of 1996 on a tile-drained Nicollet-Webster clay loam soil complex located at the Southern Research and Outreach Center, Waseca, Minnesota. The study utilized a corn-soybean rotation and several P and tillage management practices. Two adjacent sites were used. The high P site had been previously maintained at approximately 19 ppm Bray P-1 with periodic P fertilizer applications while in a corn-corn-corn-soybean rotation. The low P site had previously been in a continuous corn rotation and received no P for 15 years to mine soil P to very low levels (3 to 4 ppm Bray P-1). Tillage practices were no-till for both corn and soybean years, one pass of a field cultivator (for corn) or a disk (for soybeans) in the spring (one-pass), fall strip-till for corn [strip till (c)], followed by no-till for soybeans [no-till (s)], and chisel tillage (chisel) utilizing a chisel in the fall plus a field cultivator in the spring for both crops.

Phosphorus was applied only for corn. Phosphorus application methods for all tillage practices in the corn year included a check (no P) and a band application in the seed furrow at planting (starter). Broadcast applications with subsequent incorporation were made for the one-pass and chisel systems. The starter and broadcast P rates applied for corn every other year were 40 and 80 lb P_2O_5/A, respectively, for the high testing site and 50 and 100 lb P_2O_5/A, respectively, for the low testing site. For the strip-till and one-pass tillage practices, deep band P applications were made in the fall, prior to the corn crop, at rates of 40 and 50 lb P_2O_5/A for the high and low testing sites, respectively. In the strip-till system, two types of band positions were tested. In the fixed band treatment [deep band (f)], the band was placed about 5 in. deep, with the strip tiller in approximately the same place prior to each corn year. In the random band treatment [deep band (r)], the placements were offset by 8 in. between the two years when they were applied. In the one-pass system, the fall band treatment was placed about 5 in. deep in a band that ran at about

TABLE 2. Three-year average soybean yield responses (1998-2000) to residual P from starter fertilizer applied for corn the previous year on sites testing high and low in soil P.

Tillage for		P application	P_2O_5 applied, lb/A		Grain yield, bu/A	
Corn	Soybean	method	High P	Low P	High P	Low P
No-till	No-till	None	0	0	53.2	36.7
		Starter	40	50	53.5	46.4
One-pass	One-pass	None	0	0	55.5	37.6
		Starter	40	50	55.7	47.3
Strip-till	No-till	None	0	0	53.5	38.3
		Starter	40	50	53.2	48.8
Chisel	Chisel	None	0	0	56.0	33.7
		Starter	40	50	56.2	50.4
Average		None	0	0	54.6	36.6
		Starter	40	50	54.7	48.2

a 2º angle to where the corn row was planted. This assured that the fertilizer band was not located continuously under the corn row, but varied from directly under the row to as much as 15 in. from the row.

After each corn year, soybeans (Pioneer 91B64) were planted at a rate of 160,000 seeds/A in 8 in. rows using a drill. No fertilizer was applied to the soybeans to test the residual effects of P applied in the previous corn year.

Tillage Effects

The effects of tillage on soybean yield for both high and low P sites are shown in **Table 1**. At the low P site, there was no significant difference among the various tillage practices, and average yield for the site was 42.4 bu/A. On the high P site, soybean yields were 2 to 3 bu/A higher where either disk (55.6 bu/A) or chisel (56.1 bu/A) tillage had been done compared to no-tillage.

In **Table 1** and the following tables, the high P site exhibited higher overall yields than the low P site. Although a statistical comparison between the two sites is beyond the scope of this study, the higher yields associated with the high P site are suspected to be largely due to better P soil fertility.

Residual Effects of P Applied as a Starter Band

Soybean yield response to residual P applied in starter fertilizer in the previous year for corn are shown in **Table 2**. At the high P site, no response was observed for any tillage practice. At the low P site, significant responses occurred for all tillage systems. Yield increases were 9.7, 9.7, 10.5, and 16.7 bu/A for the no-till, one-pass, no-till following strip-till, and chisel tillage practices, respectively. Corn grain yield responses behaved similarly for each tillage practice. The overall response to starter, averaged across all tillage systems, was 11.6 bu/A.

Testing the Efficiency of Banded P

The effects on soybean yield of reducing banded rates to half the recommended broadcast rates are shown in **Table 3**. At the high P site, there was no yield difference from residual P with either broadcast or banded P applications. At the low P site, soybean yields from the broadcast P treatments were significantly greater (3.7 to 4.9 bu/A) than yields from the starter P treatments. These data suggest that band applications of P applied to corn at a half-rate to low testing soils do not supply sufficient residual P to optimize soybean yields in the following year compared to broadcast applications of P at the fully recommended rate.

Evaluating Residual Effects of Different Band Placements of P

Soybean yield responses to residual P from various band placements in the previous corn year are shown in **Table 4**. At both the high and low P sites, no significant yield difference was detected between the residual effects of P applied as starter or in deep bands in the one-pass tillage system. In no-till following the strip-till system, significantly lower soybean yields were produced

TABLE 3. Three-year average soybean yield responses (1998-2000) to residual P from starter and broadcast P applied to corn for one-pass and chisel cultivation tillage practices on sites testing high and low in soil P.

Tillage for		P application	P_2O_5 applied, lb/A		Grain yield, bu/A	
Corn	Soybean	method	High P	Low P	High P	Low P
One-pass	One-pass	None	0	0	55.5	37.6
		Starter	40	50	55.7	47.3
		Spring broadcast	80	100	54.8	52.2
Chisel	Chisel	None	0	0	56.0	33.7
		Starter	40	50	56.2	50.4
		Fall broadcast	80	100	56.4	54.1
Average		None	0	0	55.8	35.7
		Starter	40	50	56.0	48.9
		Broadcast	80	100	55.6	53.2

from residual P when fall band locations were offset from year to year [fall band (r)]. No yield reductions were detected when P was placed in the same position during each strip tillage operation [fall band (f)].

Summary

Soil test P level is an important factor for understanding soybean yield responses to residual P from various P placements and tillage practices. Placement is less of a consideration when soil tests are high. However, when soil tests are low, substantial yield increases may be seen from residual P applied either broadcast or in bands the previous year for corn. Reducing banded rates to half the rate recommended for broadcast applications did not optimize yields and overestimated the efficiency of P banding in this study. BC

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TABLE 4. Three-year average soybean yield responses (1998-2000) to residual P from starter and deep band P applied to corn for one-pass and no-till following strip-till practices on sites testing high and low in soil P.

Tillage for		P application	P_2O_5 applied, lb/A		Grain yield, bu/A	
Corn	Soybean	method	High P	Low P	High P	Low P
One-pass	One-pass	None	0	0	55.5	37.6
		Starter	40	50	55.7	47.3
		Fall band	40	50	54.8	47.6
Strip-till	No-till	None	0	0	53.5	38.3
		Starter	40	50	53.2	48.8
		Fall band (f)	40	50	54.2	48.1
		Fall band (r)	40	50	54.6	43.9

Iowa: No-Tillage Soybean Response to Banded and Broadcast and Direct and Residual Fertilizer Phosphorus and Potassium Applications

Researchers evaluated the response of soybeans to fertilizer phosphorus (P) or potassium (K) placement and rates, along with residual and direct-placed fertilization, over a two-year period (1995-1996). Studies (two P and two K tests) were conducted on farmer fields with 10-year histories of no-till. In addition, a P experiment was established on one of Iowa State University's research farms. Treatments on farmer fields included two rates of P, 0 and 40 lb P_2O_5/A, or two rates of K, 0 and 55 lb K_2O/A, placement of fertilizer (surface broadcast or subsurface band 2 in. beside and 2 in. below the seed), and time of fertilizer application. Treatments on the research farms were similar except the P fertilizer rates were 0, 40, 80, and 160 lb P_2O_5/A.

Placement effects were variable for leaf P or K concentration, and grain yields for broadcast P and K were as good as or better than banded applications. Researchers pointed out that there might be an advantage to applying P directly to the soybean crop, at least when soil test levels are optimum or lower. BC

Source: Buah, Samuel S.J., Thomas A. Polito, and Randy Killorn. 2000. Agron J. 92: 657-662.