MINNESOTA

Corn Response to Phosphorus Placement under Various Tillage Practices

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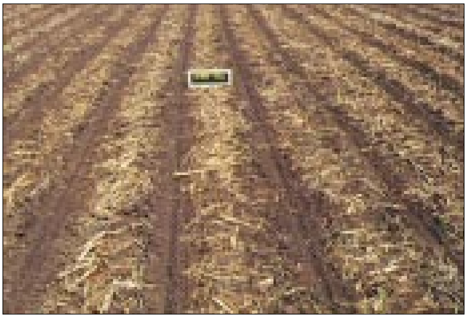
Row-crop agriculture in the Mississippi River Basin is under intense pressure to reduce sediment and nutrient losses by practicing less tillage and more precise application and placement of nutrients, especially nitrogen (N) and P. By keeping more crop residue at the soil surface, no-till can reduce sediment losses. However, 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 tillage 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. In these northern climates, where soils are cold at the time of planting and are slow to warm, alternatives to no-till are being examined.

Under very low soil test phosphorus (P) levels, large responses to P were observed for all placements. Banded applications at half the recommended broadcast rate were not sufficient to optimize corn grain yield.

Conservation tillage alternatives currently used are strip tillage and one-pass secondary tillage. Strip tillage (strip-till), 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 (see photo). Corn can be planted early and directly into the strip area that is warmer and drier. One-pass secondary tillage consists of no primary tillage in the fall 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.

In conservation tillage systems, placement of P is an important management consideration. Less soil disturbance limits the opportunity for incorporation of P fertilizers that are broadcast on the soil surface. Banded applications of P, as with starters or deep banding, serve as viable alternatives to broadcast applications. Application of P below the soil in bands serves two purposes: 1) It places P in the soil volume where it is easily accessed by roots and 2) concentrated zones of P can decrease P fixation, making it 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 levels of greater than 5 parts per million (ppm). We tested this recommendation to understand how best to manage P for the various tillage practices currently being used.

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-



Distribution of residue is shown in a field where strip tillage has been performed.

soybean rotation and several P and tillage management practices on two adjacent sites. 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 continuous corn and received no P for 15 years, resulting in very low levels (3 to 4 ppm Bray P-1). Tillage practices were no-till, one pass of a field cultivator in the spring (one-pass), fall strip-till, and conventional tillage (conventional) utilizing a chisel in the fall plus a field cultivator in the spring.

Phosphorus application methods for all tillage practices included a check (no P) and a band application in the seed furrow at planting (starter). Broadcast applications (bdcst.) with subsequent incorporation were made for the one-pass and conventional systems. The starter and broadcast P rates applied prior to 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 next season's corn crop, at rates of 40 lb P_2O_5/A for the high testing site and 50 lb P_2O_5/A for the low testing site. 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 a 2° 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.

Corn (Pioneer 36R10) was planted in 30 in. rows at a population of 32,000 seeds/A. Banded applications of P also contained a small amount of N. It was applied in the bands at rates of 15 to 20 and 11 to 16 lb/A at the low and high P sites, respectively. Small amounts of supplemental N, applied as a surface dribble, were added near the rows of plots not receiving banded P applications. This allowed the effects of P placement to be isolated and evaluated separately from the effects of N placement. Additional N to meet the season-long need was broadcast as urea + Agrotain on all plots two weeks after planting.

Tillage Effects

The low P site had no significant difference among tillage practices; yields were 121, 129, 128, and 128 bu/A for the no-till, one-pass, strip-till, and conventional systems, respectively, averaged over the four years. On the high P site, the one-pass, strip-till, and conventional systems produced similar yields of 169, 167, and 171 bu/A, respectively. The no-till system produced significantly lower yields than the others, averaging 160 bu/A.

In **Table 1** and the following tables, the high P site exhibited higher overall yields

TABLE 1. Corn grain yield response to starter fertilizer under no-till, one-pass, strip till, and conventional tillage practices on sites testing high and low in soil test P.

Tillage	P application method	P_2O_5 applied, lb/A High P site	P_2O_5 applied, lb/A Low P site	Grain yield, bu/A (1997-2000 avg.) High P site	Grain yield, bu/A (1997-2000 avg.) Low P site
No-till	none	0	0	160	102
	starter	40	50	159	141
One-pass	none	0	0	168	104
	starter	40	50	171	153
Strip-till	none	0	0	164	103
	starter	40	50	169	151
Conventional	none	0	0	171	103
	starter	40	50	172	154
Average	none			166	103
	starter			168	150

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.

Corn grain yield response to starter fertilizer applications are shown in **Table 1**. At the high P site, no significant response to starter was observed for any tillage practice. At the low P site, significant responses to starter occurred for all tillage systems. Yield increases were 39, 49, 48, and 51 bu/A for the no-till, one-pass, strip-till, and conventional tillage practices, respectively. Corn grain yield responses behaved similarly for each tillage practice. The overall response to starter, averaged across all tillage systems, was 47 bu/A.

TABLE 2. Corn grain yield response to starter and broadcast applications for one-pass and conventional tillage practices on sites testing high and low in soil test P.

Tillage	P application method	P_2O_5 applied, lb/A: High P site	P_2O_5 applied, lb/A: Low P site	Grain yield, bu/A (1997-2000 avg.): High P site	Grain yield, bu/A (1997-2000 avg.): Low P site
One-pass	none	0	0	168	104
	starter	40	50	171	153
	spring bdcst.	80	100	174	164
Conventional	none	0	0	171	103
	starter	40	50	172	154
	fall bdcst.	80	100	176	166
Average	none			170	104
	starter			172	154
	bdcst.			175	165

TABLE 3. Corn grain yield response to starter and deep band P applications for one-pass and strip tillage practices on sites testing high and low in soil test P.

Tillage	P application method	P_2O_5 applied, lb/A: High P site	P_2O_5 applied, lb/A: Low P site	Grain yield, bu/A (1997-2000 avg.): High P site	Grain yield, bu/A (1997-2000 avg.): Low P site
One-pass	none	0	0	168	104
	starter	40	50	171	153
	fall band	40	50	164	144
Strip till	none	0	0	164	103
	starter	40	50	169	151
	fall band (f)	40	50	164	147
	fall band (r)	40	50	169	139

Testing the Efficiency of Banded P

The effects on corn grain yield of reducing banded rates to half the recommended broadcast rates are shown in **Table 2**. At the high P site, there was no response to either broadcast or banded P applications. However, at the low P site, corn grain yield was increased significantly by both application methods. Broadcast applications produced an average of 11 and 12 bu/A more than banded applications for the one-pass and conventional tillage practices, respectively. Broadcasting P in the spring followed by field cultivation (one-pass) produced similar yields to fall-applied P incorporated by a chisel. Reducing banded applications to half the recommended broadcast rate on very low testing soils was not sufficient to optimize corn yields in this study and reduced yields by an average of 12 bu/A.

Evaluating Different Band Placements

Corn grain yield responses to various band placements are shown in **Table 3**. At both the high and low P sites in the one-pass tillage system, yields were significantly lower when P was deep-banded in the fall compared to applying P in starter at planting. Significantly lower yields than those attained with starter P were also seen in the strip-till system on the low P site 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 from year to year in the strip-till system [fall band (f)].

The lower yields for the fall, deep band P treatments described above were largely due to 12 to 21 bu/A reductions found in 2000 for these treatments. These reductions

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were surprising and are not easily understood. One possible explanation is the distance between the banded P and the seed which could have been an issue in the 2000 year when the seedbed conditions were very dry at planting. Seventeen days later and about one week after seedling emergence, frost occurred one day and temperatures were in the 30s for three days. This was followed by more than 5 in. of rain and saturated soils for the next two weeks. Therefore, reduced rates of root development could have been a factor.

Summary

Soil test P level is an important factor for understanding corn grain yield responses to 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 when P is applied either broadcast or banded. 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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