Broadcast and Deep Band Placement of Phosphorus for Soybeans Managed with Ridge Tillage

By A.P. Mallarino and R. Borges

Phosphorus (P) fertilization frequently increases yield of soybean on low P-testing soils in ridge-till systems in Iowa. Yields associated with broadcast and banded P applications usually do not differ. However, banded P often increases early P uptake more than broadcast P.

Fourteen trials with soybeans were evaluated in farmer fields managed with ridge-till during 3 years. All fields had been planted to corn the previous year, and the fields had 2 to 7 year histories of ridge tillage. Crop and soil management practices were those used by each farmer, except for P and potassium (K) fertilization. Row spacing was 38 in. except for Site 3, where it was 36 in.

Phosphorus rates were 0, 29, and 115 lb P_2O_5/A, applied as granular triple superphosphate (0-46-0). The highest P rate approximately represented the 2-year rate currently recommended by Iowa State University for the corn-soybean rotation when soil test P (STP) is in the Low interpretation class (9 to 15 parts per million [ppm]), Bray P-1 or Mehlich-3 tests.

Placement methods were broadcast and deep bands. The bands were approximately 6 to 8 in. deep and 1 in. wide. Banding equipment placed the fertilizer either through a vertical slit opened from the top of the ridge or through one ridge shoulder. The coulter-knife combinations opened and closed narrow slits (1 to 2 in.) that caused a minimum amount of disturbance of the ridge and placed the band 2 to 3 in. below the planned seeding depth, approximately under the planned seed row. The broadcast control received no fertilizer and the ridges were not disturbed until planting. The band control received a coulter-knife pass without fertilizer.

Soybean response to direct P application was evaluated in seven trials (Sites 1 through 7). The treatments were applied in the fall (October or November) after harvesting the previous corn crop and before soils had frozen. At the remaining seven trials (Sites 8 through 14), P was applied 1 year earlier (in the fall prior to the previous corn crop).

Soil samples were collected immediately before applying P treatments. Soil samples, comprised of 16 cores each, were collected from a depth of 0 to 6 in. One sample was collected from the ridges and another between the ridges (or valleys). At Sites 1 through 7 (direct fertilization), composite soil samples were collected from each experimental area. At Sites 8 through 14 (residual fertility), separate composite samples were collected from fertilized and unfertilized plots. Samples were analyzed for P with the Bray P-1 test.

Aboveground portions of 10 soybean plants were sampled from each plot at the V5 to V6 growth stages. Total P concentrations in the plant tissue were measured and total P uptake calculated, based on dry matter accumulation. Grain yields were corrected to 13% moisture.

Soybean Grain Yield. As **Table 1** shows, statistically significant grain yield responses occurred at four sites: Sites 1 and 2 (P applied before soybean) and Sites 10 and 13 (P applied prior to the previous year's corn crop). Yield response to P fertilization reached a maximum at the lowest rate of applied P (29 lb P_2O_5/A). Differences between placement methods were observed at two sites. At Site 2, both placement methods increased soybean yield, but banded P provided a small additional increase. At Site 10, only the broadcast application significantly increased yield. The inconsistent yield response to P placement method is in contrast with the benefit of deep-band K placement shown in a similar Iowa study (Mallarino et al., 2001).

Soils of the four responsive sites tested 7 to 18 ppm Bray P-1, according to average results for soil samples collected in and between the ridges (**Table 2**). Three of the responsive sites tested Very Low or Low and one tested Optimum (16 to 20 ppm) according to current Iowa State University interpretations (Sawyer et al., 2002). Across the entire study, eight sites tested Very Low or Low. According to current soil test interpretations, soybeans grown on soils testing in these ranges would be considered likely to respond to P fertilization. There is a 25% or lower probability of a small response in the Optimum class, for which maintenance fertilization is recommended.

Banding of P for ridge-till soybeans may increase early plant P uptake.

With only one exception, soil samples taken from the ridges were higher in P than those taken between the ridges (valleys). This is consistent with findings from other investigations in Iowa with corn (Mallarino et al., 2001) as well as studies from other states. A reclassification of the sites according to STP results from samples taken solely from the ridges indicated that only six sites tested Very Low or Low (three of which responded significantly to P fertilization) while four tested Optimum (one of which was responsive). These results, and similar results for ridge-till corn not shown in this article, were

Table 1. Soybean grain yield and P uptake at the V5 to V6 growth stages as affected by P fertilization and placement. Data are averages of two application rates (29 and 115 lb P_2O_5) because yields for these two rates were statistically similar at all sites.

P timing	Site	Control yield	Change in soybean grain yield		Control P uptake	Change in P uptake	
			Broadcast	Band		Broadcast	Band
		---------- bu/A ----------			------ 10^{-5} lb P_2O_5/plant ------		
Direct	1	32.3	**3.3**	**5.5**	1.59	**0.39**	**0.47**
	2	44.0	**3.8**	**4.3**	2.04	**0.25**[1]	**1.09**[1]
	3	59.6	2.7	-1.0	4.13	0.06	**0.43**
	4	40.2	-0.3	1.4	1.94	**0.18**	**0.57**
	5	49.2	1.0	-0.9	1.61	-0.20	**0.32**
	6	44.6	0.7	1.4	2.54	-0.02	0.31
	7	45.1	1.1	0.9	3.85	**0.32**	**0.61**
Residual	8	47.4	2.2	3.0	1.98	-0.25	0.10
	9	43.4	-1.8	-0.6	2.67	-0.16	**0.62**
	10	42.8	**1.5**	0.9	2.68	-0.05	**0.48**
	11	43.7	0.1	2.2	3.64	-0.12	0.36
	12	47.7	0.4	1.9	1.90	0.03	0.07
	13	30.7	**2.7**	**2.5**	2.82	0.20	0.08
	14	33.8	4.5	1.4	3.02	-0.15	-0.46

[1]P uptake at the higher P application rate.
Bold type indicates statistically different from the control (p<0.1).

Table 2. Initial Bray P-1 soil test levels and soil pH for various sampling positions. All levels are for samples taken from a 0 to 6 in. depth.

P Timing	Site	Years in ridge-till	Soil test P levels: In ridges	Between ridges	In and between ridges	Soil pH in and between ridges
			ppm			
Direct	1	6	8	7	7	6.5
	2	5	14	9	11	6.1
	3	2	66	56	61	6.5
	4	5	25	15	20	5.6
	5	3	26	20	23	6.4
	6	4	20	7	14	6.1
	7	6	12	7	10	6.4
Residual	8	7	16	16	16	7.0
	9	4	17	8	13	6.1
	10	6	13	9	11	6.5
	11	6	10	8	9	6.3
	12	4	13	8	11	6.0
	13	5	20	17	18	6.9
	14	5	24	15	20	6.4

used to update Iowa soil sampling recommendations for the ridge-till system (Sawyer et al., 2003). The updated guidelines recommend taking 0 to 6 in. samples from the top and shoulders of the ridges (avoiding valleys) to improve the prediction of yield response. Consideration of deep samples (6 to 12 in., not shown) indicated no benefits in prediction of response. Higher STP results for the ridges may also explain why the lowest rate of applied P (29 lb P_2O_5/A) was sufficient for statistically maximum yields. Only one site (Site 1) tested Very Low in the ridge, and this level was borderline with the Low class.

Early Season P Uptake. Uptake of P by soybean plants at the V5 to V6 growth stage was often influenced by P fertilization (**Table 1**). This was the result of the additive effects of slight (typically insignificant) responses in early plant dry matter accumulation and tissue P concentration (not shown). With the exception of Site 2, P applied at the lower rate (29 lb P_2O_5/A) increased uptake to the same extent as the higher rate (115 lb P_2O_5/A). Consequently, P uptake values reported in **Table 1** represent the lower P application rate, except for Site 2, where reported P uptake is associated with the higher fertilization rate.

When P was applied prior to the soybean year, P uptake increased significantly at most sites (six of the seven sites). At two of these sites (Sites 3 and 5), banded P increased soybean P uptake when broadcast P did not, and banded P led to greater P uptake than broadcast P at other responsive sites. When P was applied prior to corn grown the previous year, P uptake increased significantly at two of the seven sites (Sites 9 and 10). At Site 9, response was observed to banded P only. At site 10, both broadcast and banded P significantly increased P uptake when results were averaged over P rates (not shown). Across all sites, increased P uptake was observed on soils ranging from Very Low to Very High in STP. On average, P uptake was greater for banded P than for broadcast P.

Changes in Soil Test P. To evaluate changes in STP over time, seven sites were examined where P had been applied prior to the previous year's corn crop (Sites 8 through 14). The low P application rate seldom changed STP levels—an expected result because this rate was lower than the P removal rate associated with grain harvest. Consequently, only STP changes associated with the high P rate (115 lb P_2O_5/A) are presented. When fertilizer P was broadcast, STP levels in the ridge did not

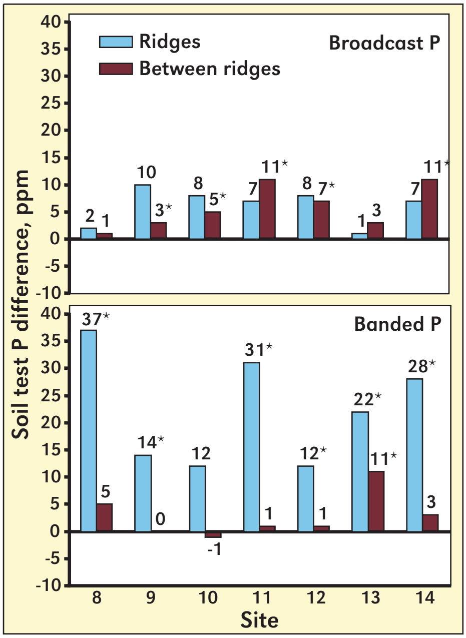

Figure 1. Effect of broadcast and banded P (115 lb P_2O_5/A) on soil-test P of ridges and areas between ridges (valleys) measured after crop harvest. Differences presented are between fertilized and unfertilized treatments. Values followed by an asterisk represent statistically significant (p<0.1) changes due to fertilization when compared to unfertilized treatments.

change significantly compared with the non-fertilized control. However, STP levels in the valleys between the ridges increased significantly at five sites (**Figure 1**).

Banded P significantly increased STP in the ridge at six of the seven sites (**Figure 1**). However, it increased STP between the ridges at only one site (Site 13).

The way in which P placement alters STP has implications on environmental nutrient management. Concentrated surface water flow occurs between ridges, mainly on trafficked areas. Because banded P seldom increases STP between ridges and also places P below the surface, this placement method is expected to reduce the chances for offsite P transport into water bodies.

Summary

Soybean yield response to P fertilization was frequent in low-testing soils, infrequent in soils testing Optimum, and did not occur in high-testing soils. Collecting soil samples solely from ridges improved the prediction of yield response to applied P. When responses occurred, STP in the ridges was 20 ppm or less. The P placement method did not influence yield response consistently, which was in contrast with the clear benefits of deep K placement observed in parallel Iowa studies with corn and soybean. However, early plant uptake of P by soybean was increased more frequently and to a greater extent by banded P than by broadcast P. Furthermore, banded P increased STP primarily in the ridges, while broadcast P increased STP levels primarily in the soil between the ridges. Therefore, banded P may not increase grain yield more than broadcast P, but it is more likely to stimulate early plant P uptake and is a viable option for reducing the risk of P loss from ridge-till fields. BC

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