DEEP BANDING PHOSPHORUS AND POTASSIUM FOR NO-TILL CORN AND SOYBEAN[1]

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INTRODUCTION

The information presented is part of ongoing research to identify effective fertilizer placement methods and diagnostic tools for phosphorus (P) and potassium (K) in no-till corn and soybeans. There is uncertainty about soil test interpretations and cost-effective methods of fertilizer application for the no-till system. Moreover, producers are uncertain about the value of soil testing in conservation tillage because of large variability and lack of knowledge concerning techniques for collection of samples. Broadcast placements are less costly than banded placements but they seem inefficient for no-till fields because fertilizers are not incorporated. Because of the reduced movement of P and K in soils, broadcast applications result in stratification of these nutrients and accumulations within the top 2 or 3 inches of the soils. Although residue cover usually improves root growth and nutrient uptake efficiency at shallow soil layers, the stratification could result in lower total P and K uptake by plants especially when topsoil is dry.

METHODS

Ten long-term trials with corn-soybean rotations were established on five Iowa State University research farms in 1994 and were evaluated until 1996. Twenty short-term trials with corn (11) and soybeans (9) receiving various P and K combinations were established during 1994, 1995, and 1996 on farmers' fields having long histories of no-till management. At research farms, the experimental areas were subdivided for separate P and K trials and corn and soybean crops (both crops were grown each year). Treatments were placements and rates of P and K fertilizers (dry granulated fertilizers), which were replicated three times. Rates used were 0 to 112 lb P_2O_5/acre and 0 to 140 lb K_2O/acre. The placements were broadcast, deep banded, and banded with the planter. Fertilizers were applied every year to corn and soybean in the rotation. At farmers' fields, the rates used were similar but an additional P-K mixture of the high rates was included. The placements evaluated at these trials were only broadcast and deep banded. The broadcast and deep banded fertilizers were applied in spring for all trials conducted in 1994 and in the fall thereafter. The coulters and knives of the deep bander were setup to apply fertilizer at a 6 to 7 inch depth and at the corn row width used by each producer (30 to 38 inches). The planter-banded fertilizer applied at research farms was banded 2 inches beside and 2 inches below the seeds. There were two controls at all trials. One was an absolute control and the other was a control that received an "empty coulter-knife" deep-band pass.

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Corn was planted in 30-inch rows at all trials except at one farmer field where the row spacing was 38 inches. In deep-banded plots and those that received the empty coulter-knife pass, the rows were on top of the fall-applied knife tracks. Soybeans was planted in 30-inch rows at the research farms and drilled in narrow rows at all farmers' fields. In the research farms and for the deep-band treatments, the soybeans were planted on top of the knife tracks.

RESULTS

The study encompassed a wide variety of growing conditions and mean yields across sites ranging from 96 to 203 bu/acre of corn and 31 to 63 bu/acre of soybeans. Study of yield responses of either crop at research farms or farmers' fields showed that there were no statistically significant differences ($P \leq 0.05$) between the two P fertilization rates and the two K fertilization rates. Also, there were no significant interactions among nutrients, rates, and placements at any site. Because of these results, and to simplify the presentation and discussion of data, only average responses to fertilization and placement will be discussed in this report.

Fertilizer placement for corn.

Phosphorus fertilization increased corn grain yields significantly ($P \leq 0.05$) at several sites that tested very low or low in soil-test P (0-6 inch depth) but at no site that tested optimum or above. Statistically maximum yields were achieved with the lowest rate used (28 lb P_2O_5/acre) at all sites and for all placements. The lowest soil-test P value observed across sites was 5 ppm and the highest was 35 ppm. The boundaries of Iowa State University interpretation classes (Bray-1 extractant) very low, low, optimum, high, and very high are 8, 16, 20, and 30 mg P/kg, respectively. The placement treatments did not differ ($P \leq 0.05$) at any of the 26 trials, although in a few trials the band treatments produced slightly higher yields. Data in Fig. 1 show the average responses to P placement of the group of sites that responded to P and for all trials. The lack of difference observed between the broadcast and deep-band placement was consistent at research farmns and farmers' fields. Unfortunately, the planter-band P placement was not evaluated at farmers' fields.

The lack of grain yield response at sites with soil-test P optimum or above coincides with published results for Iowa fields managed with chisel-plow or ridge tillage and broadcast fertilization. The soils differed in the stratification of soil-test P, which reflected the differences in histories of no-till management and P fertilization. On average, the soils had 75% more soil-test P in the 7.5 cm depth than in the 7.5 to 15 cm depth and the range across sites was 10 to 213%. Responses to P placement, however, were not observed even in soils with high stratification. The results suggest that soil-test P stratification, P placement methods, and sampling depth for P are not major issues for no-till Iowa soils and weather condictions similar to those included in this study.

Potassium fertilization increased grain yields at five sites, although statistically maximum yields were always achieved with the lowest rate used (35 lb K_2O/acre). These responses were not expected because all soils tested optimum or higher in soil test K. The lowest soil-test K value observed was 92 ppm and the highest was 262 ppm. The boundaries of Iowa State University interpretation classes (ammonium acetate extractant) very low, low, optimum, high, and very high are 60, 90, 130, and 170 mg/kg, respectively. The K placements differed statistically at only two sites, and at both sites the deep-band placement produced higher yields than other placements. When data from all sites were combined, however, responses to both K fertilization and deep-band placement were significant. The finding that significant responses to placement occurred in only a few sites is in contrast with the significance of placement in the analysis over sites. This result can be explained, however, by small but frequent yield advantage for the deep-band placement at many sites. Data in Fig. 1 shows the average responses to K placement of the group of sites that responded significantly to K fertilization and for all trials. The advantage of the deep-band placement over the broadcast placement was consistent at research farmns and farmers' fields. Unfortunately, the planter-band P placement was not evaluated at farmers' fields.

The small but frequent significant responses to K fertilization in soils that tested optimum or above in soil test K contrast with results for P and with previous research on Iowa soils managed with conventional tillage. Although responses to deep-banded K (compared with broadcast or planter-banded K) usually were small, they occurred at many sites. In most instances, however, the yield differences would not offset higher application costs. The lack of sites with low soil test K and the small yield responses to K precludes a significant correlation study across sites. Relative yield responses to deep-banded K and soil K at various depths across all sites were not significantly correlated, however. Moreover, the sites in which the response to K placement was largest did not always have the largest soil K stratification. Although the K stratification in these soils was less than for P, in average the soils had 40% higher K in the 0-7.5 cm depth than in the 7.5 to 15 cm depth.

It is likely that the responses to deep-banded K were related with weather conditions, particularly soil moisture in late spring or early summer (soil moisture was not measured). The yield response to deep-banded K relative to the response to broadcast K increased with increasing May rainfall and decreased with increasing June rainfall. Yields of nonfertilized plots were negatively correlated with May rainfall ($r = -0.49$) and positively correlated with June rainfall ($r = 0.48$), which suggests that May rainfall sometimes was excessive for corn growth and that June rainfall sometimes was deficient. These correlations provide no proof of a cause-effect relationship but they do suggest that response to deep-banded K was greater when there was little rainfall in June. It is likely that plant K uptake from shallow soil layers was reduced by dry conditions during this growth period and that the deep-banded K alleviated the problem.

Planting on the fall-applied coulter-knife track increased yields significantly at only three of 17 trials conducted in 1995 and 1996 (Table 1). Results for 1994 are not shown because there were no differences at any trial (this year all treatments were applied in spring). In all three responsive fields, application of deep-banded K further increased yields. These results are of practical significance for two main reasons. One, they show that planting on a coulter-knife track without deep banding K will seldom increase yields. Two, they show that responses to deep-banded K on grain yields were not due to the physical effects of the coulter and knife pass.

The fertilization and placement effects of both nutrients on corn early vegetative growth (V5 to V6 stages) differed markedly from effects on grain yields. Data for early growth are not shown in this presentation. The deep-banded and planter-banded P increased early plant growth markedly and frequently compared with the broadcast placement in many fields. Moreover, the planter-band P placement increased early growth more than the deep-band placement in some fields. The deep band or planter band K, however, did not increase early growth of corn at any site.

Table 1. Effect of planting on fall-applied coulter-knife track on yields of no-till corn at 17 trials.

		Soil test†		Treatment‡		
Site	Year	P	K	Control	Knife	Statistics§
				------ bu/acre -----		
1	1995	VH	H	102.6	101.3	ns
2	1995	L	O	146.5	146.7	ns
3	1995	VL	VH	101.1	106.9	*
4	1995	O	H	129.6	132.0	ns
5	1995	O	VH	156.9	162.7	*
6	1995	VH	VH	129.4	129.5	ns
7	1995	VL	H	117.7	111.3	ns
8	1995	L	VH	115.4	127.2	*
9	1995	VL	O	174.9	170.3	ns
10	1995	H	H	121.4	121.1	ns
11	1996	H	O	162.4	158.0	ns
12	1996	L	VH	148.3	145.4	ns
13	1996	VL	VH	99.6	101.1	ns
14	1996	L	H	144.4	146.0	ns
15	1996	O	VH	154.8	152.0	ns
16	1996	VL	O	113.4	124.5	ns
17	1996	L	O	102.6	106.7	ns
Means				137.5	138.3	ns

† Iowa State University soil-test interpretation classes Very Low, Low, Optimum, High, and Very High for samples collected from a 0 to 6-inch depth.
‡ Control = absolute control, Knife = coulter-knife track. These control plots received a high N rate but no P or K fertilizer for this cropping season.
§ * and ns = significant ($P \leq 0.05$) and nonsignificant treatment effect, respectively.

Fertilizer placement for soybeans.

Phosphorus fertilization increased soybean grain yields ($P \leq 0.05$) in four soils that tested very low or low soil test P, although responses did not occur at all low-testing soils. The P placement method influenced yields significantly at only one site, in which the two banded placements did not differ and both produced higher yields than the broadcast placement. The analysis of means over all sites showed no P placement effects. Data in Fig. 2 show the average responses to P placement of the group of sites that responded significantly to P and for all trials. The lack of difference observed between the broadcast and deep-band placement was consistent at research farms and farmers' fields.

Potassium fertilization increased soybean grain yields significantly ($P \leq 0.05$) at four sites. Similar to results for corn, these responses were not expected because most soils tested optimum or higher in soil test K. Although the K placement method did not affect yields significantly at any individual site, an analysis of means over all sites at research farms showed a statistically significant placement difference. Yields for the two banded placements did not differ but they were higher than yields for the broadcast placement. This result can be explained, however, by small but frequent yield advantage for the deep-band placement at many sites. Data in Fig. 2 shows these average responses. A similar apparent advantage for the deep-band placement over the broadcast placement at farmers' fields did not reach statistical significance. High rates of broadcast K did not offset the advantage of deep-banded or planter-banded K. The responses of soybeans to the two band placements, were not clearly related with deficient rainfall in late spring and early summer or with soil test K.

Planting soybeans on top of a fall-applied coulter-knife track did not affect grain yields either at a 30-inch or narrow-row spacing and data are not shown. Estimates at the V5 to V6 stage showed no evidence of effects on early growth either.

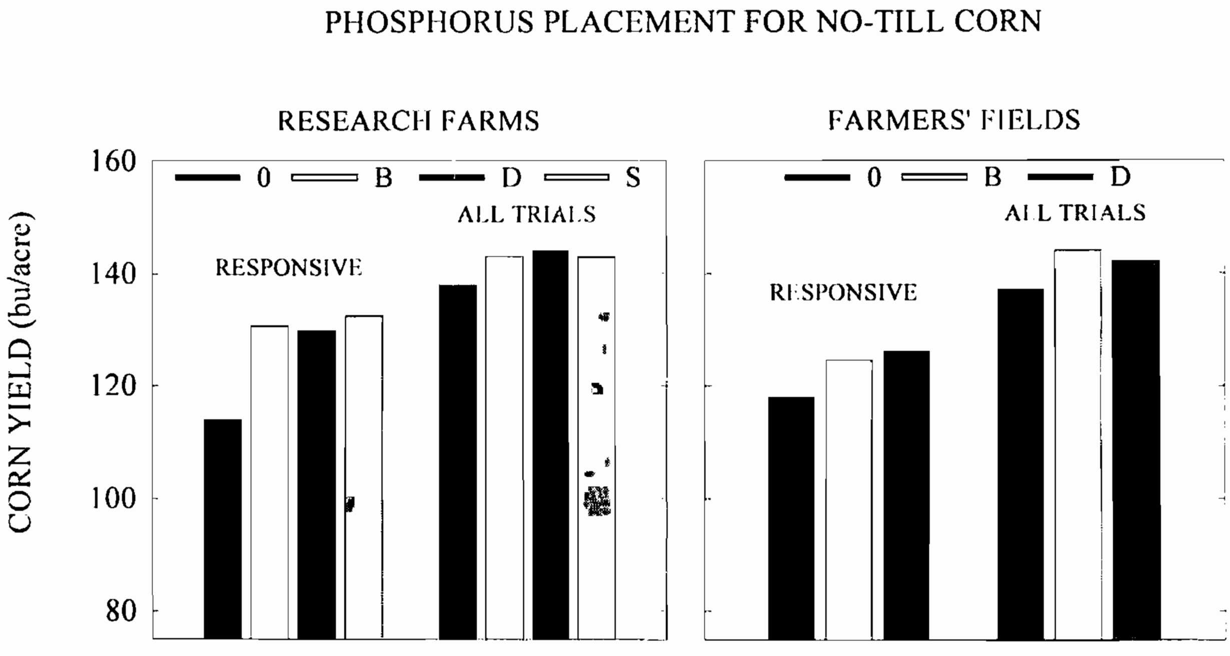
CONCLUSIONS

The results showed that P fertilization increased yields of no-till corn and soybeans in soils testing very low and low and that there were no differences among P placements. The two banded P placements increased yields of soybeans compared with the broadcast placement only at one site. Any of the placements evaluated are effective to alleviate P deficiencies in low-testing soils. In contrast, the banded P placements often enhanced early corn growth. This enhanced early growth, however, never translated into higher grain yields. The results indicate that recommended soil-test P interpretations and P fertilizer rates based on chisel-plow tillage also are appropriate for these no-till Iowa soils.

Potassium fertilization increased grain yields of no-till corn and soybeans in several soils that tested optimum or higher in soil test K. The responses of corn were higher for the deep-band placement than for broadcast or planter-band placements and seemed more related with deficient rainfall in late spring and early summer than with soil test K. The responses of soybeans were higher for the two band placement than for the broadcast placement and was not clearly related with deficient rainfall in late spring and early summer or with soil test K. In contrast to P, banded K did not enhance early growth of corn or soybeans.

Because the observed yield responses to deep-banded K usually were small, the cost-effectiveness of this placement compared with the broadcast and planter-band placements will be largely determined by differences in the costs of application.

Fig. 1. Average grain yield response of no-till corn to phosphorus and potassium placement for 26 trials conducted from 1994 to 1996 (0 = absolute control, B = broadcast, D = deep band, and S = planter band).



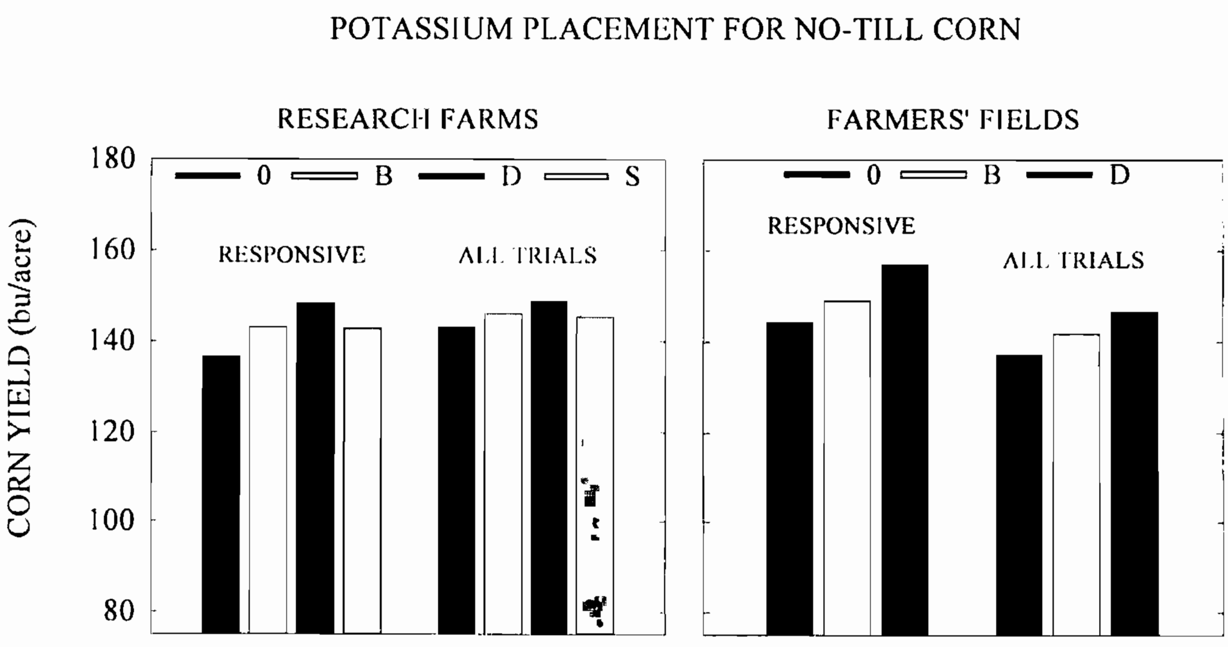
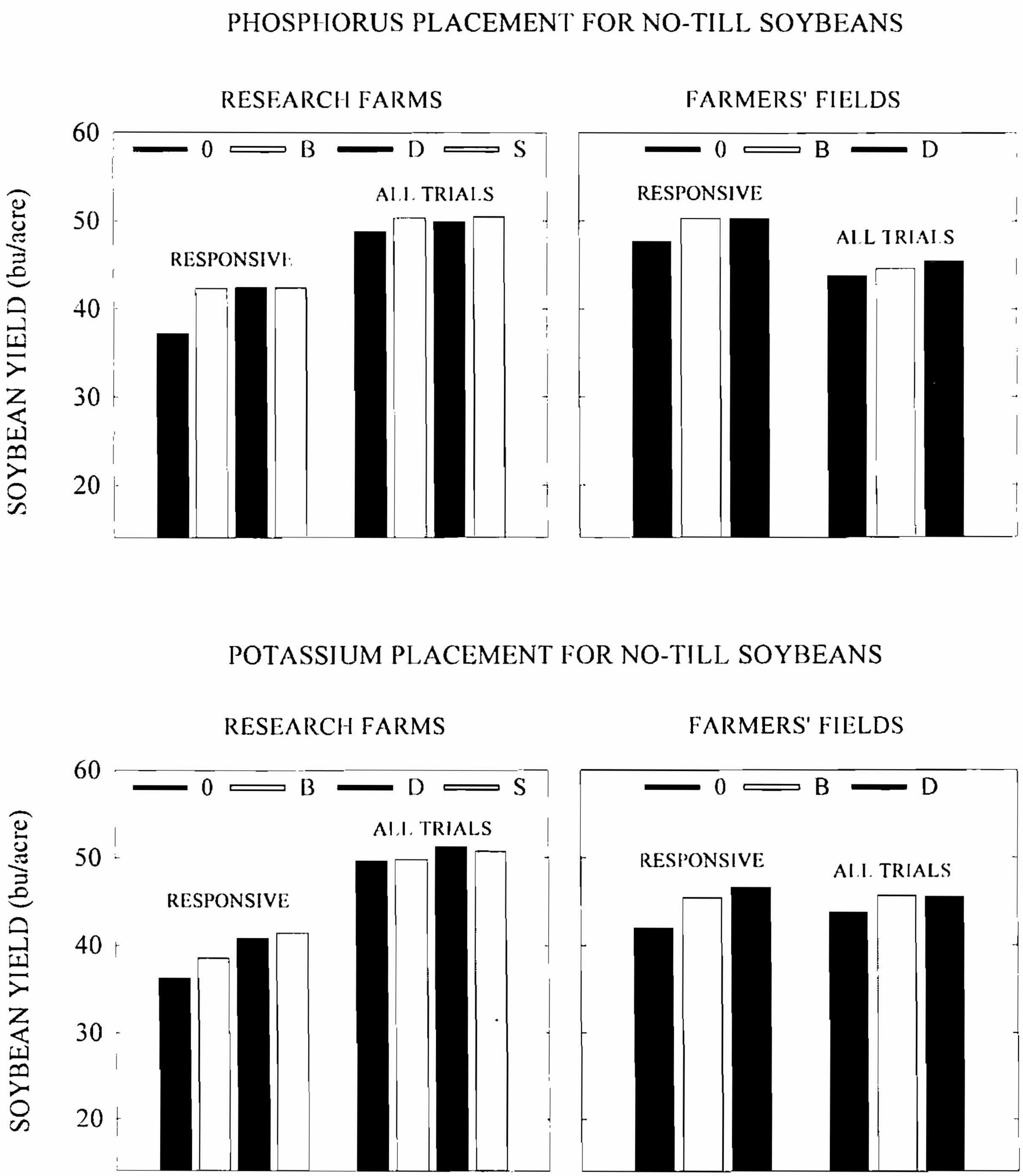


Fig. 2. Average grain yield response of no-till soybeans to phosphorus and potassium placement for 24 trials conducted from 1994 to 1996 (0 = absolute control, B = broadcast, D = deep band, and S = planter band).



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