

PLACEMENT OF PHOSPHORUS AND POTASSIUM FOR NO-TILL AND RIDGE-TILL

PART I: CORN

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(Editors' note: This article is the first of two on Antonio Mallarino's research with fertilizer placement and starters, research that has involved several PFI members. It's always a struggle to summarize complicated research in a popular format like a newsletter. If this report isn't enough for you, a more detailed report can be obtained directly from Dr. Mallarino, at 515-294-6200.)

This article summarizes results for corn of a research project initiated in 1994 to study fertilizer placement for phosphorus (P) and potassium (K) in no-till and ridge-till systems. A later article will describe results for soybeans. When we began, there was considerable uncertainty about cost-effective methods of fertilizer application and soil test interpretations for corn and soybeans grown with these systems. Broadcast fertilization is less costly than banded fertilization, but it could be inefficient because fertilizers are not incorporated (no-till) or are incorporated too late for early plant needs (ridge-till). Furthermore, banding of fertilizers into the root zone seems effective in reducing potential nutrient losses with water runoff.

We established ten long-term trials (five with P and five with K) with no-till corn-soybean rotations at five research farms. Twenty-four short-term trials (with P and K combinations) with no-till (11 trials) and ridge-till (13 trials) corn were established from 1994 to 1996 in producers' fields with their cooperation. Five PFI members were among these cooperating farmers. Treatments were placements and rates of P and K granulated fertilizers. At the research farms, fertilizers were 1) applied broadcast, 2) banded with the planter approximately 2 inches beside and below the seeds, or 3) deep-banded to a depth of 5 to 6 inches. At the farmers' fields, the fertilizers were applied broadcast or deep-banded. Fertilizer rates were 0, 28, 56, and 112 lb P₂O₅/acre and 0, 35, 70, and 140 lb K₂O/acre. The broadcast and deep-

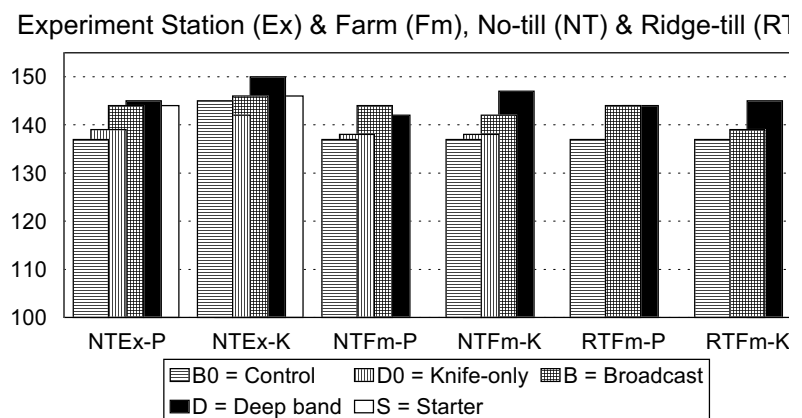
banded treatments in 1994 were applied in spring three to five weeks before planting and in 1996 were applied the previous fall. Nitrogen fertilizer was applied at rates 25 to 50% higher than local recommendations.

The study encompassed a wide variety of growing conditions, and mean yields for the treatments across sites ranged from 77 to 215 bu/acre. Study of yield responses at each site showed no statistically significant differences among P rates or among K rates and no significant interactions among nutrients, rates, and placements. Because of these results, and to simplify the data, only average responses to fertilization and placement are shown.

No-till, P

Phosphorus fertilization increased no-till corn grain yields significantly 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. When there was a yield response, statistically maximum yields were achieved with the lowest nonzero rate at all sites and for all placements. Yields from the placement treatments did not differ at any of the 26 trials, although in a few trials the band treatments produced slightly higher yields. Unfortunately, a planter-band P placement was not evaluated on farmers' fields. The soils differed in the stratifica-

Fig. 1. Banded, Deep-banded, and Starter P and K



Significance	NTEx-P	NTEx-K	NTFm-P	NTFm-K	RTFm-P	RTFm-K
Fertilizer	*	*	*	*	*	*
Placement		*		*		

tion of soil-test P. On average, the soils had 75% more P in the 0-3 inch depth than in the 3-6 inch depth. Responses to P placement, however, were not observed even in soils with large stratification. The lack of grain yield response at sites with soil-test P optimum or above coincides with previous results for Iowa fields managed with chisel-plow or ridge tillage and broadcast fertilization. The results suggest that soil-test P stratification, P placement, and sampling depth for P are not major issues for no-till Iowa soils and weather conditions similar to those included in this study (Fig. 1).

No-till, K

Potassium fertilization increased grain yields of corn at several sites, although statistically maximum yields were always achieved with the lowest non-zero rate used. These responses were not expected because all soils tested optimum or higher in soil-test K. The K placements differed statistically at only two sites. When data from all sites were combined, however, responses to both K fertilization and placement were significant. The deep-band placement produced higher yields than other placements. The significant response to placement in the analyses over sites can be explained by small but frequent yield advantage for the deep-band placement at many sites. The small but frequent responses to K fertilization in soils that tested optimum or above in K contrast with results for P and with previous research on Iowa soils managed with chisel-plow or ridge tillage and broadcast fertilization. Although responses to deep-banded K (compared with broadcast or planter-banded K) often were small, they occurred at many sites. Relative yield responses to deep-banded K and soil test 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 was less than for P, on average the soils had 40% higher K in the 0-3 inch depth than in the 3 to 6 inch depth. Responses to deep-banded K were better related with low rainfall in late June or early July than with soil-test K. 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.

The K placements differed statistically at the responsive (ridge-till) sites, and the deep-band placement produced the highest yields.

Ridge-till, P

Results for ridge-till trials conducted at farmers' fields are also summarized in Fig. 1. The results were similar to those for no-till corn. Phosphorus fertilization increased grain yields significantly at four sites and statistically maximum yields were achieved with the lowest rate used. The yields from P placements did not differ at any trial. One responsive site tested very low, one low, and one optimum when values were averaged for samples collected from a 0-6 inch depth from ridges and valleys. The lack of grain yield response to P at most sites that tested optimum or above coincides with previous results for Iowa fields managed with chisel-plow or ridge tillage and broadcast fertilization. There were several sites that tested low where responses were not observed and this is not surprising because other growth factors could have limited yields. However, soil-test P (0-6 inches) for the ridges was almost always higher than for the valleys. Studies of correlations between yield responses to P fertilization and soil-test P measured at different locations are not completed at this point. The results do suggest, however, that soil-test P from the ridges may be more important for predicting responses to P than soil-test P from the valleys.

Ridge-till, K

Potassium fertilization increased grain yields of ridge-till corn significantly at two sites, and statistically maximum yields were always achieved with the lowest rate used. These responses were not expected, because most soils tested high or very high in soil-test K when data from both ridges and valleys were averaged. Moreover, soil-test K for the ridges was even higher. The K placements differed statistically at the responsive sites, and the deep-band placement produced the highest yields. Although the K placements did not differ statistically over all sites, the deep-band placement produced on aver-

age 6 more bu/acre than the broadcast. The lack of sites with low soil-test K and the small yield responses to K prevents a significant correlation study across sites. Observations of the responses show, however, that yield responses to deep-banded K were not directly related to soil-test K, soil K stratification, or differences in soil-test K between ridges and valleys. Contrary to results for no-till corn, responses to deep-banded K in ridges were not clearly related to rainfall in late spring or early summer.

Knife Action

Planting on the fall-applied, zero-fertilizer coulters-knife track increased yields of no-till corn significantly only at four of 41 P, K, or P-K trials. Planting on ridges that received a fall-applied coulters-knife pass without fertilization did not affect yields at any of 13 trials (data not shown). These results are of practical significance for two main reasons. First, they show that planting on a coulters-knife track without deep banding K will seldom increase yields and second that grain yield responses to deep-banded K were not due to the effect of the coulters-knife pass.

Early Growth

The results of treatment effects on early corn growth (not shown) contrasted markedly with results for grain yields. Banded P fertilization (deep or with the planter) often increased early plant growth more than broadcast fertilization did on low-testing soils and

occasionally on high-testing soils. This result is in contrast with the lack of P placement effects on grain yield at any site. Potassium fertilization and placement, on the other hand, seldom increased early growth of corn. It is important to remember that most sites tested optimum or above in soil-test K. The few sites in which banded K increased early growth did not coincide with sites in which banded K increased grain yield. This general lack of K placement effects on early growth is in contrast with often small but frequent positive effects of deep-banded K on grain yields. Planting on the fall-applied coulters-knife-only track often increased early growth of no-till corn but did not increase early growth of ridge-till corn.

Concluding

In conclusion, the results suggest that some problems perceived by producers did not exist or were unimportant whereas others do exist. Perceptions about major yield losses because of broadcast P fertilization of no-till and ridge-till corn were unfounded. Phosphorus fertilization often increased yields in low-testing soils but the P placements did not differ at any site. Further enhancement of early growth due to banded P compared with broadcast P did not translate into increased grain yields. Also, soil sampling depth, soil-test interpretations, and fertilizer recommendations for P based on chisel-plow tillage also apply for no-till and ridge-till system. In ridge-till, soil sampling of ridges seems more appropriate. On the other hand, the results showed that broadcasting K or banding it with the

In a Nutshell

- Enhancements of early growth can be achieved by banding P fertilizer with planters or deep-banders but will seldom increase yields compared with broadcast fertilization. The deep banding of K, however, will seldom increase early growth but will often increase grain yields.
- Broadcasting K or banding it with the planter often (but not always) is inefficient for no-till corn. Similarly, broadcast K for ridge-till corn often (but not always) is an inefficient practice.
- Although the K placements did not differ statistically over all ridge-till sites, the deep-band placement produced on average 6 more bu/acre than the broadcast.
- Contrary to expectations, responses to deep-banded K (both ridge-till and no-till) were poorly related to soil-test K or stratification.
- Planting on the fall-applied coulters-knife-only track often increased early growth of no-till corn but did not increase early growth of ridge-till corn.
- Soil sampling depth, soil-test interpretations, and fertilizer recommendations for P based on chisel-plow tillage also apply for no-till and ridge-till system. In ridge-till, soil sampling of ridges seems more appropriate.

planter often (but not always) is inefficient for no-till corn. Similarly, broadcast K for ridge-till corn often (but not always) is an inefficient practice. Contrary to expectations, responses to deep-banded K were poorly related to soil-test K or stratification. The results also show that judging potential effects of fertilizer placements on grain yields based on effects on early crop growth is misleading in soils that are not extremely deficient. Enhancements of early

growth can be achieved by banding P fertilizer with planters or deep-banders but will seldom increase yields compared with broadcast fertilization. The deep banding of K, however, will seldom increase early growth but will often increase grain yields. The cost-effectiveness of deep-banding K will be largely determined by the costs of application.

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PLACEMENT OF PHOSPHORUS AND POTASSIUM FOR NO-TILL AND RIDGE-TILL PART II: SOYBEANS

Rick Exner

It was one year ago that the companion to this article appeared in the Practical Farmer. That piece focused on corn, instead of soybeans, and reported results of research carried out by ISU agronomist Antonio Mallarino – some of it on the farms of PFI members. PFI cooperators had been eager to collaborate with Antonio because many shared his questions about the utility of starter fertilizer and the best placement for other P and K fertilizers in reduced-till situations. Antonio described his research methods as follows:

We established ten long-term trials (five with P and five with K) with no-till corn-soybean rotations at five research farms. Several short-term trials (with P and K combinations) with no-till corn (11 trials), ridge-till corn (13 trials), no-till soybeans (11 trials), and ridge-till soybeans (14 trials) were established from 1994 to 1996 in producers' fields with their cooperation. Five PFI members were among these cooperating farmers. Treatments were placements and rates of P and K granulated fertilizers. At the research farms, fertilizers were 1) applied broadcast, 2) banded with the planter approximately 2 inches beside and below the seeds, or 3) deep-banded to a depth of 5 to 6 inches. At the farmers' fields, the fertilizers were applied broadcast or deep-banded. Fertilizer rates were 0, 28, 56, and 112 lb P₂O₅/acre and 0, 35, 70, and 140 lb K₂O/acre. The broadcast and deep-banded treatments for the 1994 growing season were applied in spring

three to five weeks before planting and thereafter were applied always in the previous fall. Nitrogen fertilizer was applied at rates 25 to 50% higher than local recommendations.

The figure of corn yields that appeared in the earlier article are reproduced in Figure 3. The main findings from analysis of the corn response were:

- Enhancements of early growth can be achieved by banding P fertilizer with planters or deep-banders but will seldom increase yields compared with broadcast fertilization. The deep banding of K, however, will seldom increase early growth but will often increase grain yields.
- Broadcasting K or banding it with the planter often (but not always) is inefficient for no-till corn. Similarly, broadcast K for ridge-till corn often (but not always) is an inefficient practice.
- The K placements differed statistically over all ridge-till sites, the deep-band placement produced on average 6 more bu/acre than the broadcast.



Deep-banding fertilizer into the sides of ridges.

- Contrary to expectations, responses to deep-banded K (both ridge-till and no-till) were poorly related to soil-test K or stratification.
- Planting on the fall-applied coultter-knife-only track often increased early growth of no-till corn but did not increase early growth of ridge-till corn.
- Soil sampling depth, soil-test interpretations, and fertilizer recommendations for P based on chisel-plow tillage also apply for no-till systems. In ridge-till, soil sampling of ridges seems more appropriate.

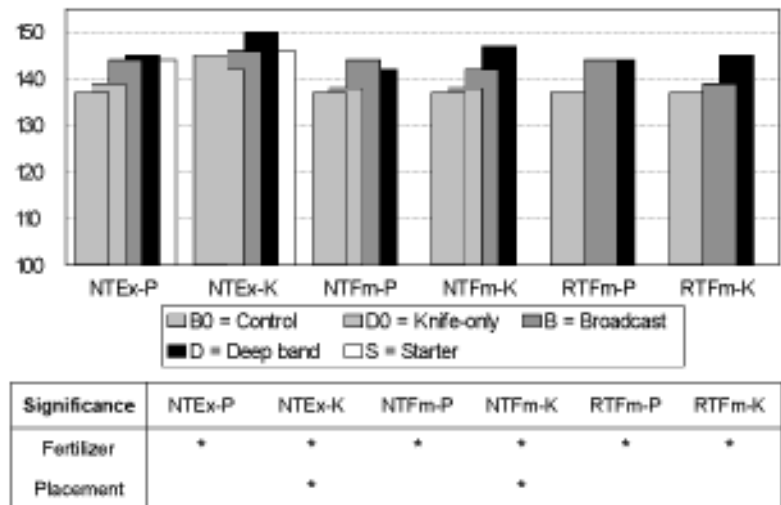
Soybeans, the other crop in the study, took much longer to write up. For one thing, explains Antonio, the data were not as clear as in corn. So what did the agronomists find? Figure 4 summarizes the yield results.

No-till, P

In eight of the 20 site-years on experiment stations, soybeans (30" row spacing) exhibited a response to phosphorus fertilization. The soil at all these sites tested low or very low in P, but not all sites testing low responded to fertilizer. Neither was stratification of available phosphorus associated with a yield response in soybeans. The significant placement effects at three sites were inconsistent. In one site, there was response only to broadcast P, in another site the broadcast was better than the two banded placements, and in the other the two banded placements were better than broadcast.

On the other hand, two of 11 on-farm site-years (with soybeans grown in narrow rows) showed a small advantage to deep banding. However, there was not a significant placement effect overall for these on-farm trials. Mallarino's team concludes that fertilizer placement and stratification of available P are not major issues for no-till soybeans in Iowa. The lack of large yield response to P in several of the low-testing soils causes them to wonder if recommen-

Fig. 3. Corn – Banded, Deep-banded, and Starter P and K Experiment Station (Ex) & Farm (Fm), No-till (NT) & Ridge-till (RT)

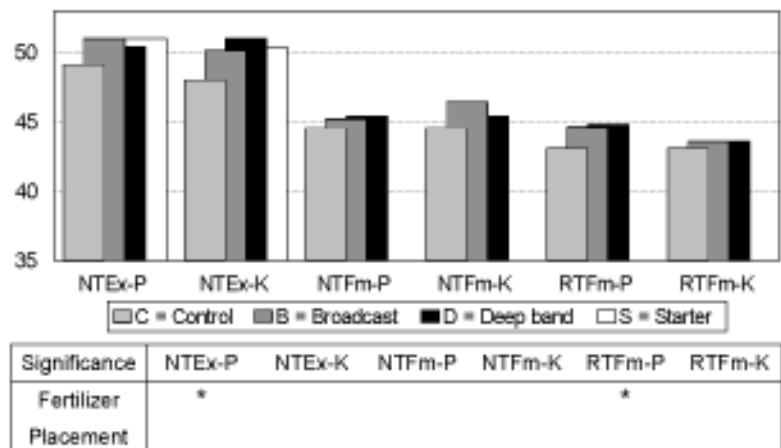


dations for no-till soybeans might require a separate calibration.

No-till, K

In five of the experiment farm site-years showed yield responses to potassium fertilizer even though the soils already tested adequate in K. Mallarino thinks these responses were related to dry soil conditions in spring, not stratification of K in the soil profile. Analysis over all site-years showed a small but significant response to both K fertilizer and placement.

Fig. 4. Soybeans – Banded, Deep-banded, and Starter P and K Experiment Station (Ex) & Farm (Fm), No-till (NT) & Ridge-till (RT)



Knife-only and Zero-disturbance controls combined. Two levels of P fertilizer combined. Two levels of K fertilizer combined.

Ridge-till, P

Phosphorus fertilizer increased soybean yields on FOUR of the 14 farm site-years, and there was a significant P fertilizer effect over all trials. Several sites testing below optimum did not respond to P fertilizer. Most likely this is explained by responsive trends that were too small to become statistically significant, because there was a highly significant response over all sites. It is also possible, however, that other factors limited yield and that a soil test of just the ridge could more accurately predict soybean response.

Ridge-till, K

Potassium increased yield only at two sites, and the placements differed only at one (deep band was better). Analyses over all 14 trials showed no significant response to either potassium fertilizer or placement. Most soils tested high and very high in potassium anyway, and the ridges tested even higher.

Soybeans in Reduced-till

In no-till and ridge-till, when soil test phosphorus was below optimum, soybeans sometimes responded to fertilizer, but placement method was not critical. The degree of P stratification in the soil profile was less useful in predicting whether that response would occur than was the number of consecutive dry days during the spring. Soybeans sometimes responded to potassium fertilizer even when soil test K was optimum or higher. Again, the method of placement was not critical, and weather was a greater factor than was stratification in predicting a response.

Planter-banded and deep-banded fertilizer more often affected early soybean growth than it did grain yield. This is consistent with the observations of many producers who use in-row fertilizers and see a response early in the season. Mallarino's work in ridge tillage showed



that early nutrient uptake was even more sensitive to fertilization than was early growth, and deep banding was the superior placement. However, there was no correlation between yield response and either uptake or early growth in this study. Deep banding can produce luxury consumption of P and K in soybeans, but under ordinary circumstances this is not translated into yield. If deep-banded P or K ever provided a yield advantage, it might be when prolonged dry conditions prevented normal root development or nutrient uptake from topsoil.

So what is the big picture for fertilizer placement in no-till and ridge tillage?

- If you deep-band, do it to provide potassium to the corn. Corn was insensitive to placement of phosphorus, and soybeans usually did not respond to placement of either P or K. Results not shown here suggest that the deep-band K effects persist up to two years after the application.
- Problems remain correlating soil tests to crop needs in no-till and ridge-till. Corn and soybeans sometimes responded to K even when soil levels were optimum or above. No-till soybeans sometimes failed to respond to P even when soil tests were below optimum.
- Nutrient stratification, sometimes considered the culprit, was not a yield factor in this study. Soil test values are (usually) higher in the ridges than the inter-row valleys. More research is needed to know if different soil sampling methods are called for, or if recommendations need to be calibrated especially for combinations of crop and tillage system.

