ALTERNATIVES FOR P AND K MANAGEMENT: A ROLE FOR DEEP BANDING AND STARTER?

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Introduction

Adequate amounts of soil phosphorus (P) and potassium (K) are needed to support sustained corn and soybean production. These requirements have been recognized for a long time, and soil testing is a useful tool to estimate P and K fertilization needs. Obviously, fertilizer applications to low-testing soils increase grain yield and result in economic benefits for crop producers. Continued P and K fertilizer applications increase soil-test P and K values over time, and this is considered a desirable consequence of fertilization when soil test are initially low. However, long-term use of fertilization has increased soil-test P and K levels of many Iowa soils to levels usually considered above optimum for corn or soybean. With current low crop prices, producers are looking at ways of cutting back in inputs. The presentation will review aspects of P and K management related to use of soil testing to decide fertilizer rates and will summarize recent information on alternative placement methods for P and K, which include starter and dep band preplant applications. With this information, producers can make decisions about most appropriate fertilization practices for their conditions.

Soil Test Interpretations and Yield Response to Fertilization

Field trials conducted since 1976 provide valuable information about soil test interpretations and fertilizer recommendations for corn and soybean managed with chisel-plow or disk tillage. The soil test data showed that the annual or biannual rates of fertilizer needed to maintain soil-test P or K values for the corn-soybean rotation vary among trials and depend mostly on the soil type, the overall yield levels (which affect P and K removal), and the soil test level to be maintained. The annual maintenance rates varied from about 30 to 65 lb P_2O_5 acre and 35 to 75 lb K_2O/acre. The higher rates usually corresponded to soils with sustained high yields and when high soil test levels were maintained. Corn and soybeans usually responded to P fertilization only in soils that tested less than optimum. Fig. 1 shows the relationship between soil test P and grain yield of corn and soybean. There is no major difference in soil-test P requirements between crops. However, there was more variability for soybean than for corn and the proportion of nonresponsive low-testing soils tended to be higher for soybean.

The results of experiments to evaluate the relationships between crop response to K fertilization and soil-test K were more variable and less conclusive than for P. Soybean (and corn) usually responded to K fertilization in soils that tested less than optimum. There was high unexplained variation in responses, however, within what could be considered a critical concentration range (Fig. 2). Although there was no major difference between crops in the required soil-test K concentration to attain maximum yield, soybean yield was more limited in soils with low available K. For example, relatives yield of corn never were less that 60% of the maximum yield attained with fertilization but soybean yield was as low as 38% for comparable soil test levels. New research was initiated in 1999 to obtain more information. Much of the unexplained variability likely was related to the failure of the ammonium acetate test to estimate plant availability of K.

Article published in p. 247-253, Proceedings of The Integrated Crop Management Conference. Dec. 1-2, 1999. Iowa State Univ. Extension. Ames.

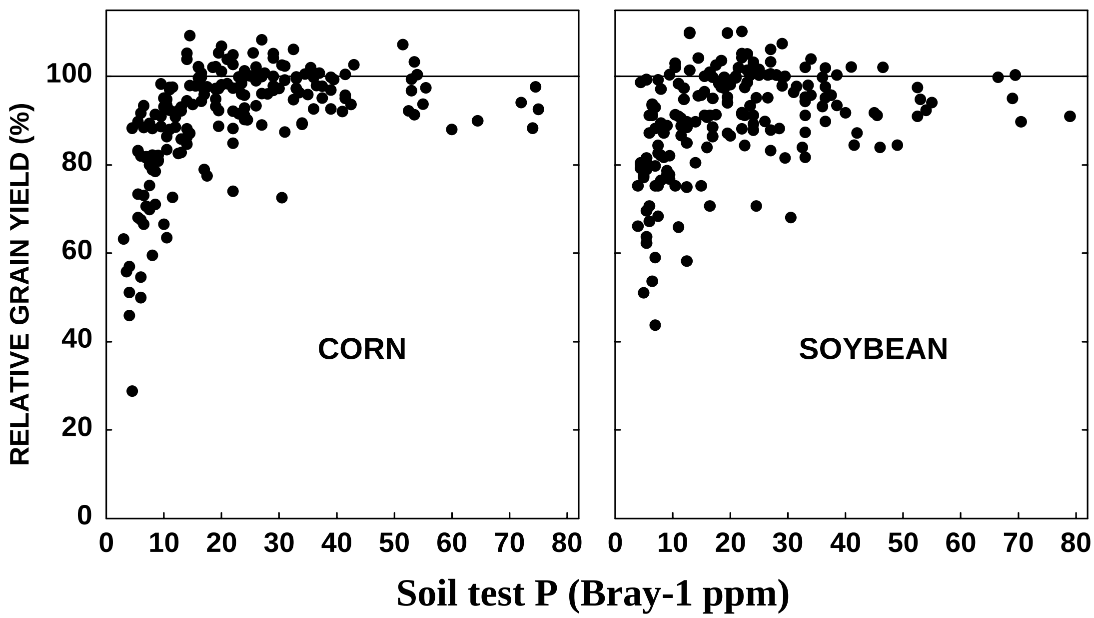

Fig. 1. Comparison of the relationships between soil-test P and grain yield of corn and soybean for several Iowa soils.

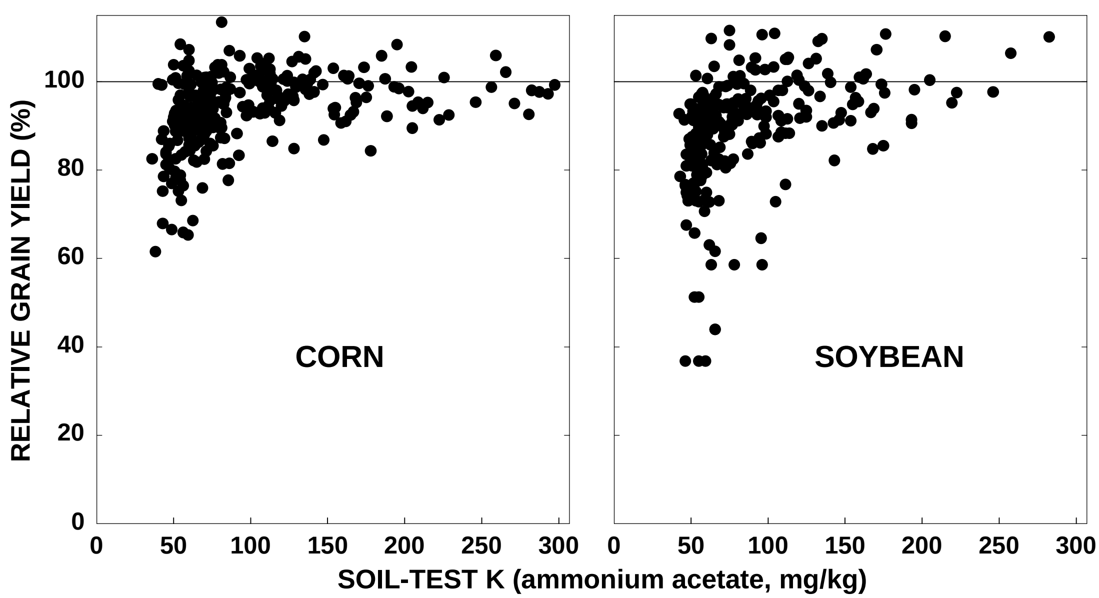

Fig. 2. Comparison of the relationships between soil-test K and grain yield of corn and soybean for several Iowa soils.

The yield response data for the different rates used in many trials over several years (not presented) showed that rates higher than 45 lb P_2O_5/acre or 48 lb K_2O/acre resulted in additional yield increases only when soils tested very low. Higher rates are needed in these ranges if build up of soil P and K levels are needed. This is considered in ISU fertilizer recommendations that are explained in the ISU Extension publication Pm-1688.

The cost-effectiveness of P and K fertilization can be evaluated by studying the relationships between net returns to fertilization and soil-test levels. Summary results of calculations for response data showed above is presented in Figs. 3 and 4.

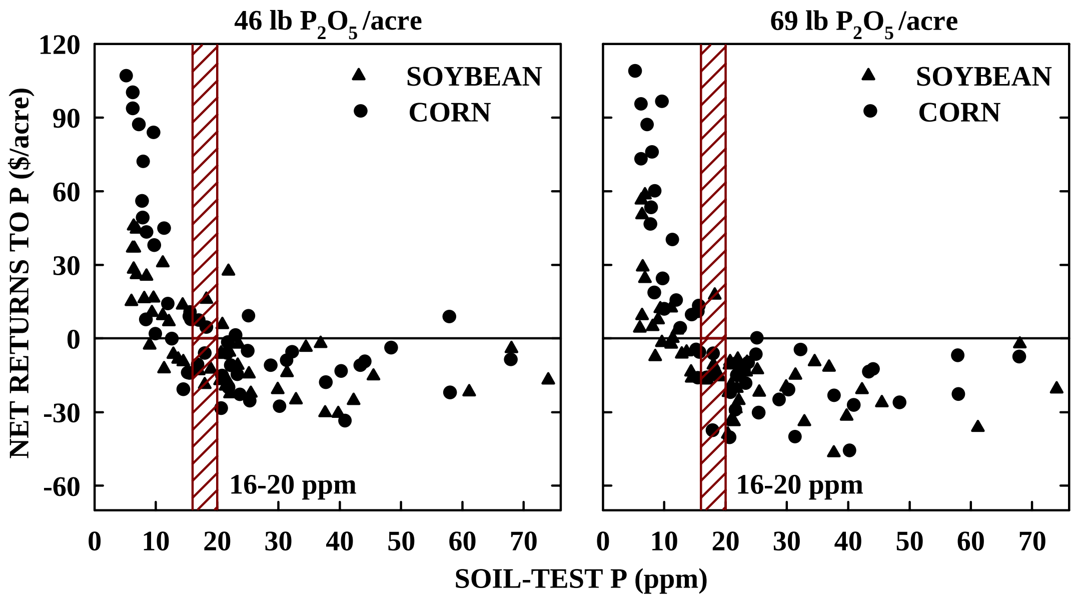

Fig. 3. Relationships between soil test P and net returns to two P fertilization rates for corn and soybean.

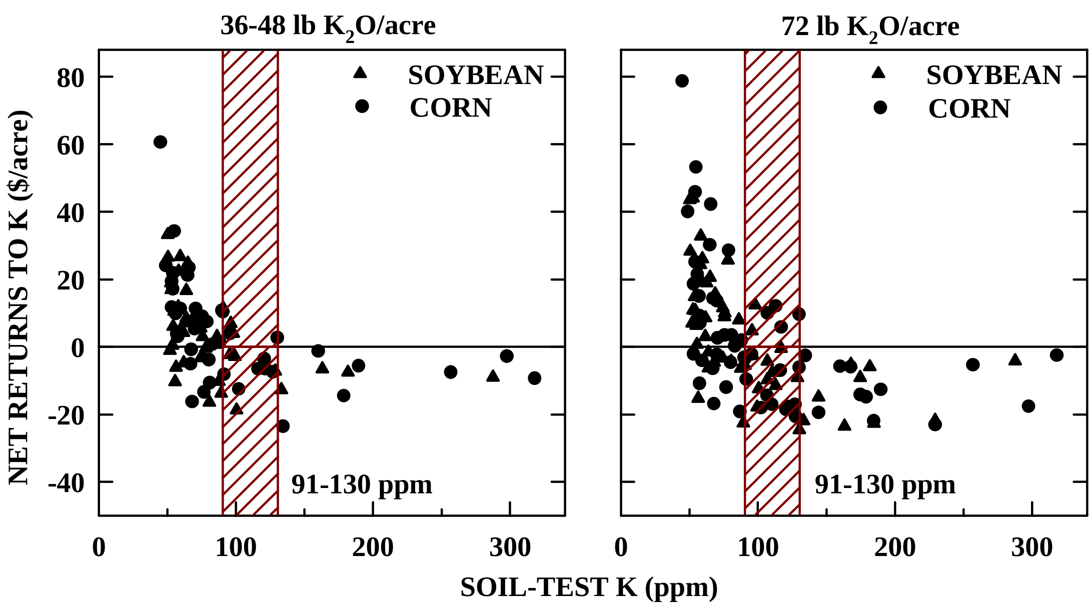

Fig. 4. Relationships between soil test K and net returns to two levels of K fertilization for corn and soybean.

The net returns to fertilization were calculated by subtracting the costs of fertilizer materials and fertilizer application from the value of the additional grain produced with fertilization compared with the yield of nonfertilized plots. Prevailing prices for grain, fertilizer material, and fertilizer application were used in the calculations. The data show that, in general, the relationship between net returns and soil-test P or K values are similar for corn and soybean. The range in soil test levels that produced "break even" returns was similar for both crops. In soils that tested very low, however, net returns tended to be higher for corn than for soybean. This is the consequence of differences in yield increases from fertilization and grain prices between the crops. These results clearly show that fertilization of soybean is profitable in low-testing soils. This is important to consider because most Iowa producers apply all the P and K ahead of the corn and rarely use soil testing for soybean. This should not be a problem if the needs of the soybean are consider when the fertilizer is applied ahead of the corn. This type of relationship provides a useful criterion concerning economically optimum soil test values to be maintained. Optimum soil test values can be attained either by direct fertilization or by applying additional P or K fertilizers to the previous crop.

Placement of Granulated P and K for Corn and Soybean

Several long-term experiments comparing P and K placement methods for corn-soybean rotations managed with no-till and chisel/disk tillage systems were established in 1994 at five research farms (five for P and five for K). Approximately 50 additional experiments were conducted from 1995 to 1997 at producers' fields managed with no-tillage and ridge-tillage. The placements evaluated at the research farms were preplant broadcast and deep-band (5 to 6 inches deep) fertilization, and bands applied with the planter 2 inches beside and below the seeds. Only the broadcast and deep-band placements were evaluated a farmers' fields. Granulated fertilizers were used, and rates were a check and rates up to 120 lb P2O5/acre and 140 lb K2O/acre. An additional control evaluated the physical effect of the coulter-knife pass (strip tillage) on grain yield and early growth.

Average data for trials at research farms for chisel-disk and no-tillage are shown as examples of the results obtained. The results obtained at no-till and ridge-till producers' fields were similar in nature. One general important conclusion from these experiments was that, even in low testing soils, any response to P or K placement was similar for all the rates used. This finding has a major significance because it shows that, contrary to expectations by many producers, P and K fertilizer rates needed to achieve optimum yields of corn or soybean cannot be reduced by banding. It must be noted, however, that the soils in these studies did not have extremely low soil test levels. Only one soil testes 5 ppm in P and all others were in the low range or higher ranges, and the lowest K levels were in the upper low range. Also, when producers have limited amount of money to invest, a lower rate applied banded may be a good option even if maximum yields are not achieved.. Because of these results, and to simplify the presentation and discussion of data, only average responses to fertilization and placement will be discussed in the following sections.

Phosphorus fertilization increased corn yield at several sites that tested very low or low in soil-test P but at no site that tested optimum or higher. The placements did not differ statistically at any trial, although in a few trials the band treatments produced slightly higher yields. The upper two graphs in Fig. 5 show the average responses to P placement of the group of sites where fertilization increased yield. Contrary to results for grain yield, early growth of corn was greatly increased by P fertilizer applications. This response occurred even in high-testing soils, although it tended to be larger in soils that tested below optimum in P. Responses almost always were larger for the planter-band placement (starter), less for the deep-band placement, and even less for the broadcast placement. The combination of responses in grain yield and early growth shows that the obvious effects of banded P on early growth not necessarily translate into higher grain yields. The P effects on early growth usually are explained by high P needs during periods of rapid cell multiplication and colder soil temperatures. These results suggest that plants often can compensate for slower early growth.

Potassium fertilization increased corn grain yield at several sites. These responses were not expected because all soils tested in the lower optimum range or higher in soil-test K. A small discrepancy with older data from long term experiments could be explained by the change in the soil test method for K. Until the early 90s K was analyzed on field moist samples. Since the mid 90s samples are dried, as it is done all over the U.S. New research was begun this year to look at soil test interpretations for K in more detail. The deep-band K placement had a small but fairly consistent yield advantage over the other two placements. The lower two graphs in Fig. 5 show the average responses to K placement of the group of sites where K fertilizer increased yields. Potassium fertilization and placement seldom influenced early growth of corn. This result is in sharp contrast effects of P placement on early growth and of K placement on grain yield. It coincides with the well known fact crop responses to starter fertilizer usually are explained by N or P. It also could be explained by the usually high levels of soil K at the fields.

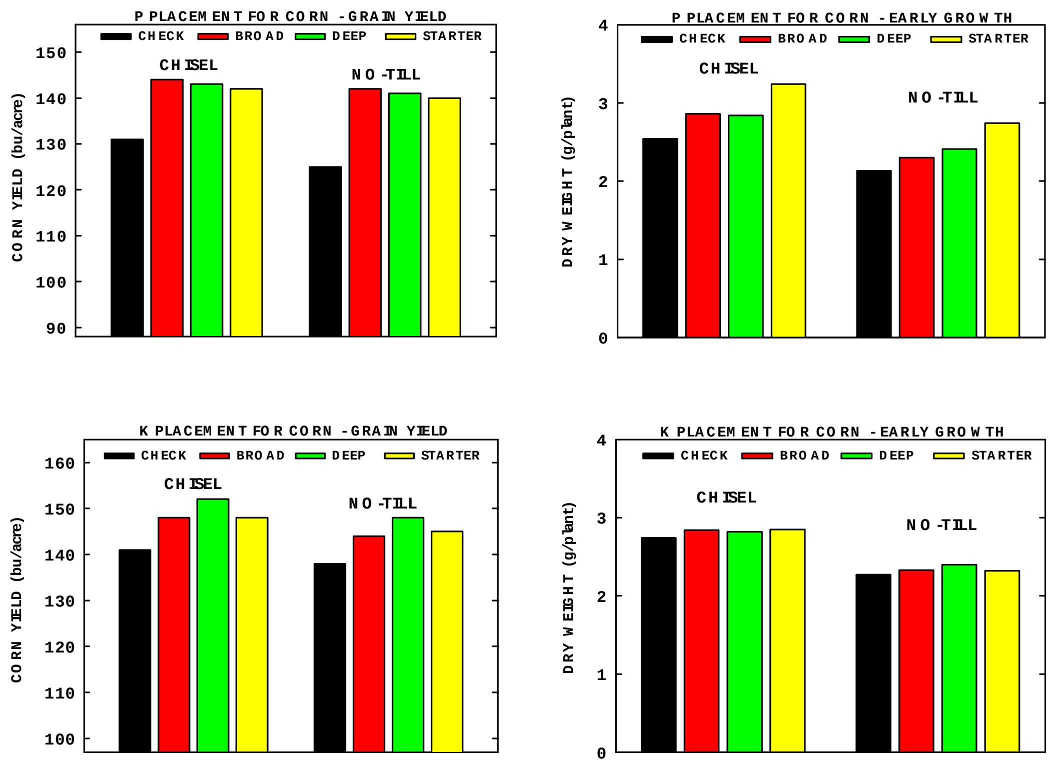

Fig. 5. Average effects of P and K fertilization and placement on early growth and grain yield of corn managed with chisel-disk and no-till tillage for fields that responded to P fertilization.

On average, the soils had 75% more soil-test P in the 0-3 in. depth than in the 3-6 in. depth and ranged from about 10 to 200% across sites. Responses to P placement, however, were not observed even in soils with high stratification. The results suggest that soil-test P stratification, placement methods, and sampling depth for P are not major issues for no-till Iowa soils and weather conditions similar to those included in this study. The shallow soil sampling was a better predictor of yield responses only in very few instances. Several considerations are important when interpreting the lack of response to P placement and comparing it with results for other regions. Aspects that may explain a lack of response to P placement include the moderate P fixation capacity of Iowa soils, the lack of extremely deficient soils, the fall broadcast fertilization in no-till, and the usually good soil physical properties for root growth (as compared with soils of other regions). Thus, the results do not exclude the possibility of benefits of P banding in Iowa under special conditions such as in highly calcareous soils and in soils very deficient in P and/or with less favorable physical properties.

Fields in which the response to K placement was largest did not 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 0-3 in. depth than in the 3-6 in. 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. The yield response to deep-banded K relative to the response to broadcast K decreased with increasing June or early

July rainfall. These correlations suggest that responses to deep-banded K are greater when there is little rainfall during the period of fastest corn growth. It is likely that plant K uptake from shallow soil layers is reduced by dry topsoil and that the deep-banded K alleviates the problem.

The results of P placement studies for soybeans showed similar results to those for corn and data will not be shown. Phosphorus increased yield only in soils testing lower than optimum, the band applications increased early growth slightly more than the broadcast did, but seldom increased grain yield. Potassium fertilization increased soybean grain yields significantly at several sites. Similar to results for corn, these responses were not expected because most soils tested optimum or higher in soil test K. Although statistical analysis confirmed an influence of the K placement method only at few sites, an analysis of averages across all sites showed a significant placement difference for no-till soybeans. The responses of soybeans to the band placements was smaller than that of corn, and was not clearly related with deficient rainfall in late spring and early summer or with soil test K. Potassium fertilization and placement seldom influenced early growth of soybeans. This result is in contrast to effects of P placement on early growth and of K placement on grain yield.

Response of No-Till Corn to Liquid Starter

The response of no-till corn to liquid P-K mixtures applied with the planter was tested at several farmers' fields. The mixture was either 7-21-7, 6-18-6, or 9-18-9 applied at a rate of 5 to 7 gal/acre 2 inches besides and below the seeds in most trials. High rates of N in addition to rates applied by the farmers were applied broadcast by hand between planting and corn emergence to minimize as much as possible any response to the N in the mixtures. The response to the starter was tested at eight sites in plots with or without the recommended broadcast P-K fertilization rate the previous fall. Data in Table 1 shows that the starter without P-K preplant increased yields at most sites.

Table 1. Response of no-till corn to liquid N-P-K starter with or without preplant fertilization.†

		Preplant (fall) P and K fertilization					
		None			Maintenance or as needed		
SITE	Soil P	No starter	Starter	Statistics	No starter	Starter	Statistics
		------ bu/acre -----			------ bu/acre -----		
1	VH	129	134	ns	132	129	ns
2	VL	115	116	ns	132	127	ns
3	L	121	126	ns	129	131	ns
4	VL	173	199	s	191	192	ns
5	VL	119	139	s	142	154	s
6	L	105	130	s	126	131	ns
7	L	90	110	s	111	114	ns
8	L	148	155	s	147	147	ns
Mean	--	125	138	s	139	141	ns

† High N rates were applied at planting to minimize N starter effects. Trials were conducted over two years.

In some sites there a very high response to such a small amount of fertilizer. Soil test for P were very low or low except at one site where it was very high. Soil test K was optimum to very high in all soils. When preplant P-K was applied at recommended rates, however, the response to the starter was eliminated with the exception of one site, which was in north-central Iowa and has one of the highest residue cover. It is noteworthy that the starter increased early plant growth significantly in most fields (not shown). The yield results tend to agree with other data from conventionally tilled soils, which show that responses to starter P-K are unlikely in high testing soils or when preplant P or K is applied before planting in spring or fall.

Summary and Conclusions

Soil testing is a useful tool for P and K management for corn, soybeans and other crops, although high variability is expected under some conditions. The soil test P and K values required to optimize yields of corn and soybean are very similar. Both crops respond to fertilization in low-testing soils. Responses are small in soils testing optimum and only applying the estimated crop removal is recommended. There was no response of corn or soybeans to P fertilizer placement, although responses to very small amounts of starter fertilization produced high yields in soils testing low in P. Responses to starter are unlikely or very small in soils testing high in P or when the starter is applied after broadcast fertilization, even in no-tilled soils. There was a small but consistent response of corn to deep-band K, and a slightly lower response of soybeans too. By using soil testing, producers can manage their P and K fertilization according to their specific needs. Applying what the crop will remove is not economically sound in high testing soils, especially when crop prices are low. A combination of reduced rates or frequency of broadcast fertilization in combinations with small starter applications seem a viable alternative when fields are in the optimum range and producers need to reduce inputs.