Phosphorus and potassium fertilizer placement options when crop prices are low

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Introduction

Crop prices are low and farmers are looking for ways to reduce inputs. Both farmers and crop advisers are asking what placement application methods allow for a reduction of phosphorus (P) and potassium (K) rates while maintaining high yield and the profitability of corn and soybean production. Iowa research from the late 1950s until the early 1970s with corn and soybean managed with tillage showed infrequent and small yield differences between broadcast or banded P and K fertilization methods. Therefore, the typical Iowa farmer used tillage, broadcast P and K before planting crops often applying once before corn the P and K fertilizer rates needed for the two years of the corn-soybean rotation. Use of granulated or liquid N-P-K starter mixtures applied besides and below the seeds was common mainly in the northern regions of the state until the late 1960s but declined sharply as most farmers began applying buildup P and K rates (which reduces response to starter) and both field and planter sizes began to increase.

Major crop and soil management changes in Iowa from the late 1980s to early 1990s demanded further research on P and K fertilizer application methods. Chisel-plowing/disking had displaced moldboard plowing, more farmers began using annual fertilization, areas of ridge-till began to decrease, and fields began to be managed with strip-tillage. With reduced tillage and strip tillage, but also with chisel-plow/disk tillage, crop residues and broadcast fertilizers are not incorporated or are partially incorporated into the shallowest soil layers. This management results in significant residue cover, cooler and wetter soils in early spring, and accumulation of P and K in the top few inches of soil since both nutrients move little down the soil profile except in sandy soils. Increased residue cover limits early crop growth and P and K uptake, but during the summer it improves water availability and root efficiency in the shallow soil layers.

Therefore, in 1994 ten long-term trials were established to study broadcast, 2x2 band, and deep-band placement methods for granulated P or K fertilizers in corn and soybean managed with no-till and chisel-plow/disk tillage systems. These long-term trials were complemented by numerous on-farm replicated strip trials that compared the broadcast and deep-band placement methods in fields managed with no-till or ridge-till systems. Many on-farm trials also evaluated liquid P and K starter for corn separately or in mixture using 2x2 or in-furrow application methods.

This article briefly summarizes information on preplant placement methods for the primary P and K application for corn and soybean. Starter fertilization is not addressed due to space limitations.

Long-term tillage system and P and K placement trials

Phosphorus and K placement methods for corn-soybean rotations managed with no-till or chisel-plow/disk tillage were evaluated at ten long-term trials from 1994 to 2018 at five Iowa State University research farms. Separate P and K trials were established at each farm located in North, NE, NW, SE, and SW Iowa, in which both crops were planted each year for each P or K trial on two areas with similar soils and treatments. The crops at each trial were switched each year to complete the two-year rotation over time. Granulated triple superphosphate (0-46-0) or potash (0-0-62) were used. Until 2001, treatments at each P or K trial at all five research farms were annual rates of 0, 28, and 56 lb P_2O5/acre or 0, 35, and 70 lb K_2O/acre for the placement methods broadcast, deep bands (both applied in the fall) and bands applied with planter attachments. Additional treatments at all farms were rates of 112 lb P_2O_5/acre and 140 lb K_2O/acre applied only once every other year either before corn or soybean. Additional two annual

treatments at four farms (except the Northeast farm) were 56 lb P_2O_5/acre (P trials) or 70 lb K_2O/acre (K trials) applied one-half broadcast and one-half banded with the planter or one-half broadcast and one-half deep banded. The deep bands were applied at a depth of 5 to 6 inches at a 30-inch spacing, the bander coulter and knife soil disturbance varied greatly over time with the different machines used. The planter bands were applied about 2 inches besides and below the seeds. The broadcast and planter-band methods continued to be evaluated until 2018.

Figure 1 summarizes yield results for the eight initial years of the long-term trials during which the three placement methods were evaluated. The data shown are averages across two P trials (North and NW farms) and three K trials (Northeast, North, and Southeast farms) in which fertilization resulted in consistent yield increases. Results for the other trials are not included because initial soil-test values were high and there were small and inconsistent yield responses. This figure shows results only for the annual treatments of 0, 28, and 56 lb P_2O_5/acre or 0, 35 and 70 lb K_2O/acre for the three placement methods because the additional treatments evaluated did not differ from one or more of these annual treatments. The results in Figure 1 confirm results older Iowa studies at showing no difference or small and inconsistent differences between broadcast and planter-band P or K placement methods for any tillage system, crop, or area of the state. Such a lack of difference between broadcast and planter-band methods was observed even with significant soil-test P or K stratification for both tillage systems. Soil-test levels were higher in the top 3 inches of soil compared with a depth of 3 to 6 inches, and the difference increased over time. Many are surpassed by this result, since assume that banded P or K would be more efficient than broadcast and would allow for a reduced application rate. However, this is a common result in regions such as Iowa with humid climate and soils with little capacity to transform applied P or K into forms of lower availability to plants.

The deep-band placement of P fertilizer did not differ from the broadcast and planter-band methods for any tillage system, crop, or trial (Figure 1). The deep-band placement of K fertilizer did not differ from the other two methods with tillage management, but occasionally increased yield further with no-till management, which resulted in slightly higher yield for the long-term averages. The additional yield increases due to deep banded K were larger and more consistent for corn than for soybean. Data from numerous on-farm replicated strip trials that compared the broadcast and deep-band placement methods in fields managed with no-tillage are not shown because the results were similar to results shown by the long-term trials. A very relevant result was that both the low and high deep-band K rates increased yield (larger increase for the higher rate) but the deep-band K effect was proportionally similar for both rates. Therefore, deep-K banding did not reduce the K rate needed to maximize yield. Large variation in the no-till corn response to deep-band K was more related to deficient soil moisture in late spring and early summer than to soil-test K stratification. Therefore, conditions for large yield responses that offset costs are difficult to predict.

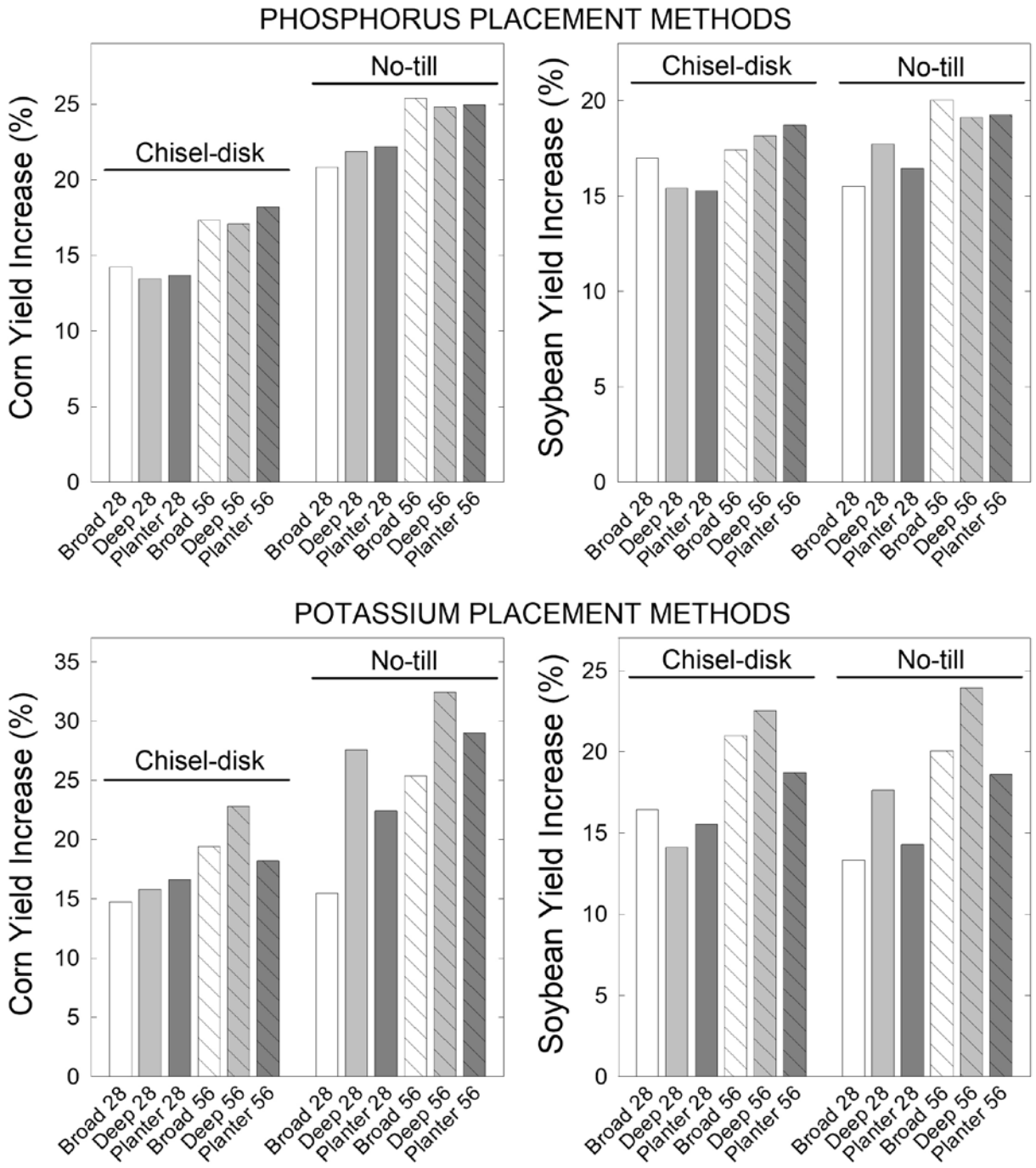

Figure 1. Relative corn and soybean yield increase from annual application of 28 and 56 lb P_2O_5/acre or 35 and 70 lb K_2O/acre using three fertilizer placement methods for no-till or chisel-plow/disk tillage systems in Iowa. Averages across eight initial years of long-term trials in which the three methods were evaluated and yield responses were observed consistently. Broad, broadcast; Deep, deep bands; Planter, planter bands.

The placement methods effects on plant early growth were very different, however. Data in Figure 2 show that planter-band P greatly increased early plant growth compared with the other P placement methods but this increase did not translate into higher yield. On the other hand, deep-band K greatly increased early plant growth compared with the other K placement methods, although the relative increase was less than for grain yield.

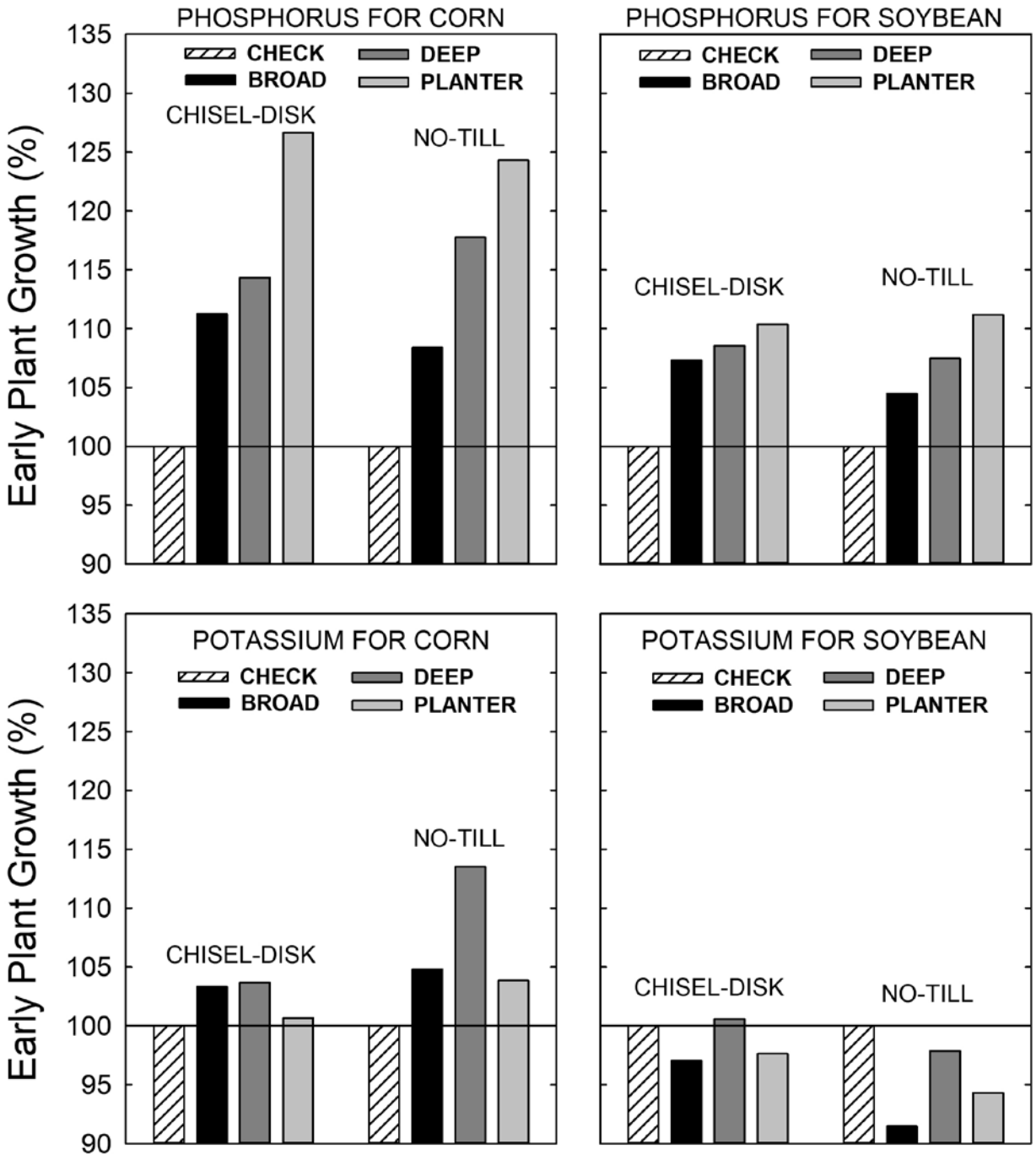

Figure 2. Relative corn and soybean early plant growth (V5-V6 growth stage) response to P and K fertilization using three placement methods for no-till or chisel-plow/disk tillage systems in Iowa. Averages across four years of five Iowa long-term field trials and annual rates of 28 to 56 lb P_2O_5/acre or 35 to 70 lb K_2O/acre. Broad, broadcast; Deep, deep bands; Planter, planter bands.

Figures 3 and 4 summarize grain yield results from 2002 through 2014 for the broadcast and planter-band placement methods because the deep-band treatments were discontinued after the harvest of 2001. Data management of results from 2015 to 2018 were not completed by the time this article was written. Also, in 2002 new annual treatments of 112 lb P_2O_5/acre or 140 lb K_2O/acre began to be applied to plots of a treatment in each P or K trial that in the previous eight years received annual rates of 56 lb P_2O_5/acre or 70 lb K_2O/acre one-half deep banded and one-half banded with the planter. These new higher annual P and K rates began to be applied to assure that P and K did not limit yield and to better study soil-test build-up over time.

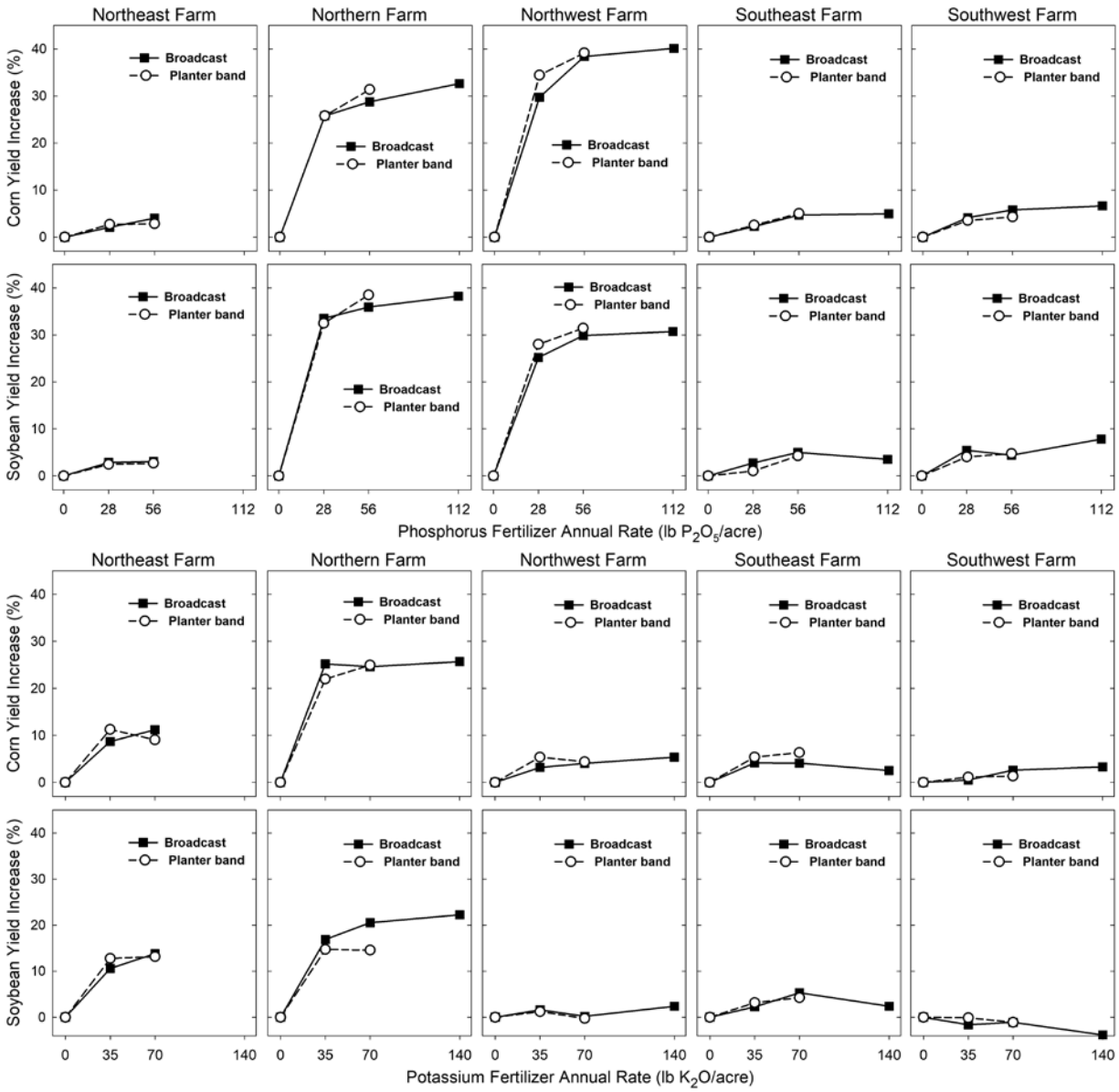

Figure 3. Relative grain yield increases of corn and soybean managed with chisel-plow/disk tillage from annual applications of 28 and 56 lb P_2O_5/acre or 35 and 70 lb K_2O/acre using broadcast or planter-band placement methods for five Iowa long-term trials. Averages across the years 2002 through 2014.

Figure 3 shows yield results for management with chisel-plow/disk tillage and Figure 4 shows yield results for no-till management. Both figures show averages across all years of both P and K trials because although there were different yield levels and yield increases from fertilization over time and across the research farms, the differences between the two placement methods were consistent over time.

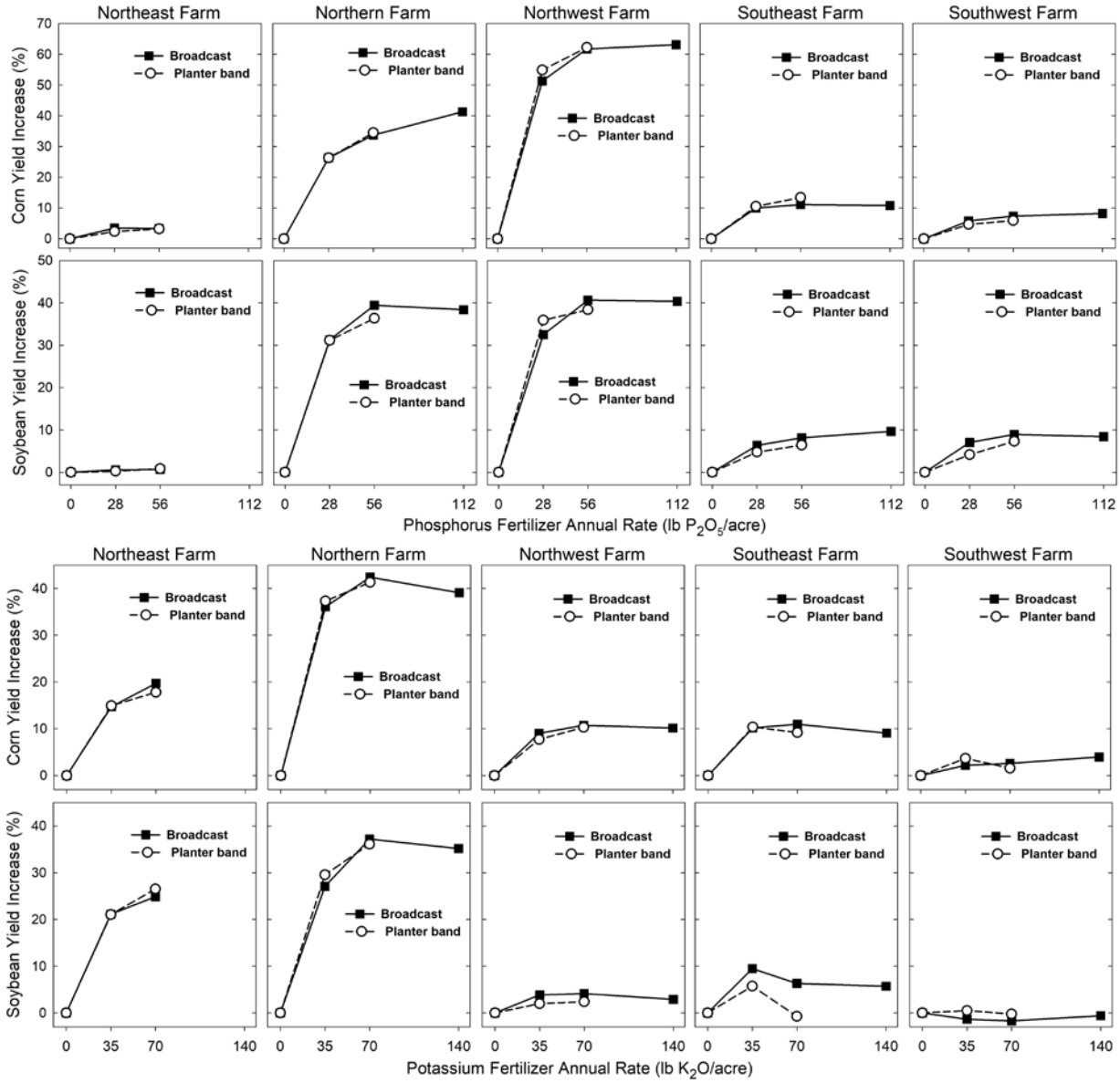

Figure 4. Relative grain yield increases of no-till corn and soybean from annual applications of 28 and 56 lb P_2O_5/acre or 35 and 70 lb K_2O/acre using broadcast or planter-band placement methods for five Iowa long-term trials. Averages across the years 2002 through 2014.

The results in both Figures 3 and 4 confirm results from the early years of the long-term trials in that corn and soybean yield increases from P or K fertilization seldom differed for the broadcast and planter-band placement methods across tillage systems, crops, or areas of the state. Such a lack of difference between placement methods was observed even with significant soil-test P or K stratification for both tillage systems, which increased over time. The only placement method differences that was statistically significant in Figure 3 was for soybean managed with tillage at the Northern farm, and in Figure 4

soybean managed with no-till at the Northeast farm. In both instances the higher banded K rate reduced soybean yield compared with the low banded K rate and similar or higher broadcast K rates. Apparent soybean yield decreases by the highest annual rate (140 lb K_2O/acre) in a couple of farms were not statistically significant. The soybean yield decrease by the 70-lb banded K rate was consistent in the last few years and may be explained by cumulative salt effects in the band zone.

On-farm K placement trials for fields managed with ridge-tillage

On-farm replicated strip trials compared broadcast and deep-band P or K placement methods in corn and soybean fields managed with ridge-tillage. There were 15 P-K trials with corn and 14 P-K trials with soybean. The fertilization rates (granulated fertilizers) were 28 or 112 lb P_2O_5/acre and 35 or 140 lb K_2O/acre applied before planting. In all trials, the farmers rebuilt the ridges when the crops were at the V6 to V7 growth stage. The deep bands were approximately one inch in width and were placed below the surface either through a narrow vertical slit opened from the top and center of the ridge or a slit opened in one shoulder of the ridge at a 45° angle, and the band was zero to four inches from the center of the ridge. Both methods placed the fertilizer band at approximately two to 3 inches below the seeding depth.

Figure 5 summarizes the results of the ridge-till trials by showing yield averages across the trials in which there was a yield response to P (nine corn trials and five soybean trials) or K (eight corn trials and three soybean trials). This figure also shows averages across the two rates applied for each nutrient because the high rate seldom increased yield more than the low rate did.

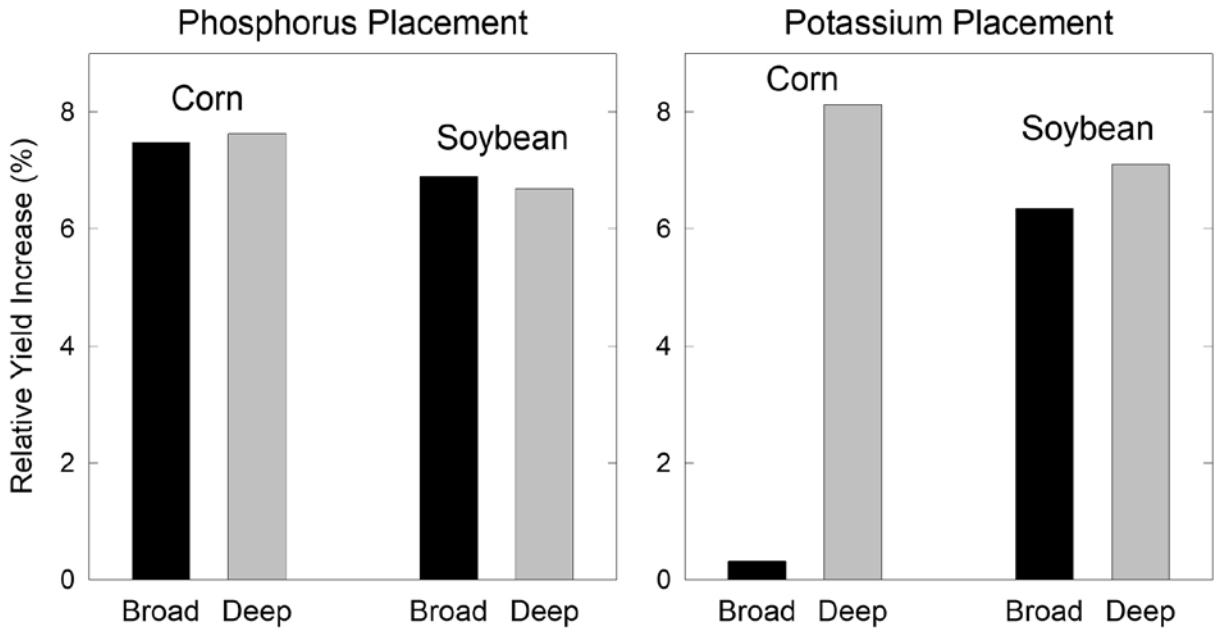

Figure 5. Relative grain yield increases of corn and soybean managed with ridge-tillage from broadcast or deep-band P or K fertilization. Averages of two application rates across on-farm corn or soybean replicated strip trials that showed a yield response to P or K.

The average results from the P trials in Figure 5 show no statistically significant differences between the broadcast and deep-band placement methods. In the individual trials either there were no differences or were small and inconsistent across the trials. However, the results for K in Figure 5 show a very large difference in favor of deep-band K for corn, and a much smaller difference for soybean. Only in two of the nine corn trials responsive to K fertilization the broadcast and deep band methods did not differ or yield was slightly higher for the broadcast K. In the three trials with soybean response to K, however, the placement methods did not differ in two trials and yield was higher for the deep-band method in the other trial.

Summary and conclusions

Based on these results, the P fertilizer recommendations in Iowa State University Extension and Outreach publication PM 1688 do not include specific guidelines for P placement methods, except for suggesting starter fertilization under a few specific conditions. However, deep-band K is recommended for ridge-till and no-till or strip-till systems, although it is stated that for no-till or strip-till the yield increase from deep K banding often is not large and may not always offset increased application costs compared with broadcast fertilization. Large variation in the no-till corn response to deep-band K was more related to soil moisture in late spring and early summer than to soil-test stratification, and responses tended to be larger when rainfall was deficient in June. Although there is no consistent yield response to deep P placement, P fertilizer also can be deep banded together with K fertilizer.

In contrast to beliefs by some farmers and crop consultants based on research from other regions with different soils and/or climate, the results of numerous long-term trials and short-term on-farm trials in Iowa showed that fertilizer rates cannot be reduced by banding without limiting grain yield compared with broadcast fertilization for any tillage system. The Iowa research evaluated application rates of 28 lb P_2O_5/acre or 35 lb K_2O/acre and higher rates. Therefore, the results cannot completely exclude the possibility of placement methods differences for P or K when lower fertilizer rates are applied to low-testing soils. With lower and deficient rates, the planter-band placement method could be more effective than the broadcast method but this would seriously limit yield and the profitability of cropping. In soils testing optimum, banded P or K rates smaller than the recommended removal-based rates could attain similar yield levels, but the smaller rates will not maintain soil-test values and will necessitate higher application rates in the future.

Iowa farmers trying to reduce costs should not reduce recommended P and K rates for low-testing soils and should not change from broadcasting to banding with the expectation of attaining similar yield levels with lower rates. Instead, many farmers could greatly reduce costs and increase profits by not applying removal-based P or K rates to high-testing field areas.