Making rational adjustments to phosphorus, potassium, and lime application rates when crop prices are low and producers want to cut inputs

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Corn and soybean grain prices have been declining and there is considerable uncertainty about the future. It helps somewhat that the prices of phosphorus (P) and potassium (K) fertilizers and lime have remained approximately constant or have declined slightly. Therefore, producers are thinking of reducing fertilizer or lime application rates. There are a few useful things that producers and crop consultants should consider when making fertilization decisions with unfavorable crop/fertilizer price ratios.

Reducing P and K fertilization or liming application rates across all conditions is not a rational or good management decision

Producers should not cut or reduce P, K, or lime application rates in low-testing soils, where yield increases and profits from fertilization or liming are very likely even with unfavorable prices. However, they should not fertilize high-testing soils and should not apply lime when soil pH is at or above levels that optimize crop yield. Soil testing is not a perfect diagnostic tool but is very useful, and compared to the overall costs of production has become less expensive in recent years. Its use is even more relevant with unfavorable crop prices. Iowa field research results have been used to develop soil sampling guidelines for P, K, and other nutrients in the Iowa State University (ISU) extension publication PM-287 (Take a Good Sample to Help Make Good Decisions). Data from many response trials conducted at farmers' field and research farms with corn and soybean were used to update in the fall 2013 soil-test interpretations and application guidelines in publication PM 1688 (A General Guide for Crop Nutrient and Limestone Recommendations in Iowa). Research report articles and other related publications and articles can be found at the ISU Soil Fertility web site.

Crop yield increases from P and K fertilization are large and highly likely in low-testing soils, but the size and likelihood of the response decreases as soil-test values increase and become very unlikely in high-testing soils. Iowa and most states have established soil-test interpretation categories that encompass very low to very high nutrient levels. For P soil tests with corn and soybean in Iowa, the optimum interpretation category is 16 to 20 ppm for the Bray-1 and the colorimetric Melhich-3 methods, 26 to 35 ppm for the Mehlich-ICP method, and 10-13 ppm for the Olsen method. The optimum interpretation category for K by both the ammonium-acetate and Mehlich-3 methods is 161 to 200 ppm for testing soil samples dried in the laboratory and 86 to 120 for the field-moist or slurry sample processing method (see publication PM 1688). Figures 1 and 2 show how corn and soybean grain yield increases from fertilization relate to soil-test P or K levels. There are many potential sources of error in soil testing that include sampling error in the field, analytical error, and is difficult to accurately predict conditions that limit response to fertilization or induce a higher than expected response. Therefore, it is important that recommendations provide the probability of crop response for different soil-test categories. In Iowa, the percentage of P or K applications expected on average to produce a yield increase is approximately 80% for Very Low, 65% for Low, 25% for Optimum, 5% for High, and <1% for Very High categories.

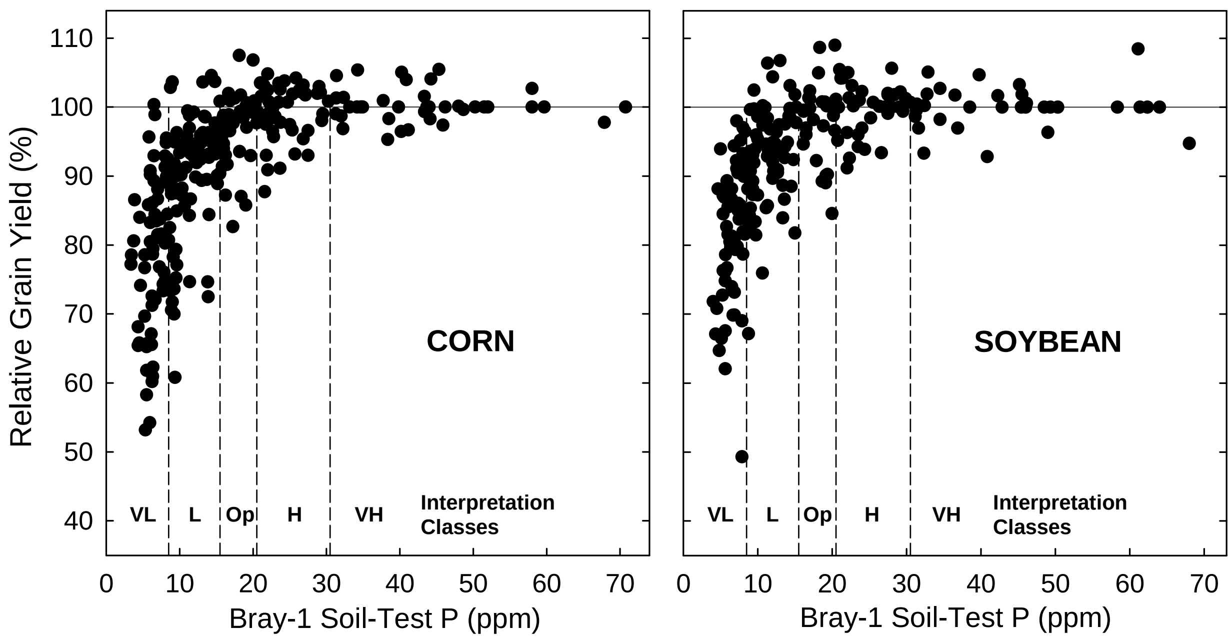

Fig. 1. Relationships between relative corn and soybean grain yields and soil-test P in Iowa. Interpretation categories are from publication PM 1688.

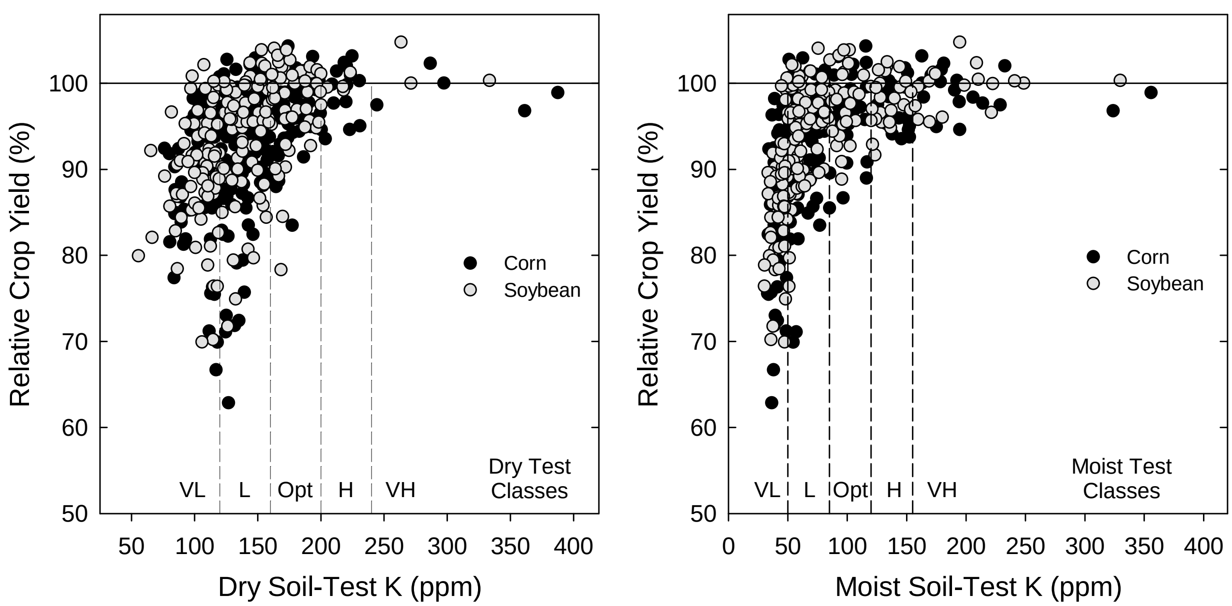

Fig. 2. Relationships between relative corn and soybean grain yields and soil-test K in Iowa measured by dry and moist tests. Interpretation categories are from publication PM 1688.

Figure 3 shows, as an example for P, how profits from fertilization relate to soil-test levels as affected by prices. Large and likely benefits in soils testing very low decrease sharply as soil-test levels increase to the optimum level, which is the level recommended to be maintained by P or K application based on crop removal. If the farmer economic condition is particularly bad, field tenure is uncertain, or price ratios are unfavorable, the removal-based maintenance rate can be reduced to increase short-term profits.

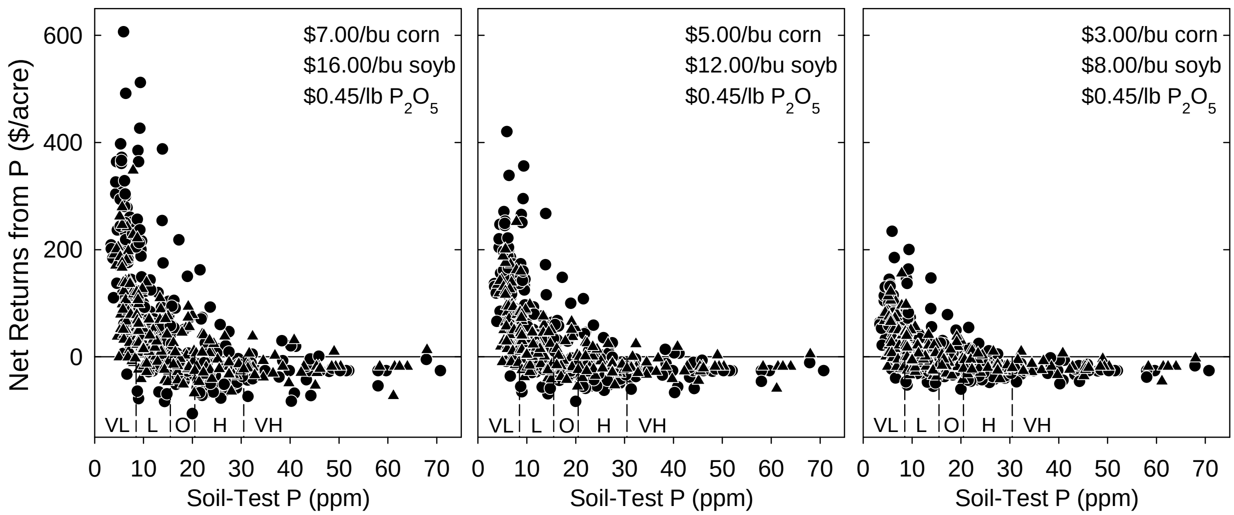

Fig. 3. Net returns to P fertilization for different soil-test P levels (Bray-1) in Iowa soils assuming the shown grain and P fertilizer prices. Interpretation categories are from publication PM 1688.

Concerning soil pH and lime application, publication PM 1688 indicates that soil pH 6.9 is sufficient for alfalfa or alfalfa-grass mixtures and pH 6.0 is sufficient for other forages. For corn and soybean, soil pH 6.5 is sufficient in soil association areas (which include several soil associations) with low-pH subsoil but a lower pH 6.0 is sufficient in areas with high-pH (calcareous) subsoil (see map included in the publication). The soil association areas with high-pH subsoil are in central and northern Iowa and in western Iowa. Figure 4 summarizes results from an on-farm project that evaluated crop responses to lime application at 14 fields during four years. There were no statistical differences between the responses of corn and soybean.

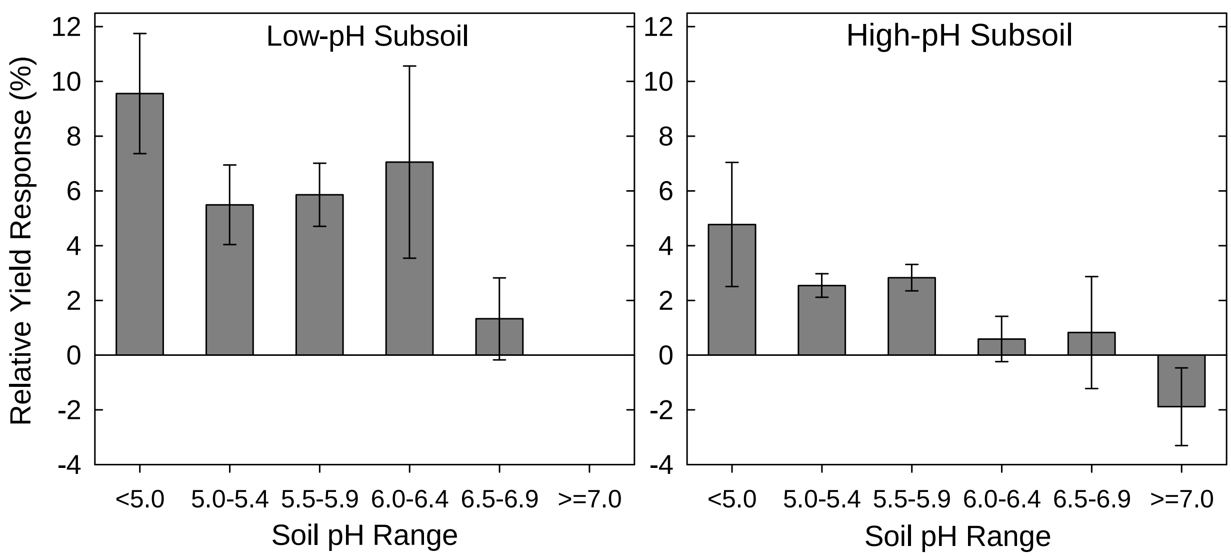

Fig. 4. Relative grain yield response from lime application across corn and soybean crops for several initial soil pH ranges for soil association areas with low or high pH (adapted from Pagani and Mallarino, 2015). Vertical lines are statistical confidence intervals.

Use a good soil sampling method and variable-rate technology to vary as needed the P, K, and lime application rate within fields

Use of variable-rate P and K fertilization is a good option to improve P and K management in fields that have significant variation in soil-test or crop yield levels. With variable-rate liming, the key is to apply lime according to soil pH and the application rate indicated by the buffer pH measurement. Variable-rate technology (VRT) can be used to target applications to the most deficient field areas to get the highest possible return when price ratios are unfavorable and also to improve maintenance fertilization by considering yield and removal variation. Yield maps from the past two to four years (not just the last one) should be used together with soil-test values to help define P and K application rates. Research suggests that either grid sampling or zone sampling methods are superior to the classic sampling by soil type method (see publication PM 287 concerning sampling methods). The traditional sampling by soil map unit often is not the best for precision management of P, K, and lime. The soil survey maps may not have the required scale and precision that may be required and, moreover, soil-test variability often is very large even within soil map units or seemingly uniform field areas in fields with long histories of cropping and fertilizer or manure application.

Zone sampling assumes that sampling areas with relatively homogeneous soil-test values can be identified based on previous management and soil or crop characteristics which can be mapped using various precision agriculture tools. These may include soil map units with slope or erosion phases, elevation models, soil or crop canopy images, yield monitor maps, and estimates of soil electrical conductivity (EC). However, apparently homogenous areas often do not have homogeneous soil-test P, K, and pH values because those measurements may not reflect well the nutrient levels variation due to other non-measured soil properties or management practices. Extensive on-farm research in Iowa that used crop yield response to compare different sampling methods for P and K showed that in most fields grid sampling based on 2.5-acre cells was the most effective method, sampling by soil type was the least effective, and zone sampling was intermediate. As an example, Fig. 5 shows results of soil sampling for P in two contrasting fields using grid, soil type, and zone sampling. Although the sampling and testing costs often are the highest for a 2.5-acre grid sampling, zone sampling may results in as many samples in some fields and has higher planning and implementation costs. One very useful use of the zone sampling method is in fields with high-pH calcareous soils intermingled with neutral or acidic soils because soybean iron-induced chlorosis can map very well the location of these areas. This is very useful because producers must avoid applying lime to calcareous soils; not only it is a waste of money but can reduce crop yield.

The criteria discussed above concerning interpretation of soil-test values and crop yield levels to decide fertilization and liming application rates also apply to use of a dense soil sampling method and VRT. Producers sometimes use VRT but apply higher than needed rates in low-testing and apply removal P and K based rates or lime to high-testing soils that do not need additional fertilize or lime. This practice does not result in more efficient use of inputs or increased profits with unfavorable price ratios, and doesn’t make sense with uncertain land tenure. In many Iowa fields, the main reason adopting VRT will increase profits is by reducing the amount of fertilizer or lime applied to high-testing field areas. The actual impact of VRT on crop yield and the profitability of fertilizer and lime use will vary greatly depending on the level at which soil-tests and yield (impacting estimated P and K removal) vary across a field and the proportion of low-testing areas.

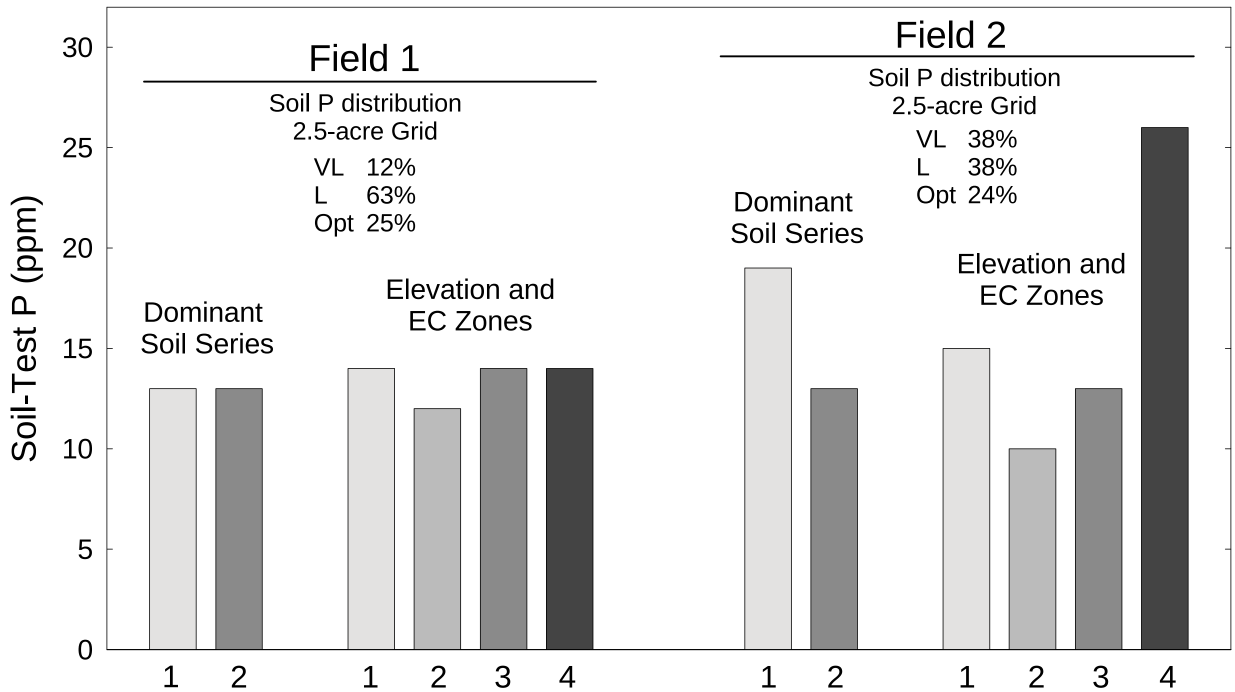

Fig. 5. Soil-test P in two contrasting fields from samples taken using different sampling methods (adapted from Sawchik and Mallarino, 2007).

Banding of P and K before planting or with the planter does not reduce the application rate needed to optimize crop yield no matter the tillage system

Research in Iowa soils and other soils of the humid Corn Belt has shown that banding of P and K fertilizers seldom is more efficient than broadcasting the fertilizers, even with no-till management. Therefore, cutting the fertilizer rate for low-testing soils when banding is used will increase the risk of yield loss and may reduce profits from crop production, and the future fertilization needs will increase. Figure 6 shows results for no-till corn yield response to broadcast or planter-band P and K from long-term trials at three ISU research farms. A similar lack of placement methods differences have been observed for fields managed with chisel-plow/disk tillage, with soybean, and at other farms with smaller responses to P and K.

Research in many Iowa fields has shown that deep placement of K fertilizer (about 5 to 6 inches deep) is beneficial with ridge-tillage, but only sometimes with no-tillage or strip-tillage. Deep banding was not of benefit for P. However, reducing the K application rate called for by ISU soil-test interpretations when deep banding K fertilizer is not recommended. In some conditions, a small amount of starter fertilizer applied to the corn seed furrow or beside the seeds can complement a primary broadcast application. This happens mainly when applying the P and K rate for one crop year in soils testing extremely low and/or with a thick residue cover and cool or wet soil in spring. However, there is no yield response to starter when the fertilizer rate for the two-year corn-soybean rotation is applied once before corn.

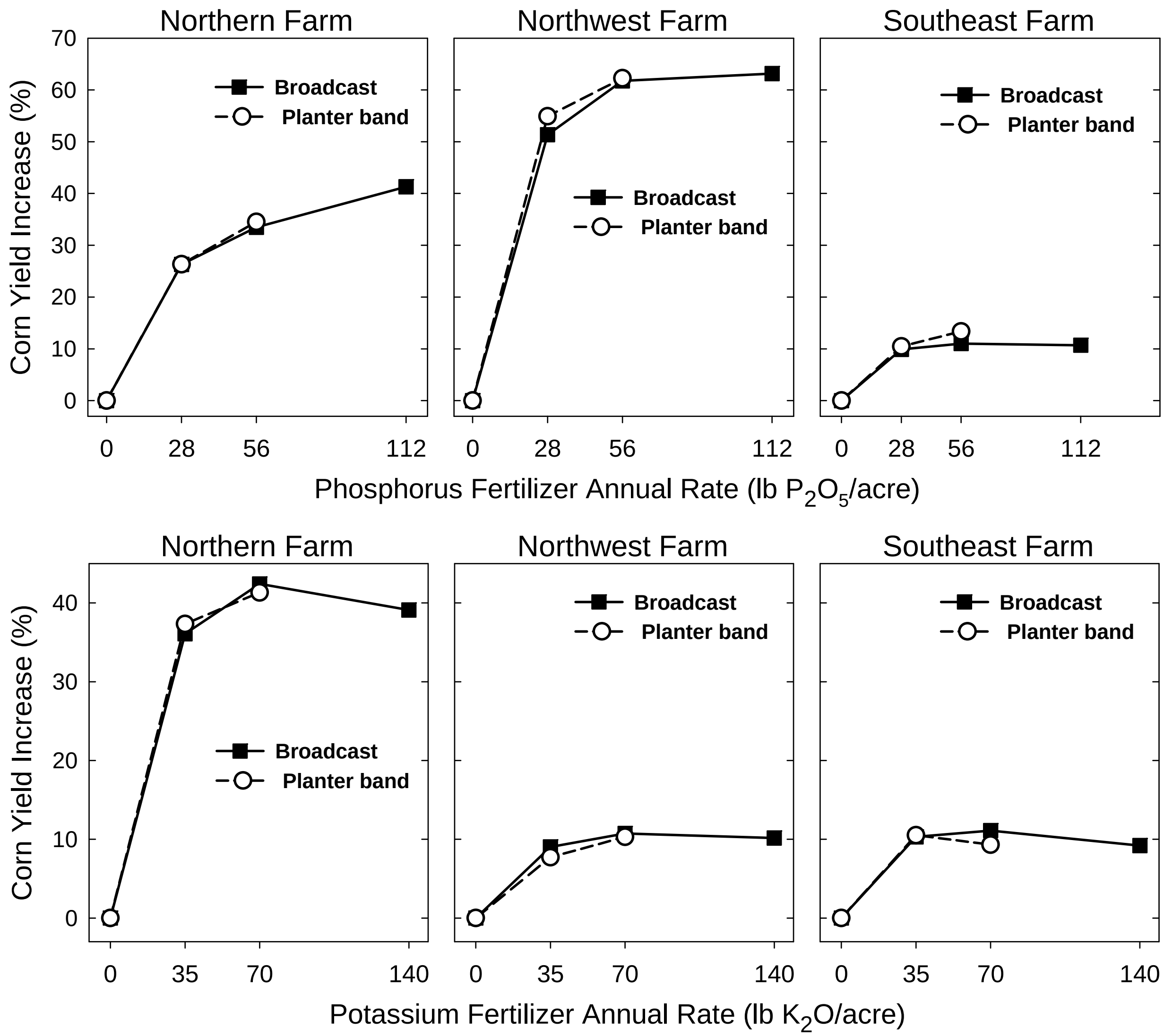

Fig. 6. Relative no-till corn response to broadcast or planter-band P or K placement from long-term trials conducted a three Iowa State University research farms.

Give credit to P and K in animal manures and apply manure carefully

Iowa research has shown that manures are excellent P and K sources, when used in conjunction with manure analysis and careful application methods. The research results have been used to develop manure nutrient management guidelines in extension publication PMR 1003 (Using Manure Nutrients for Crop Production). The K availability of all animal manures is 90 to 100 % compared to fertilizer. The P availability varies more, however, being 90 to 100% for poultry and liquid swine manures and 60 to 100% for other manures. These values are based on field research that represented the variety of conditions found in Iowa fields. In contrast to manure nitrogen, potential losses from volatilization or leaching and the time of application (fall or spring) are not issues for manure P and K. Therefore, the most common factors that may affect the effectiveness of manure P and K use are how the manure analyses represent the manure actually applied and the uniformity of the application.

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