

Fertilizing crops in the new price age – phosphorus and potassium

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What is the problem?

Profitable crop production requires appropriate soil phosphorus (P) and potassium (K) levels, so careful fertilization planning is required. Grain and fertilizer prices have increased significantly during the last two years. Increasing prices may not be a major issue as long as the historical ratio between crop and fertilizer prices is approximately maintained. Recently, however, fertilizer prices have been increasing steadily while grain prices have fluctuated significantly. If there is a crop yield response to fertilization, high crop prices certainly help pay for more expensive fertilizer and may result in even greater net return to fertilization than when crop prices are low. The problem is that largely unpredictable price fluctuations complicate fertilization decisions and encourage many producers to change production practices and cut fertilizer rates. Reducing P and K rates across all conditions is not necessarily a good management decision, however.

Test soils for P and K levels

Soil testing is the most important diagnostic tool on which P and K fertilization should be based. Compared to the cost of nutrient inputs, soil testing has become less expensive, provides an objective basis for making P and K fertilization decisions, and investment in soil sampling and testing results in good returns. *Soil testing is not a perfect tool but is very useful and should be used to know what fertilizer rates are needed.* Soil-test levels vary greatly across and within Iowa fields. Field research conducted over the years has been used to develop Iowa soil sampling and soil-test interpretations for P, K, and lime. See the ISU Extension publication PM-287, *Take a Good Sample to Help Make Good Decisions*, for soil sampling suggestions. Research has shown that dense soil sampling methods (such as grid sampling) and frequent soil sampling (every 2 years instead of every 4 years for corn-soybean rotations, for example) coupled with variable-rate fertilizer application result in better nutrient management. These practices are more costly than sampling by soil type every 4 years, for example, but their profitability increases with high fertilizer and grain prices.

For soil-test interpretations and fertilizer recommendations see ISU Extension publication PM 1688, *A General Guide for Crop Nutrient and Limestone Recommendations in Iowa*. Table 1 shows a summarized version of the tables with recommendations for corn and soybean grain harvest. Field research has shown that the percentage of P and K applications expected on average to produce a yield response within each soil-test category is 80% for Very Low, 65% for Low, 25% for Optimum, 5% for High, and < 1% for Very High. This means that as soil-test levels increase, the probability of a yield increase to fertilization and the size of expected yield increase decrease. Philosophies about soil-test interpretations and fertilizer recommendations vary across states and countries. Some emphasize short-term profitability from fertilization, a high return per pound of fertilizer applied, and reduced risk of fertilizer over-application by accepting moderate risk of yield loss (often referred to as sufficiency philosophy). Others emphasize long-term profitability from fertilization, maximum returns over a long term, and reduced

risk of yield loss due to insufficient fertility (often referred to as buildup and maintenance philosophy). The philosophy behind soil-test interpretations in Iowa (as in most Midwestern states) combines aspects of both philosophies. Based on expected yield increases and returns, fertilizer applications for low-testing Iowa soils are designed to be profitable, to minimize risk of yield loss, and to increase soil-test values to the Optimum category over time. Moderate soil-test buildup happens even with economically optimum rates, and is explained by partial plant uptake, recycling to the soil with residues, and soil properties that keep P and K in crop-available forms over time. Most Iowa soils have no chemical and mineralogical properties that result in significant transformation of applied P and K into unavailable forms as can happen in soils of other regions. Therefore, much of the applied P and K to Iowa soils can be “banked” in the soil.

No matter the philosophy supporting recommendations, however, the net returns to investment in fertilizer are high in low-testing soils, decrease as soil-test levels increase, and usually become negative at the High and Very High test categories (see an example for P in Fig. 1). *Fertilization of low-testing soils usually results in significant returns even with current high P and K fertilizer prices because the probability of a large yield response is high.* In high-testing soils, however, the likelihood of large loss to investment in fertilization is very high with current prices because the probability of a yield response is very low and any response is small. Therefore, *avoiding unnecessary fertilization of high-testing soils is the most profitable change a producer can use in times of high or uncertain prices.* Based on expected yield increases, the Optimum soil test category in Iowa is the most profitable category to maintain over time, with application of removal-based rates. However, decisions are not simple and there is no single best answer concerning fertilization of soils testing in the Optimum category when prices fluctuate significantly.

What soil-test levels should be maintained?

Allowing a soil-test decline in soils testing in the Optimum soil-test category may result in a yield loss. Application of P and K based on crop removal are recommended for the Optimum soil-test class as publication Pm-1688 indicates, and the provided default rates should be adjusted for actual yield levels. After fertilizer or manure application, the most important factor determining change in soil-test P and K values over time in Iowa soils, is P and K removal with harvest. Due to crop removal, however, withholding fertilizer or manure P and K applications will result in a gradual soil-test decline (see example for P in Fig. 2). Allowing a soil-test decline to occur in high-testing soils increases the profitability of crop production because there is a very low probability of yield response to fertilization, and in the case of P also reduces the risk of water quality impairment. Some believe that allowing a soil-test K decline may not be a good business decision because a K excess has no environmental impact and K fertilizer prices may be even higher in the future. This would be considered a risky business decision that each producer should ponder carefully, and may not be a good nutrient management decision. Although both P and K can be “banked” in Iowa soils, the rate of soil-test decline becomes greater as the soil-test level increases, probably due to larger nutrient loss with soil erosion, surface runoff, and “luxury” uptake and removal especially with corn silage and hay.

Research has shown the large effect of yield level on P and K removal and the fertilization rate needed to maintain soil-test values. This is a very important concept to remember, especially because of increasing corn and soybean yields. Although maintaining soil-test values in the

Optimum category is a good practice to sustain profitable crop production over time, fertilizer applications can be reduced or even withheld until the next year. This is because the removal-based rate is designed to maintain soil-test values, the probability of a yield response in this test category is 25% or less, and the expected yield response is small. *Applying a rate lower than the removal-based rate may be reasonable when the fertilizer/grain price ratio is higher than usual, fertilizer or manure supply is scarce, limited funds are needed for more critical production inputs, or land tenure is uncertain. And, any profit increase will be temporary because higher application rates will be needed in the future.* Soil-test decline without sufficient P and K application is gradual but does occur (Fig. 2). Therefore, application of partial crop removal or commonly used starter rates will provide adequate fertilization for the small and occasional yield response in the Optimum category for one year but will not avoid a soil-test decline over time.

Many producers apply once before corn the P and K needs of corn and soybean. Previous and ongoing long-term research shows that this practice is as effective as applying those nutrients ahead of each crop, but only as long as the fertilizer applied is sufficient for both crops. If fertilizer price or supply will be better next fall (which is difficult to predict), money could be saved now by applying the nutrient need of one crop and fertilizing again next year. *The cost of fertilizer application in relation to total fertilizer or crop production costs is relatively less than in the past. Therefore, making single-year applications when fertilizer prices are temporarily high is a reasonable option.*

Can fertilizer rates for low-testing soils be reduced with high prices?

A short answer is yes but only by accepting a high risk of yield and profit loss, and doing so when funds are insufficient to buy other critical inputs and/or with very uncertain land tenure. Reasons for this short answer should be obvious after the discussion in the previous sections. *Reducing the fertilizer rate in low-testing soils seldom is a good business decision because there is a high probability of a large crop response to fertilization and profit, and recommended rates slowly build up soil-test values to levels that should be maintained for long term productivity and high economic return.* Some producers speculate that similar yield levels can be achieved by using reduced planter-band P and K fertilizer rates compared with broadcast fertilization in low-testing soils. Iowa research across many years on many fields indicates that this is not the case. Less than optimum fertilizer rates, no matter the placement method, reduce total return to fertilization, but do increase the return per pound of nutrient applied. This is because of the usual curvilinear shape of the crop response to fertilization. The yield increase per pound of nutrient applied is largest at very low rates and decreases as the rate increases, and so do returns per pound. Because P or K rates higher than optimal rates seldom decrease yield, a yield plateau is reached at a certain rate. A maximum total return is achieved at a rate lower than the rate that maximizes yield (how lower depends on price ratios) and higher rates decrease total return, which may become negative with excessively high rates. Figure 3 shows an example of grain yield and returns from K fertilization for two field trials in soils with different soil-test K. *Therefore, producers should carefully study if and when application rates to low-testing soils can be reduced, and a sound decision requires consideration of many factors including the producer business management philosophy.*

What about substituting expensive fertilizer with manure P and K?

Manure can supply many nutrients required by crops, including nitrogen (N), P, and K and is a resource that can always be used but especially when fertilizer prices are very high. Because manure contains many nutrients, applications should consider not only what is needed for the crop to be grown but also the ratio of nutrients as determined by manure analysis. The many issues that should be considered when using manure to supply P and K for crops, which include availability of manure nutrients and management practices, will not be addressed here because a very recent ISU Extension publication discusses those issues and provides research-based application guidelines (see PR 1003, *Using Manure Nutrients for Crop Production*). As this publication indicates, manure K (all inorganic) is 90 to 100% available for crops and manure P (both organic and inorganic in variable proportions) is 90 to 100% available in swine and poultry manures but 60 to 100% available in beef and dairy manures. These availability ranges account for variation in manure sampling and analysis and also for the importance of adequate P and K supply with deficient to adequate soil-test levels. Mainly with beef and dairy manure, a portion of manure P may not be available immediately after application but all P is potentially available over time. The lower availability values are recommended for low-testing soils where large yield loss could occur if insufficient P or K is applied and a reasonable buildup is desirable. The highest availability values should be used when manure is applied to maintain soil-test P and K in the Optimum soil test category, when a removal rate is recommended and the probability of a yield response is low. *Manure is an excellent source of P and K for crops when used based on appropriate manure testing and with careful application methods, and is a good way of using available resources especially when fertilizer prices are high or supply is scarce.*

Summary

Soil testing and estimates of P and K removal are key pieces of information that should be used together with fertilizer/crop price ratios when deciding P and K application rates. Although many nutrient management considerations in relation to prices are similar for all nutrients, there are some clear differences for P and K compared with N. One main difference is that soil-test P and K levels of Iowa soils can be managed for buildup, maintenance, or draw-down over time. An important consequence is that although a higher than optimum N rate almost always means an investment loss for the excess N portion, an excessive P and K rate one year does not necessarily mean money lost. Most of the P and K applied in excess will be available for the following crop, and soil testing can be used to adjust future application rates. Rapidly changing fertilizer and crop prices, however, make P and K management more challenging than in the past. Producers, crop consultants, and dealers should consider factors other than fertilizer/crop price ratios such as fertilizer and manure supply, producers' economic conditions in relation to purchase of critical production inputs, land tenure, and producers' business management philosophy. Simply reducing P and K fertilizer rates across all conditions during times of high prices is not a good nutrient or business management decision process.

References

Extension publications referred to in this article are available ISU Extension Publications web page (<http://www.extension.iastate.edu/Publications>) and the Agronomy Extension Soil Fertility web site (<http://www.agronext.iastate.edu/soilfertility>).

Table 1. Soil-test interpretations for P and K and fertilization rates for corn and soybean from publication Pm-1688.†

Nutrient	Soil-Test Category	Soil-test range §	Corn Yield ‡		Soybean Yield ‡	
			150 bu	200 bu	50 bu	60 bu
		ppm	----- lb P ₂ O ₅ or K ₂ O/acre -----			
P	Very low	0-8	100	100	80	80
	Low	9-15	75	75	60	60
	Optimum	16-20	55	75	40	48
	High	21-30	0	0	0	
K	Very low	0-90	130	130	120	120
	Low	91-130	90	90	90	90
	Optimum	131-170	45	60	75	90
	High	171-200	0	0	0	0

† Interpretations for soil series with low subsoil P and K and for K fine-textured soil.

‡ See publication Pm-1688 for guidelines to adjust maintenance rates for the Optimum category.

§ Bray-1 or Mehlich-3 tests with a colorimetric determination for P and ammonium acetate or Mehlich-3 for K.

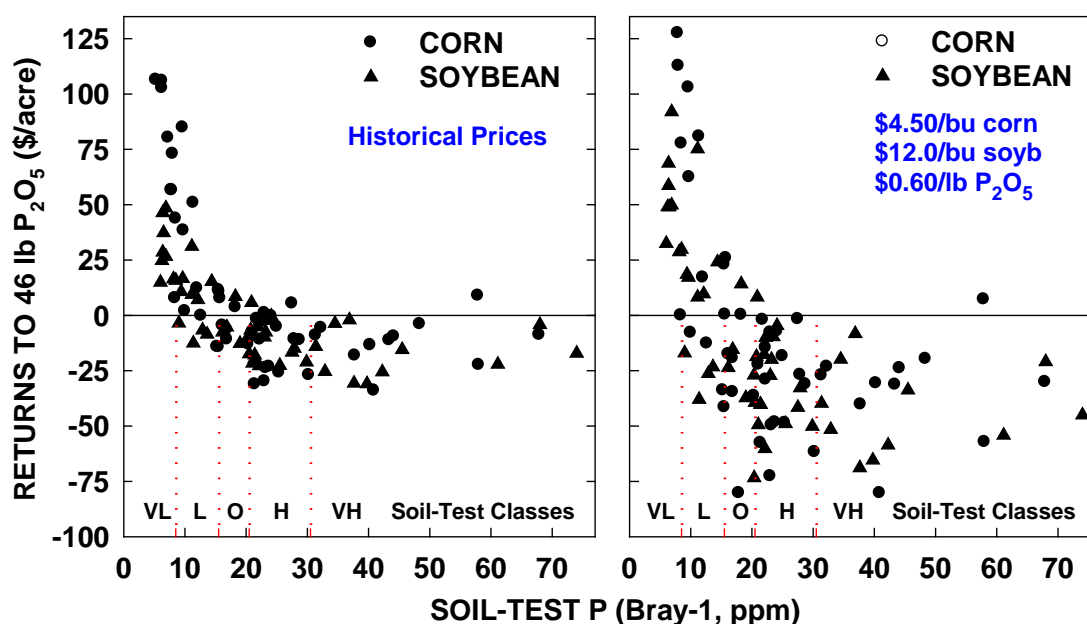


Figure 1. Net returns to P application for different soil-test P levels and crop/fertilizer prices.

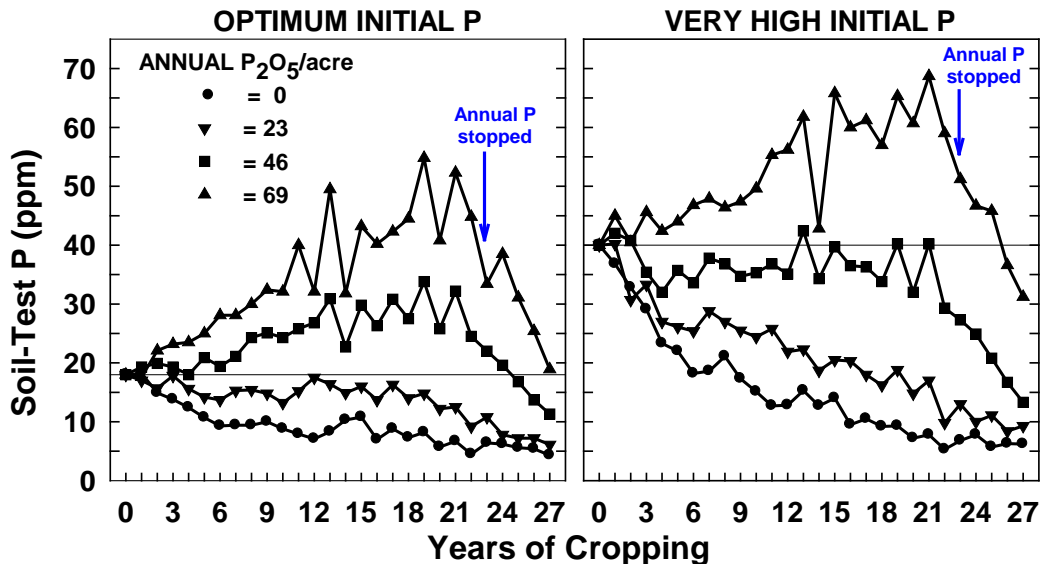


Figure 2. Change in soil-test P over time with different initial soil-test levels and P fertilizer rates for corn-soybean rotations.

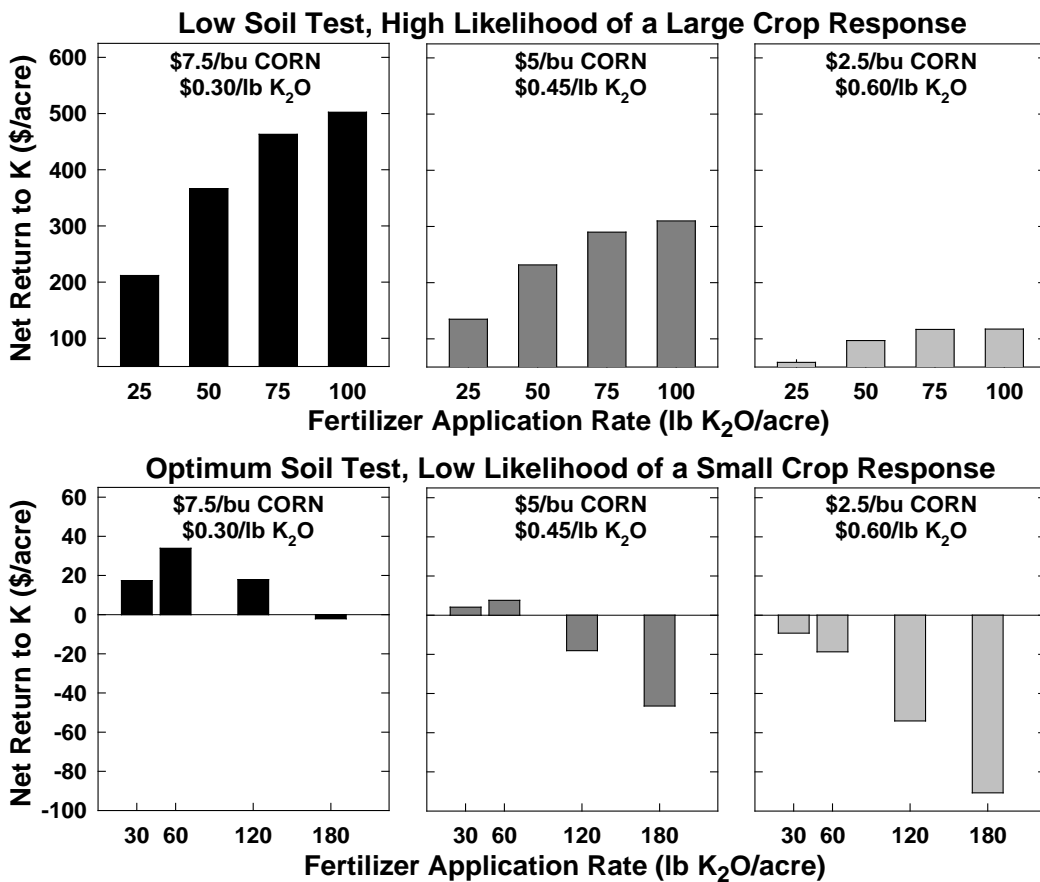


Figure 3. Examples of net returns to K fertilization in soils with large and small corn yield response to application according to the soil-test K level.