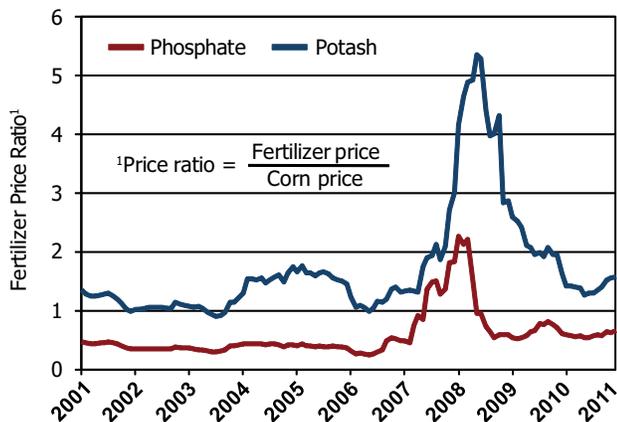


# Phosphorus and Potassium Fertility for Corn and Soybean

Recent years have seen increased price volatility for both farm inputs and products. Few inputs have experienced such dramatic price fluctuations relative to grain as have phosphorus (P) and potassium (K) fertilizers (Figure 1). Given unstable market conditions, careful management of fertilizer inputs is more important than ever to maximize net returns. This article describes best P and K fertility management practices for corn and soybeans in an era of high prices and market uncertainty.



**Figure 1.** Monthly price ratios for phosphate and potash fertilizers over the course of the last decade.

## Interpreting Soil Test Results – Nutrient Sufficiency vs. Build and Maintain

Soil test results ultimately serve as the basis for making P and K rate recommendations. Soil test interpretations and fertilizer recommendations vary among regions and states, but most approaches can be described in terms of two dominant fertility paradigms, **nutrient sufficiency** and **build and maintain**:

**NUTRIENT SUFFICIENCY** is a philosophy for P and K fertility that focuses on applying the minimum amount of fertilizer needed to maximize profitability in the year of application, with no concern for future soil test values or fertilizer requirements. Generally, recommendations based on nutrient sufficiency will provide 90 to 95 percent of maximum yield and a high rate of return per unit of fertilizer applied. The nutrient sufficiency approach is **most logical** when:

- Fertilizer prices are high relative to grain prices
- Resources are limited in a particular year
- Growers are operating under a short-term land tenure situation
- Soils have a high capacity to convert readily available P and K to forms that are unavailable to crops in the short-term

**Disadvantages** of nutrient sufficiency-based recommendations include:

- The need for regular and accurate soil testing
- Precise knowledge of optimum application rates
- Risk of limiting long-term crop productivity



*Fertilizer P and K are often broadcast-applied in the fall following soybean harvest. (Photo courtesy of Deere and Co.)*

**BUILD AND MAINTAIN** fertility programs contrast with the nutrient sufficiency approach in that they are not intended to maximize economic returns in any given year. Rather, they are designed to provide flexibility and consistent economic returns over the long-term by removing P and K as yield-limiting factors. At low soil test levels, build and maintain recommendations focus on increasing P and K to the critical test level and maintaining soil nutrient supply at or above this point through application of additional fertilizer to account for crop removal (see Table 1 for critical levels and crop removal rates). Build and maintain programs also advise that fertilizer be applied to account for crop removal in the optimum soil test range. Generally, recommendations based on a build and maintain philosophy will provide 100 percent of maximum yield with low risk of yield loss due to insufficient fertility.

**Table 1.** Critical P and K soil test levels and crop removal rates for corn and soybeans (Warncke, et al., 2004).

Crop	Critical Soil Test Level				Crop Removal		
	P	K at CEC <sup>1</sup>			P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	
		5	10	20	30		
		-----ppm-----				- lb/bushel -	
Corn	20	88	100	125	150	0.37	0.30
Soybean	20	88	100	125	150	0.80	1.50

<sup>1</sup> Critical soil test level for K = 75 + (2.5 x CEC) for corn and soybean.

The build and maintain approach is **attractive** when:

- Grain prices are high relative to fertilizer
- Recent or complete soil test data are unavailable
- Crop yields are expected to increase in the future
- Resources are currently available and fertilizer prices are expected to increase in the future

**Disadvantages** of build and maintain-based recommendations include:

- Higher fertilizer cost during the build phase when soil test levels are below the critical value
- Risk of sub-optimal economic return in a given year

It is important to note that application of P and K at higher than economically optimal rates in a particular year can offset fertilizer requirements in future years. Both P and K are relatively stable in soils and can be “banked” for later use if economically advantageous. Rate recommendations for P and K fertilization based on the nutrient sufficiency and build and maintain paradigms are presented in Tables 2 and 3.

**Table 2.** Phosphorus rate recommendations for corn and soybean based on nutrient sufficiency and build and maintain approaches. Adapted from Warncke, et al., 2004.

Basis for Recommendation	Soil Test (ppm)				
	Very Low (0-8)	Low (9-15)	Opt. (16-20)	High (21-30)	Very High (31+)
	----- lb P <sub>2</sub> O <sub>5</sub> /acre/year -----				
Nutrient Sufficiency (corn and soybean) <sup>1</sup>	60-100	25-55	0-20	0	0
Build and Maintain (corn) <sup>2</sup>	125-165	90-110	65-85	0-65 <sup>4</sup>	0
Build and Maintain (soybean) <sup>3</sup>	110-150	75-95	50-70	0-70 <sup>4</sup>	0

<sup>1</sup> Calculated as: [(Critical level - soil test) x5]

<sup>2</sup> Nutrient Sufficiency + crop removal at 175 bu/acre yield

<sup>3</sup> Nutrient Sufficiency + crop removal at 60 bu/acre yield

<sup>4</sup> Fertilize high testing soils only under favorable crop and fertilizer prices or as a band at planting



**New equipment advances allow for accurate fixed-rate or variable-rate application of dry fertilizer. (Photo courtesy of Case-IH.)**

**Table 3.** Potassium rate recommendations for corn and soybean based on nutrient sufficiency and build and maintain approaches. Adapted from Warncke, et al., 2004.

Basis for Recommendation	Soil Test (ppm)				
	Very Low (0-70)	Low (71-110)	Opt. (111-150)	High (151-180)	Very High (181+)
	----- lb K <sub>2</sub> O/acre/year <sup>1</sup> -----				
Nutrient Sufficiency (corn and soybean) <sup>2</sup>	110-250	30-100	0-25	0	0
Build and Maintain (corn) <sup>3</sup>	160-300	80-150	50-75	0-50 <sup>5</sup>	0
Build and Maintain (soybean) <sup>4</sup>	200-340	120-190	90-115	0-90 <sup>5</sup>	0

<sup>1</sup> Recommendations based on a K critical value of 125 ppm at CEC of 20 meq/100 g

<sup>2</sup> Calculated as: [(Critical level - soil test) x5]

<sup>3</sup> Nutrient Sufficiency + crop removal at 175 bu/acre yield

<sup>4</sup> Nutrient Sufficiency + crop removal at 60 bu/acre yield

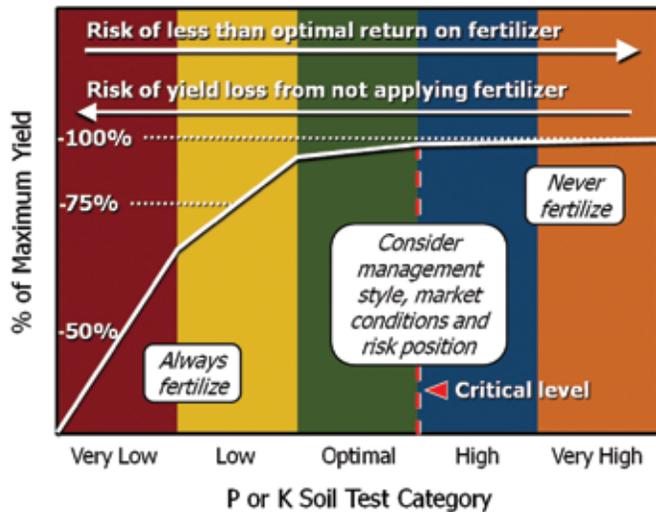
<sup>5</sup> Fertilize high testing soils only under favorable crop and fertilizer prices or as a band at planting

It is often said that nutrient sufficiency recommendations focus on feeding the crop, while build and maintain recommendations focus on feeding the soil. Both approaches are valid. The decision to adopt one strategy over another ultimately depends on market conditions, management style and risk position (Leikam et al., 2010).

In reality, P and K rate recommendations provided by most university extension services incorporate elements of both nutrient sufficiency and build and maintain strategies. For example, Iowa State University’s recommendations fall between strict interpretation of either paradigm at low soil test levels, but conform to the build and maintain philosophy at and above the optimum soil test range. In contrast, Michigan State University’s recommendations embrace a build and maintain philosophy but include underlying equations allowing users to determine rate recommendations based on either approach. Kansas State University offers separate nutrient sufficiency and build and maintain rate recommendations.

Regardless of which paradigm or set of guidelines is used to develop rate recommendations, the following general rules of thumb apply (Figure 2):

- Always fertilize when soil test levels fall below the optimal range; risk of yield loss is high and return to fertilizer investment is greatest for very low and low testing soils
- Avoid application on high testing soils and never apply on soils that test in the very high range; return on fertilizer investment decreases as soil test level increases
- When in doubt, fertilize based on expected rates of crop removal



**Figure 2.** Fertilizer response, risk factors and general fertility guidelines with respect to soil test category.

## Conclusions

In an era of volatile commodity markets, careful management of P and K fertilizers is more important than ever. Soil test results can be used in conjunction with information regarding P and K removal rates to develop fertilizer rate recommendations that best fit market conditions, management style and risk position. Rate recommendations can be developed to maximize short-term returns following a nutrient sufficiency approach, or to provide consistent, long-term profitability following a build and maintain approach. Consult state extension guidelines or local Pioneer sales professionals for region-specific rate recommendations.

## References

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