PART 3

Phosphorus and Potassium Economics in Crop Production: Putting the Pieces Together

By T.S. Murrell and R.D. Munson

Fertilizer used properly can result in yield increases that help spread fixed and variable costs over more bushels, lowering cost per bushel. Lower expenses per bushel mean that the farm is operating more efficiently, a characteristic seen on more profitable farms. Calculating costs per bushel requires not only fertilizer costs, but also the entire set of overhead and direct costs associated with a farm and a particular crop.

In the event the farmer has not accounted for all of his or her expenses, local farm management associations may have summary data of farmers belonging to a local association.

To calculate costs per bushel, one simply divides total production costs by the bushels produced. As an example, consider corn response to K fertilization in **Table 1**. In this example, the costs considered were soil sample analyses, fertilizer, application, and harvest costs. Soil samples, taken every 2 years, representing 5 acres, and analyzed for P, K, and pH, were assumed to cost \$0.75/A/year for chemical analysis. Potassium fertilizer price was set at \$0.14/lb K_2O, and application costs were \$2.25/A/year. Corn price was \$2.00/bu; harvest costs included \$0.15/bu for handling and hauling and \$0.17/bu drying costs, assuming corn was harvested at 23 percent (pt) moisture and dried to 15.5 percent at \$0.022/pt/bu [(23 pt - 15.5 pt) (\$0.022/pt/bu) = \$0.17/bu].

When times are tough, farmers try to lower their fixed and variable costs. Fixed costs are relatively inflexible and often hard to reduce. They can be controlled somewhat by improving efficiency and by making decisions such as maintaining a functional piece of equipment rather than purchasing a new one. Many farmers may target variable costs, such as fertilizer, for cost reductions. However, before cutting down on phosphorus (P) and potassium (K) use, they should carefully evaluate their soils and fertility program. Nitrogen (N), P and K account for a high percentage of crop yields and are critical to successful farming operations. Those who fine-tune their system for maximum economic yields maximize their profits in good times and minimize their losses in bad times.

These data demonstrate that crop responses to appropriate application rates of K can lower unit costs of production and increase net profit per acre. In this example, the total cost per bushel dropped from \$2.05 to \$1.84. Higher investments led to greater returns and a more efficient production system. The same concepts apply to appropriate P fertilization. Local crop response data, where they exist, provide estimates for the profitability of P or K additions. Where local data do not exist, generalized responses, such as those discussed in **Part 2** of this series, may provide first approximations needed to calculate expected returns. It should also be noted that the returns and lower unit costs were based on response data from a single crop in a rotation. Residual effects of P or K applications on future crops were not considered. These data, then, probably underestimate the true value of P and K fertilization, depending on the rates used.

Prices and Recommended Rates

Optimum fertilizer rate is determined by the farmer's preference of marginal net return. Marginal net return is the added dollar value returned per last dollar invested. **Figure 1** shows marginal returns for long-term P response data. The optimum rate was determined from single year crop response as the P rate yielding $1.00 returned per $1.00 invested. Applying more P than optimum would result in less than $1.00 return per $1.00 invested, cutting into profits. Such curves do not normally consider multiple-year effects of a single application.

An analysis of economic optimum rates, which maximize profit or minimize loss, is based on current market prices. Changing market conditions will lead to changes in optimum fertilizer rates. Two important economic factors that vary from year to year are crop price and fertilizer material cost. Curves similar to that in **Figure 1** were constructed for corn prices ranging from $2.00 to $4.00/bu and for P_2O_5 prices ranging from $0.15 to $0.35/lb. **Table 2** shows the influence of these two variables on the optimum P rate calculated from the previous examples. This table demonstrates that optimum P rates for the example in **Figure 1** can vary from 28 to 51 lb P_2O_5/A, considering P_2O_5 prices from $0.15 to $0.35/lb and corn prices from $2.00 to $4.00/bu. Fluctuations in P fertilizer price affect optimum rates less at higher corn prices. Fluctuations in crop price affect optimum rates less at lower P fertilizer prices. If modest swings in P fertilizer cost or corn price are expected in a given year, the optimum P rate chosen for a particular crop year does not change greatly. For instance, if the corn price increases from $2.00 to $2.50 and P costs are

TABLE 1. Potassium fertilization increases corn yields and return per acre by lowering the unit cost of production (Ohio).

K_2O rate, lb/A	Corn grain yield, bu/A	Additional yield, bu/A	Added gross revenue, $/A	Additional costs from yield response to K, $/A	Added costs from K fertilization, $/A	Net return, $/A	Added net return, $/A	Total cost per bushel, $/bu
0	146	—	—	—	—	-8.00	—	2.05
50	167	21	42.00	6.72	10.00	17.28	25.28	1.90
100	174	7	14.00	2.24	7.00	22.04	4.76	1.87
200	187	13	26.00	4.16	14.00	29.88	7.84	1.84

Base cost without K: $300/A; soil test K: 126 to 209 lb/A; corn price: $2.00/bu.

TABLE 2. Effects of crop prices and fertilizer expenses on recommended P rates for corn, based on an Iowa State University 14-year P rate study.

P_2O_5 price, $/lb	Recommended P_2O_5 rate, lb/A @ corn prices, $/bu					Difference from $2.00/bu corn prices, lb P_2O_5
	2.00	2.50	3.00	3.50	4.00	
0.15	44	47	49	50	51	7
0.20	40	44	47	48	49	9
0.25	36	41	44	46	48	12
0.30	32	38	42	44	46	14
0.35	28	35	40	42	44	16
Differences from $0.20/lb fertilizer costs (lb P_2O_5/A):	16	12	9	8	7	

Data: J.R. Webb, A.P. Mallarino, and A.M. Blackmer, ISU.

$0.20/lb P_2O_5, the optimum rate changes by only 4 lb P_2O_5/A, which is beyond the precision of most application equipment.

Managing Risk

There are three basic types of risk that producers face in their fertilization program: 1) risk that a fertilizer application will not be profitable, 2) risk that soil test levels within a field are yield-limiting, and 3) risk that soil test levels are not high enough to cushion errors or financially-trying times (reduced flexibility). **Figure 2** shows how these risks are related to soil test levels. At lower soil test levels, there is a higher probability that a fertilizer application will be profitable in the year of application, but increased risk that soil test levels are yield-limiting or do not allow much room for error. Soil fertility held very near medium, based on general small plot soil test calibration research, requires that soil testing and sampling be performed well and that the sampled field have fairly uniform soil test levels. Uniformity of soil test levels can be tested by more intensive sampling.

Farmers should be aware that there are several examples where more intensive sampling has identified field areas testing much lower and much higher than the field average. Soil test levels close to the medium range require annual fertilizer additions, or at least additions large enough to cover the nutrient needs of the crops produced between applications. Building soil test levels to the high side of medium or to high allows more room for error and reduces the risk that soil tests might be yield limiting. In addition, producers who have built their soil tests to high or very high levels may be able to skip an annual P or K application, but use row applications where appropriate. However, building soil tests to levels higher than medium increases the risk that annual yield returns will not cover fertilizer expenses. Each producer must realize the risks associated with the various soil test levels and make decisions based on the risks he or she is willing to accept.

Managing Soil Test Levels

Without soil testing, no reasonable estimate of yield responses to fertilizer can be

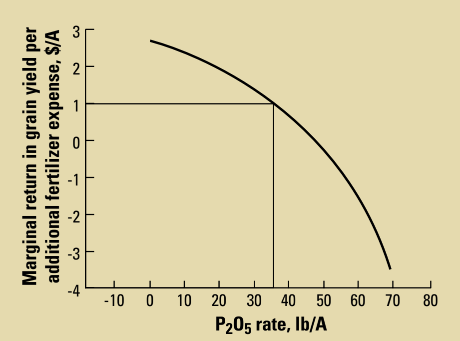

Figure 1. Marginal returns to phosphate fertilizer expenses for $2.00/bu corn, $0.25/lb P_2O_5, and added handling, harvest, and drying costs. Data source: J.R. Webb, A.P. Mallarino, and A.M. Blackmer, ISU.

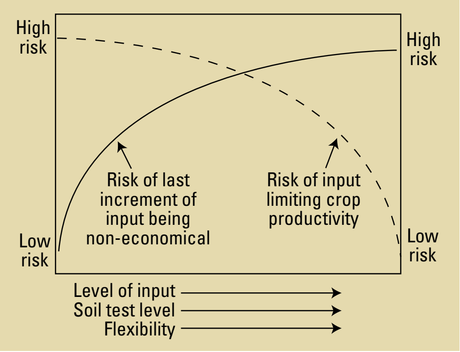

Figure 2. Risk incurred at various soil test levels (D. Leikam, personal communication).

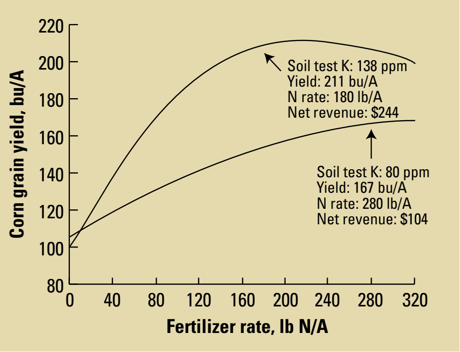

Figure 3. Higher soil test K levels increase N use efficiency and net returns to N fertilization (Data: Ohio; prices set at $2.50/bu corn, $0.20/lb N).

TABLE 3. Average P and K crop removal numbers for corn, soybeans and wheat.

Crop	P removal, lb P_2O_5/bu	K removal, lb K_2O/bu
Corn	0.38	0.28
Soybeans	0.80	1.40
Wheat	0.50	0.26

made unless check strips are left and harvested separately. The previous discussion has demonstrated that soil testing is important for managing risk. Soil testing is a very inexpensive management practice on which important decisions can be made. Similar small investments producing valuable information are field scouting and plant analysis. Time spent on management decisions, such as analysis and problem assessment, is a characteristic of more profitable producers.

It is important to remember that nutrients are removed from a field when harvested portions of the crop are removed. Some average removal rates for corn, soybeans and wheat are listed in **Table 3**. Crop removals will reduce the quantity of P and K in the soil. This will be reflected in reduced soil test P and K values. The effects of crop removal are shown in **Part 1**, **Table 2** of this series. Since no annual P was applied after the first year, soil test levels decreased with time. It is also interesting to note that soil tests declined more rapidly for the soil with a higher initial soil test level. This is a relationship that is commonly observed in long-term studies. For this reason, farmers with soil test levels high enough to skip an application of P or K should closely monitor changes in soil tests to ensure they have not dropped to yield-limiting levels.

Nutrient Interactions

Information presented so far has concentrated upon the effects of a single nutrient. However, nutrients often interact to provide benefits beyond those possible for one nutrient. An example of this is shown in **Figure 3**.

This 1999 Midwest corn showed symptoms of K deficiency. In a recent summary of soil test levels, 44 percent of North American samples tested medium or below in K, with several Corn Belt states exceeding 60 percent.

Optimum N rate at the higher soil test K level of 139 parts per million (ppm) produced approximately 44 bu/A more grain with 100 lb/A less N than did the optimum N rate at the lowest soil test K level. This resulted in an additional \$140/A net return to N fertilization, or about \$2.37 for each ppm of increased soil test K. Higher levels of K led to lower N requirements to produce higher yields and profits. Knowledge of interactions is important when trying to assess the effects of one nutrient application. Yield-limiting levels of one nutrient reduce yield and quality effects of another nutrient. For this reason, balanced nutrition is necessary to ensure optimum crop growth and yield.

Both P and K are important parts of a profitable farming operation. They provide many benefits in addition to yield. In times of low crop prices, they can increase efficiency and improve profits. Knowledgeable decisions related to the management of these nutrients can be of great assistance to farmers as they find ways to improve their farming operations. BC

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