

## **Potassium Fertilization Guidelines in Iowa: Are They Working and Should Applications Be Adjusted with High Fertilizer Prices?**

Antonio P. Mallarino, Professor, Agronomy, Iowa State University

Pedro A. Barbagelata, Research Assistant, Agronomy, Iowa State University

David J. Wittry, Research Scientist, Agronomy, Iowa State University

### **Introduction**

Iowa State University (ISU) researchers have conducted much research over time with help from Iowa farmers, crop consultants, and agribusiness to study potassium (K) fertilization of crops and use of soil-test K as a tool to determine crop K needs. Results of this research are reflected on current fertilizer recommendations, which are explained in the ISU Extension publications Pm-1688 and Pm-1310. The research continues to keep pace with changes of production practices, new hybrids and varieties, and new questions. This year Iowa farmers are looking very carefully at fertilization practices because recent sharp increases in fertilizer and fuel prices have not been matched by increases in grain prices. The ISU K recommendations were last updated for the 2003 crop year. The most significant changes were (1) to recommend maintenance of higher soil-test K levels for optimum crop production and (2) to suggest deep K fertilizer placement for grain crops managed with ridge-till and no-till systems. In this presentation we review the K recommendations and share highlights of recent on-farm research. Decisions about fertilization for any economic situation should be made based on knowledge of the probability and size of crop response to fertilization for different soil-test levels, fertilization rates, and prices.

### **What are optimum soil-test potassium levels? Why were the recommended levels increased in 2003?**

A need to update the soil-test K interpretations used in Iowa since the late 1980s was suggested by an increasing frequency of corn K deficiency symptoms on some soils that tested optimum according to those interpretations. Also, field experiments designed primarily to evaluate K fertilizer placement methods for conservation tillage often showed larger than expected crop yield response in soils testing optimum and sometimes also in soils testing high. Numerous soil-test correlation field trials conducted for corn and soybean confirmed that use of the existing interpretations sometimes would recommend too little or no K fertilizer in fields with a high probability of a large response. Data in Table 1 show, as an example, the old and current soil-test K interpretations and K fertilizer recommendations for corn and soybean. These are interpretations for soils classified as having low subsoil K, which are the most common in Iowa. More complete tables for other crops and soils are shown in publication Pm-1688, which is available at the ISU Extension Publications web site and at Extension offices.

In the old interpretations the optimum class encompassed 91 to 130 ppm measured by the ammonium-acetate or Mehlich-3 K tests on samples collected from a 6-inch soil depth. In the updated interpretations, the soil-test K range of the old optimum category was reclassified as low,

and maintenance K fertilization is now recommended for the former high category, which now is designated optimum. Therefore, the new interpretations recommend a higher soil-test K level for optimal crop production. The K fertilization rate recommended for the optimum category should be adjusted for prevailing yield levels at each field and should take care of expected yield responses within this category.

The new soil-test K interpretations reflect results of field research conducted during many years at Iowa research farms and farmers' fields. As an example, results of the grain yield correlation research conducted for corn until 2003 are summarized in Fig. 1. This figure shows the relationship between relative grain yield of corn and soil-test K measured with the commonly used ammonium-acetate test. Each data point represents one site-year and averages of three to six field replications of treatments. Similar results were observed for soybean, although the data were more variable. The soil-test results and the correlations for the Mehlich-3 K test were similar to those for the ammonium-acetate test and are not shown.

Data in Fig. 1 show the classic relationship between yield response and soil-test values, but also shows that there was much variation. This variation should not be surprising because farmers and crop consultants are well aware of the large variation over time in crop yield and soil-test K values due to many factors, some not well understood. In spite of the variation in crop response, the distribution of the data points indicates two important results. One is that there is a clear-cut soil-test K value at about 170 ppm above which no crop response is likely or large. The other important result is high variation in response below that soil-test K value. The data points for sites with less than about 170 ppm K suggest different results for two groups of soils, which were represented by white or black symbols in the figure. The white symbols represent results for soil series in which soil-test K levels ranging from about 130 to 145 ppm produced more than 95% of the maximum yield. The fit of various mathematical models confirmed this could be considered a critical concentration range for those soils (not shown). The black symbols represent results for soil series for which the critical concentration range is higher and could not be determined with certainty but is at least 170 ppm.

Results for some soils represented by the black symbols blend with the general relationship observed for the white symbols, so the difference between the two soil groups is not well defined. Subsoil K levels did not explain the differences. The black symbols mainly represent moderately to poorly drained soils with fine texture, usually high exchangeable Ca compared with other Iowa soils, and deep profiles that are found on low topographic positions. These soils are abundant in central and north-central Iowa (such as Nicollet, Webster, Canisteo, and other series) but are also present in other regions. A few of these soils (Canisteo and Harps) have high pH due to calcium carbonate. Although results suggest different soil-test K requirements for different soils, there is much variation below a value of about 170 ppm so the new interpretations were made to apply across all Iowa soil series until new research data are available.

### **Why is deep potassium placement recommended for ridge-till and no-till systems?**

With reduced tillage, broadcast fertilizers are not incorporated (such as in no-till) or are incorporated in a way that does not optimize early nutrient uptake (such as in ridge-till). Use

of broadcast or planter-band fertilizer application methods for these tillage systems and nutrient recycling with crop residues result in large P and K accumulation near the soil surface. Increased residue cover with conservation tillage improves water availability and root efficiency in shallow soil layers during dry periods but results in cooler and wetter soils in early spring, which may reduce early crop growth and nutrient uptake. Consideration of these facts and slow but steady increased adoption of no-till management has prompted extensive fertilizer placement research in Iowa. The results for P fertilization showed small and inconsistent differences between placement methods for any crop or tillage system. Results for K placement for crops managed with chisel-plow/disk tillage also showed small and inconsistent differences between placement methods. However, the results for corn and soybean managed with no-tillage and ridge-tillage indicated that deep-band K application (to a depth of 5 to 7 inches) often produces higher yield than either broadcast or planter-band K application.

Figure 2 show average results of many K field trials conducted until the early 2000s for no-till corn and ridge-till corn. The differences between K placement methods were more consistent and larger for ridge-till corn than for no-till corn. Results for soybean followed similar trends but responses to deep K banding were smaller and less consistent than for corn. Results of comparisons of strip tillage and deep K placement for no-till indicated that the response to deep K placement is observed in addition to any strip tillage effect on early growth or grain yield. Also, the results showed that the benefits of deep K banding are similar when the banding is done every year or every other year either before corn or soybean. Deep banding every other year reduces application costs.

Based on the research results, the ISU fertilizer recommendations do not include specific guidelines about placement methods for P fertilizer, except for suggesting a common starter fertilizer mixture under a few specific conditions. Deep-band K fertilization is recommended for no-till and ridge-till systems, although it is stated that for no-till the yield increase from deep banding compared with broadcast application is smaller and less consistent than for ridge-till and sometimes may not offset increased application costs. Large variation in the no-till corn response to deep-band K was more related to low topsoil moisture in late spring and early summer than to soil-test K stratification or years of no-till. Some no-till producers are using strip tillage for corn, and the strip tillage and deep K placement can be combined. Although we have not seen consistent yield response to deep P placement, P fertilizer can also be deep banded together with the K fertilizer.

### **What about within-field soil-test K variability and variable-rate fertilization?**

Soil-test K variation is very high in most fields. Previous presentations at this conference showed this variation and discussed advantages and disadvantages of soil sampling methods such as soil type, management zones, and grid sampling. The ISU Extension Pm-287 discusses sampling procedures for these methods. The results of thousands of analyses for soil samples collected from Iowa fields using different sampling approaches indicate that there is no single soil sampling method that is the most cost effective for all conditions or fields, and that a general recommendation is not possible. Grid soil sampling is very effective at describing soil-test variability when appropriate numbers of cores are collected from each cell or sampling point. It is more effective than sampling by soil type or zone sampling to describe small-scale soil-test

variability, and obviously it is a good method to use in conjunction with variable-rate fertilization technology. It is more expensive than other sampling methods, however, and is less cost effective when most field areas test optimum or high because there is little or no crop response to pay for the increased sampling and testing costs. Its cost-effectiveness increases when fertilizer prices are high, however, because fertilizer savings as a result of reduced fertilization of high-testing areas becomes significant.

Our research also shows that the high within-field variability in soil-test K is reflected on high variation in crop response to K fertilization, which seem to justify dense soil sampling and variable-rate fertilization. Results of many on-farm trials with corn and soybean are summarized in Fig. 3. These are results of field-scale trials harvested with yield monitors and GPS, and show the crop response to K fertilization at different parts of long and narrow strips having initial soil-test K values ranging from very low to high in most fields. These results show the obvious potential of variable-rate fertilization to increase the profitability of K management. The data in Fig. 3 has to be interpreted with care, however, because the soil sampling used for that research was based on a very dense grid-point sampling approach (0.5 to 1-acre cells that is not recommended for crop production) with 12 cores collected for each composite sample. The potential usefulness of this technology may not be so large for the common 2.5-acre grid size and with the usually fewer numbers of cores collected per composite sample.

### **Do optimum soil-test levels need to be maintained when prices are unfavorable?**

As with many issues related to crop production and nutrient management the answer is “Probably yes, but it depends on several things”. The research data clearly indicate that in low-testing soils there is a high probability of a large yield response and large economic returns to K fertilization. There is unlikely economic or environmental justification to produce crops in low-testing soils without K fertilization. The Optimum soil-test category is defined as the soil-test range in which the probability of a large crop response is low, and is less than about 25%. The research indicates that this soil-test range is the most profitable to maintain over the long term. However, producers and crop advisors should adjust interpretations and make decisions based on current prices, each person’s philosophies concerning economic risk when using various inputs needed for crop production, the economic condition of each producer, assumptions about how a particular soil-test result represents a field or field zone, land tenure issues, and other factors. The following few considerations may help producers and crop advisors make a decision.

Although the most recent research suggested that probably two sets of interpretations would be needed for large groups of Iowa soil series, large variation in crop response across fields and years due to poorly understood reasons does not allow for establishing reliable separate interpretations at this time. Due to this uncertainty, the recommendations are targeted to minimize yield loss for soils with the higher K requirements. Therefore, reducing or withhold K fertilization of fields where well-drained, upland soils predominate probably will result in less risk of yield or economic loss than for other fields.

Our results indicate that the usual 2-year K fertilizer application rate applied before corn for corn-soybean rotations is necessary to maintain soil-test K over the 2-year period but is not

necessary to produce maximum yield of the first crop. Therefore, producers can apply a smaller rate for the first crop and apply the rest of the K next year. Moreover, ongoing research that we could not summarize on time for this article indicates that a common starter K rate applied to corn often is enough to maximize yield of this crop in soils that test in the optimum category. This result was observed for granulated K fertilizer applied using “2 by 2” starter planter attachments at rates ranging from 30 to 35 lb  $K_2O$ /acre (lower rates were not evaluated). This result was also observed for lower K rates applied to the seed furrow when low-salt, liquid 3-18-18 starter fertilizer was applied at 5 to 6 gallons/acre (about 10 to 14 lb  $K_2O$ /acre). We have compared each starter application method to broadcast application, but have not compared the two starter application methods at the same field and under otherwise similar conditions. Of course, these small starter K rates, especially the lower in-furrow rates, cannot maintain soil-test K levels too long and broadcast fertilization likely is needed for a following crop.

### **Summary**

Field research justified a major change of Iowa STK interpretations and K fertilizer recommendations in 2003. Results of field calibrations for the commonly used ammonium-acetate and Mehlich-3 K tests showed that a higher soil-test K level was needed for many soils and cropping conditions. More recent research results confirm previous results. The soil-test K interpretations and K fertilizer recommendations are based on the best knowledge available and on average cropping conditions and on predominant nutrient management philosophies. These recommendations should result in the most profitable K fertilizer management over the long term. However, producers and crop advisors should also be aware of research results (such as those shared in this article) and make decisions based on current prices, producer's philosophies concerning economic risk when using inputs needed for crop production, the economic condition of each producer, assumptions about how well a particular soil-test result represents a field, land tenure issues, and many factors. Ongoing research should provide additional useful information for continuing improving K fertilizer recommendations in Iowa.

Table 1. Iowa soil-test K interpretation categories for the ammonium-acetate and Mehlich-3 K tests and K fertilizer recommendations for corn and soybean.<sup>†</sup>

Soil-test Category	Recommendations until 2002			Current Recommendations		
	Soil-test K	K fertilizer rate		Soil-test K	K fertilizer rate	
		Corn	Soybean		Corn	Soybean
	-- ppm --	--- lb K <sub>2</sub> O/acre ---		-- ppm --	--- lb K <sub>2</sub> O/acre ---	
Very Low	0-60	120	90	0-90	130	120
Low	61-90	90	75	91-130	90	90
Optimum †	91-130	40	65	131-170	45	75
High	131-170	0	0	171-200	0	0
Very High	171+	0	0	201+	0	0

† Interpretations for soil series with low subsoil K, which are the majority in Iowa.

‡ Fertilizer amounts for the Optimum class assume corn and soybean yield of 150 and 55 bu/acre and should be adjusted as appropriate. See ISU Extension publication Pm-1688.

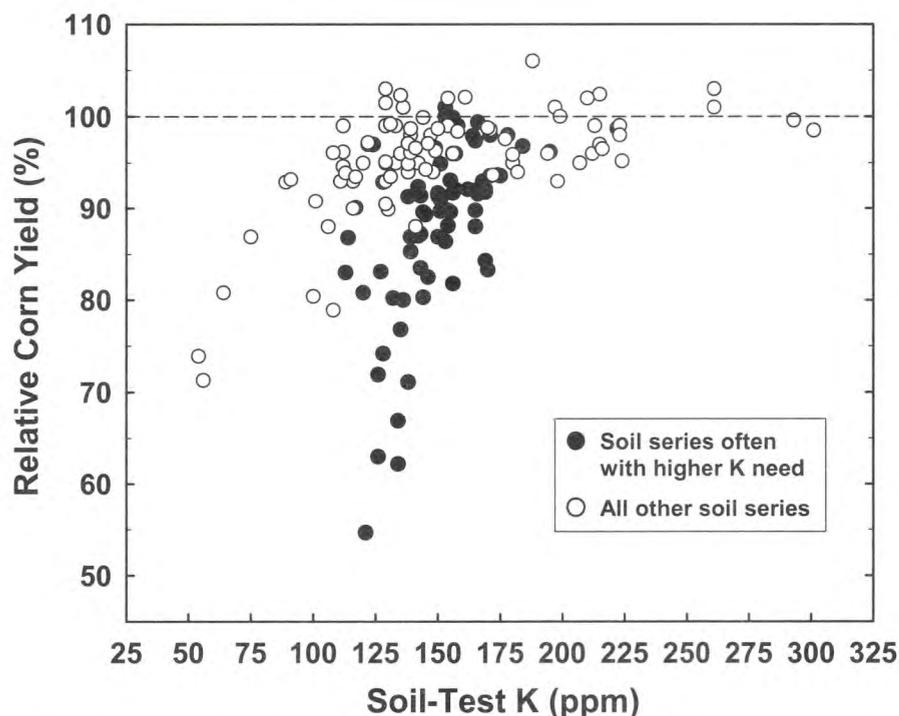


Fig. 1. Relationship between relative corn yield and soil-test K (ammonium-acetate test) across Iowa fields.

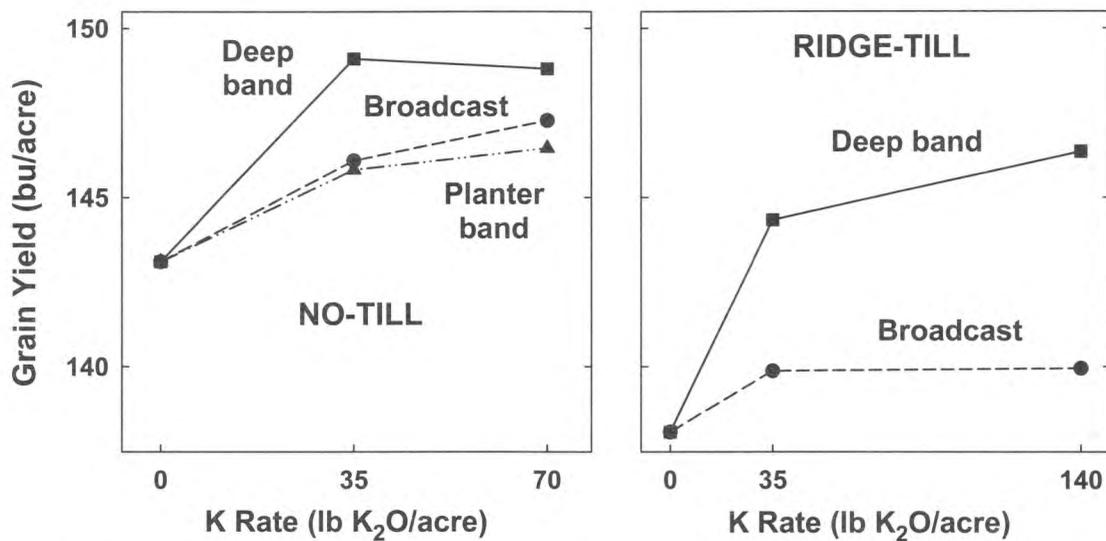


Fig. 2. Yield response of no-till and ridge-till corn to broadcast and deep-band K fertilizer placement methods in Iowa. Averages of 20 site-years for no-till and 15 site-years for ridge-till. Yields between tillage systems should not be compared because sites and years were different.

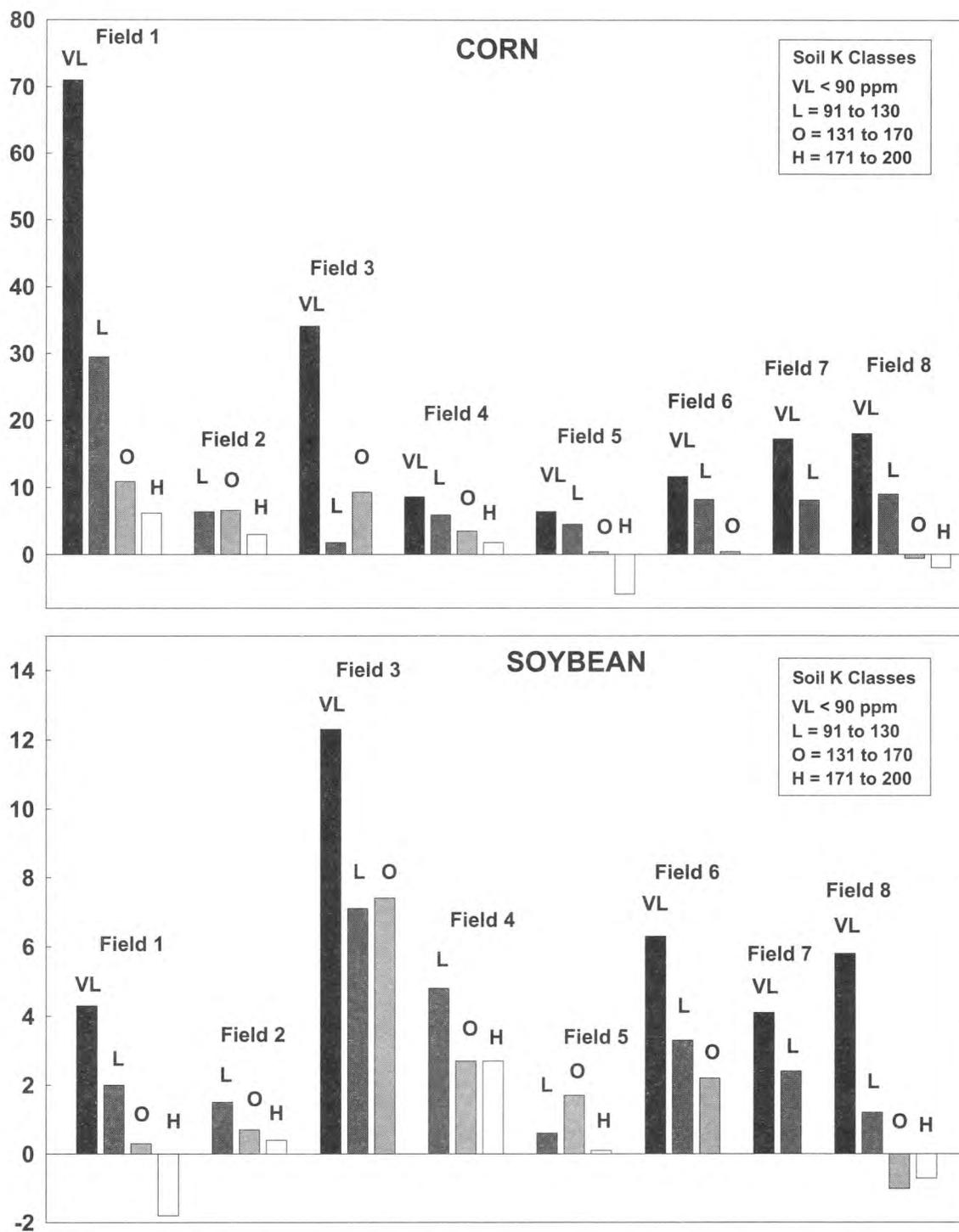


Fig. 3. Within-field variation of corn and soybean yield response to K fertilization for several Iowa fields having initial soil-test K in different interpretation classes. The field numeric codes are arbitrary and do not indicate the same field or site for both crops.