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PHOSPHORUS AND POTASSIUM FERTILIZATION OF CORN AND SOYBEAN

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Introduction

Fertilization practices for phosphorus (P) and potassium (K) during the last three decades have increased soil-test P (STP) values and soil-test K (STK) values of most agricultural soils in Iowa. This tendency for soil-test values to increase with time generally has been considered a desirable consequence of fertilization. This was especially true about 30 or 40 years ago when many Iowa soils tested very low or low in STP and STK. Recent soil-test summaries (Killorn, Voss, and Eik, 1990) and surveys (Blackmer and Mallarino, unpublished), however, indicate that more than 70% of Iowa soils test high or very high in STP and STK. This situation suggests the possibility that many crop producers may be using more P and K fertilizers than needed. This possibility deserves attention because large areas of Iowa are planted to corn and soybean and because P and K fertilization represent a significant cost for producers.

Here I present an overview of various long-term and short-term P and K trials with corn and soybean conducted by various researchers in the Department of Agronomy. Some of the data presented have been published in more detail (Mallarino, Webb, and Blackmer, 1991a and 1991b; Mallarino and Blackmer, 1992; Webb, Mallarino, and Blackmer, 1992). The results shown here include changes of soil-test values over time, yield responses, critical soil-test values, maintenance rates, and economic returns from fertilization.

Methods

The long-term trials summarized in this report involve four trials established in the 1970’s in central (Boone), northcentral (Kanawha), and northeast (Nashua) Iowa. Three of the trials involved initial applications of P or K fertilizers that resulted in contrasting initial levels of STP or STK and four annual rates of P or K fertilizers. The other trial was established on a high testing soil and involved annual applications of various combinations of P and K fertilizers. Corn and soybean were grown at all sites in rotations produced either by alternating the crops between halves of the experimental areas or by alternating the crops over time.

The data summarized for short-term trials are partial results of P and K trials with corn conducted during 1989 and 1990 on farmers’ fields. There were 25 P trials and 28 K trials. Each trial included four rates of P or K fertilizer. Sites were selected to represent the range of soils, soil-test values, hybrids, previous crops, and tillage systems commonly found in Iowa. Management practices except fertilization were those normally used by each farmer.
Soil samples were collected from most plots in most years. For the long-term trials STP was determined by the Bray P-1 method and STK was determined by the ammonium acetate method in field-moist samples. For the short-term trials STP was determined by the Bray-1 method and STK was determined by the ammonium acetate method in air-dried samples. Net economic returns from fertilization were calculated by subtracting the cost of fertilization from the value of additional grain produced in fertilized plots compared with plots receiving no fertilizer. Prices used were mean prices received or paid by farmers during the last decade.

Results

Long-term trials

Soil-test P and STK values for plots that received no annual additions of fertilizer decreased over time at all trials. Examples of this trend are shown for the P and K long-term trials conducted at Kanawha (Fig. 1).

Decreases occurred more rapidly during the first years of the trials. Annual P or K additions required to maintain the initial STP or STK values increased with the initial soil-test level. For the P trial, for example, the maintenance rate ranged from about 35 P₂O₅/acre for plots testing medium to more than 70 lb P₂O₅/acre for plots testing very high. For the K trials, for example, the maintenance rates ranged from about 80 K₂O/acre for plots testing between medium and high to much higher undetermined amounts (the highest annual rate applied was not high enough) for plots testing very high.

There was no statistically significant yield response of either corn or soybean to annual additions of P or K in plots having soil-test values above the medium class. Responses observed for each year indicate that 7 to 10 years of cropping without fertilization were required before responses were observed for plots initially testing high or very high in P or K.

Phosphorus rates higher than 23 lb P₂O₅/acre resulted in additional yield increases over lower rates only in 4 of the 27 instances when significant responses were observed. There were no major differences in the P fertilizer needs of corn and soybean. Data in Fig. 2 show that net economic returns to investments on P fertilizer tended to be positive for plots having soil-test values below medium and negative for plots testing above medium. For plots testing medium, there was equal frequency of positive or negative returns when 23 or 46 lb P₂O₅/acre were used but returns usually were negative when higher rates were used.
Fig. 1. Changes of soil-test values over time for plots of two long-term trials conducted at Kanawha (K was determined on moist soil samples).

Fig. 2. Relationships between net returns to P fertilization and soil-test P values for plots of two long-term trials.
Potassium rates higher than 72 lb K$_2$O/acre resulted in additional significant yield increases over lower rates only in two of 45 responsive instances. Soybean responded to K fertilization more frequently than did corn. Of the 60 opportunities for each crop, 15 positive responses were observed for corn and 30 were observed for soybean. Data in Fig. 3 show that net economic returns to investments on annual applications of K fertilizer tended to be positive for plots having soil-test values below medium and negative for plots testing above medium. For plots testing medium, there was equal frequency of positive and negative returns when 24 to 36 lb K$_2$O/acre were used but returns usually were negative when higher rates was used. Net returns observed for each trial and year of the studies showed that many years of cropping without fertilization of high-testing soils were required before fertilization became profitable.

![Graph](image)

Fig. 3. Relationships between net returns to K fertilization and soil-test K values for plots of three long-term trials (K was determined on moist soil samples).

**Short-term trials**

Phosphorus fertilization increased yields of corn significantly at six of the 25 P trials. Five of the responsive soils tested very low or low in STP and one tested medium. Rates of 100 or 150 lb P$_2$O$_5$/acre resulted in no additional yield increases over the 50-lb rate at any of the responsive sites. Figure 4 shows mean net returns to investments on P fertilizer for soils testing within various soil-test classes. There were positive returns when 50 lb P$_2$O$_5$/acre were applied to low-testing soils but higher rates of application for these soils resulted in negative returns. Application of P fertilizer to soils testing medium or higher resulted in negative returns.

Potassium fertilization had no significant effect on yields at 26 of the 28 K trials, increased yields at one site, and decreased yields at another site. The responsive soil tested low in STK. Figure 5 shows mean net returns to investments on K fertilizer for soils testing within various soil-test classes. There were positive returns when any of the three rates of K fertilizer was applied to low-testing soils. Application of K fertilizer to soils testing medium or higher, however, usually resulted in negative returns.
The short-term trials were conducted on a variety of soil types and involved various corn hybrids and tillage systems. The fact that results for these trials were similar to results from long-term trials confirms that soil testing, although no perfect, is a useful tool for separating soils likely to respond to additional fertilization from soils unlikely to respond.

Fig. 4. Net returns to P fertilization observed in the short-term trials.

Fig. 5. Net returns to K fertilization observed in the short-term trials.
Summary and Conclusions

The results of these long-term and short-term studies show that it is not profitable to increase soil-test values for P and K above the medium soil-test class for production of either corn or soybean. Because soil test summaries and surveys show that more than 70% of Iowa soils planted to corn or soybean test above medium, the results suggest that many farmers could increase their profits by withholding P and K applications until soil-test values decrease to levels that are profitable to maintain.

References


