Corn tissue tests for excess phosphorus and potassium

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Corn tissue tests for excess phosphorus and potassium

Abstract
Profitable corn production requires adequate amounts of plant-available phosphorus (P) and potassium (K) in the soil. Deficiencies of these nutrients are not a problem in many Iowa soils. In fact, recent soil-test summaries and surveys show that fertilization practices have increased initially low values of P and K in most soils to levels higher than needed to maximize yields. Additional studies indicate that applying P or K fertilizers to corn and soybeans grown on soils testing high in these nutrients is not profitable. Consequently, evaluating excess P and K is now more important than evaluating P and K deficiencies.

Keywords
Agronomy, Soils and agronomy

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences
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Background and goals
Profitable corn production requires adequate amounts of plant-available phosphorus (P) and potassium (K) in the soil. Deficiencies of these nutrients are not a problem in many Iowa soils. In fact, recent soil-test summaries and surveys show that fertilization practices have increased initially low values of P and K in most soils to levels higher than needed to maximize yields. Additional studies indicate that applying P or K fertilizers to corn and soybeans grown on soils testing high in these nutrients is not profitable, Consequently, evaluating excess P and K is now more important than evaluating P and K deficiencies.

Tissue testing is typically used to evaluate the nutrient status of crops. The most commonly used tissue test for corn, the ear-leaf test, has been well evaluated and used for detecting nutrient deficiencies. Now, we need better information on the performance of tissue testing in soils where P and K are in the optimal-to-excessive availability range, because few studies have evaluated the ear-leaf test or other tissue tests for detecting P or K excesses during corn production. Thus, the specific purpose of this project was to develop a tissue test that can be used to evaluate the P and K status of corn plants grown on soils having optimal to excessive amounts of these nutrients. The general goal of this research was to promote more sustainable P and K fertilization practices in Iowa.

Approach and methods
Investigators conducted trials on 25 plots for P response and 28 plots for K response during 1989 and 1990. They applied 0, 50, 100, and 150 pounds (lb) of P₂O₅ as triple superphosphate per acre. The treatments for the K trials consisted of 0, 60, 120, and 180 lb K₂O per acre as potassium chloride. All trials were established and replicated three times on farmers’ fields having a wide variety of crop and soil management practices. Adequate amounts of N fertilizers were broadcast applied to all plots in spring before the P and K fertilizer rate treatments were applied. Soils were sampled up to 6 inches (in.) deep in spring, again before the fertilizer treatments were applied. Soil-test P and soil-test K were determined by standard methods.

Investigators collected tissue samples as whole young plants, ear leaves, lower stalks, and grain. These samples were collected from the plots of all trials. Ten whole plants from each plot were collected in late spring when they were 6 to 12 in. tall. Twenty ear-leaf blades opposite and below the primary ear node were collected from each plot when approximately 75% of the ear shoots had visible silks. Ten sections of stalk were cut 6 to 14 in. above ground one to two weeks after physiological maturity (black layering). Approximately 1.5 lb of shelled grain was saved at harvest from each plot.

Investigators extracted total P from the tissues by digesting oven-dried and ground samples with concentrated sulfuric acid and a catalyst mixture. Phosphorus in the digests was then determined by colorimetrically. Total K in grain was extracted by digestion with concentrated sulfuric acid and a catalyst mixture; K in the vegetative tissues was extracted with water. Preliminary studies showed that similar amounts of K were extracted from vegetative tissues by water or acid; K in digests and extracts was determined by flame photometry.
Investigators then analyzed effects on yields and tissue concentrations, studying the relationships between relative corn yields and concentrations of P and K in the tissues for all plots. In order to study the effect of selected site variables such as rainfall, pH, organic matter, plant population, soil-test P, soil-test K, and available P and K in subsoil, investigators related the concentration of P and K in the tissues for nonfertilized plots with these site variables by using linear, nonlinear, and multiple regression analysis techniques. Relative yields were calculated by expressing the yields of nonfertilized plots as percentages of the mean yields of fertilized plots for each site. Expressing yields in relative terms is useful when studying plant responses to fertilization across many sites, many years, or both.

Findings
Phosphorus fertilizer increased yields at six of the 25 sites. Rates of 100 or 150 lb P per acre resulted in no additional yield increases over the lowest rate applied. Potassium fertilizer increased yields at only one of the 28 sites. At this site, 60 lb K per acre, the lowest rate applied, was enough to produce maximum yields.

Phosphorus fertilizer increased the P concentration of young plants at five sites, of leaves at 12 sites, and of grain at 6 sites. Potassium fertilizer increased the K concentration of young plants at 10 sites, of leaves at 12 sites, of stalks at 16 sites, and of grain at 5 sites. The variation in the concentrations of P and K of the tissues, however, was much larger among sites than among fertilizer treatments. For example, multiple regression analyses showed that the proportion of the variation in K concentrations across sites that could be accounted for by site variables was 47% for stalks, 63% for mature grain, 74% for young plants, and 76% for ear leaves.

Only the P concentrations of leaves and grain were significantly related to yield response (Fig. 1). P concentrations in leaves and grain accounted for only 17% and 14% respectively of variation in grain yield. None of these tests clearly separated responsive from nonresponsive soils. The K concentrations of the tissues were not significantly related to yield response (Fig. 2). This result for K is not surprising because the K treatments increased yields in only one of 28 sites. The relationships determined for both P and K, however, clearly show that commonly used critical concentrations for P and K for the ear-leaf test were too high. (Critical concentrations are those that distinguish between adequate and inadequate supplies of nutrients.)

The P and K concentrations of the tissues were often related to soil-test values, but again the correlations were poor. Positive correlations between tissue and soil tests across optimal and excessive levels indicate that the tissue tests evaluate "luxury" consumption of nutri-
ents. Luxury consumption occurs when plants accumulate nutrients above levels that are optimal to achieve maximum yields. The P and K concentrations of the leaves, however, tended to reach a plateau at soil-test values that maximized yields. These trends indicate that the ear-leaf test is not a reliable tool for evaluating P or K status in the optimal-to-excessive range.

In conclusion, the ear-leaf test for P and K in corn, a commonly used tissue test, is not a reliable indicator of P and K status in the optimal-to-excessive availability range. Moreover, the commonly used critical concentrations for this test may encourage unneeded P and K fertilization. The P and K concentrations of young plants, lower stalks, and grain were evaluated as alternative tissue tests.

These tissue tests, like the ear-leaf test, were influenced more by climatic and soil variables than by P or K availability in soils. The P and K concentrations of young plants, however, could be a valuable index of P and K availability under controlled conditions, such as in greenhouse studies. However, until reliable tissue tests can be developed for these nutrients, evaluations of the P and K status of cornfields should be based solely on soil tests having appropriate critical concentrations.

Implications

Recent soil test summaries and surveys for Iowa show that fertilization practices have increased initially low soil-test values to levels higher than needed to maximize yields. Because of this situation, evaluating excess P or K is currently more important than evaluating deficiency of these nutrients. Better information is needed about the performance of tissue testing in soils when P and K are in the optimal to excessive availability range.

The results of the study indicate that the commonly used ear-leaf test for corn is not a reliable indicator of P and K status in the optimal-to-excessive availability range. Moreover, the commonly used critical concentrations for this test probably encourage unneeded P and K fertilization of corn.

Use of the ear-leaf test should be actively discouraged in efforts to develop fertilization practices that are more sustainable. Until reliable tissue tests can be developed for these nutrients, evaluations of the P and K status of cornfields should be based solely on soil tests having appropriate critical concentrations.

Investigators coordinated this work with several other research projects. One was a detailed analysis of data collected from long-term P and K experiments funded by the Integrated Farm Management Demonstration Project. Another was the Transition to Sustainable Farming Practices study funded by the Northwest Area Foundation and conducted in cooperation with Practical Farmers of Iowa, in which the investigators of the project described here conducted the soil management component. The primary objective there was to evaluate the nutrient status of fields belonging to farmers who had been classified as conventional, transitional, or sustainable. The data resulting from all three projects, when evaluated as a whole, should provide extensive new knowledge about P and K management for Iowa soils under various farming systems.

Another coordinated project, funded by the Leopold Center, focused on developing operating procedures for the use of the late-spring soil test for nitrogen availability. The sampling locations and extensive interactions with dealers and extensionists on that project established a foundation for involving fertilizer dealers with the development of new tests for P and K as well.

The investigators have presented preliminary results of this research and its implications for production agriculture to the general public through six field days as well as at various meetings and conferences. These results may also be used in updating fertilizer recommendations for phosphorus and potassium in Iowa.

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