Corn and Soybean Grain Yield Response to Different Phosphorus Fertilization Rates and Soil-Test Phosphorus Levels

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Introduction

Phosphorus (P) fertilization is needed for profitable crop production in most Iowa soils. Extensive research has been conducted for decades on crop yield response to P and calibration of soil-test P methods. Frequent changes in crop genotypes and increasing yield levels necessitates continuous research to revise and update management guidelines as needed. This report summarizes results of a multi-year experiment conducted to evaluate corn and soybean grain yield response to different P fertilization rates and soil-test P levels.

Materials and Methods

An experiment using corn-soybean rotations and several P application rates was conducted in an area with a Floyd soil that tested low in P (11 ppm, Bray-1 test) from 2009 to 2012, to compare the P supply value of a byproduct of the bioenergy industry compared with triple-superphosphate fertilizer (0-46-0). The P rates applied for corn in 2009 were 0, 25, 50, 75, 100, 150, and 250 lb P_2O_5/acre. There were three replications. No P was applied for soybean planted in 2010, a rate of 150 P_2O_5/acre was applied for corn planted in 2011 to plots that had received 25 P_2O_5/acre in 2009, and no P was applied for soybean grown in 2012. Results for this early 4-yr period summarized in a report written in 2013 showed no difference between the P sources and very large yield responses. Therefore, the cumulative P rates applied from 2009 until 2012 were 0, 50, 75, 100, 150, 175, and 250 lb P_2O_5/acre.

Soybean was planted in 2013 but no P was applied and yield was not recorded. The site was evaluated with a corn-soybean rotation from 2014 until 2017. Phosphorus rates of 75, 100, or 150 lb P_2O_5/acre using triple-superphosphate fertilizer were applied to selected plots in different years to create a wide range of soil-test P levels useful to assess relationships between yield response and soil-test P values. The cumulative P rates applied to different plots from 2009 until 2017 were 0, 50, 75, 100, 150, 200, 250, 325, and 550 lb P_2O_5/acre. In this report, we summarize relationships between corn and soybean grain yield response and soil-test P values for the last 4-yr period.

Results and Discussion

The combination of several initial P fertilization rates and selected P rates applied to some plots until the spring of 2017 (before the last crop) resulted in soil-test P values ranging from the very low to the very high ISU interpretation categories. The interpretations can be found in ISU Extension publication PM 1688. For corn and soybean by the Bray-1 or Mehlich-3 (colorimetric) P tests are 0-8, 9-15, 16-20, 21-30, and 30+ ppm for the categories very low, low, optimum, high, and very high. Crop grain yields varied across years due to weather effects. The corn yields (averages of replications) ranged from 175 to 233 bushels/acre across treatments and years. Soybean yields ranged from 42 to 76 bushels/acre across treatments and years.

The highest yielding treatment (mean of replications) for each crop and year was used to calculate relative yield responses, to be able to relate yield to soil-test P values for years having different yield levels. Percent relative yield was calculated by dividing the yield for each plot that did not receive P for a specific crop year by the maximum yield from that year and multiplying the result by 100. Therefore, the relative yield to the maximum increases from a low value (large response) with deficient soil-test level to a value approaching 100 percent (small or no yield responses) as soil-test values increase.

Figure 1 shows the relationship between relative grain yield response and soil-test P values for corn and soybean across the two years for each crop. The ranges of Bray-1 P soil-test values were 5 to 29 ppm for corn and 4 to 21 ppm for soybean (6-in. sampling depth). Results for both crops show relative yield levels increased from very low soil-test P values and approached about 100 percent (little or no yield increase from fertilization). Therefore, results showed there were large yield responses with low-testing soil-test P values, but small or no yield increases when soil-test P was higher than about 15 ppm.

The results for both corn years were very similar and fit well with the expected response curve. The results for soybean were more variable, and there was a clear difference between the two years even when relative yields were used to indicate the responses. The general soybean yield level was lower in 2014 than in 2016, but the relative yield responses were larger in 2014 than in 2016. The corn yield levels were lower in 2015 than in 2017, but the difference was less obvious than for soybean. Previous research has shown that sometimes the relative crop response to P fertilization can be higher in years when some soil factors (such as moisture or compaction) limit crop yield.

Conclusions

Results for this single trial and small data set matched well with previous results from hundreds of P response trials conducted in Iowa during the last couple of decades, which were used to develop current soil-test P interpretations in publication PM 1688. Large P fertilization rates are recommended for corn and soybean when soil P tests within the very-low and low interpretation categories. Only fertilization based on crop removal is recommended when soil-test P is within the optimum interpretation category. A removal-based rate is sufficient to maximize yield in the optimum category and to maintain the soil-tests level over time.

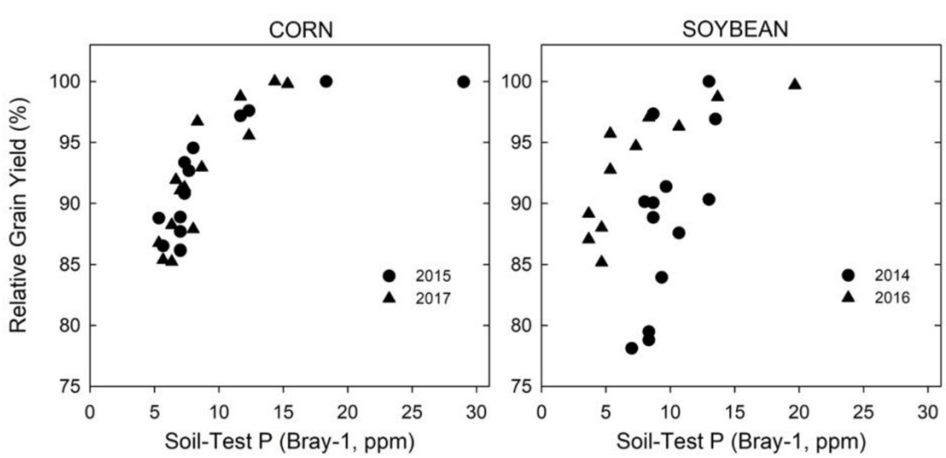

Figure 1. Relationship between relative corn and soybean grain yield response to P fertilization and soil-test P values across two years for each crop.