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## Phosphorus and Potassium Recommendations for Illinois Crops

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### INTRODUCTION

Corn (*Zea mays* L.), soybean (*Glycine max* [L.] Merr.), and wheat (*Triticum aestivum* L.) are the three most extensively-grown crops in the state. Large amounts of phosphorus (P) and potassium (K) are required to attain high yields in these crops. Phosphorus is an essential structural element (integral part of DNA), responsible for energy transfer, photosynthesis efficiency, and shoot growth. Likewise, K is a multi-tasking nutrient that increases the ability of these crops to withstand biotic and abiotic stresses, and helps in overall plant health. High requirements for these nutrients typically results in the need to fertilize the soil to provide these crops with an adequate supply of P and K. Application of P and K represents a multi-billion dollar investment for Illinois farmers.

To determine the proper rate of application of these nutrients, and ensure maximum yields, producers are advised to follow university recommendations listed in the Illinois Agronomy Handbook (Fernández and Hoeft, 2009). This recommendation system for P and K applications is based on yield response to soil test levels. These yield response curves were used to determine 1) the critical soil test level, or point at which near maximum yields could be obtained; and 2) the soil test level at which additional fertilization is very unlikely to increase yields. The range of soil test values between these two points is defined as the maintenance level. Fertilizer application rates at the maintenance level are determined by the amount of P and K removed by the crop. When soil test values are below the critical level, in addition to the maintenance rate, a rate of 9 lb P<sub>2</sub>O<sub>5</sub> acre<sup>-1</sup> for P or 4 lb K<sub>2</sub>O acre<sup>-1</sup> for K is normally added to increase soil test levels by 1 lb acre<sup>-1</sup>.

While the new 24<sup>th</sup> edition of the Illinois Agronomy Handbook was published in 2009, P and K recommendations values are based on work conducted during the 1960's. Obviously, much has changed since this set of recommendations were established, not only in terms of yield, but also other factors such as economics, greater awareness of environmental sustainability, hybrids, nutrient distribution and nutrient status of the soil, climate, and management. The fact that these values were generated more than 40 years ago, during what could be considered a different era of agricultural production in Illinois, calls into question the validity of the recommendations for current production systems.

Re-evaluating the P and K recommendation system is an ambitious endeavor that requires strategic planning and considerable amounts of time, but must be done to ensure conscientious

management of these nutrients. Thus, our project was established to address the need to re-evaluate P and K recommendations for the state. This work will include determination of P and K removal rates in grain, soil P and K correlation and calibration studies, and evaluation of new soil P and K extraction and analysis methods.

## **MATERIALS AND METHODS**

In order to evaluate the of removal rates of P and K in seed of corn and soybean samples collected by the University of Illinois Variety Testing trials around the state were analyzed with funds received from FREC. Additional corn and soybean grain samples were evaluated for removal rates from an established P and K study. This study is located in East Central Illinois in three different farmer's fields. Treatments were established in 2007 on a corn-soybean rotation and have remained in the same location since that time.

Funding from FREC also allowed us to establish a seven year Lo Farm P and K rate trial in corn and soybeans in rotation with both crops present each year. All treatments were randomly assigned in 3 replications blocked by tillage practice. The study consists of three tillage practices and fertilizer placement methods; No-till broadcast (NT-BC), No-till deep-placement (NT-DP), and Strip-till deep-placement (ST-DP). The treatments stayed in place for the duration of the experiment. Four P levels: 0, 25, 50, 75 lbs. P<sub>2</sub>O<sub>5</sub>/acre/yr and four K levels: 0, 45, 90, 180 lbs. K<sub>2</sub>O/acre/yr were applied. From this study we are able to look at the changes in soil P and K tests at different soil depths, yield information and grain removal of nutrients over six years. Plant samples have also been analyzed allowing us to look closely at plant uptake of P and K. This established trial produced valuable information and leads us to the need to further evaluate the phosphorus and potassium recommendations for Illinois crops.

Objective 1 of the Phosphorus and Potassium Recommendations for Illinois Crops Project is to establish long-term P and K rate studies at the University of Illinois Research and Education Centers around the state. The goal is to set up plots that can be used for the other objectives of this project as well as to provide future research opportunities related to re-evaluation of P and K recommendations. In 2012 P and K rate studies were established at the 6 Crop Sciences Research & Education Centers located throughout Illinois (Brownstown, Monmouth, Perry, Shabbona, Simpson, and Urbana). In order to generate response curves, fields with low to medium starting P or K levels were selected at each location to conduct P and K fertilizer rate studies. Sites were select for soils that are most important and representative for agriculture in the state. A continuous corn and corn-soybean rotation was established with no-till and conventional tillage components at Urbana and Monmouth; a continuous corn and corn-soybean rotation was established at Perry and Shabbona; and a continuous corn and corn-soybean-wheat rotation was established at Brownstown and Simpson. Each crop is present each year for each of the rotation studies. The P-rate studies consist of six P-fertilizer rates (0, 30, 60, 90, 120 lb P<sub>2</sub>O<sub>5</sub> acre<sup>-1</sup> year<sup>-1</sup>) and the K-rate studies have six K-fertilizer rates (0, 30, 60, 90, 120 lb K<sub>2</sub>O acre<sup>-1</sup> year<sup>-1</sup>). Due to field area limitations at Perry, the treatments were reduced to three P-fertilizer rates (0, 60, 120 lbs. P<sub>2</sub>O<sub>5</sub> acre<sup>-1</sup> year<sup>-1</sup>) and three K-fertilizer rates (0, 60, 120 lbs. K<sub>2</sub>O acre<sup>-1</sup> year<sup>-1</sup>). Fertilizer treatments will remain in the same plot during successive years. The P or K rates are arranged in a randomized complete block design replicated 4 times for each

of the crop rotations. This setup will allow accomplishing the objectives of this proposal, and will establish research plots that can provide opportunities for studies in the future. Except for P and K, all cultural practices are designed to obtain the highest possible yields. For all crop rotations, the rates on each P and K study will be broadcast-applied each fall prior to chisel plowing.

Pretreatment soil samples were collected in Urbana from the 0-3, 3-7, 7-12, 12-24, and 24-36 inch soil depth increments to establish baseline information for P and K levels. Soil samples were collected prior to treatment at the remaining 5 research centers from the 0-3, 3-7, 7-12 inch soil depth increments. Time constraints and soil conditions prohibited the sampling of the 12-24, and 24-36 inch soil depth increments at the remaining 5 research centers during spring 2012.

The second objective of the project is to improve soil-test-based fertilizer recommendations by correlating soil test nutrient levels to crop response and by calibrating P and K fertilization rates to maximize productivity and economic returns. This objective includes evaluation of the traditional soil analysis methods (colorimetric analysis of Bray P-1 for P and atomic absorption spectroscopy analysis of ammonium acetate for K) and new methodologies being used by commercial testing labs for which there is no correlation and calibration work done in Illinois. These new methodologies include Mehlich-3 extractions of P and K analyzed by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP) and moist soil extraction of K (slurry method.) Following harvest in 2013, field moist 0-7 inch soil depth samples were collected from 2 established long-term P and K studies in central Illinois. The field moist samples were analyzed for K determination by the slurry method and will be further analyzed by standard testing methods.

The third objective of the project is to establish strip trials throughout the state and create a central repository of existing geo-referenced data. A repository of geo-referenced seed yield and soil test data will be collected from the trials. Measures will be taken to ensure the database is populated with high quality data. Before incorporating new data we will obtain as much information as possible to determine the soundness of the approach used during data collection. Sites have adequate P and K levels (within maintenance range as suggested by current recommendations). Fields with lower P or K fertility will be considered. Cooperators can conduct this study for both corn and soybean. Information on the previous two crops will also be reported.

The treatments consisted of replicated strips (4 to 8 times) with no P or no K applied in the fall and strips with fall applications equal to at least 1.5 times the removal rate of P or K in grain. The strips were normally as wide as the width of the applicator and harvest was done in the center of the strip. The length of the strip was at least 300 ft. Cooperators used cultural practices that are representative of the cultural practices being used in their area of the state. Geo-referenced soil P and K tests information from the top 7 inches was collected on a maximum of one sample/acre density before treatment application. Yield data was collected with yield monitor or weigh wagon from each treatment and replication. The GPS coordinates were recorded to obtain soil map information for each field using the NRCS Web Soil Survey database (<http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>).

## **PROGRESS DISCUSSION**

### Objective 1: STANDARD TESTING OF SOIL AND GRAIN

In the spring of 2012 P and K rate studies were applied at six Crop Sciences Research & Education Centers located throughout Illinois (Brownstown, Monmouth, Perry, Shabbona, Simpson, and Urbana). At harvest in 2012 yield data was collected from the center portion of each plot at the six Research & Education Centers. Harvest 2012 grain samples were saved from Urbana and Shabbona. Grain samples collected from each plot have been analyzed for P and K concentration.

In 2013 all six centers collected yield data and grain samples from each plot. This grain has been analyzed for P and K concentrations. Removal amounts still need to be calculated based on nutrient concentration and seed yield amounts. Simpson and Brownstown centers have continued the winter wheat rotation. —During November 2013 Perry and Brownstown plots received P and K rate applications while Urbana, Shabbona, Monmouth and Dixon Springs received treatments in the spring of 2014.

Following harvest in 2013 soil samples were collected at the 0-7 inch depth for all treatments at Perry, Shabbona, Brownstown and Simpson. Soil samples were collected in the same manner prior to treatment from Urbana and Monmouth in the spring of 2014. Soil samples were dried and ground for colorimetric analysis of Bray P-1 for P and atomic absorption spectroscopy analysis of ammonium acetate for K.

In the fall of 2014 yield and grain removal data was collected for the six locations. Following harvest 2014 soil samples were collected at Shabbona, Dixon Springs, Perry and Brownstown. Late fall soil sampling was conducted from the K study in Urbana.

To date sample testing is complete. Statistical analysis is underway and results will be compiled for the final report this spring.

The final soil sampling at Monmouth and the Urbana P plots will be completed as soon as conditions are fit.

### Objective 2: FIELD MOIST SOIL TESTING

The field moist samples were analyzed for K and P determination by the slurry method as well as dried and ground for Bray1 and Olsen methods at the SOLUM lab. The same dry and ground samples will be further analyzed using the Mehlich 3 and Bray 1 method for test method comparison for phosphorus and potassium by another commercial lab.

### Objective 3: STRIP TRIALS

In 2014 yield, grain and soil data was collected from three sets of P and K strip trials. Results will be included in the final report this spring.

## Reference

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