PROGRESS REPORT

Relationship Between Soil-Test Potassium and Crop Yield

Summary of Work in the 2005 Season - April 2006

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Introduction

The objectives of this ongoing project have been to (1) study the variability in soil-test potassium (K) and corn response to K fertilizer and (2) evaluate K soil tests currently used in the Midwest and new tests with potential to improve the prediction of crop response to K. Results of previous years have been very useful, were used to update Iowa K recommendations 2 years ago, and have generated interest and new K research across the Midwest. However, they also pointed to problems that need continued investigation and demonstration. These include understanding very large crop response variation below soil-test K levels of 170 to 180 ppm (6-inch depth samples, for ammonium-acetate or Mehlich-3 K tests), getting field calibrations for a test based on field-moist samples, assessing the value of the tetraphenyl-boron K test to measure part of non-exchangeable K, and study within-field soil K and crop response variation within fields. Also, recent large crop response to K fertilizer in soils formerly classified as testing Optimum or High in K raised the possibility of response to chloride, especially in long-term trials where non-fertilized plots have not received potassium chloride for many years.

All experiments of the project are managed with corn-soybean rotations and the work focused on three groups of experiments. One group involved continuing the evaluation of eight long-term K trials. However, to address potential crop response to chloride in the potash fertilizer, two of the trials were modified to evaluate this possibility. Another group involved twelve short-term conventional plot trials conducted with the same objectives and methods used in 2003 and 2004 for these type of trial. The third group involved ten strip trials conducted on farmers' fields with the same objectives and methods used in 2003 and 2004 for this type of trial. The funding was used to work on the corn phase of the rotations because complementary funding was available to work I soybean but not with corn. A significant donation of potash fertilizer by PCS was very helpful to be able to maintain a reasonable workload with a relatively small funding. A new research project initiated in 2005 with separate FAR funding to study the interaction between K fertilization and soybean leaf/stem fungal diseases was summarized in a separate progress report. Details of work in the project are summarized in the following sections.

1. Long-Term Trials

Methods.
Eight conventional long-term K trials continued to be evaluated as in the past. Three trials evaluate effects of annual K fertilizer rates applied since the middle 1970s for corn-soybean rotations at Ames (with corn in 2005), Northeast (with both crop phases each year), and

Northern (soybean in 2005) research farms. At two trials (Ames and Northern farms) only the highest annual K rate has been applied since 1998 to study decline of soil-test K over time and to expand soil-test calibration research. Plots of these two trials were used to study response to chloride by applying 50 lb Cl/acre as either calcium chloride or potassium chloride to plots that had not received K since 1998 (five replications in one trial and six in the other). Five other trials at the Northeast, Northern, Northwest, Southeast, and Southwest research farms (both crop phases each year) evaluate four broadcast K fertilizer rates and two planter-band K rates applied with "2 x 2" starter attachments. These plots are managed with no-till or chisel-plow tillage. Grain samples have been collected from selected plots and have been analyzed with partial in-kind PPI support through a contributing laboratory, but not in 2005 because of insufficient funding.

Summary results.
The yield data have shown large yield response to K to all annual treatments (35 to 108 lb K_2O/acre) when soil-test K of non-fertilized plots was below a value of 140 to 150 ppm. Obvious K deficiency symptoms were observed, mainly in corn. Responses were small to large depending on the location for trials in which non-fertilized plots tested about 150 to 180 ppm. There have been no K placement differences in the five long-term trials evaluating fertilizer placement since deep-band treatments for no-till were discontinued in 2002. However, last year there was an exception at the Southeast Research farm. Probably because deficient moisture during July and early August, for the first time banding K with the planter increased yield of no-till corn more than broadcast K did. Soil-test K values from samples collected from selected plots are being entered into databases to study long-trend over time.

Comparisons of calcium chloride and potassium chloride fertilization showed no effect of chloride at the two trials (one in corn and one in soybean). Potassium chloride fertilizer increased yield of both crops significantly but calcium chloride applied at a similar Cl rate did not increase yield. This is a very important result. The largest responses to K that I have seen in Iowa have been in these two long-term trials, where soil-test K of plots that received no potassium chloride since the 1970s has been at about 110 to 130 ppm for many years. The results indicate that crops indeed have been responding K, not to Cl. These Cl treatments will be evaluated again in 2006 at these two trials by switching crops of the rotation.

2. Short-Term and Multi-Rate Conventional Trials

Methods.
The objectives of several two-year K trials are to determine rates of K needed to maximize crop yield in different soils having soil-test K within the current Low or Optimum interpretation classes and to measure the residual response of a second crop, K fertilization effects on after-harvest soil K, and K removal with grain harvest. They are established at various research farms across the state. Five K fertilizer rates ranging from 0 to 180 lb K_2O/acre are applied to the first corn or soybean crop, and for the second crop plots are subdivided to apply no K or 120 lb K_2O/acre. In 2005, four trials (two with corn and two with soybean) were in the second year of the rotation and eight new trials were established (four with corn and four with soybean), which will be evaluated for a second year in 2006. Soil samples were collected from each plot of all trials before applying the treatments and after crop harvest. Soil is analyzed for ammonium-

acetate K, Mehlich-3 K, and tetraphenyl-boron K. Small-plant samples (V5 to V6) and ear-leaves (at silking) were sampled to be analyzed for K content. Grain also was sampled to measure grain K concentration and K removal.

Summary results.
The yield responses have shown very large for all annual treatments (30 to 180 lb K_2O/acre) when soil-test K of the area (new trials) or non-fertilized plots (second-year trials) was below a value of 120 to 130 ppm. Obvious K deficiency symptoms were observed in three corn trials. Responses were small to moderate for trials in which soil-test K of non-fertilized plots tested about 130 to 170 ppm. For some reason not yet understood, responses have not been as large as in the long-term trials, even with similar soils and soil-test K values. One very interesting result observed from the after-harvest soil-test K results in the 2004 trials (many results from Fall 2005 are not available yet) is that K fertilization did not build-up soil-test K nearly as much as expected in soils of the Webster or Canisteo soils. Data for after-harvest soil samples analyzed with the tetraphenyl-boron K test and grain K removal should be able to explain this result, but these results are available only for the 2004 season and have not be summarized yet. Incidentally, sample numbers are so large and some tests are very expensive so some samples collected during 2005 are being analyzed but others will have to wait for additional funding. I am very interested in continuing these studies in 2006 because they will provide very useful information for K management across many different soils and yield levels.

On-farm Strip Trials Managed with Precision Agriculture Technologies

Methods.
Treatments for ten strip trials (four with corn) consisted of a check and a K fertilizer rate of 200 to 200 lb K_2O/acre applied to strips 60 to 70 feet wide and as long as 1,500 feet replicated four times at each field. Soil-test K was analyzed in samples taken before applying the fertilizer treatments from cells approximately 0.5 acres in size. Grain was harvested with combines equipped with yield monitors and GPS receivers. After crop harvest, soil samples were collected again from trials that would be continued for a second crop in 2006 to study fertilizer effects on soil-test K and have initial values for the new season. The soil sampling density was multiplied by a factor of two because samples were collected from each treatment.

Summary results.
All field trials were conducted successfully except for one soybean trial, for which yield was lost due to a problem with the yield monitor. The yield maps are still being processed, only averages of raw data are available, and little can be shared at this time. The strip average data from trials conducted in 2004 showed large variation in corn response across fields. Study of average soil-test K data for each field confirmed that little or not crop response should be expected at values above 170 to 180 ppm but that soil-test K is a very poor predictor of crop response below those values. I have not finished the GIS work to overlay grain yields, soil-test values, and soil map units to study response variation along the landscape within each field. The graduate student working on these trials (Pedro Barbagelata) graduated last year and we could not include these trials on his Dissertation. A new student started last fall (Matt Clover) but has been very busy establishing new trials and working in the laboratory. However, observation of the yield and soil-test K maps do indicate large variation in response within each field, which suggests GIS

studies for these trials will be very useful.

Soil Test for K in Field Moist Samples

Methods.
A major effort has been made since 2003 to study K testing on field-moist samples as a possible way of improving the value of soil testing for K. The soil tests compared have been the routine ammonium-acetate K and Mehlich-3 K tests, and a field-moist based ammonium-acetate K test. The study included correlations of amounts of K extracted in the laboratory, field calibrations, and comparison of the moist test we are using with the slurry (moist) test used in Iowa during the 1970s and 1980s. Work on this objective was based on selected samples from all the types of experiments described above.

Summary results.
Data until the 2004 crop season have been processed. Samples analyzed for the 2005 crop year have not been correlated with yields yet for the same reason given above (graduate student changes). Available results were shown by Pedro Barbagelata in an oral presentation at the ASA meetings last fall and were also summarized in his Dissertation. Soil K extracted with the dry test was higher than for the moist test, the difference increased with increasing drying temperature (from air dried to dried at 50 ºC), and the drying effect varied greatly between soil series. No single measured soil property could be used to relate test results partly because the difference between tests was inversely related to the soil K level. The moist K test correlated better with yield response than the dry test and showed a better defined critical K concentration. Results showed that different calibrations are needed for different soils and (or) growing conditions for the commonly used dry K test but not for the moist test. Critical concentration ranges for corn defined by Cate-Nelson and linear-plateau models across sites until 2004 were 144 to 201 ppm for the dry test and 62 to 76 for the moist test. The degree of the improvement may justify the more laborious laboratory procedures for the field-moist test. This part of the project also continues in 2006, and both dry and moist tests results are available for samples collected in Fall 2005.

Extension Activities

A large effort was dedicated to share previous years' results at scientific meetings and meetings targeted to farmers or professional agronomists. The main thrust was on explaining the need for higher soil-test K levels for optimum crop production in many soils, results of new soil-test calibrations, problems associated with soil sampling drying in the laboratory, and factors that may induce K deficiency even when soil-test K is high. These issues were discussed and shared to Iowa farmers and professional agronomists at 12 meetings, conferences, or field days. Results were also presented at the ASA annual meetings, invited conferences in Illinois and South Dakota, and at the Four-State Soil Test Conference. Several presentations were summarized in abstracts or short articles. Many K management issues and project results also have been shared during many interviews to reporters of farm magazines.

Plans for the 2006 Crop Season

I plan to continue the project with minor modifications. The long-term K trials will continued to be evaluated as last year because they have been very productive, and also are providing new information (such study of the moist K test by all trials and response to chloride by two trials).

The two-year multi-rate trials that go into their second year will be evaluated as planned using the same field and laboratory methods used in 2005. Four new trials using the same K fertilizer treatments (five rates ranging form 0 to 180 lb K_2O/acre) will be established this year. However, a major change will provide new and more information concerning K nutrition of corn. Instead of subdividing plots to assess fresh fertilization effects on soybean in a second year, the fertilizer plots will be split in the first year to plant two corn hybrids and corn will be planted again in 2007. I want to evaluate the impact of the rootworm resistant gene on K uptake by corn and yield. This change will increase the cost of these multi-rate trials mainly because in selected plots I plan to evaluate rootworm infestation and whole-plant K uptake near the silking stage.

A more limited portion of expected funds for 2006 will be used for strip trials compared with last year. Although FAR has not confirmed the level of funds for this season, last fall we used some university funding to establish five new trials for corn using treatments, design, and methods as used last year. Soil samples were collected and are being analyzed (by dry and moist K tests) , hoping the level of funding will be maintained. I may not be able to collect plant samples (at the V5 to V6) growth stage as in previous years because of limited funding.