Between and Within Field Variability of the Relationship Between Soil-Test Potassium and Crop Yield

Year 2001 Progress Report
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Introduction

The main objectives of this ongoing research are (1) to study the variability in soil-test potassium (K) and corn response to K fertilization and (2) to evaluate soil tests for K currently used in the Midwest and a new soil test for K with potential to improve the predictability of response to K fertilization. The research is based on evaluation of long-term trials at three research farms and several on-farm, replicated strip trials. The conventional trials compare several rates of K fertilizer and the strip trials compared fixed-rate and variable-rate fertilization. The various K treatments applied to trials at research farms are replicated three to six times depending on the farm. At the on-farm trials, treatments applied to strips 60 feet wide and as long as the fields were replicated three to four times across each field. Initial soil-test K before applying the fertilizer treatments is measured on soil samples collected from 0.75-acre cells, and after harvest soil samples are collected from each strip and cell (0.25-acre cells). Grain is harvested with plot combines at the research farms trials and with yield monitors at producers' fields.

Research Progress

An important addition to the research methods used during the past year (compared with the plans included in the original proposal) was a study of the effect of soil sample drying on soil K measured by the commonly used ammonium acetate test. This aspect was added after preliminary results strongly suggested it likely is the main cause of problems.

<u>Trials at research farms</u>.
In the 2001 season, soil samples, plant tissue samples, and corn grain yields were collected from two long-term, conventional trials established at two research farms. Data from soybeans from one trial where corn was grown in 2000 are shown in this report, although funding from the Iowa Soybean Promotion Board was used for the work with soybeans.

One of the most remarkable aspect of the results from the research farms trials has been corroboration of sometimes obvious K deficiency symptoms and large yield responses of both corn and soybeans in the Optimum and High Iowa State University (ISU) soil-test interpretations for K. According to these interpretations, small responses should be expected when soil-test K is in the Optimum class (90 to 130 ppm) and no response should be expected for the High class (131 to 170 ppm). Thus, only maintenance fertilization is recommended for the Optimum class.

The relationship between yield response and soil-test K (as measured by the commonly used ammonium acetate test on dried soil samples) are shown in the following three figures. Figures 1 and 2 show data for two trials established on Nicollet or Webster soils (Central Iowa and in Northen Iowa). Both sites are managed with a corn-soybean rotation, and corn is grown in even years at the Northern Iowa site and in odd years at the Central Iowa site.

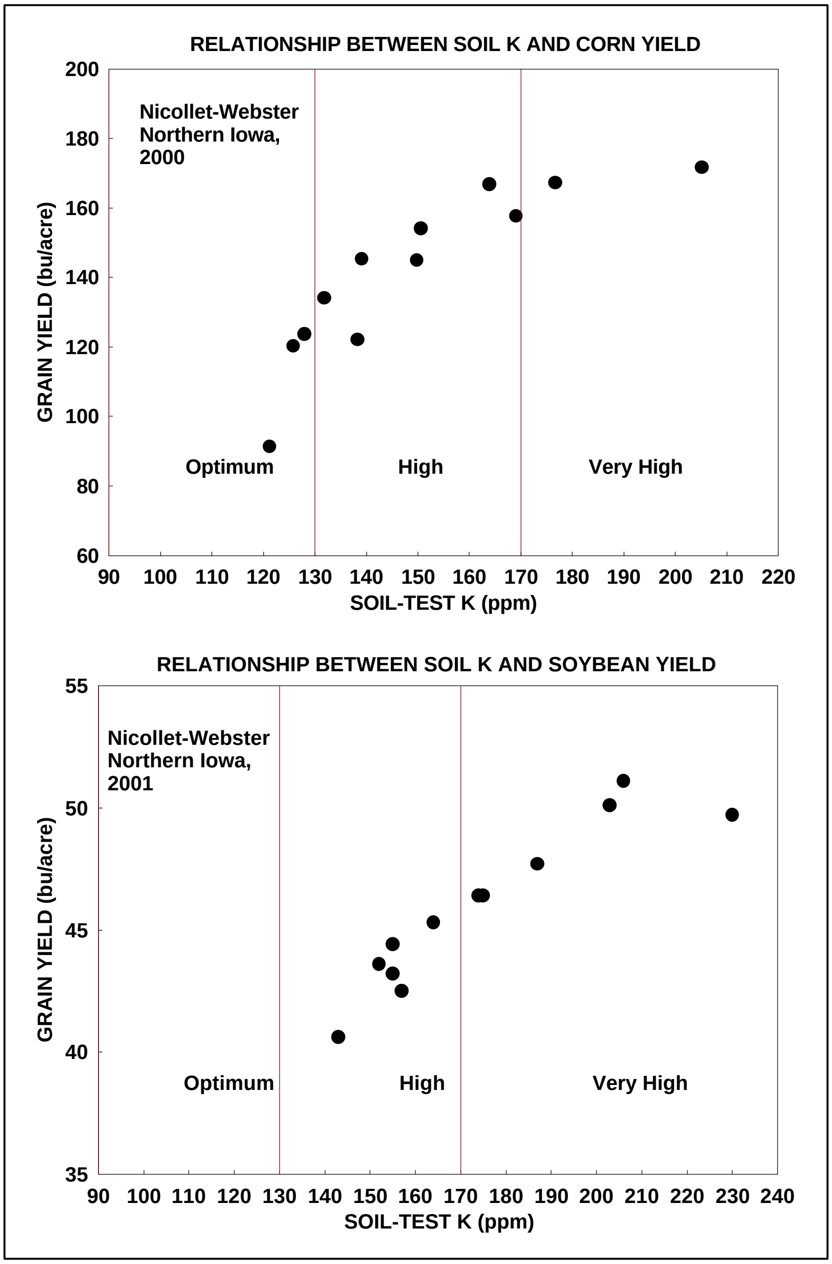

Fig. 1. Relationship between soil-test K (ammonium acetate test) and corn yield for a trial conducted in Northern Iowa.

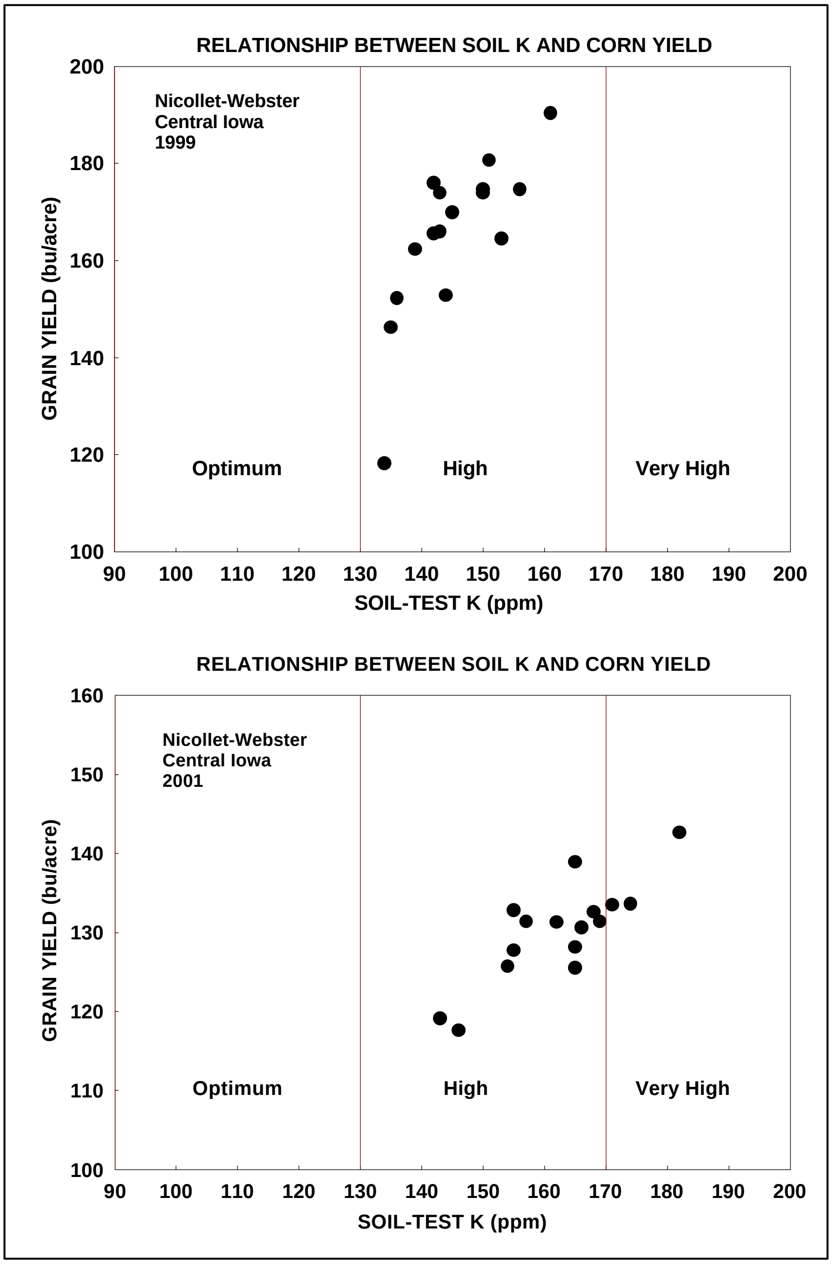

Fig. 2. Relationship between soil-test K (ammonium acetate test) and corn yield for a trial conducted in Central Iowa.

Figure 3 show corn data for three years for a trial established mainly on a Kenyon soil in Northeast Iowa (corn are soybean are grown each year at adjacent similar trials at this site). Obviously, these data suggest that K fertilizer should be added when soils test in the High class, although the magnitude of the yield response is greater for the trials established on Nicollet-Webster soils.

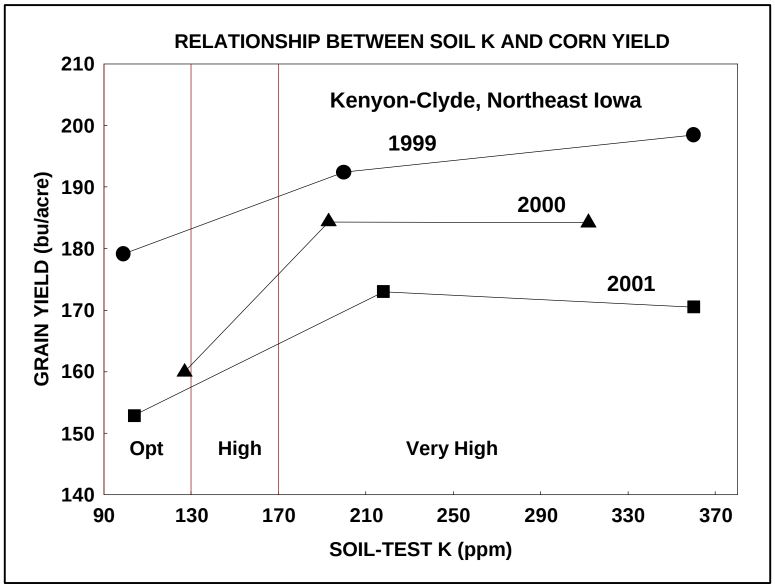

Fig. 3. Relationship between soil-test K (ammonium acetate test) and corn yield for a trial conducted in Northeast Iowa.

Another important result is that plant tissue analyses confirm large increases in K uptake when soil-test K increases into the High and Very High interpretation classes. Data in Fig. 4 show, as an example, this relationship for one of Nicollet-Webster sites. Although these tissue tests correspond to a V6 growth stage, and no widely accepted calibrations exist for this stage, the results show that the tissue K increase matches increases in both soil-test K and grain yield.

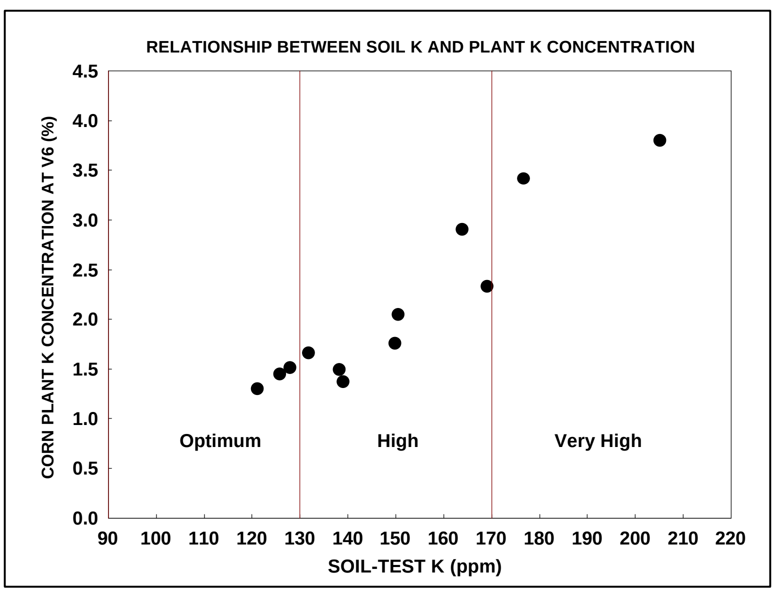

Fig. 4. Example of the relationship between tissue K concentration (V6 stage) and soil-test K.

<u>On-farm strip trials</u>.
In the 2001 season, soil samples, plant tissue samples, corn grain yields were collected from four on-farm strip trials. These trials add to an approximately similar number of conducted last year. Crops of the on-farm strip trials were harvested successfully but only raw yield data averages from the yield monitors are available at this time (yield maps are being processed), so no data can be presented.

Soil analyses of soil samples collected before applying the K treatments showed large variation in soil-test K within and across fields, which was also shown in previous years. The results of the previous seasons showed large yield responses to K at some fields (up to 20 bu/acre), and the whole-field average soil-test K of responsive fields always was within the current Low (61 to 90 ppm) or Optimum (91 to 130 ppm) Iowa State University interpretation classes for K. The methods of fertilizer application differed slightly only at one of six fields field, and this small response existed only because one of the fixed-rate strips (of four replications) happened to have the lowest initial soil-test K values of the entire field.

The within-field variation in soil-test K was very high at most fields, however, and use of yield monitor maps are useful to study yield responses for different parts of the fields. The data in Fig. 5 show the yield response for areas testing within various current soil-test K interpretation classes within each field and across all fields. The bars represent the average of fixed-rate and variable-rate treatments because these two treatments seldom differed statistically.

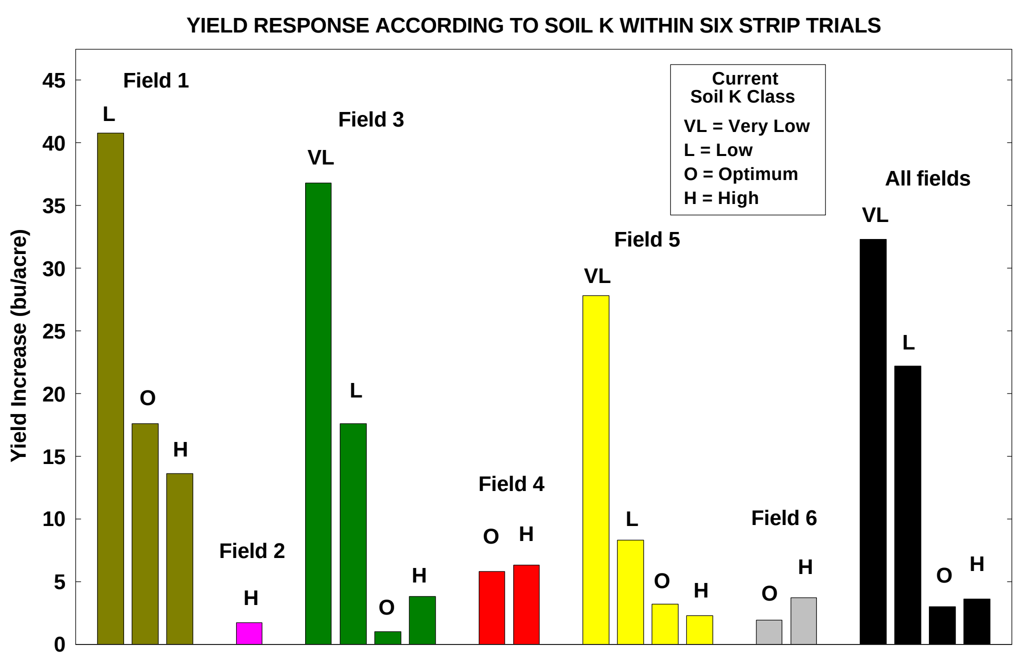

Fig. 5. Yield response of corn to K fertilization for areas within fields testing within various current soil-test K interpretation classes.

As expected, responses were high in the low-testing areas and small in areas testing within the Optimum class. An unexpected result was, however, that there were moderate responses (about 5 bu/acre) in areas testing High, which were approximately similar to responses observed in the Optimum class. Although Iowa State University currently does not recommend K fertilization, we still applied at least an amount of K equivalent to one crop removal in grain small amount (50 lb K_2O/acre). This showed that current recommendations may not be appropriate because these small responses in the High soil test class were relatively consistent across fields.

Correlations between soil tests.

Work was conducted to study the impact of soil sample drying on the K extracted by the commonly used ammonium acetate test, and to study the Mehlich-3 and tetraphenyl-boron tests. Research during the last three decades has shown that drying tends to increase extractable K (usually a quick estimate of exchangeable K). Iowa State University used a field-moist K test until 1991, when it began recommending drying the sample mainly because no other university or private lab wanted to do the field-moist test. The scarce research at that time (1960s and 1970s) seemed to show that drying the sample increased extractable K but did not change the correlations with yield response. Thus, based on research conducted at the time, since 1992 ISU used a coefficient of 1.25 to adjust the existing soil-test interpretations.

The preliminary research in this project confirms differences between amounts of K extracted. Data in Figs. 6, 7, and 8 show that drying increase extractable K in widely different proportions across soils, that the drying temperature is an important factor and that a coefficient would vary greatly across soils, and that relationships between K extracted by the ammonium acetate and tetraphenyl-boron tests also vary across soils.

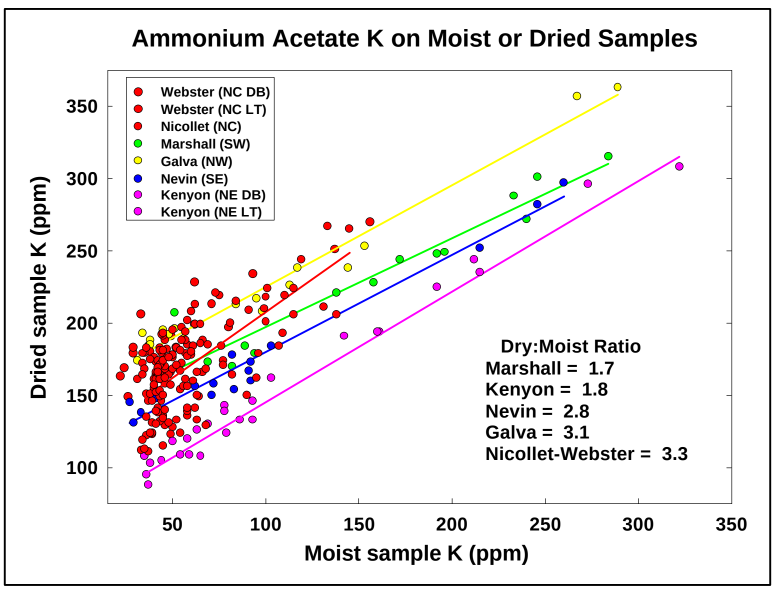

Fig. 6. Relationship between amounts of K extracted by the ammonium acetate test from field-moist and dried (40 °C) soil samples across several soils.

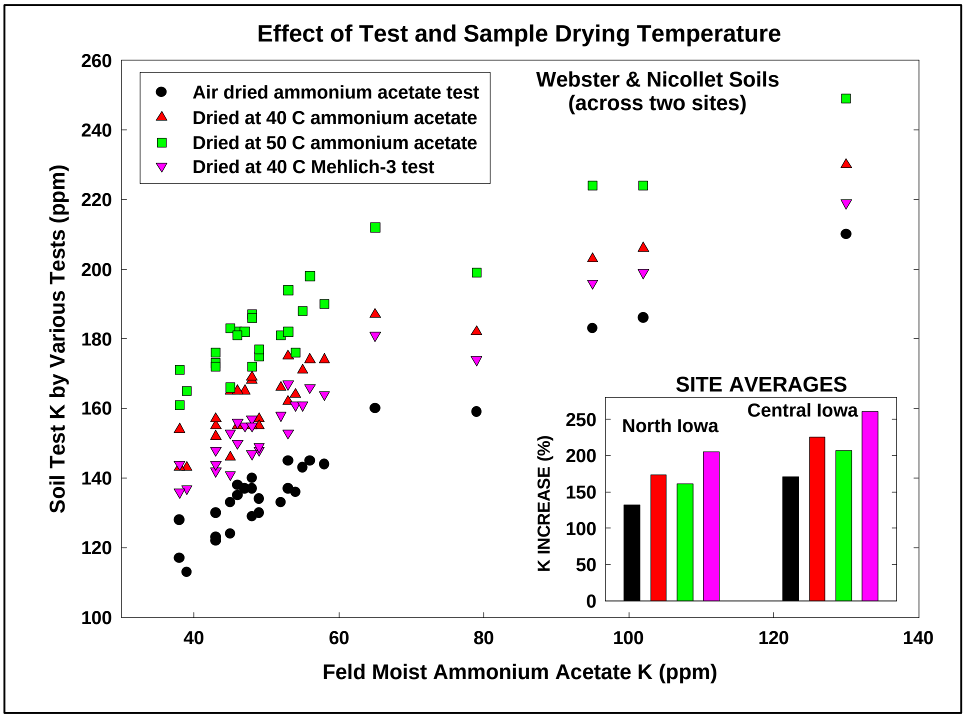

Fig. 7. Effect of the soil sample drying temperature on K extracted by the commonly used ammonium acetate test from two soil of two trials (Nicollet-Websters soils).

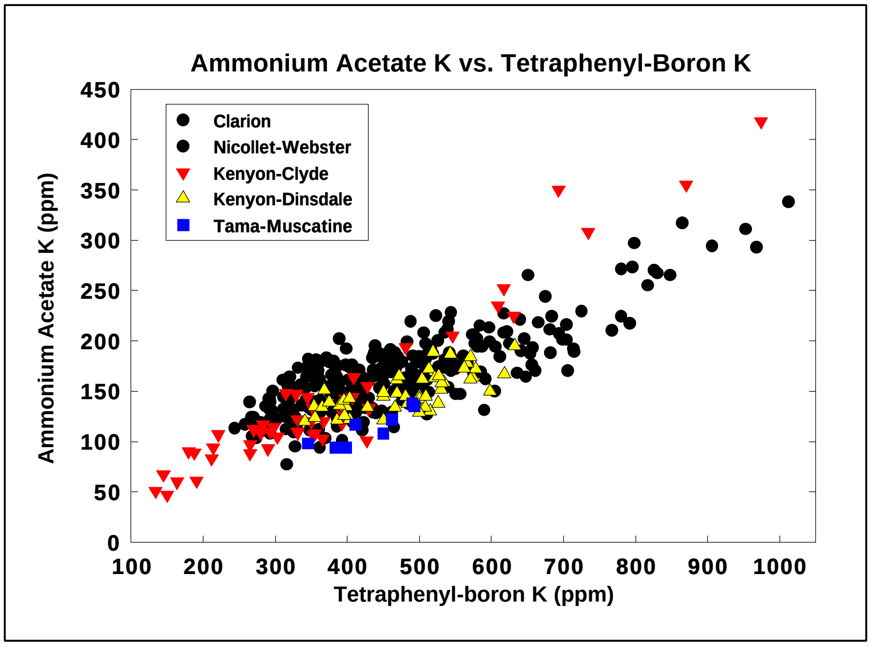

Fig. 8. Relationship between amounts of K extracted by the ammonium acetate test and the tetraphenyl-boron test from dried (40 °C) soil samples across several soils.

Of course, relationships between yield response and soil-test K measured by the different tests should answer the question of what test is better related with K sufficiency for crops. These data are not shown in this report because of the little time to prepare this summary since crop harvest. All these tests were performed on samples collected in Fall 2000, and the data should be correlated with 2001 grain yields. Work to do this is being conducted at this time. A thorough study of these correlations and of relationships with plant K uptake and grain yield responses should provide useful information to arrive at final recommendations concerning soil testing for K and fertilizer recommendations.

Summary discussion.

The still incomplete results of the project confirm the need of this research and earlier suspicions about a problem with soil-test interpretations and K fertilizer recommendations. The results show that higher soil K levels than normally recommended are needed to optimize crop yield in many fields. The new results from this project show the marked impact of the drying temperature on extractable K. Furthermore, results suggest that adjustments made in the early 90s to ISU calibrations based on analyses of field moist samples to convert them to analyses of dry samples were not appropriate. The data suggest that the overestimation of soil K supply is worse in soils of the Clarion-Nicollet-Webster, which dominate a major part of Central and Northern Iowa and Southern Minnesota, but that the problem also exists for soils of other associations. One interesting aspects, for which no definite answer exists at this point of the research, is that the problem seems worse for data from the long-term experiments. This difference could be explained by the different methodologies used for conventional small plots and on-farm strip trials, but it could also be related to the longer histories of fertilization and cropping of the long-term trials. If the latter were the main reason for the difference, an important implication would be that short-term experiments underestimate K needs of crops. This conclusion cannot be confirmed, however, until more years of data are gathered and soil analyses by the tetraphenyl-boron test are completed.

Year 2002 Research Plans

The results of the project obviously suggest that at least one more year of research is needed. This need arises mainly from use of the different sample treatments introduced in Fall 2000 (sample drying for the ammonium acetate K test) and also to get sound field calibrations for these tests (different drying temperature), the Mehlich-3 test, and the tetraphenyl-boron test. I must emphasize that the study of soil sample drying was not included in the original proposed work, and was added after preliminary results strongly suggested it likely is the main cause of the problems.

Fertilizer treatments were already applied this fall. Chemical analyses of the Fall 2001 soil samples and of plant samples collected during summer 2001 will continue. Plant samples and grain yield data will be collected for the 2002 crops to develop relationships between soil K tests, between soil-test K and plant tissue K content, and between soil-test K by various methods and grain yield response.

It should be noted that complementary work made possible by a separate in-kind grant from FAR. This in-kind help involves analyses of K in grain harvested from trials at research farms, which were not shown in this report. Continuation of these two complementary research projects for will greatly expand the scope and potential impact of this research project in production agriculture.