Year 2000 Progress Report and Renewal Proposal

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

Antonio P. Mallarino
Department of Agronomy, Iowa State University
December 2000

1. Summary Introduction

The main objectives of this research are (1) to study the variability in soil-test 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 crop response to K fertilization. In the 2000 season, the second year of the project, soil samples and grain yields were collected from three long-term, conventional trials at three research farms and from three on-farm strip trials. These trials added to a similar number of trials conducted in 1999. The conventional trials compared 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 were 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 was measured on soil samples collected from 0.75-acre cells, and after harvest soil samples were collected from each strip and cell (0.25- acre cells). Grain was harvested with plot combines at the research farms and with yield monitors at the producers' fields. The yield results for the 2000 season should be interpreted with caution because no outlier or statistical analyses have been conducted, and yield data management (mainly for strip trials harvested with yield monitors) was rushed to meet the request for an early report. Yields for the 1999 season, which were shown in last year's report are shown together with the 2000 data.

2. Summary of Results

A. On-farm strip trials.

Yields and initial soil-test K values for the on-farm strip trials are shown in Table 1. Soil analyses showed large variation in soil-test K within and across fields. In the 1999 season there were large yield responses at two fields (12 to 20 bu/acre) and no response at one field. The whole-field average soil-test K of responsive fields was within the current Low (Field 3) or Optimum (Field 1) soil-test interpretation classes. Soil-test K ranged from Low to Very High in Field 1 and from Very Low to High in Field 3. In the unresponsive field, the average soil-test K was borderline between the current High and Very High classes, and although there was large variation no sampling cell tested Optimum or below. The methods of fertilizer application differed only at Field 3. This field had large and contiguous areas testing very low, where the variable-rate application increased yield more than the fixed rate.

In the 2000 season there were yield responses at the three fields, although the response was large only at one field (8 bu/acre). The field-average soil-test K was borderline between the current Low and Optimum classes for the field with the largest response (Field 5), and was within the High class in the other two fields. Soil-test K ranged from Low to Very High in Field 4, from Very Low to High in Field 5, and from Optimum to Very High in Field 6. This year the methods of fertilizer application did not differ at any field.

Table 1. Corn yield and soil-test K for three replicated strip trials comparing fixed-rate and variable-rate K application methods.

			Soil-test K			Corn yield		
Year	Field	Predominant Soil	Min	Mean	Max	Check	Fixed	Variable
			------------- ppm ------------			----------- bu/acre ----------		
1999	1	Tama	70	129	276	160	178	177
	2	Kenyon, Dinsdale	132	172	219	150	153	150
	3	Kenyon, Floyd	38	85	161	165	178	185
2000	4	Clarion, Webster	85	165	369	143	147	146
	5	Kenyon, Floyd	56	88	136	154	163	160
	6	Kenyon, Dinsdale	117	140	221	138	143	140

One of the advantages of on-farm strip trials with GPS, intensive soil sampling, and yield monitors is the possibility to study yield responses for areas within a field with contrasting soil-test values. The data in Fig. 1 show the yield response for areas testing within various current soil-test K interpretation classes within each field and across all fields.

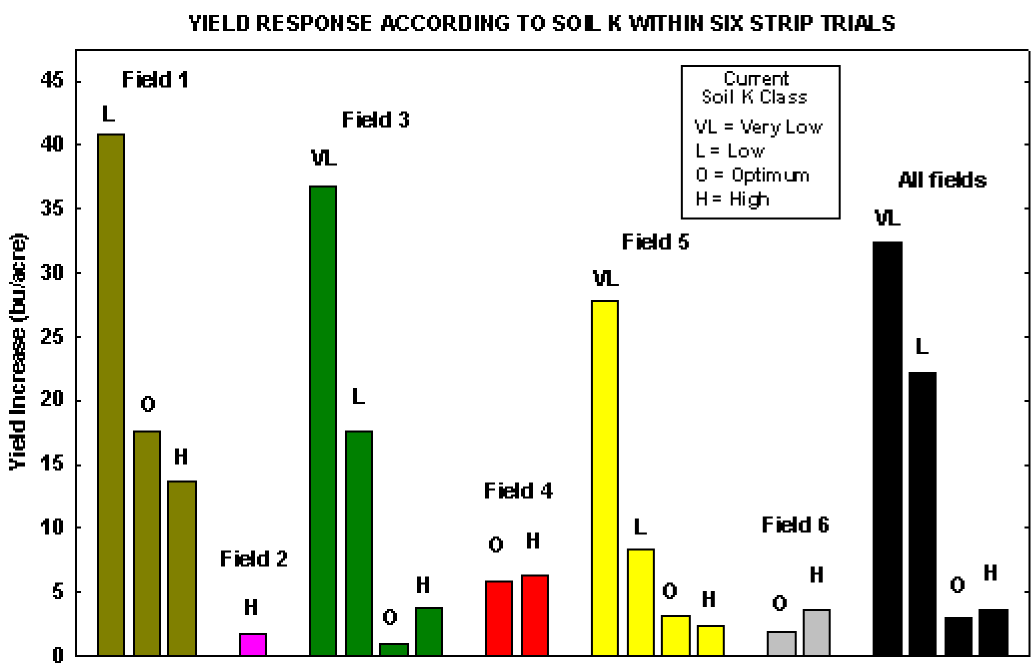

Fig. 1. Differential yield response to K fertilization for areas within fields testing within various current soil-test K interpretation classes.

As expected, responses were high in the low-testing areas and small in areas testing within the Optimum class. It must be noted that data for a single 0.75-acre cell testing Low in Field 4 were not included in the figure. An interesting unexpected result was, however, the small responses (about 5 bu/acre) in areas testing High, which were approximately similar to responses observed within the Optimum class. Although no K fertilization is recommended for the High class by current soil-test interpretations, a small amount (50 lb K2O/acre) was applied with variable-rate in these trials (a fixed rate was applied all along each fixed-rate treatment strip according to the field-average soil-test K value).

B. Trials at research farms.

Yields and initial soil-test K values for the trials at the research farms are shown in Table 2 through Table 4. Very large responses were observed in the three farms. At the Northeast farm (Table 2), the response was about 20 bu/acre in both years. Two years of corn data are available because at this trial corn and soybean were grown each year by alternating halves of identical treatment designs. The corn response at the Central Iowa farm (in 1999) was about 70 bu/acre and at the Northern Iowa farm (in 2000) was about 80 bu/acre. A remarkable aspect of the large yield responses at the research farms is that these responses were not expected given current Iowa soil-test interpretations for K. Only small and infrequent responses are expected when soil-test K is in the Optimum class (90 to 130 ppm) and only maintenance fertilization is recommended. No K fertilization is recommended for the High class (131 to 170 ppm).

At the Northeast farm, soil-test K of plots that received no K fertilizer for almost 20 years was in the lower Optimum class in both years (and different field halves). The observed yield response was higher than the expected small response for this class. Annual fertilization with 72 lb K_2O/acre increased both soil-test K and yield significantly, and the higher 144-lb rate produced a small 4-bu response in 1999 but not in 2000.

Table 2. Corn yield and initial soil-test K from a long-term experiment conducted on a Kenyon soil in Northeast Iowa.

Year	Field	Annual K	Soil-test K	Corn yield
		lb K_2O/acre	ppm	bu/acre
1999	West	0	101	179
		72	198	192
		144	372	198
2000	East	0	127	160
		72	193	184
		144	312	184

At the Central Iowa farm (Table 3) the lowest soil-test K value was 149 ppm (in the High range) but the corresponding grain yield was 72 bu/acre less than for plots with the highest soil-test K values or those receiving the annual K fertilization treatment. Moreover, there were significant responses (10 to 15 bu/ace) even at soil-test K levels of about 180 ppm. A large response of soybeans grown in the 2000 season (data not shown) confirms that the corn response in 1999 was not the result of experimental error or an isolated year effect.

Table 3. Corn yield and soil-test K for from a long term experiment conducted on a Nicollet-Webster soil in Central Iowa (1999 season).

Annual K		Initial K soil test K level							
		1	2	3	4	1	2	3	4
76 - 97	98 - 00	Soil-test K				Corn yield			
lb K_2O/acre		ppm				bu/acre			
0	0	149	167	174	169	118	152	174	166
36	0	155	172	173	178	146	153	176	175
72	0	166	175	172	179	162	165	170	181
108	108	--	--	--	–	166	174	175	190

At the Northern Iowa farm (Table 4) the lowest soil-test K value of plots receiving no K fertilizer was 124 ppm (upper Optimum class) the response compared with plots with the highest soil-test K levels or plots receiving annual fertilization was about 80 bu/acre. The year 2000 was a particularly bad year for K nutrition in major parts of Iowa because of dry conditions in spring and early summer. Potassium deficiencies were widespread in this study and in many producers' fields throughout Central, Eastern, and Northern Iowa.

Table 4. Corn yield and soil-test K from a long term experiment conducted on a Webster soil in Northern Iowa (2000 season).

Annual K		Initial K soil test K level					
		1	2	3	1	2	3
1976-1997	1998-2000	Soil-test K			Corn yield		
lb K_2O/acre		ppm			bu/acre		
0	0	121	126	138	91	120	122
36	0	128	132	151	124	134	154
72	0	150	139	169	145	145	158
108	108	164	177	205	167	167	172

C. Correlations between soil tests.

Work was first conducted to adjust the lab technique of the new tetraphenyl-boron K test. This test seems much less affected by sample moisture variations then the two tests most commonly used in the Midwest (the ammonium acetate and Mehlich-3 tests). Development of the routine lab procedures of this test is in progress at this time. A parallel work involving a sample exchange is being conducted with Indiana researchers using samples of the North American Proficiency Testing program to further fine-tune the routine lab technique.

A preliminary group of soil samples was selected from several sites of the project to study correlations between the ammonium acetate and Mehlich-3 tests with the tetraphenyl-boron test. The correlations showed that the ammonium acetate and Mehlich-3 tests extracted rather similar amounts of K, and usually amounts of K extracted were well correlated across most soils. The only exception seems to be the Kenyon soil at one of the locations. Data in Fig. 2 suggests a lower extraction by the Mehlich-3 test in this soil. Analyses of more samples are needed before any firm conclusion can be made. If confirmed, this result would be very important because current recommendations in the Midwest assign similar K interpretations to the ammonium acetate and Mehlich-3 soil tests.

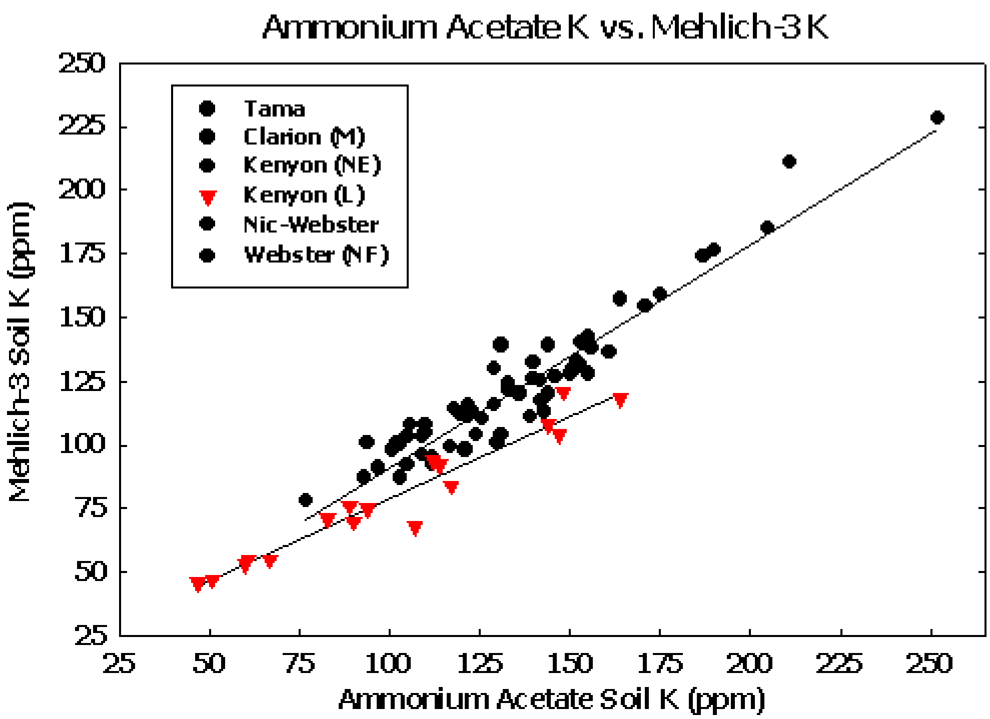

Fig. 2. Relationship between amounts of K extracted by the ammonium acetate and Mehlich-3 soil tests across several soils.

Data in Fig. 3 show marked differences between the K extraction by the ammonium acetate (or Mehlich-3) and the tetraphenyl-boron tests. Differences are small for some soils but large for others. Analyses of more samples that encompass a wide range of K concentrations are needed to confirm the trends observed from these preliminary samples and to understand the possible causes for the differences. 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.

D. 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. It is very likely that adjustments made in the early 90s to calibrations based on analyses of field moist samples to convert them to analyses of dry samples were not appropriate. These results suggest the problem may be of different magnitude depending on the soil association or geomorphological region. The data for the first two years of research suggest that the overestimation of soil K supply is worse in soils of the Clarion-Webster and Clarion-Nicollet-Webster soil associations, which dominate a major part of Central and Northern Iowa and Southern Minnesota (the Des Moines glaciation lobe). However, it is particularly interesting that the problem seems much worse for data from the long-term experiments. This difference may be due to the different methodologies used (conventional small plots versus on-farm strip trials), but it could also be related to the much longer histories of fertilization and cropping of the long-term trials at research farms. 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.

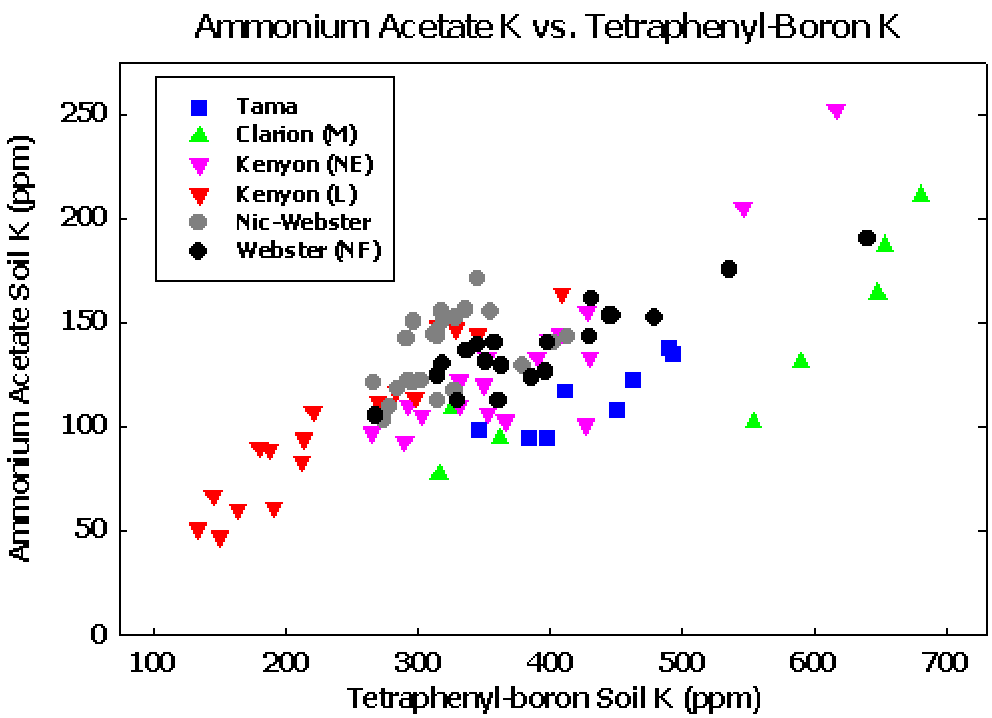

Fig. 3. Relationship between amounts of K extracted by the ammonium acetate test and the tetraphenyl-boron extractant across several soils.

3. Year 2001 Research Plans

At least a similar level of funding is requested for the 2001 season. Plans for next year (the third year of the project) involve continuing the field research with a similar number of fields, the GIS analyses of strip trials, analyses of soil samples (including the tetraphenyl-boron test), and study of relationships between response and soil test values. Strip trials will be established in other fields so that the information from three years can be used to formulate new soil-test interpretations and fertilizer recommendations.

The funding provided to this project by FAR and industry was sufficient (as originally planned) to conduct the study of grain yields and soil tests described above. The same level of funding will be sufficient for the third year of the project. However, the work could be markedly improved by conducting part of all of the following additional work, as was discussed in the 2000 summer field tour.

1. Analysis of K concentration of vegetative plant parts. These analyses are useful to study relationships between yield response, soil test values, and plant K uptake or concentration. These relationships, especially between soil tests and plant K concentrations, are better indices of K availability than grain yield in many situations and will supplement yield response data to study the soil test K extraction across soils. During the 1999 and 2000 season plant samples were collected at the V5 and ear-leaf growth stages from all trials. Analyses of plant tissue for selected plots of one research farm, although not completed, confirm the apparent inadequacy of the current interpretations for the ammonium acetate and Mehlich-3 soil tests (at least for some soil associations). With the current level of funding, analyses can be performed on samples from only a few selected plots of trials at research farms.

2. Soil test analyses of field-moist samples. It has become obvious since the project began that ultimate answers to the apparent problem of soil K testing would be provided only by analyses of field-moist samples, the soil test ISU conducted until 1991. Following informal discussions during the late summer field tour of the plots, extra soil was collected for samples taken after harvest in Fall 2000 in order to conduct these analyses, at least in selected plots. These analyses involve much labor and additional funding is needed to analyze a significant number of samples.

It should be noted that complementary work made possible by funding from other sources will greatly expand the scope and potential impact of this research project in production agriculture. One aspect involves analyses of K in grain harvested from trials at research farms. This complementary work (not shown in this report) has been made possible for the last two years by a separate in-kind grant from FAR. Continuation of this help will make possible analyses of samples collected in the 2000 season. Another important aspect is that secured funding from the Iowa Soybean Association will allow for evaluation of responses of soybeans grown in rotation with corn during the next two years. It must be remembered that the current funding from FAR and industry is used to study corn responses. This complementary work will be a major improvement because a similar study of yield, soil tests, and plant K uptake will be conducted with soybeans.