Mapping K-fixing Soils in the San Joaquin Valley and Calibration of a Rapid Soil K fixation Test with Standard Methods

FINAL REPORT

TO THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
FERTILIZER RESEARCH AND EDUCATION PROGRAM
January 1, 2001 – August 31, 2003

Agreement No. 00-058 between
the California Department of Food and Agriculture and
the Regents of the University of California

FINAL REPORT TO COTTON INCORPORATED
FINAL REPORT
to the CDFA Fertilizer Research and Education Program
January 1, 2001 – August 31, 2003

PROJECT TITLE: Location of K-fixing Soils in the San Joaquin Valley and a New, Practical Soil K Test Procedure (00-0508)

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SUMMARY
Research was conducted on mapping the location of K-fixing soils in the San Joaquin Valley. Thirty three soil profiles were sampled by horizon from three categories: Sierra Nevada coarse-textured alluvium, Coast Range coarse-textured alluvium, and fine-textured alluvium. Mineralogical assays were conducted on selected profiles and on silt and clay fractions to qualitatively determine vermiculite content. All soil samles were analyzed in the laboratory for exchangeable K, and capacity for K fixation, using several methods. In most cases, soils formed on Sierra Nevadan alluvium have high amounts of vermiculite and fix K, especially in the deeper horizons. Soils formed in Coast Range sediment, typically show no K fixation in the surface and a small amount in the deeper horizons and little or no

vermiculite. We speculate that Coast Range alluvium has more chlorite than the Sierra Nevadan-derived soils.
At a 4 sites, K fertilizer rate experiments were conducted. No yield response was obtained at the Shafter Field Station. On the grower fields, we observed yield responses to conventional rates of K fertilizer but not to very high rates (300-400 lb K_2O/acre). Results were consistent with K soil test values.

We compared a sodium tetraphenyl boron method (NaBPh4, hypothesized to extract exchangeable K and a portion of fixed K) to the conventional exchangeable K soil test and to a 7-day test incubation test for K fixation capacity. The NaBPh4 test was not consistently related to conventional soil test K, or to the source of parent material and does not appear to be useful for identifying K-fixing soils. On the other hand, K fixation measured by the amount of K removed from a ~2 mM solution in a 7-day incubation was related to source of parent material. A similar 1-hr test, which would be more practical for agricultural laboratories than the 7-day test, works nearly as well.

We also produced a GIS map showing the location of potentially K fixing soils and cotton land in the southern San Joaquin Valley. Potentially K fixing soils were identified by degree of development inferred by Great Group and Order (USDA soil taxonomy), by source of parent material inferred by location, by texture obtained from the Family level of the taxonomy, and by slope. We used seven USDA SSURGO digitized county soil surveys that cover the study area. According to our model, 1,542,329 acres of land in the eastern San Joaquin Valley is potentially K fixing. We have not been able yet to determine the area of this land that is in cotton production, but it appears to be much less than a previously published estimate that 60% of cotton soils in the SJV are vermiculitic and therefore fix K. We are continuing research needed to establish the validity of our K-fixation model.

Is it necessary for production managers or crop advisers to determine K-fixation capacity with a soil test? We compared exchangeable K and K fixation capacity, the latter determined with our proposed 1-hr K fixation procedure. Samples with exchangeable K levels 50 ppm (mg K/kg soil) or less always fixed K. No samples with >200 ppm exchangeable K fixed K. Soils with soil test K values between 50 and 200 ppm exhibited K fixation ranging from negative (i.e., increasing the K concentration of the incubating solution) to strong K fixation. Note that the upper UC K critical level (exchangeable K by ammonium acetate extraction) is 110 ppm. We recommend that for soils with exchangeable K values between 50 and 200 ppm and located within the area identified as potentially K fixing in our map, a K fixation soil test should be strongly considered. Further research is needed to translate the K fixation test result into a K fertilizer application rate.

OBJECTIVES

1. Predict soil K-fixation from soil texture and mineralogy as inferred from soil surveys.
2. Test K extraction methods for predicting K-fixation capacity on soils collected from the San Joaquin Valley.

Results of this project and a recommendation for soil testing will be made available to agricultural laboratories, crop advisers, fertilizer suppliers, and cotton growers in the San Joaquin Valley.

Funding for this project is being provided by the CDFA FREP and the California State Support Committee of Cotton, Inc.

DESCRIPTION

During 2001, initial maps of coarse textured soil were produced from the USDA-NRCS SSURGO database, the project soil survey was begun, and a K fertilizer strip trial was conducted with grower Gene Nord near Kerman, Fresno County. During 2002, we continued investigation of the location and mineralogy of K-fixing soils. Also in 2002, four K fertilizer trials were conducted in Kern Co. (Shafter field station), Kings Co. (two at Stan & Shawn Champlin farm near Hanford), and Fresno Co. (Scott Haupt farm south of Kerman). Soil and plant sample analysis from the 2002 fertilizer trials are not completed. This report will focus on the soil survey and laboratory K fixation test activities.

We have collected soil samples from 33 profiles representing three categories:

1. Coarse loamy or fine loamy with coarse surface texture soils derived from granitic, Sierra Nevadan parent material (expected high K fixation potential);
2. Coarse loamy family or fine loamy with coarse surface texture derived from coastal, non-granitic parent material (expected low K fixation potential);
3. Finer-textured soils from either source of parent material (expected low K fixation potential);

Most of the sites were either in cotton production at the time of sampling or in a cotton rotation. Initially, sampling sites were selected based on map classes as defined above. Soil grab samples were collected from the 15-45 cm depth from a total of 48 separate fields in four counties (Fresno, Kings, Kern and Tulare) that received no K fertilizer in the fall of 2000, nor at any time during 2001-2002. In a reconnaissance survey at each site, three grab samples were collected 10 crop rows apart from each other. Surface texture was estimated by feel throughout the field, and at one of the three grab sample sites, texture was determined to a depth of 100 cm. Grab samples were brought to the laboratory, and exchangeable K^+ was extracted using 1M NH_4Cl. Locations for full profile sampling were chosen for the sites that had less than 200 mg/kg NH_4Cl-extractable K. During February-August 2002, soil samples were collected by horizons from 31 farm fields including at locations of 5 trial fields. Soil pits for profile description were dug in furrows after hand leveling cotton beds to provide a consistent reference point for depth.

Selected sites representing the first soil category listed above (Sierra Nevada parent material) are mapped as Hesperia sandy loam, Grangeville fine sandy loam, Armona loam, Boggs sandy loam, Kimberlina fine sandy loam and Wasco sandy loam. Sites in the second soil category (Coast Range parent material) included Panoche loam, Kimberlina fine sandy loam, Wasco sandy loam and Milham sandy loam. Fine-texured soils sampled included Rossi clay loam, Gepford clay, Armona loam, Tulare clay, Buttonwillow clay, Panoche loam and McFarland loam.

Soil samples were separated into size fractions using a pipette method and centrifugation. Mineralogical composition of the fractions will be analyzed using a Diano XRD 8000 diffractometer producing Cu K□ radiation. The K methods (Table 1) are being performed on whole soil samples. We are testing a recently modified method for estimating plant-available K. This test, the sodium tetraphenylboron method ($NaBPh_4$), requires a five-minute incubation and routine wet chemistry techniques. This method extracts a portion of the fixed (non NH_4OAc-extractable) K that has been shown by researchers at Purdue University to be closely correlated with plant uptake of K in greenhouse studies. The greatest advantage of the $NaBPh_4$ method is that the release mechanism of nonexchangeable K in the procedure more closely simulates the extraction of this nutrient by plant roots. Other soil properties measured include pH, CEC (NH_4OAc, pH 7), and carbonate equivalent.

METHODS – CHARACTERIZATION OF SOIL K

K fixation

To estimate potassium fixation we modified K. Cassman's method (1990). The original method requires 7 days incubation with shaking for 45 minutes daily. We tried to decrease incubation time with KCl to 1, 2 hours and overnight shaking. A one-hour incubation with shaking for the entire hour with KCl seems to be a good alternative to the 7 days incubation. Increase in concentrations of KCl from 1.8mmol/L to 2.5mmol/L, as well as increasing shaking time with NH_4Cl from 0.5 hr to 2 hr did not affect the amount of K fixed.

We used 1hr incubation method for our study. Three replicates of each soil samples were saturated with 1.8 mM KCl (1:10 ratio) and shaken for 1 hour. Ten mL of 4M NH_4Cl was then added to each sample to give 1 M NH_4Cl. After 30 min shaking and centrifuging (2000 rpm for 20min), K was measured in the solution using a Perkin-Elmer AAnalyst 800 Atomic Absorption spectrophotometer. Fixed K was calculated as the difference between blank and measured solution concentrations.

Exchangeable K

Exchangeable K was extracted by 1 M NH_4OAc (pH 7) with a mechanical vacuum extractor (Soil Survey Laboratory Methods Manual, 1996). Soil samples (2.5 to 3g) were saturated with 1 M NH_4OAc and extracted overnight.

Sodium tetraphenyl boron (TPB) K

Plant-available K (exchangeable and nonexchangeable pools) was extracted by using modified sodium tetraphenylboron method described by A. E. Cox and co-authors (1996, 1999). Samples (three replicates) of 1g soil were weighed into 50-mL Erlenmeyer flask and 3 mL of extracting solution (0.2M $NaBPh_4$ + 1.7 M NaCl + 0.01 M EDTA) was added. Soils were incubated for 5 minutes and 25 mL of quenching solution (0.5M NH4Cl + 0.11 M CuCl2) was added to the solutions for recovery of precipitated K^+. The flasks were placed on a hot plate at about 150°C and let mixture to boil gently until the precipitate dissolve completely (30-45 min). After the precipitate was completely dissolve 22 mL of deionized water was added to bring the volume to 50 mL. Samples were shaken and allowed to settle for 1 hour. After that clear liquid was pour out from the flask to a centrifuge tube containing about 3-4 drops of 6N HCl to prevent precipitation of Cu and breakdown products of NaBPh4. Samples were centrifuged for 5 min at 2000 rpm. Samples were diluted 1:10 and analyzed with Perkin-Elmer AAnalyst 800 Atomic Absorption spectrophotometer. Standards were prepared using blank solution to match the matrix of the diluted samples.

The particle size distribution was determined on the samples from each of the profiles described. The pipette method, as described in Soil Survey Laboratory Methods Manual (1996) was employed in the determination of the clay fractions. Sand fractions were determined gravimetrically after sieving, and silt content was calculated as difference. Prior to particle size analysis samples were treated twice with 1M NH_4OAc (pH 5) in order to remove carbonates, and Clorox (pH 9.5) to remove organics. Sand was separated into coarse (0.5-2mm), medium (0.25-0.5mm), fine (0.1-0.25mm) and very fine (0.1-0.05mm) fractions by sieving.

X-ray analyses were made using a Diano XRD 8000 diffractometer (Diano Corporation, Woburn, MA) producing Cu K□ radiation.

Results

GIS mapping. See attached paper that was prepared for the 2004 Beltwide Cotton on line proceedings.

Laboratory characterization and development of soil test for K fixation capacity. See attached poster (in MS Powerpoint) that was presented at the 2003 Soil Science Society of America Annual Meeting in Denver, November 3-6, 2003.

Literature

Cassman K.G., Bryant D.C. and Roberts B.A. 1990. Comparison of soil test methods for cotton response to soil and fertilizer potassium on potassium fixing soils. Commun. in Soil Science. Plant Anal., 21(13-16): 1727-1743.

Cox, A. E., Joern, B. C., Brouder, S. M., and Gao, D. 1999. Plant-available potassium assessment with a modified sodium tetraphenylboron method. Soil Science Society of America Journal, 63: 905-910.

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Soil Survey Laboratory Methods Manual. Soil Survey Investigations Report no.42. Version 3.0. January 1996. NSSC, Lincoln, NE.

Miller, R.O., B.L. Weir, R.N. Vargas, S.D. Wright, R.L. Travis, B.A. Roberts, D.W. Rains, D.S. Munk, D.J. Munier, and M. Keeley. 1997. Cotton potassium fertility guidelines for the San Joaquin Valley of California. Pub. 21562. Division of Agriculture and Natural Resources, University of California. Oakland, CA

2002-04 PRESENTATIONS, POSTERS and ABSTRACTS

Date	Event	Title	Audience	Location
1/24/02	Geospatial Technologies in Agriculture Symposium	Using SSURGO soil maps in agriculture	70	UC Kearney Ag Center, Parlier
7/16/02	6th International Conference on Precision Agriculture	Use of SSURGO to identify potentially K-fixing soils	40	Minneapolis, MN
11/13/02	ASA/CSSA/SSSA Annual Meetings	Potassium fixation potential predicted from SSURGO data in soils of the San Joaquin Valley, California (poster)	--	Indianapolis, IN
11/19/02	California Dept. of Food & Agriculture Fertilizer Research & Education Program Conference	Location of K-fixing soils in the San Joaquin Valley and a new practical soil K test procedure	50	Tulare, CA
12/05/02	UC Cotton Workgroup annual meeting with state support committee	Location of K-fixing soils in the San Joaquin Valley and a new practical soil K test procedure	30	Tulare, CA
1/05/03	Beltwide Cotton Meeting	Location of K-fixing soils in the San Joaquin Valley and a new practical soil K test procedure	--	Memphis, TN
11/05/03	ASA/CSSA/SSSA Annual Meetings	(poster)	--	Denver, CO
1/08/04	2004 Cotton Beltwide Meeting	Can we predict K fixation in the San Joaquin Valley from soil texture and mineralogy?	50	San Antonio, TX

Pettygrove, S. and R. Southard. 2002. Location of potassium-fixing soils in the San Joaquin Valley and a new, practical soil potassium test procedure. p. 75-77. *In* Fertilizer Research and Education Program Conference Proceedings. (November 14, 2001, Tulare CA). California Department of Food & Agriculture, Sacramento, CA.

Rasmussen, C., D.G. McGahan, G.S. Pettygrove, M. Meese, and R.J. Southard. 2002. Use of SSURGO to identify potentially K-fixing soils. p. 53. *In* Conference Abstracts, 6th International Conference Precision Agriculture. (July 14-17, 2002, Minneapolis, MN). Soil Science Society of America. Madison, WI.

Murashkina-Meese, M., D.G. McGahan, C. Rasmussen, R.J. Southard, and G.S. Pettygrove. 2002. Potassium fixation potential predicted from SSURGO data in soils of the San Joaquin Valley, California. Annual Meeting Abstracts. (Nov. 11-14, 2002. Indianapolis, IN). CD-ROM. ASA-CSSA-SSSA. Madison, WI.

2003 ASA/SSSA/CSSA Annual meeting abstracts

2003 California Department of Food & Agriculture Fertilizer Research and Education Program summary

2003 and 2004 Beltwide Cotton Conference papers