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RESEARCH-BASED SOIL TESTING INTERPRETATION AND RECOMMENDATIONS FOR COTTON ON COASTAL PLAIN SOILS

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Abstract

The Southern Extension and Research Information Exchange Group on Soil Testing and Plant Analysis (SERA-6) has proposed a research-based, cooperative, web-based publication to summarize existing research related to soil test calibration and recommendations for cotton on Coastal Plain soils. Since public soil testing laboratories in states with Coastal Plain soils use similar soil test methodology (Mehlich-1 or Mehlich-3 extractants), research should be applicable across state lines. In support of this, long-term soil fertility research at 5 Alabama locations has already been summarized. Interestingly, calibration (critical soil test values for P and K) and interpretations (recommendations) are very similar among those states in this region (AL, FL, GA, NC, SC, and VA). These have been verified by on-going soil fertility experiments in the Coastal Plain of Alabama. Nitrogen rate recommendations and P and K calibrations appear reliable for modern cultivars and cropping systems.

Introduction

In spite of a strong research basis for soil testing in the southern U.S., producers and their consultants often question the validity of soil test interpretations. Part of this is due to a wide range of interpretations available from different public and private soil testing services, opinions of consultants, and competition for fertilizer sales. Emphasis on precision agriculture may have created expectations from soil testing beyond what it is capable of delivering. Nevertheless, as producers adopt new technologies, genetically improved varieties, and new production practices, they expect and deserve periodic verification of soil testing interpretations from their public laboratories.

The Southern Extension and Research Activity Information Exchange Group on Nutrient Analysis of Soils, Plants, Water, and Waste Materials (designated SERA-6) develops, modifies, and documents reference laboratory procedures, "regionalizes" soil test calibration/correlation and interpretation efforts among states that share similar soils and climate, and encourages both analytical proficiency and adequate quality control/quality assurance for nutrient analysis laboratories in the Southern Region of the United States. One of the most difficult challenges has been to "regionalize" soil test calibration/correlation and interpretation efforts among states. Until resent years, each state was able to conduct its own research program, develop its own soil test methodology calibration, and develop its own soil test recommendations for its main crops. With ever decreasing public support for soil test calibration/interpretation type research and more emphasis on environmental-type research, state Land Grant universities are not able to conduct statewide research in these areas. They must collaborate and cooperate across state lines to get the research-based information needed to make reliable nutrient recommendations. SERA-6 facilitates this effort.

Success with Peanuts

In the early 1990s, differences in soil test calibration and fertilizer recommendations for peanuts were quite different in Alabama and Georgia even on the same soil type. Each state argued in support of their view. Some producers near the Chattahoochee River that divides the two states were confused and losing confidence in our state-supported soil testing laboratories. Adding to this confusion were private soil testing laboratories with their own interpretation of research-based calibration and recommendations. The situation wasn't much better in Florida, South Carolina, North Carolina, and Virginia. All states grow peanuts on soils of the Atlantic and Gulf Coastal Plain. We should have more in common.

Dr. Gale Buchanan, Director of the Georgia Coastal Plain Experiment Station at that time, brought researchers together to study the situation and resolve differences. The result was a SERA-6 sponsored Southern Regional Publication in 1994 entitled, "Research-based Soil Testing Interpretation and Fertilizer Recommendations for Peanuts on Coastal Plain Soils." Both published and on-going soil fertility research with peanuts was reviewed. Very specific guidelines were published regarding soil testing, calibration, interpretation, and nutrient recommendations for phosphorus, potassium, secondary nutrients, and micronutrients on peanuts for these soils. Today, all public laboratories in the Southern Region use this as a basis for their recommendations.

Soil Testing for Cotton

There is a need to do the same thing with cotton and other crops that was done with peanuts. However, cotton is produced on many more soils types under a wide range of conditions. In addition, each state in the southern region has extensive research backing up their soil testing programs and recommendation for cotton. The decision was made to try and "regionalize" as much of the cotton research as possible. Tentatively, major cotton producing regions served by SERA-6 were identified as: (1) The Atlantic and Gulf Coastal Plain, (2) Mississippi Delta and related regions, and (3) Texas and Oklahoma Plains and related regions.

In Alabama, we have completed summarizing long-term soil fertility research with cotton at 5 Alabama locations. Four of these are on Coastal Plain soils. Additional shorter-term research is being conducted by Dr. Glenn Harris and others in Coastal Plain Soils. Therefore, we agreed to coordinate the effort to do with cotton on Coastal Plain soils what we did with peanuts in 1994.

This effort should be easier and less controversial because we have found that most state laboratories in the Coastal Plain region use similar soil testing methodology (Mehlich-1 or Mehlich-3 extractants). An extensive history of soil fertility experiments with cotton seem to support current Mehlich-1 calibration for P and K and recommendations for N. North Carolina has some calibration for Mehlich-3. Following is a summary of the recent Alabama research that supports current calibration with Mehlich-1 methodology and will be included in the publication.

Nitrogen Rates for Cotton in Alabama Coastal Plain Soils

Although nitrogen (N) is the most difficult nutrient to manage in cotton production, it has more impact on yields, earliness, and lint quality than any other primary plant nutrient. It is also the most costly plant nutrient applied per acre. Potential nitrate-N leaching into ground waters is a driving force behind water quality issues and nutrient management planning policies. As higher yields become possible with new, genetically modified varieties, growers legitimately question older research upon which standard N recommendations are made. Some laboratories adjust N recommendations based upon realistic yield goals.

Standard N Rates and Cropping System

Nitrogen rate studies from 1992 through 1998 on four Coastal Plain soils in South Alabama support Alabama's current standard N recommendations used on soil test reports. For most sandy and loamy Alabama soils, the standard recommendation is a total of 90 (±30) pounds N per acre during the growing season; 60 (±30) pounds N per acre is standard for the deep, red, silt and clay loams of the limestone valleys of North Alabama (Fig. 1). These rates are very similar to standard rates recommended by other state laboratories in the southeastern Coastal Plain region. However, in complementary experiments on the same sites where cotton followed soybean or peanut, optimum N rates were impossible to predict. Residue from a good soybean or peanut crop may contribute 20 to 30 pounds N per acre to the following cotton crop. Because as many as 6 months could elapse between soybean/peanut harvest in the fall and cotton planting the following April or May, much of the residual N may be lost from the soil. Therefore, N recommendations should be accompanied by a modifying statement regarding cropping systems effects.

N Rates and Yields Goals

Promoters of fertilizer use have often espoused the concept of recommendations based on yield goals or yield potential. This is a particularly popular and reasonable practice with grain crops such as corn, wheat, sorghum and forages. These crops remove large quantities of N in the harvested portion of the crop. However, Alabama's long-term N experiments do not support this practice for cotton under the conditions of these experiments. All five Alabama sites had similar results so only two Coastal Plain sites are presented in Fig. 2. In a disaster year when cotton yields are less than a bale per acre, very little if any N fertilizer is needed. No farmer plans on a disaster year and never fertilizes for these situations. But even in outstanding production years when yields far exceed anticipated yield goals (e.g., 3+ bales per acre), data from Alabama's research stations support the "standard" recommendation plus or minus about 30 pounds N per acre.

Genetically Modified Cotton Cultivars

At one Alabama Coastal Plain site, N-rate plots were split and a Bollgard® variety, 'Deltapine NuCotn 35B' (DP35B), was planted on half of each plot and a conventional variety of similar genetics, 'Deltapine DP 5690' (DP5690), was planted on the other half of each plot. There were significant differences ($P<0.05$) due to N rate and variety each year. The 'DP35B' yielded an average of 85 pounds more lint per acre per year than the conventional variety over all N rates. Therefore, we see no need to modify standard N recommendations as we progress to newer, higher yielding varieties.

Cotton Response to P in Alabama Coastal Plain Soils

The purpose of this study was to summarize cotton yield response to residual soil P since 1992 in order to validate or update Alabama's current soil test calibration for P using modern varieties with higher yield potentials.

Cotton yields from P variable treatments on the "Two-year Rotation" (circa 1929) and "Rates of N-P-K" experiments (circa 1954) on 4 Coastal Plain and a Limestone Valley site were compared with yields from a standard treatment that receives a full complement of fertilizers to develop relative yields for each location and year. When Mehlich-1 extractable soil P is calibrated with relative cotton yields for each of the experiments at each of the five location, several locations and tests fail to demonstrate a response to increasing levels of residual soil P. Treatments on all soils except the Lucedale s.c.l. at Prattville Experiment Field would be rated "low" by the southern public soil testing laboratories. Failure to get dramatic responses all the time demonstrate the inherent difficulties of trying to make soil testing a definitive and infallible tool. However, when yield and soil data from both tests at all Coastal Plain locations over the entire 7-yr period are pooled (Fig. 3), a reasonable critical value for Mehlich-1 extractable P can be estimated. The current critical value used by the Auburn University Soil Testing Laboratory for these soils is 25 mg P/kg (50 pounds P per acre). The Soil Science Society of America defines *critical soil test concentration* as ". . . that concentration at which 95% of maximum *relative yield* is achieved. . . usually coincides with the inflection point of a curvilinear yield response curve." Above this value, no fertilizer P is recommended because the probability of a yield response is extremely low. Below this value, P is recommended in increasing increments. Alabama's critical value is within the range used by other public soil testing laboratories in the region for Mehlich-1 P and cotton on Coastal Plain soil (18 to 30 mg P/kg). The fine-textured soils of the Tennessee Valley have a high P fixation capacity and a lower critical P value as currently used by the Auburn University Soil Testing Laboratory. These data verify the current value of 15 mg P/kg for these soils.

Cotton Response to Potassium in Alabama's Coastal Plain Soils

With increasing cotton acreage and yields on sandy, Coastal Plain soils, new varieties, eradication of the boll weevil, and new technologies for insect control, K nutrition is of renewed concern to growers.

Mean cotton lint yield from residual K treatments in Alabama's long-term soil fertility experiments was compared with mean yield for a standard fertilization treatment that received 60 lb. K_2O/acre/yr to calculate a relative yield. Relative yield is expressed as a percentage of the standard treatment yield. Relative yield by location and year was then compared to the mean soil test K value for each treatment at that location to develop a soil test calibration for cotton for the period 1992 through 1998 (Fig. 4). There has been much grower concern that with higher yielding, earlier maturing, modern varieties, soil test calibration for K on cotton needs adjusting. However, these data indicate that the sufficiency level approach to *critical K values as used by the Auburn University Soil Testing program in Alabama and other southern states is still very reliable and accurate*. The weakly buffered soils with a CEC $\leq$ 4.6 cmol kg^{-1} (the Dothan and Benndale series) are included in one graph and the two Lucedale soils (CEC = 4.6 to 9.0 cmol kg^{-1}) are included in another graph according to current Alabama soil test calibration. The Decatur soil which is representative of cotton producing soils of the Tennessee Valley region has the highest CEC (10.0 cmol kg^{-1}) and the highest critical soil test K level. The fine textured, highly buffered, smectitic and often calcareous soils of the Alabama Black Belt prairie region are tested with the Mississippi/Lancaster extractant and have a different calibration not included in this study. Potassium recommendations for cotton are made using a linear regression for each of the three groups of soils designated by CEC. Recommendations decrease from 120 pounds K_2O per acre per year at the lowest soil test values to none at the critical soil test value.

In a separate but related study, we found that cotton yields on the two Lucedale soils and on the Benndale soil were highly significantly related ($P<.05$) to soil test K in the 0 to 20 cm depth, in the 20 to 40 cm depth, or in the 40 to 60 cm depth. However, using soil test K from different depths did not improve soil test calibration.

Summary

Public soil testing laboratories in the Coastal Plain region of the South use similar soil testing methodology (Mehlich-1 and Mehlich-3 extractants) and interestingly, their calibration (critical soil test values for P and K) and interpretations (recommendations) are very similar. These have been verified by on-going soil fertility experiments in the Coastal Plain of Alabama. Nitrogen rate recommendations and P and K calibrations appear reliable for modern cultivars and cropping systems.

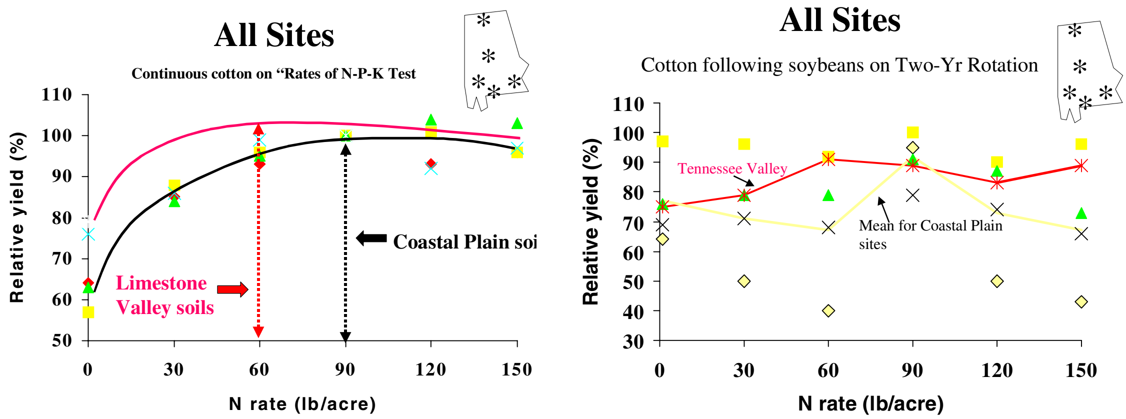

Figure 1. Nitrogen rates where cotton is planted every year ("Rates of N-P-K Test") and cotton following soybean ("Two-Year Rotation Experiment") at five Alabama locations, 1992-1998. Relative yield is the lint yield compared to the lint yield of a treatment receiving 90 pounds N per acre. All N is applied in split applications.

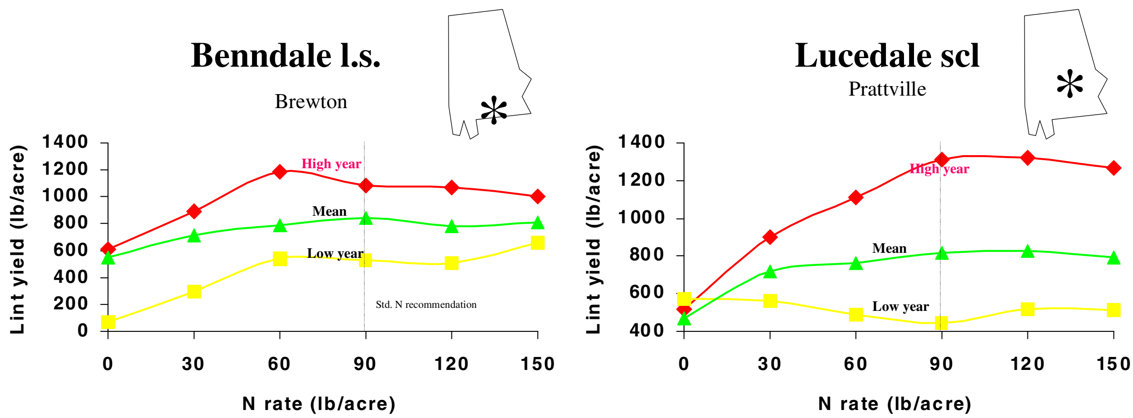

Figure 2. Cotton yield response to nitrogen rates on the "rates of N-P-K Test" (c. 1954), 1992-1998, at 2 Coastal Plain locations. Lines represent the highest yielding year, the lowest yielding year, and the mean of 7 years.

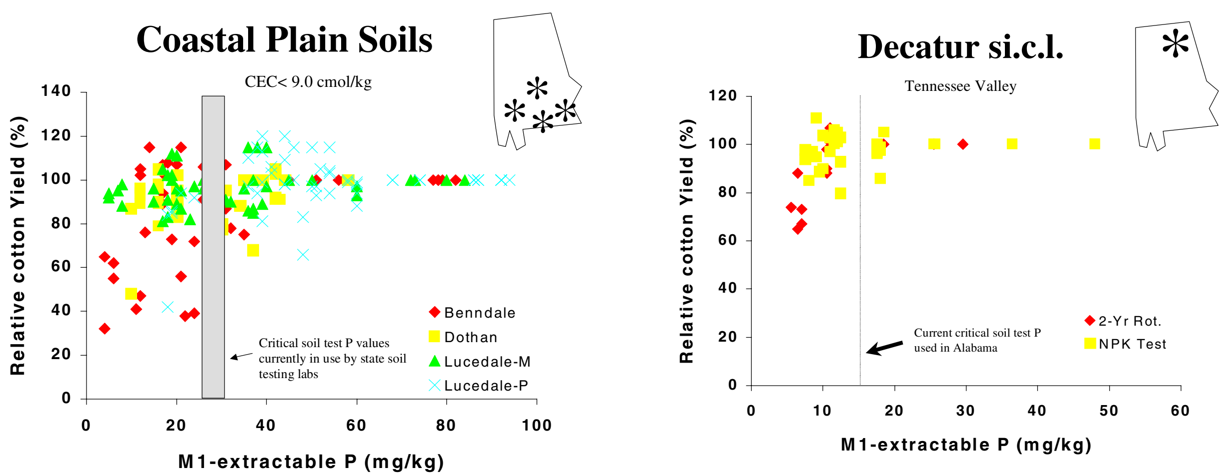

Figure 3. Mehlich-1 soil test calibration for cotton based on data from Alabama's "Two-year Rotation" and "Rates of N-P-K" experiments at five Alabama locations. Shaded area includes the current critical Mehlich-1 extractable P values used by public soil testing laboratories in Alabama, Georgia, Florida, South Carolina, and Tennessee. All Coastal Plain soils in these experiments had CEC < 9.0 cmol/kg.

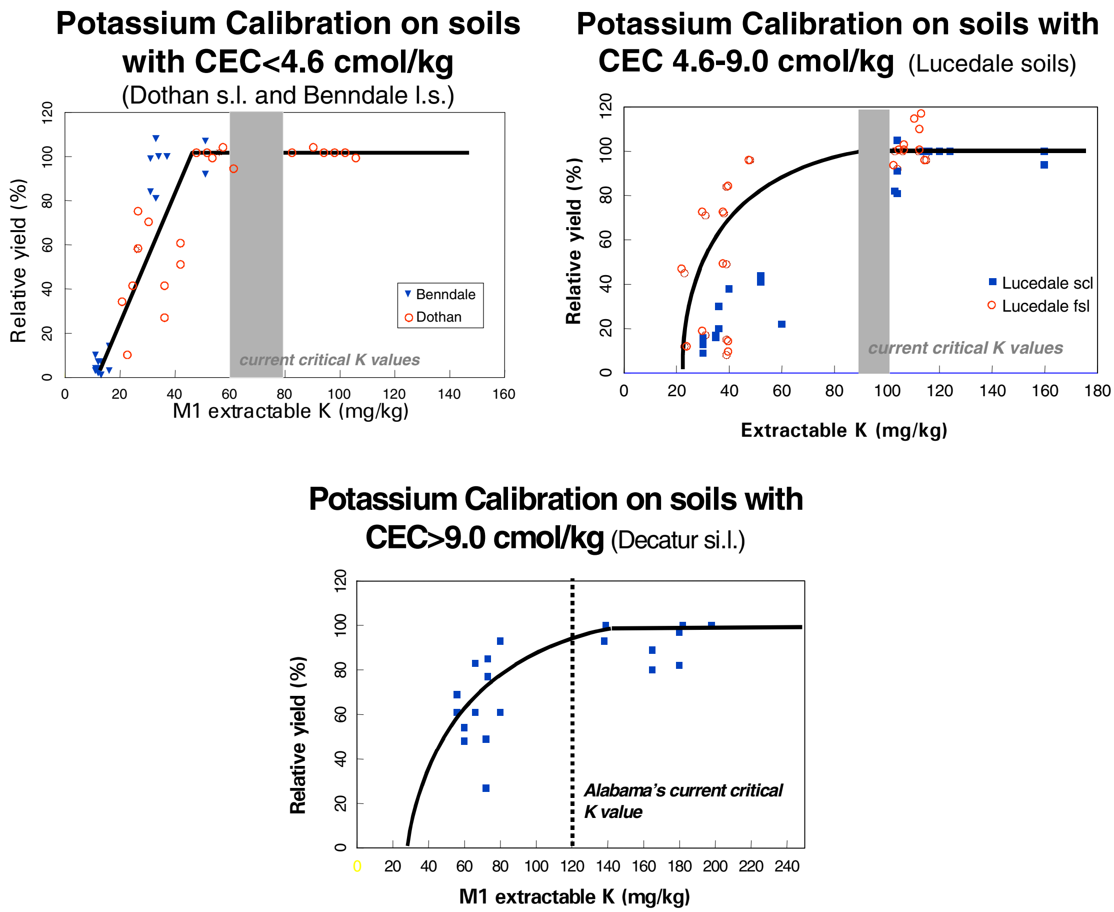

Figure 4. Potassium calibration for cotton based on current values in use by public soil testing laboratories using the Mehlich-1 extract and Alabama data from K variables on the "Two-Year Rotation" experiment, 1992-1998. Shaded areas are the ranges in critical soil test K values in the southeastern U.S.