Southern Cooperative Series Bulletin

PROCEDURES USED BY STATE SOIL TESTING LABORATORIES IN THE SOUTHERN REGION OF THE UNITED STATES

SOUTHERN COOPERATIVE SERIES BULLETIN #190-D

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ABSTRACT

This bulletin is the mechanism used by the Southern Extension Research Activity-Information Exchange Group-6 (SERA-IEG-6) to document in summary form procedures used by state university soil testing programs. This document, when used in conjunction with earlier printed versions, chronicles method changes and improvements to soil testing interpretations throughout the Southern Region. For detailed descriptions of these procedures, each state university maintains laboratory manuals that may be of further assistance to the reader. The intent of this document is to provide a reference for current soil-testing methods and interpretations. Since both methods and related interpretations are continuously being improved, the information in this document will be updated periodically. The reader is encouraged to take note of the version date.

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FOREWORD AND OBJECTIVES

Participants from the 13 southeastern States, the Virgin Islands, and Puerto Rico have been actively seeking better and more appropriate soil testing methodologies through the Southern Extension Research Activity-Information Exchange Group-6 (SERA-IEG-6). Representatives have promulgated changes to soil testing based upon field and laboratory evidence seeking more accurate fertilizer recommendations and improved fertilizer management strategies. Objectives of the group are as follows:

SERA-IEG-6 objectives: *Nutrient Analysis of Soils, Plants, Water, and Waste Materials*

1. To develop, modify, and document reference analytical procedures for laboratories performing nutrient analyses in the Southern region.
2.To encourage uniformity in the soil test correlation/calibration/interpretation process for the development of nutrient and resource management guidelines among geographic areas that share similar soils, crops, climate, and environmental concerns.
3.To encourage analytical proficiency and adequate quality assurance/quality control among laboratories in the Southern region.
4.To provide unbiased scientific reasoning for the proper use and interpretation of soil, plant, byproduct, and water analyses and their application to resource management.
5.To facilitate the sharing and transfer of research data and educational materials among public institutions, laboratories, and other entities that use information generated from soil, plant, byproduct, and water analyses.

Publication history This publication is the fourth tabulation of procedures used in the southern region. The original document, Bulletin 102, was published in June 1965, and revised in 1974. Bulletin No. 190 was published in November 1984, documenting significant changes in soil testing within the region. Bulletin No. 190-B was published in 1998 with additional changes. Bulletin No. 190-C was published in August, 2001 as a revision of 190-B. This version (190-D) has been prepared to reflect the most recent changes and improvements to state university soil testing programs, and is intended to replace Bulletin 190-C. Changes can occur often in our dynamic environment of soil testing and individuals should check with the individual laboratory supervisor to make sure that methods listed here are still current.

Publication scope The contents of the bulletin are designed to catalog the procedures used by state university soil testing programs. Other publications within the Southern Cooperative Series (see Additional Bulletins listing) have been written describing specific methodology for each of the procedures named in this document. Rather, it is the intent of this document to provide information concerning soil-testing procedures currently in use and to assist with an understanding of the results from those procedures. This publication also documents changes with time throughout the region.

The participants in the Southern Extension Research Activity-Information Exchange Group-6 (SERA-IEG-6) representing the 13 southern United States, the Virgin Islands, and Puerto Rico produced this publication.

ACKNOWLEDGMENTS

The editor wishes to express his appreciation to all SERA-IEG-6 participants who contributed to this publication by providing the most recent information and methodologies used by their soil testing laboratories.
H. J. Savoy, Editor

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1. David Hardy
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3. Rodney Henderson
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This bulletin from SERA-IEG # 6 included researchers from 13 southern states. It is being electronically published with the approval of the Directors of the Southern Agricultural Experiment Stations. Under the procedure of cooperative publications, it becomes in effect, a separate publication for each of the cooperating stations listed.

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SOIL TESTING: A TOOL FOR FERTILIZER AND LIME MANAGEMENT

Use of fertilizer and lime should be based upon an understanding that such additions will result in improved crop performance and economic benefit without excessive waste or possible adverse environmental effects. One tool for achieving these goals is through a calibrated soil test. Calibrated soil testing procedures are those methods of soil analysis that predict potential (probability) for crop response to added fertilizer or lime under field conditions.

As the members of the SERA-IEG-6 continue to work together, the number of soil tests in use throughout the southern region has been reduced since the publication of Bulletin 102 in 1965. There are several reasons for these changes: 1) adjacent states pool research information to improve calibration; 2) personal preference has given way to more widely adopted procedures; and 3) acceptance of tests based upon reliability (quality assurance as well as calibration data) and convenience. Increased uniformity in methodology and recommendations among states having similar soils and crops is a continuing goal of the SERA-IEG-6 members.

SOIL-TEST DETERMINATIONS

Changes in soil testing procedures have been gradual throughout the history of the SERA-IEG-6 group. The 13 southern states, Puerto Rico, and the Virgin Islands have routinely offered soil pH (water suspension), and some form of extractable P and K for several decades (Table 1). Most laboratories also offer tests for Ca and Mg. Changes in extraction methodology and analytical instrumentation have led to increased availability of tests dealing with Zn, Mn, Cu, Fe, B, S, and nitrates. Some state laboratories now offer standard determination of these nutrients, while other laboratories have introduced these tests upon request. In general, the trend within the southern region has been to increase the availability of these tests. However, some tests have limited usefulness, lacking substantive correlation with plant uptake and growth; and/or calibration data.

SAMPLE PREPARATION

Typically, soil samples are dried at relatively low temperatures (Table 2) before further processing and screening. Between 1984 and 2003, no changes in drying temperatures have been made. The length of drying has changed for three states, and two states have changed from a fixed length to terms such as "overnight" or "until dry".

A marked shift to hammermill crushing has occurred in the last 10 years, only two laboratories use other means. Sieve size has changed for only one state since 1984 (Table 2).

SOIL PH

Most laboratories have instituted changes including volumetric sample size decreases and increases of equilibration times for soil pH (water) since 1984 (Table 3). Nine states use a 1:1 soil:solution ratio but five use 1:2. Most states use deionized water but Georgia began using 0.01 M CaCl2 in 2004. The use of units among laboratories is becoming more consistent, but four laboratories measure a volume of soil and make some form of weight assumption [disturbed bulk density (w/v)] or measure the weight of the scooped sample.

LIME REQUIREMENT

In recent years, several states have undertaken research to eliminate hazardous chemicals from the SMP buffer (Kentucky) and the Adam-Evans buffer (Alabama) or have implemented new procedures such as the modified Mehlich buffer by Virginia, a modified Adams-Evans buffer by Alabama (called Modified Adams-Evans), Kentucky (named the Sikora buffer), South Carolina and Tennessee (named the Moore-Sikora buffer), and a calcium hydroxide titration by Georgia. The lime requirement methods currently in use are given in Table 4. Nine laboratories use buffers, three use some form of calcium hydroxide titration, and two use other indicators such as pH, Ca concentration, or crop for determining the lime requirement.

EXTRACTABLE ELEMENTS

Some laboratories have changed extraction procedures for P and K, adopting the Mehlich-3 extractant, increasing the total number of laboratories using this procedure to four (Tables 5 and 6). Six laboratories employ the Mehlich-1 extractant. One laboratory has added the AB-DTPA extractant. Three laboratories have changed their reporting method from a weight/volume basis to a volume/volume basis. The remaining eight laboratories continue to use a weight/volume reporting basis.

The number of laboratories using ICP for chemical analysis has increased from one in 1984 to twelve in 2007. Some laboratories use either colorimetric and/or ICP analysis for P. However, if ICP is available, most laboratories use it for K, Ca, and Mg.

SOIL TEST CALIBRATION

The calibration process A calibrated soil test is a soil extraction procedure resulting in a soil-test value that can be correlated with a positive crop response to fertilization. The calibration process involves replicated field trials including a wide range of soil, water regimes, and climatic conditions, and is crop specific. Calibration for crops and environments should be conducted as a joint effort among state universities. The use of soil testing for regulatory or environmental purposes accentuates the need for regional, coordinated activity. This regional activity must address the need for reliable calibration data, but must include the extension of this information to the public. Soil testing is a tool to aid with fertilization decisions. The calibration process keeps that tool reliable.

Rating scales and continuous curves The analytical values of a calibrated soil test have little meaning unless they can be expressed in terms of crop response and a fertilizer recommendation. The laboratories within SERA-IEG-6 subscribe to the "fertilize the crop" approach. This philosophy, often called percent sufficiency, sufficiency level, single limiting available nutrient, or crop nutrient requirement has proven to be efficient with limited fertilizer resources. While soil-test values may increase with time, it is not a specific goal to bring about this increase. Typically, one may expect soil-test values to increase for immobile nutrients even with efficient nutrient management. In highly weathered, leached soils found throughout the southern United States, this philosophy is especially appropriate. Mobile nutrient losses through leaching to water bodies are minimized using this approach.

Table 1. Standard determinations or determinations made upon request. "O" indicates that this determination is made on all soil samples. "X" indicates that this determination is made only on request.

State	Soil PH	Lime Requirement	Organic Matter	P	K	Ca	Mg	B	Mn	Zn	Fe	Cu	Na	NO_3	S	Electrical Conductivity	Salinity	Texture
AL	O	O	X	O	O	O	O	X	X	X	X	X	X	X	X	X		X
AR	O		X	O	O	O	O	O	O	O	O	O	O	X	O	X		X
FL	O	O[e]	X	O	O	O	O		X	X		X		X[d]		X		O
GA	O	O	X	O	O	O	O	X	O	O	X	X	X	X	X	X		X
KY	O	O	X	O	O	O	O	X	X	O		X	X	X[d]		X[a]		X
LA	O	O[b]	X	O	O	O	O	X	X	O	X	O	O		O	X	X	O
MS	O	O	X	O	O	O	O		O	O			O	X	X	X		X
NC	O	O	O[c]	O	O	O	O		O	O		O	O	X	O	X	X	
OK	O	O	X	O	O	X	X	X		X	X	X	X	O	X	X	X	X
PR	O			O	O	O	O		X	X	X	X	X			X		
SC	O	O	X	O	O	O	O	O	O	O		O	O	X	X	X	X	
TN	O	O[f]	X	O	O	O	O	X	X	X	X	X	X	X	X	X		
TX	O	O	X	O	O	O	O	X	X	X	X	X	O	O	O	O	X	X
VA	O	O	X	O	O	O	O	O	O	O	O	O				X		

[a] Salinity based upon either 2:1 (water:soil) or saturated paste electrical conductivity.

[b] Lime or sulfur requirement analyzed by requirement of crop listed. Also, Al, As, Cd, Pb, and Ni analyzed upon request.

[c] Organic matter test is for humic matter.

[d] Offered for greenhouse potting media only.

[e] Soil pH $\leq$6.2.

[f] Soil pH <6.1.

Table 2. Methods of soil sample preparation.

State	Drying, Crushing & Screening procedures				
	Duration	**Temperature**	**Method**	**NIST Sieve No.[a]**	**Comments**
	Hr.	Fahrenheit			
AL	24	135	Hammermill[b]	10	
AR	72	153	Hammermill[b]	10	24-hr drying, crushed, followed by 48-hr drying
FL	Until dry	105	Hammermill[bd]	10	
GA	12	95	Hammermill[b]	10	
KY	16-40	100	Hammermill[b]	10	
LA	16-40	100	Bico	20	Ceramic plate grinder
MS	24	90	Standard crusher	20	
NC	Until dry	100-105	Hammermill[b]	10	
OK	Overnight	150	Disc grinder	10	
PR	72	86	Hammermill	10	
SC	Overnight	115	Hammermill[b]	10[c]	
TN	Until dry	150	Hammermill	10	
TX	16-18	110	Hammermill[b]	20	
VA	Overnight or Until dry	Ambient (max=104F)	Hammermill[b]	10	

[a] NIST sieve No. 10 is 9 mesh with an opening of 2.00 mm, sieve No. 20 is 20 mesh with an opening of 0.841 mm.

[b] Supplier is Custom Labs, Inc, FL.

[c] Actual mesh size is 14.

[d] Most soils require screening only.

Table 3. Methods for determining soil pH.

State	Sample Size	Soil to solution ratio	Standing time Min.
AL	20 ml	1:1	60
AR	20 g**	1:2	15
FL	20 ml**	1:2	30
GA	20 ml	1:1***	30
KY	10 ml	1:1*	15
LA	10 ml	1:1	120
MS	10 g**	1:2*	15
NC	10 ml	1:1	60
OK	15 g	1:1	30
PR	20 g	1:2	30
SC	15 g	1:1	60
TN	10 g**	1:1	30
TX	20g	1:2	30
VA	10 ml	1:1	10-120

* Potting media pH from saturated paste.
** Weight estimated by measuring specific volume.
*** Uses 0.01 $CaCl_2$ solution.

Table 4. Methods for determining lime requirement.

State	Method
AL	Modified Adams-Evans
AR	pH & texture (Ca content)
FL	Adams-Evans
GA	Single addition of Ca (OH)
KY	Sikora buffer & pH
LA	Calcium hydroxide
MS	Modified Woodruff
NC	Mehlich buffer,pH, target pH of crop and soil class
OK	Sikora buffer
PR	Calcium hydroxide & calcium carbonate
SC	Moore-Sikora buffer
TN	Moore-Sikora buffer
TX	Crop & pH, or HCl-Al
VA	Mehlich buffer

Table 5. Soil sample size, extracting reagent, soil:solution ratio, shaking time, and analytical procedure for determining soil-test phosphorus.

State	Sample Size g or mL	Extracting reagent	Soil to solution ratio	Shaking time min.	Method of Analysis[a]	Notes
AL	5 g	Mehlich 1	1:4	30	Color	Soil scooped, weighed, and results adjusted for weight.
						Mehlich 1: 0.05 M HCl + 0.0125 M H_2SO_4.
AR	2 g	Mehlich 3	1:10	5	ICP	Weight estimated from specific volume.
FL	5 g	Mehlich 1	1:4	5	ICP	Weight estimated from specific volume (4.0cm^3).
	12.5g	AB-DTPA	1:2	15	ICP	Soils with pH>7.5. Weight estimated from specific volume (12.5 g/10.0 cm^3).
	4mL	Acetic Acid (0.5 M)	1:12.5	50	Color	Organic soils. Samples are wetted and allowed to stand overnight before shaking.
GA	5 g	Mehlich 1	1:4	5	ICP	Weight estimated from specific volume.
KY	2 mL	Mehlich 3	1:10	5	ICP	Lbs/acre obtained by assuming soil density is 1g/cm^3 and weight of soil per acre is 2 million pounds .
LA	2 mL	Mehlich 3	1:10	5	ICP	Soil scooped, weighed, and results adjusted for weight.
MS	5 g	Lancaster (two stages)	1:5	15	Color	Soil Weighed, Lancaster: 0.05 M HCl, then Buffered (acetic-malic-malonic) AlF_3, pH 4.0.
NC	2.5 mL	Mehlich 3	1:10	5	ICP	Extraction and calculation strictly by volume.
OK	1.7 mL	Mehlich 3	1:10	5	ICP	Soil scooped, 2 g is used for calculation
PR	1 g	Bray-Kurtz (P1)	1:10	5	Color	Bray-Kurtz (P1): 0.03 M NH_4F + 0.025 M HCl.
	5 g	Olsen	1:20	30	Color	Olsen: 0.5 M $NaHCO_3$, pH=8.5.
	5 g	Bray P2 (strong Bray)	1:6	1	Color	Bray P2: 0.1 M HCl + 0.03 M NH_4F
SC	5 g	Mehlich 1	1:4	5	ICP	Weight estimated from specific volume (4.0 cm^3).
TN	5 mL	Mehlich 1	1:4	5	ICP	Weight estimated from specific volume.
TX	2 g	Morgan (modified)	1:20	45	ICP/Color	Weight estimated from specific volume. Morgan: 1.4 M NH_4OAC+1 M HCl+0.025 M EDTA, pH 4.2.
VA	4 mL	Mehlich 1	1:5	5	ICP	Pounds/acre obtained by assuming scoop density of 1.25 g/cm^3 and weight of soil per acre of 2 million pounds.

[a] Color = molybdenum blue color formation and spectrophotometry; ICP = inductively coupled plasma spectrophotometry.

Table 6. Soil sample size, extracting reagent, soil to solution ratio, shaking time, and analytical procedure for determining soil-test K, Ca, and Mg.

State	Sample size g or mL	Extracting Reagent	Soil to solution ratio	Shaking time min.	Method of Determination K, Ca, Mg [a]	Notes
AL	5 g	Mehlich 1	1:4	30	AAS	Soil scooped, weighed, and results adjusted for weight.
	5 g	Lancaster (modified)	1:4	30	AAS	Soil scooped, weighed, and results adjusted for weight.
AR	2 g	Mehlich 3	1:10	5	ICP	Weight estimated from specific volume.
FL	5 g	Mehlich 1	1:4	5	ICP	Weight estimated from specific volume (5.0g).
GA	5 g	Mehlich 1	1:4	5	ICP	Weight estimated from specific volume.
KY	2 mL	Mehlich 3	1:10	5	ICP	Lbs/acre obtained by assuming soil density is 1g/cm^3 and weight of soil per acre is 2 million pounds.
LA	2 mL	Mehlich 3	1:10	5	ICP	Soil scooped, weighed, and results adjusted for weight
MS	5 g	Lancaster	1:5	15	ICP	Weighed out
NC	2.5 mL	Mehlich 3	1:10	5	ICP	Extraction and calculation strictly by volume.
OK	1.7 mL	Mehlich 3	1:10	5	ICP	Soil scooped, 2 g used for calculation
PR	5 g	Ammonium Acetate	1:10	30	Ca, Mg by AAS; K by FE	Ammonium acetate: 1 M, pH = 7.0.
SC	5g	Mehlich 1	1:4	5	ICP	Weight calculated from specific volume.
TN	5 mL	Mehlich 1	1:4	5	ICP	Weight estimated from specific volume.
TX	2g	Morgan (modified)	1:20	60	ICP	Weight estimated from specific volume.
VA	4 mL	Mehlich 1	1:5	5	ICP	Pounds/acre obtained by assuming scoop density of 1.25 g/cm^3 and weight of soil per acre of 2 million pounds.

[a] AAS = atomic absorption spectrophotometry; ICP = inductively coupled plasma spectrophotometry; FE = flame emission.

Thirteen laboratories use some form of rating scale, specifying either three or five categories within which the soil-test value may be placed. An example from Florida and Alabama is typical of the scale used by other laboratories:

Very low Less than 50% of crop yield potential is expected without addition of the nutrient in question. Yield increase to the added nutrient is always expected. A large portion of the crop nutrient requirement must come from fertilization.

Low 50 to 75% of the crop yield potential is expected without addition of the nutrient. Yield increase to added nutrient is expected. A portion of the crop nutrient requirement must come from fertilization.

Medium 75 to 100% of the crop yield potential is expected without addition of the nutrient. Yield increase to added nutrient is expected. A small portion of the crop nutrient requirement must come from fertilization.

High Yield increase to the added nutrient is not expected. The soil can supply the entire crop nutrient requirement. No additional fertilizer is needed.

Very high Yield increase to the added nutrient is not expected. The soil can supply much more than the entire crop nutrient requirement. Additional fertilizer should not be added to avoid nutritional problems and adverse environmental consequences.

Extremely high This term is used in Alabama (phosphorus only) to indicate that the supply of phosphorus is more than four times the amount considered adequate. The level is excessive, may be detrimental to the crop, and may contribute to pollution of surface water.

There are several advantages and disadvantages of this rating method.

1) While the soil-test value and predicted crop response to added nutrition are linked, the linkage is not too closely defined. The grower is given enough information to <u>assist</u> with fertilization decisions, reflecting the fact that soil testing is only one component in these decisions.

2) The rating scale decreases the potential for adverse fertilization recommendations, i.e., insufficient nutrition. For example, a soil-test value of 15 lb. P/acre is interpreted the same as soil tests ranging from 0 to 20 lb. P/acre (Florida's very low range for Mehlich-1 extractable P, Table 7). The calibration is not exact due to the complexity of the biological system, and doubt exists to some extent.
3) A major disadvantage of this system arises when the soil-test value is near the boundaries of adjacent ratings. For example, a soil-test value of 20 lb. P/acre may be at the upper end of the very low scale, making 21 lb. P/acre the lower end of the low scale. A change in one soil-test unit can result in a fertilizer recommendation difference of 30 or more lb. P_2O_5/acre.

An alternative to placing the soil-test value in a specific category is the use of continuous curves in which the fertilizer recommendation is calculated as a continuous function of the soil-test value. Regression equations are utilized to generate the recommended amounts of P_2O_5 and K_2O. The final recommended rate is generally rounded off to the nearest five to ten pounds. This approach is easily implemented in laboratories that make computerized soil test recommendations. The disadvantage of large changes in fertilization near rating boundaries is avoided, and more complex statistical models can be used to describe the relationship between soil-test value and fertilizer recommendation for a specific crop. To date, only two laboratories have adopted this approach.

Six laboratories use a single rating scale for all crops and soils. The other laboratories use multiple ratings depending upon one or more of the following: crop, landscape soil category, soil texture, and/or cation exchange capacity.

Differences among extractants The number of extractants in use throughout the southern region continues to be a research topic. Since 1984, the number of extractants has decreased. However, one state added another extractant to address calcareous soils. The Mehlich-1 extractant is used in six states. This extractant is appropriate for acidic soils with pH<6.5 and exchange capacities <10 cmol/100 g, suitable for the sandy Coastal Plain soils where the method is used. However, in cropping conditions where irrigation water is pumped from limestone aquifers, soil pH continues to increase, reducing the effectiveness of this extractant. On finer textured soils, other extractants are in use: Mehlich 3 (4 labs);

Lancaster (2 labs); and the Morgan, Bray-Kurtz, Bray P2, and Olsen (1 lab each). For K, Ca, and Mg, one laboratory uses the ammonium acetate method.

The selection of the Mehlich 3 method is enhanced by its simultaneous extraction of a suite of nutrients for use with ICP instrumentation. This extractant continues to receive significant attention from other states trying to take advantage of these properties. This extractant has been found to be suitable over a wide range of soil conditions, greatly increasing its versatility. However, it is not very user or instrument friendly.

Differences/similarities of calibrations using the same extractant The soil-test categorical ranges within extractants vary among states to some extent. An attempt has been made by each state to calibrate the soil test to local conditions, including soil and climatic variables. For this reason, differences among states using the same extractant should be expected. As additional factors are included in the calibration process, i.e., soil landscape type, soil cation exchange capacity, soil texture, and crop, the usefulness of the soil test should be enhanced. Use of these other factors also suggests that field calibration research data are available to justify these refinements.

Major changes since 1984 (Bulletin 190) Several laboratories adopted the Mehlich-3 extractant. University of Arkansas switched from modified Mehlich-3 (1:7) to standard Mehlich-3 (1:10) beginning in 2006. Sample handling changed little in the last decade, but there was a notable shift to using a hammermill for crushing dry soil samples. Calibration data has changed to a small degree. Florida now uses one scale for both agronomic and horticultural crops, for example. Instrumentation has progressed toward the more sophisticated ICP analysis.

The SERA-IEG-6 participants continue to exhibit a willingness to provide quality soil testing programs to their clientele by new, proven technology and methodology, wherever possible. This effort has led to significant soil-test-related improvements across the region, providing a flow of information among states, while still recognizing the need for diversity.

Table 7. Soil-test calibrations by extractant for phosphorus and potassium.

State	Method [a]	Soil	Crop	Phosphorus, lb./acre					Soil Text.	CEC	Potassium, lb./acre [b]				
				VL	L	M	H	VH		me/100g	VL	L	M	H	VH
AL	Mehlich 1	All	Peanuts	0-4	5-10	11-19	20-50	51-200[d]		0-9					
		All	Peanuts							0-4.5	0-20	21-28	29-40	41-100	101+
										4.6-9.0	21-30	31-42	43-60	61-150	151+
										>9.0	31-40	41-57	58-80	81-200	201+
		All CEC< 9	All except peanuts	O-12	13-25	26-50	51-100	101-200		0-9.0					
		All CEC 9^+	All except peanuts	0-7	8-15	16-30	31-60	61-120		>9.0					
	Lan-caster	All Black Belt Clays	All	0-18	19-36	37-72	73-144	145-288		>9.0					
	Mehlich 1		Cotton, legumes, and vegetables							0-4.5	0-30		61-120	121-240	241+
			Grasses, corn, peanut, and soybean							0-4.5	0-20	21-40	41-80	81-160	161+
			Cotton, legumes, and vegetables							4.6-9.0	0-45	46-90	91-180	181-360	361+
			Grasses, corn, peanut, and soybean							4.6-9.0	0-30	31-60	61-120	121-240	241+
			Cotton, legumes, and vegetables							>9.0	0-60	161-120	121-240	241-280	481+
			Grasses, corn, peanut, and soybean							>9.0	0-40	41-80	81-160	161-320	321+
	Lan-caster		Cotton, legumes, and vegetables							>9.0	0.80	81-160	161-240	241-480	481+
			Grasses, corn, peanut, and soybean							>9.0	0.50	51-120	121-190	191-320	321+
AR	Mehlich 3	All	Cotton	< 32	32-50	51-70	71-100	> 101			< 120	121-180	181-260	261-350	> 350
			Corn	< 32	32-50	51-70	71-100	> 101			< 120	121-180	181-260	261-350	> 350
			Soybean	< 32	32-50	51-70	71-100	> 101			< 120	121-180	181-260	261-350	> 350

State	Method [a]	Soil	Crop	Phosphorus, lb./acre					Soil Text.	CEC	Potassium, lb./acre [b]				
				VL	L	M	H	VH		meq/ 100g	VL	L	M	H	VH
AR			Wheat	< 32	32-50	51-70	71-100	> 101			< 120	121-180	181-260	261-350	> 350
			Rice	< 32	32-50	51-70	71-100	> 101			< 120	121-180	181-260	261-350	> 350
			Grain sorghum	< 32	32-50	51-70	71-100	> 101			< 120	121-180	181-260	261-350	> 350
			Forages for pasture (including legumes)	< 32	32-50	51-70	71-100	> 101			< 120	121-180	181-260	261-350	> 350
			Forages for pasture	< 32	32-50	51-70	71-100	> 101			< 120	121-180	181-260	261-350	> 350
			Turf grasses	< 32	32-50	51-70	71-100	> 101			<42	42-80	81-120	121-200	>200
			Commercial vegetables	< 40	40-60	61-80	81-150	>151			<122	122-180	181-260	261-350	351-6000
FL	Mehlich 1	All	All	0-20	21-30	31-60	61-119	120+			0-40	41-70	71-120	121-250	251+
GA	Mehlich 1	Coastal Plain	All except peanut, legumes, cotton, stone fruits, nuts, lawns, ornamentals, and vegetables		0-30	31-60	61-100	101+				0-60	61-150	151-250	251+
		Coastal Plain	Cotton, legumes, stone fruits, nuts, and vegetables		0-30	31-60	61-100	101+				0-70	71-170	171-275	276+
		Coastal Plain	Peanut		0-15	16-30	31-60	61+				0-30	31-75	76-125	125+
		Piedmont	All except peanut, legumes, cotton, stone fruits, nuts, lawns,		0-20	21-40	41-75	76+				0-100	101-200	201-350	351+

			ornamentals, vegetables												
		Piedmont	Cotton, legumes, stone fruits,nuts, vegetables		0-20	21-40	41-75	76+				0-120	121-250	251-400	401+
		Piedmont	Peanut		0-10	11-20	21-35	35+				0-50	51-100	101-175	175+
GA	Mehlich 1	All	Golf greens and tees, ornamentals, and flowers		0-50	51-100	101-200	201+				0-150	151-250	251-450	451+
State	**Method [a]**	**Soil**	**Crop**	**Phosphorus, lb./acre**					**Soil Text.**	**CEC**	**Potassium, lb./acre [b]**				
				VL	**L**	**M**	**H**	**VH**		**me/100g**	**VL**	**L**	**M**	**H**	**VH**
KY	Mehlich 3	All	Corn, soybean	0-5	6-27	28-60	61+				0-99	100-190	191-300	301+	
	Mehlich 3	All	Burley tobacco	0-6	7-28	29-57	58-79	81+			0-96	96-205	206-303	304-450	451+
	Mehlich 3	All	Alfalfa	0-8	9-27	28-60	61+				0-97	97-203	204-296	297-447	448+
LA	Mehlich 3	Coastal Plain	All	0-10	11-40	41-80	81+		Sandy loams	4	0-90	91-136	137-227	228+	
		Flatwoods	All	0-10	11-35	36-70	71+		VFsandy loams	6	0-113	114-182	183-273	274+	
		Miss. Terraces	All	0-10	11-35	36-70	71+		Silt loams	8	0-136	137-227	228-318	319+	
									Silt loams	10	0-182	183-273	274-364	365+	
		Coastal prairies	All	0-10	11-30	31-70	71+		Very fine sandy loams	8	0-136	137-227	228-318	319+	
									Silt loams	10	0-182	183-273	274-364	365+	
									Clay loams	15	0-227	228-364	365-455	456+	
		Alluvial	All	0-40	41-60	61-120	121+		Loamy sands	4	0-90	91-136	137-227	228+	
									Very fine sandy loams	8	0-136	137-227	228-318	319+	
									Silt loams	10	0-182	183-273	274-364	365+	
									Silt loams	15	0-227	228-364	365-500	501+	

State	Method [a]	Soil	Crop	Phosphorus, lb./acre					Soil Text.	CEC	Potassium, lb./acre [b]				
				VL	L	M	H	VH		me/100g	VL	L	M	H	VH
									Clays	20	0-318	319-454	455-682	683+	
MS	Lan-caster	All	All except rice	0-18	19-36	37-72	73-144	145+							
			Rice	0-9	10-18	19-36	37-45	46+							
		Group 1 [c]								<7	0-40	41-80	81-120	121-210	211+
										7-14	0-50	51-110	111-160	161-280	281+
										15-25	0-60	61-130	131-180	181-315	316+
										25+	0-70	71-150	151-200	201-350	351+
		Group 2								<8	0-50	51-110	111-160	161-280	281+
										8-14	0-60	61-140	141-190	191-335	336+
										15-25	0-70	71-160	161-210	211-370	371+
										25+	0-80	81-180	181-240	241-420	421+
		Group 3								<8	0-70	71-150	151-200	201-350	351+
										8-14	0-90	91-190	191-240	241-420	421+
										15-25	0-120	121-240	241-290	291-510	511+
										25+	0-150	151-260	261-320	321-560	561+
NC[a]	Mehlich 3	All	All	0-21	22-54	55-107	108-214	215+			0-34	35-87	88-174	175-348	349+
OK	Mehlich 3	All	All	0-20.	21-40	41-65	65+				0-50	51-150	151-250	251-350	351+
PR	Bray P1		All		0-10	11-20	21+					<156	156-312	313+	
	Bray P2				0-10	21-40	41+					<156	156-312	313+	
	Olsen				0-12	13-35	36+					<156	156-312	313+	

State	Method [a]	Soil	Crop	Phosphorus, lb./acre					Soil Text.	CEC	Potassium, lb./acre [b]				
				VL	L	M	H	VH		me/100g	VL	L	M	H	VH
SC	Mehlich 1	Coastal Plain	All except peanut		0-30	31-60	61-120	121-240				0-70	71-156	157-235	236+
		Piedmont	All except peanut		0-20	21-40	41-80	81-240				0-70	71-156	157-235	236+
		All	Peanut		0-10	11-19	20-50	50+				0-28	29-40	41-100	100+
TN	Mehlich 1	All	All except cotton		0-18	19-30	31-120	121+				0-90	91-160	161-320	321+
			cotton									0-140	141-180	181-319	320+
TX	Modified Morgan		All	0-10	12-20	22-40	42-80	82+			0-139	140-238	239-348	350-600	601+
VA	Mehlich 1	All	All	0-3	4-11	12-35	36-110	111+			0-15	16-75	76-175	176-310	311+

[a] Extractants listed for phosphorus in Table 5.
[b] Extractants listed for potassium in Table 6.
[c] Groups are combinations of soil types and crops.
[d] In Alabama only this is termed Extremely High (EH) instead of Very High (VH) (for phosphorus only) to indicate that the supply of phosphorus is more than five times the critical value.

Table 8. Soil-test calibrations by extractant for calcium and magnesium.

State	Extractant	Crop	Soil Type	Soil Texture	CEC	Calcium, lb./acre			Magnesium, lb./acre		
					meq/100g	L	M	H	L	M	H
AL	Mehlich 1	All	All		0-4.6				0-25		26+
					4.6+				0-50		51+
		Peanuts				0-175	176-300	301+			
		Vegetables, fruit, nuts				0-300	301-500	501+			
AR	Mehlich 3	Corn grain Corn silage	All			No interpretation for Ca.			<62	61-280	>280
FL	Mehlich 1	All	All			No interpretation for Ca.			0-30	31-60	61+
	Acetic Acid	All				No interpretation for Ca.			No interpretation for Mg.		
GA	Mehlich 1	All except alfalfa, peanuts, ornamentals, stone fruits, nuts, and vegetables	Coastal Plain			0-200		201+	0-30	31-60	61+
		Peanuts	Coastal Plain			Low if Ca soil test 10-14 days after planting is < 500 or if Ca:K ratio is >3:1 in top 3 inches			0-30	31-60	61+
		Alfalfa, ornamentals, fruits, nuts, and vegetables	Coastal Plain			0-200		201+	0-60	61-120	121+
		All except alfalfa, ornamentals, stone fruits, nuts and vegetables	Pied-mont			0-400		401+	0-60	61-120	121+
		Peanuts	Pied-mont			Low if Ca soil test 10-14 days after planting is < 500 or if Ca:K ratio is >3:1 in top 3 inches			0-60	61-120	121+
		Alfalfa, ornamentals, stone fruits, nuts, and vegetables	Pied-mont			0-400		401+	0-120	121-240	241+
KY	Mehlich 3	All*	All						0-60	61-120	121+
LA	Mehlich 3		Coastal Plain	Sandy loams	4	0-1000	1001-1400	1401+	0-100	100-140	141+
				Very fine sandy loams	6	0-1400	1401-1800	1801+	0-140	141-180	181+
			Flat-woods	Very fine sandy loams	6	0-1400	1401-2000	2001+	0-140	141-200	201+

				Silt loams	8	0-2000	2001-2600	2601+	0-200	201-260	261+
			Miss. Terraces	Silt loams	8	0-2000	2001-2600	2601+	0-200	201-260	261+
	Extractant	**Crop**	**Soil Type**	**Soil Texture**	**CEC**	**Calcium, lb./acre**			**Magnesium, lb./acre**		
LA					meq/100g	L	M	H	L	M	H
				Silt loams	10	1-2400	2401-3200	3201+	0-240	241-320	321+
			Coastal prairies	Very fine sandy loams	8	0-2000	2001-2600	2601+	0-200	201-260	261+
				Silt loams	10	0-2400	2401-3200	3201+	0-240	241-320	321+
				Clay loams	15	0-3600	3601-4800	4801+	0-360	361-480	481+
			Alluvial	Loamy sands	4	0-1000	1001-1600	1601+	0-100	100-160	161+
				Very fine sandy loams	8	0-2000	2001-2600	2601+	0-200	201-260	261+
				Silt loams	10	0-2400	2401-3200	3201+	0-240	241-320	321+
				Silt loams	15	0-3600	3601-4800	4801+	0-360	361-480	481+
				Clay loams (32% clay)	20	0-4800	4801-6400	6401+	0-480	481-640	641+
MS						No interpretation for Ca.			VL | L	M | H	VH
					<5.0				0-12 | 13-24	25-48 | 49-96	96+
					>5.0				<0.85[d] | 0.86-1.75	1.76-3.3 | 3.31-6.6	6.6+
NC	Mehlich 3					No interpretation for Ca.			If Mg % of CEC < 10 % or <0.5 meq/100cm³, interpretation and course-of-action is specified		
OK	Mehlich 3					0-300[a]	301-750	751+	0-50	51-100	101+
State	Extractant	Crop	Soil Type	Soil Texture	CEC	Calcium, lb./acre			Magnesium, lb./acre		
					meq/100g	L	M	H	L	M	H
SC	Mehlich 1	All	Coastal Plain			0-400	401-800	801+	0-32	33-60	61+
			Pied-mont			0-400	401-800	801+	0-46	47-100	101+
TN	Mehlich 1	Cabbage, tomato, grape, tobacco,	All						0-39		40+

		ornamentals									
		Tomato, pepper	All			< 500		500+			
TX	ModifiedMorgan	All	All			0-358	359-919	920-1500	0-200	201-300	301+
VA	Mehlich 1	All	All			0-720	721-1440	1441-2160 [b]	0-72	73-144	145-216 [c]

[a] For peanut only.
[b] Also a VH range = 2161+.
[c] Also a VH range = 217+.
[d] percent saturation

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Procedures Used By State Soil Testing Laboratories In the Southern Region of the United States

APPENDICES

USEFUL SOIL-TEST TERMINOLOGY

These definitions are a subset of terms found in the *Glossary of Soil Science Terms*, published by the Soil Science Society of America.

Available Soil Nutrients - Soil nutrients in chemical forms accessible to plant roots or compounds likely to be convertible to such forms during the growing season.

Composite Soil Sample - A soil sample consisting of several single core samples to a specified depth that mixed together, represent an area.

Crop Nutrient Requirement – The amount of a specific nutrient required for optimum, high quality crop growth.

Extractable Soil Nutrients - Plant nutrients that can be removed from the soil by a specified soil test procedure.

Lime Requirement - The quantity of liming material, expressed as either calcium equivalent (CE) or calcium carbonate equivalent (CCE), required to increase the pH of a specified depth of soil to a desired level.

Percent Sufficiency Concept - This concept states that a given level of a slightly soluble soil nutrient will always produce a definite relative or percentage yield irrespective of the actual yield level.

Plateau Yield Point - The point on a yield or response curve where the dependent variable (i.e. yield or nutrient uptake) no longer responds positively to added input (i.e. nutrient application).

Relative or Percentage Yield - The yield with or without limited supplementation of the nutrient in question times 100 divided by the yield when that nutrient is completely adequate.

Soil Sampling - The procedure of collecting a portion of soil from a field that is representative of an area and to the same depth used in calibration of a soil test.

Soil Test Calibration - The process of determining the agronomic meaning of soil test values in terms of crop response. It is used to establish soil test categories such as low, medium, and high.

Soil Test Category - An interval of soil test values associated with the corresponding probabilities of crop response to nutrient applications. Common interval names are low, medium, and high. The low soil test category would be associated with a high probability of crop response to fertilization.

Soil Test Correlation - The process of determining the relationship between plant nutrient uptake or yield and the amount of nutrient extracted by a particular soil test. This procedure is used to select a suitable soil test.

Soil Test Critical Level - The concentration of an extractable nutrient above which a yield response to added fertilizer would not be expected for a particular soil test method.

Soil Test Interpretation - The process of developing nutrient application recommendations from soil test levels and other soil, crop and climatic conditions.

Yield Goal - The yield a producer aims to achieve. It should be based on the producer's overall management ability, which is reflected in past production.

Yield or Response Curve - A smooth line created by plotting nutrient application rates (X coordinate) versus crop yield or nutrient uptake (Y coordinate). The curve can have many shapes from linear to curvilinear, and can be positive and/or negative in slope.