VIII. Soil Test Rating System

1. Introduction

The Clemson University Agricultural Service Laboratory Soil Test Rating System describes the essential plant nutrient element concentration range, defining the fertility status of the tested soil. In turn, the expected crop response to an addition of the determined plant nutrient element is correlated to the soil test-determined concentration level.

With this rating system, expected crop response to an applied essential plant nutrient element as fertilizer will depend on whether:

- adequate soil moisture is available
- other environmental conditions are equally favorable
- cultural factors (planting date, seed quality, plant spacing, seed bed preparation, etc.) are at their optimum

It is also assumed that the soil pH is within the recommended range, and that weeds, insects and disease organisms are not present, therefore not factors that would interfere with the normal growth of the crop.

2. Rating System

Plant nutrient element soil test levels are divided into 5 categories that define the soil nutrient element status and expected crop response to applied fertilizer amendments.

a. Low: soil plant nutrient element level is deficient and an application of this element will result in a significant yield increase. A high application rate is needed to:

- meet the crop requirement
- compensate for soil interaction
- build the soil reserves

If the soil temperature is low (<60^{o}F), part of the fertilizer, especially P, should be banded beside the row for row crops when planted in the spring.

b. Medium: soil plant nutrient element level is adequate for moderate agronomic crop yields, but a yield response can be expected about 50% of the time from an application of this element. For Soil Groups 1 and 2, it may not be either possible or economical to build K, Ca, and/or Mg higher than this level. For moderate yield goals, there is probably a sufficient amount of this plant nutrient element without the need to add more than that expected to be removed by the crop; however, for high yield goals, the recommendation should be greater than that needed to compensate for crop removal.

c. Sufficient: soil plant nutrient element level is in that range adequate to meet the crop requirement as well as that needed for consistent high crop yield production. A maintenance application rate is recommended to compensate for expected crop removal. Maintaining the surface soil within the “Sufficient” range will ensure that the subsoil essential plant nutrient element level will not be depleted.

d. High: this soil plant nutrient element level can adversely affect crop yield and product quality, and a further increase can lead to crop yield decreases as well as plant nutrient element imbalances. Therefore, no addition of this element is recommended, unless needed to compensate for expected high crop removal.

e. Excessive: this soil plant nutrient element level will adversely affect plant yield, create nutrient element deficiencies due to imbalances, and can lead to potential ecological damage to the surrounding environment.

Range in Extractable Phosphorus, Potassium, Calcium, and Magnesium Represented by the Soil Test Ratings of the Clemson University Agricultural Service Laboratory

Soil Test Rating	P		K	Ca	Mg	
	Soil Groups 1,2,3&6	Soil Groups 4&5	All Soil Groups	All Soil Groups	Soil Groups 1,2,3&5	Soil Groups 4&6
			lbs/acre			
Low	<31	<21	<71	<401	<33	<47
Medium	31 – 60	21 – 40	71 – 156	401 – 800	33 – 60	47 – 100
Sufficient	61 – 80	41 – 54	157 – 182	801 – 1600	>60	>100
High	81 – 120	55– 80	183 – 235	1601 – 2000		
Excessive	>120	>80	>235	>2000		

Soil Test Ratings and Corresponding Ranges in Extractable P and K for Peanuts.
(Applicable for all soils on which peanuts are grown)

Soil Test Rating	P	K
	lbs/acre	
Low	<11	<29
Medium	11 – 19	29 – 40
Sufficient	20 – 35	41 – 60
High	36 – 50	61 – 100
Excessive	>50	>100

IX. Interpreting Soil Test Rating for Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulfur, Manganese, Zinc, Boron, and Copper

1. Explanation of Recommendations

The Clemson University Agricultural Service Laboratory Soil Test Report-includes lime and fertilizer application recommendations based on:

- correction of soil acidity, or that needed to sustain the existing soil pH level

- correction of nutrient element deficiencies or excesses in order to satisfy the crop requirement and bring the soil fertility level to sufficiency
- expectation that a plant response is likely to occur
- maintaining the existing nutrient element level in order to sustain the soil in its present fertile condition.

These recommendations are also based on:

- soil type
- soil test results
- crop or plant to be grown
- cropping history
- a combination of yield response experiments conducted in South Carolina and adjacent states over many growing seasons and weather conditions on soils typical of South Carolina and the Southeast, together with accumulated experiences of growers and crop advisors who have formulated recommendations to meet changing cultural and crop variety requirements needed to achieve high sustained yields of superior quality. In addition, these recommendations are designed not only to satisfy the nutritional requirements of plants, but are environmentally sound while sustaining the fertility status of soils in order to prevent insufficiencies.

2. Major Plant Nutrient Elements

The plant nutrient elements needed in largest amounts for most crops are the fertilizer elements, nitrogen, phosphorus and potassium. In many cases, these are the only plant nutrient elements that need to be applied on a regular basis. Our recommendations are adequate for optimum yield production under most soil and crop management conditions. Experience has shown that yield increases are not obtained when the recommended rates are exceeded or when a fertilizer application is made when the soil testing rating is "High" or above.

a. Nitrogen (N)

Nitrogen is recommended each year for all crops except legumes. Most of the plant-available nitrogen in soil is in the form of nitrate-nitrogen, which readily leaches from the soil. Unless a special request is made, a soil test for nitrate-nitrogen is not included as a part of the regular soil test because most cropland soils in South Carolina have little carryover of plant-available nitrogen as well as having low soil organic matter contents. Therefore, most soils in South Carolina cannot supply sufficient nitrogen to meet crop yield goals without the need to apply nitrogen fertilizer. If there is reason to believe that a substantial amount of plant-available nitrogen remains in the soil from a previous nitrogen fertilizer application, that should be confirmed by having a 3-foot soil core analyzed for its content of nitrate-nitrogen.

Generally, the yield of most non-leguminous crops is more sensitive to nitrogen than any of the other plant nutrient elements. For several crops, comments provided with the nitrogen recommendation describe when nitrogen rates should be adjusted, either up or down, depending on past experience, soil conditions and crop management procedures. For example, the normal recommendation for nitrogen on non-irrigated corn is 100 pounds nitrogen per acre when it is grown on very sandy soils having a yield potential of just 80 bushels per acre or less. When corn is grown in river bottom soils and other locations where yields of 100 to 120 bushels per acre are commonly obtained, the nitrogen rate is increased to 120 to 140 pounds nitrogen per acre, respectively. Similar guidance is given for adjusting the nitrogen rate for Coastal bermudagrass, bahiagrass, cotton, small grain used for grazing and for several horticultural crops. This guidance is provided in the comments that accompany the recommendation.

Will the nitrogen rate recommended achieve the yield goal? It has been found that fertilization rates of 1.0 to 1.25 pounds nitrogen per bushel of corn and 1.25 to 1.4 pounds nitrogen per bushel of wheat typically will support reasonable yield goals. Considering these two important crops, corn and wheat, based on these estimates for yield responses, the recommended nitrogen fertilizer rates and yield potentials are:

Crop	Fertilizer Rate, lbs N/A		Yield Potential, bu/A	
	Low	High	Low	High
Wheat	80	100	57 – 64	71 – 80
Corn, not irrigated	100	140	80	120
Corn, irrigated	140	240	120	200

If yields above or below these ranges are expected, the N rate should be adjusted up or down, accordingly.

b. Phosphorus (P) and **Potassium (K):** recommended for all crops when the soil test level is "Medium" or less, replacement rates for some crops when soil test level is "Sufficient" and for a few crops even when soil test level is "High." Phosphorus is not recommended when the soil test level is "excessive."

c. Calcium (Ca) and **Magnesium (Mg):** usually sufficient when the soil pH is maintained within the desired range. When lime is not needed but soil test calcium and/or magnesium are low, they can be supplied by addition of gypsum ($CaSO_4.H_2O$) for Ca and Epsom salt ($MgSO_4 \cdot 7H_2O$) or sulfate of potash magnesia (SUL-PO-MAG) for Mg.

d. Sulfur (S): routinely recommended only for those soils that do not have a clay layer within 20 inches of the surface (Soil Groups 1 and 2). Other soils may not need sulfur fertilization based on factors given in the section on **Subsoil Fertility**.

3. Micronutrients

Micronutrient deficiencies most commonly occurring in South Carolina are manganese, zinc, boron, and copper, their deficiencies most likely to occur on sandy Coastal Plain soils that are high in pH (>6.0 or 6.5 due to overliming), have extremes in organic matter contents (<1.0% or >10%), or have been or are being intensively cropped. Some of the commonly grown crops in South Carolina are also sensitive to micronutrient deficiencies, the major crops being corn, soybean and cotton as well as some vegetable, fruit and nut tree crops.

a. Manganese (Mn): most soils have sufficient manganese to meet the crop requirement, except for poorly drained Coastal Plain soils with a soil pH above 6.1 and other coarse textured Coastal Plain soils that have a soil pH greater than 6.4. Manganese deficiencies are most common when the soil pH of well-drained soils rises above 6.7. Peanut, oat, wheat, and cotton are the crops prone to manganese deficiency when soil pH is higher than that recommended (pH >6.5). For soybeans, manganese deficiency occurs more likely on soils when the pH range is between 6.2 and 6.5.

b. Zinc (Zn): routinely recommended only for corn grown on deep sandy soils (Soil Groups 1 and 2, soils that do not have a clay layer within 20 inches of the surface). For pecan, peach, and apple, when a zinc deficiency is confirmed based on a leaf analysis, the most effective corrective treatment is a foliar application of a zinc chelate.

c. Boron (B): normally there is sufficient boron in most South Carolina soils to satisfy the crop requirement for low boron-requirement crops. Boron is routinely recommended only for the high boron requirement crops, alfalfa, apple, broccoli, cabbage, cauliflower, clover (when reseeding or if to be harvested for seed), cotton, peanut, and root crops.

d. Copper (Cu): reported for diagnostic purposes but not normally recommended. Copper deficiency is most likely to occur only on organic soils, soils high in organic matter content, and coarse textured soils that have been overlimed.

X. Soil Nutrient Element Fertility Management

1. Introduction

Establishing and maintaining a cropland soil within the desired fertility status, soil pH and essential plant nutrient element level, is not an easy task. An infertile soil can not be quickly made fertile in one step. Maintaining a cropland soil at a desirable fertility status requires:

- continuously testing and monitoring the soil pH and essential plant nutrient element levels
- keeping track of the frequency and rate of lime and fertilizer applications
- maintaining cropping sequence records
- measuring crop yields and estimating crop removal amounts

2. Basic Concepts

There are basically two concepts for managing the fertility status of a cropland soil. One is based on adding plant nutrient element(s) sufficient to satisfy the crop requirement with minimal regard to altering the fertility level of the soil. This concept was widely practiced when NPK fertilizer grades were the primary fertilizers available for use. One would select a particular fertilizer grade for a specific crop, adjusting the fertilizer phosphate:potash (P_2O_5:K_2O) ratio based on the fertility status of the soil as determined by a soil test.

With fertilizer formulation blending, specific amounts of each of the fertilizer elements, nitrogen, phosphate, and potash, can be put into the formulated fertilizer based on actual need determined by the combination of crop requirement and soil test level.

3. Plant Nutrient Element Management

Establishing and then maintaining the soil fertility level within that range designated as "sufficient," is best for consistent high crop yields and quality products. Both the physical and chemical properties of the soil need to be considered as some soils have relatively low nutrient element storage capacity, mainly low (<5 meq/100g) cation exchange capacity (CEC) due to low clay and/or organic matter contents. For these low CEC soils, the major elements, potassium, calcium, and magnesium, are those elements primarily affected. ` Maintaining these soils at the "Medium" soil test level is the goal.

4. Monitoring the Fertility Status of a Soil by Means of Soil Tests

Liming, fertilizing and cropping a soil can significantly alter the soil pH and nutrient element test levels. The monitoring aspect of a calendar series of soil test results can be a valuable guide in developing and instituting a soil fertility program that will sustain long-term high crop yields. By maintaining a graph of yearly soil test results, management practices can be instituted before deficiencies or excesses occur.

XI. Subsoil Fertility

1. Introduction

Subsoil fertility can have a significant impact on crop performance, as an acid infertile subsoil can be a major factor in poor crop yield and product quality. The subsoil can be distinctly different than the surface soil in terms of its physical and chemical properties. The subsoil may be only a few inches below the surface soil or a foot or more below. In some situations, there may exist a "hardpan" or "plow pan" between the subsoil and surface soil that prevents water and nutrient element movement between these two soil levels as well as limiting or preventing root penetration into the subsoil.

The status of subsoil fertility is determined by:

- natural conditions
- fertility level of the surface soil
- cropping practices
- tillage systems

It should be remembered that for some crop plants, their roots can penetrate the soil to considerable depths if the conditions are conducive to good root growth. Therefore, the subsoil can be a significant source for both water and essential plant nutrient elements.

In general, the fertility status of the subsoil is enhanced when the surface soil is maintained in a highly fertile condition. As building subsoil fertility is a slow process, subsoil nutrient element content may be depleted when plant roots forage the subsoil, extracting both water and essential plant nutrient elements.

2. Modification of Nutrient Element Recommendations for Coastal Plain Soils based on Subsoil Fertility Status

Potassium, sulfur and magnesium are the elements that can be leached from the surface of sandy Coastal Plain soils, accumulating in the more clayey subsoil. These plant nutrient elements are available to crops if and when roots penetrate the layer where clay has accumulated. If the clay layer is within 20 inches of the surface, the subsoil can be an important source of potassium, sulfur and magnesium, if the subsoil pH is not too acidic (subsoil pH should be 5.5 or greater) and subsoiling is practiced. Subsoiling is a very important management practice on Coastal Plain soils because it allows roots to proliferate into the clay layer and extract water and plant nutrient elements.

The subsoil sample should be taken to a depth of 3 to 4 inches below the top of the more clayey layer (or top of the subsoil), using the same auger-hole from which a surface sample had been obtained. All the general guidelines for routine sampling should be followed when subsoil sampling.

Fertilizer recommendation adjustments for the plant nutrient elements, potassium, magnesium and sulfur, based on a subsoil analysis results are as follows:

Subsoil Nutrient Element Level	**Recommended Adjustments Based on Surface Soil Test Level***
Potassium (K)	
Low	no adjustment of K_2O fertilizer rate
Medium	reduce K_2O fertilizer rate by 1/4
Sufficient	reduce K_2O fertilizer rate by 1/2
High	reduce K_2O fertilizer rate by 3/4
Excessive	apply only maintenance K_2O rate
Magnesium (Mg)	
Sufficient to High	disregard any Mg recommendation based on surface soil test level
Sulfur (S)	
Sufficient	disregard any recommendation for S

*these modifications of the potassium, magnesium and sulfur fertilizer recommendations require in-row subsoiling as a part of the cultural practice for row crops