CHAPTER 7d

Sampling Soil and Crop Tissue

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Soil Sampling and Analysis

Conventional Soil Sampling

Conventional soil sampling prior to land application of animal manures is required by DHEC (Sections 100.100 9 & 200.100.9).

Soil sampling (usually 6-8 inch depth) shall be conducted for each field prior to manure application to determine the appropriate application rate. Each field should be sampled at least once per year. If manure application frequency shall be less than once per year, then at least one soil sample shall be taken prior to returning to that field for land application. (Sections 100.100 9 & 200.100.9).

Soil analysis results should be used by the farmer to ensure that the pH and nutrient levels are conducive to producing a good crop. Excessive levels of phosphorus, zinc, and copper may be revealed by this type of soil sample. The soil phosphorus level of the conventional soil sample will be used in the Natural Resources Conservation Service Phosphorus Index to determine the suitability of the field for manure application and whether nitrogen or phosphorus loading is used to determine the application rate. Additional runoff control or soil conservation practices may be required based on the phosphorus level of this sample. Zinc and copper may be toxic to some crops in certain soils and analysis of this soil sample may indicate a need for liming or planting a more tolerant crop.

The first step to obtaining a representative soil sample is to separate each field into areas of like soil and management history. Soil areas of greater than a half acre should be considered for sampling. Differences in surface soil color are the most evident feature separating soil types. Dark soils will indicate accumulations of organic matter arising from low areas in the landscape where water accumulates or recent clearing of pasture or trees. Reddish surfaces in the Coastal Plain region will indicate erosion and mixing of the subsoil with the surface soil. Surface soils of different color will likely have different pH and nutrient levels and therefore require different additions of lime and nutrients and should be sampled separately.

Crop and fertilization histories are also important factors to consider when obtaining representative soil samples. Crops grown in South Carolina are traditionally provided nutrients in different amounts. High value crops, such as tobacco, peanuts, and cotton usually receive excessive to adequate levels of nutrients whereas corn, soybeans, and wheat receive deficient to adequate levels of nutrients. Also land recently cleared from trees will usually be extremely low in pH and nutrient levels. Pastures are usually maintained at fairly low pH and nutrient status.

In any case, no sample should represent more than 20 acres. An accurate field map should be constructed so these different sampling areas can be identified and sampled again next year. Once each sampling area is identified, 15-20 soil cores should be obtained from throughout the area. A zig-zag pattern is often used to ensure that the sampling area is adequately represented. The depth of sampling is 6 to 8 inches deep for row crops and 3 to 4 inches deep for pastures and hay fields. Small areas of obviously different soil (less than a half acre) should be avoided. The soil cores should be placed in a clean plastic bucket, mixed thoroughly, and a subsample taken to fill a one pint soil box.

Soil boxes, submission forms and further advice on proper sampling technique, can be obtained from your County Agent. Mailing of the samples to the Clemson Agricultural Service Laboratory will also be provided by the County Extension office. Generally within one week of submission the soil samples will be analyzed and the results returned. The Agent is available at this time for discussing the analysis and lime and nutrient recommendations.

Deep Soil Sampling for Nitrate and Phosphorus

Soil sampling for nitrate and plant-available phosphorus to a depth of 18 inches in 6-inch increments is required by DHEC Sections 100.100 10 & 200.100.10).

Soil sampling to a depth of eighteen inches shall be performed within 45 days after each application of animal manure, but no more than two times per year if the application frequency is more than twice per year. This sampling shall be performed for at least three years after the initial application on at least one representative manure utilization area for each crop grown to verify the estimated calculated manure application rates for the utilization areas. The date of manure application and the date of sampling shall be carefully recorded. The sampling shall be conducted at depths of zero to six inches, six to twelve inches, and twelve to eighteen inches with nitrates and phosphorus being analyzed.

Nitrate Sampling and Interpretation of Soil Analysis Results

Several of the requirements for taking representative soil samples for nitrate analysis are the same as those for taking traditional soil samples. Fields should be separated into different soil types. Areas that were cropped, fertilized, or manured differently should be sampled separately. Soil samples should represent no more than 20 acres, and each sample should be comprised of fifteen or more cores (approximate diameter of 3/4 inch).

One difference between soil sampling for nitrate analysis and traditional soil sampling is sample handling. Soil samples for nitrate should be spread thinly to air dry within one hour of sampling or kept on ice until they can be dried. If left moist and warm, additional organic nitrogen will be released and measured as nitrate. After the samples have dried, each incremental sample should be sent to the laboratory as a separate sample. The results of soil nitrate tests are usually reported in parts per million (ppm) of nitrate-N. To convert ppm to pounds per acre, multiply ppm by 2 for 6-inch samples and by 4 for 12-inch samples.

The results of the pre-application and post-application sampling shall be used by the producer to adjust as necessary, the amount of animal manure to be applied to a manure utilization area to meet the agronomic application rate for the crop(s) to be grown. These results shall be submitted to the Department at the time of application for permit renewal. (Sections 100.100 11 & 200.100.11).

Nitrate-nitrogen in the soil after manure application may arise from a number of sources. These include:

1. leftover or residual nitrate-nitrogen from fertilizer or manure applied to the previous crop,
2. nitrogen mineralized and nitrified from the stover of the previous crop,
3. nitrogen mineralized and nitrified from soil organic matter,
4. nitrogen mineralized from organic-nitrogen in the manure, nitrified from ammonium-nitrogen in the manure, or applied as nitrate-nitrogen in the manure.

The amount of nitrate-nitrogen found in the upper 18 inches of soil within 45 days of manure application is dependent on a number of factors. The soil temperature and moisture levels between manure application and sampling will determine how much mineralization of organic-nitrogen occurs and how much ammonium-nitrogen is converted to nitrate-nitrogen. The type of soil, its water holding capacity and permeability, will determine the potential for nitrate leaching below the 18 inch sampling depth when rainfall occurs. The amount, intensity, and temporal distribution of rainfall received after application will determine the actual amount of leaching. Crop uptake will also remove some nitrate-nitrogen from the soil. With warm soil temperatures, > 80 ^{o}F, the majority of the organic-nitrogen mineralization and conversion of ammonium-nitrogen to nitrate should be complete in 3 to 4 weeks. Mineralization and conversion will be slower with cooler temperatures.

Expect the summation of nitrate-nitrogen in the upper 18 inches of soil 21-45 days after application to equal the intended plant-available nitrogen application rate plus or minus 50 pounds of nitrogen per acre. If the amount of nitrate-nitrogen found in the 18-inch sample is greater than 50 pounds per acre less than the predicted plant-available nitrogen, and temperatures were conducive to nitrogen mineralization and nitrification, and leaching and crop uptake were not substantial, then the application rate and/or availability of nitrogen in the manure was probably less than expected.

If the amount nitrate-nitrogen found in the 18-inch soil sample is more than 50 pounds per acre greater than the predicted plant-available nitrogen then the application rate and/or availability of nitrogen in the manure was probably higher than expected, a large amount of residual nitrogen remained in th soil from the previous season, and/or a substantial amount of nitrogen was released from previous crop residues and/or soil organic matter.

Rationale for Deep Soil Sampling for Phosphorus

Phosphorus can leach downward in the soil profile when over-applied to sandy soils, thus the rationale for deep soil sampling and measurement of phosphorus. Plant-available phosphorus (soil-test phosphorus) below the plow layer (greater than 6 to 8 inches deep) is a good measure of

the amount of phosphorus leaching, since little phosphorus is found naturally in most South Carolina soils. The potential for phosphorus leaching and subsequent lateral movement to surface waters is a component of the NRCS-PI to determine the suitability of the field for manure application and the nutrient determining the application rate (either nitrogen or phosphorus). Lateral flow of soil water containing phosphorus can occur in the absence of tile drains, but is accelerated by artificial drainage.

Plant Sampling and Analysis

Plant analysis is a good tool for monitoring the nutrient status of the crop to determine whether nutrients are in sufficient concentration to allow optimum growth. Plant analysis is most often used to assess the sufficiency of nutrients that soil testing does not evaluate well, such as nitrogen and the micronutrients. Because tissue nutrient levels change with the growth stage of the crop and the plant part sampled, specific plant tissues at specific stages of growth are targeted for sampling (Table 7.d.1). Sufficiency ranges for each nutrient have been developed for these crops based on the plant part and stage of growth (Table 7.d.2).

Plant sample submission forms and further advice on proper sampling technique, can be obtained from your County Agent. Mailing of the samples to the Clemson Agricultural Service Laboratory will also be provided by the County Extension office. Generally within one week of submission the tissue will be analyzed and the results returned. The Agent is available at this time for discussing the analysis and recommendations.

For routine nutrient monitoring purposes samples should be taken only from representative areas of the field. Approximate sampling numbers are listed in Table 7.d.1. The complete sample should be mixed thoroughly and a subsample taken to fill a lunch-size paper bag ½ full. The sample can be air-dried or oven dried (170 ^{o}F). Extremely moist samples should be air-dried at least one day prior to mailing. Plastic bags are not recommended because moist samples will decompose in route to the laboratory.

Only clean plant tissues should be sampled. Soil is generally splashed by rainfall on to the lower portions of the plant. These tissues should be avoided or the tissue cleaned prior to sampling. Soil contamination can seriously compromise the interpretation of nutrient analysis, particularly iron, manganese, and aluminum. If nutrient applications have been made close to the time of sampling and insufficient rainfall has occurred to rinse those substances from the plant tissue, the tissue should also be washed.

Tissue should be washed rapidly in a 2% phosphorus-free detergent solution with gentle hand rubbing of the tissue. The tissue should be rinsed immediately and thoroughly with clean cold water. Tissue is best washed when fresh. Excessive washing should be avoided because some nutrients, particularly potassium, will be washed from the tissue by the cleansing procedure. Washing without detergent is better than not washing at all.

SAMPLING GUIDELINES FOR CROP GROWTH PROBLEMS

Clemson University County Extension Agents are available for assisting agricultural producers determine the cause of crop growth problems. The Extension Agent may elect to send

a series of samples to the Agricultural Service Laboratory Plant Problem Clinic. Generally, plant and soil samples are obtained from areas of poor crop growth, as well as areas of good crop growth. Plant tissue samples do not have to be obtained at the designated stage of growth because the good growth area is obtained simultaneously for comparison to the poor crop growth area. Whole plant samples with intact root systems, in addition to leaf tissue, should also be obtained. Intact plant samples will be examined for the presence of plant diseases and damaging insects. Intact plant samples should be packaged separately from plant tissue being sent for nutrient analysis so soil from the intact sample does not contaminate the tissue for nutrient analysis. Soil samples will be analyzed for the presence of plant damaging nematodes, as well as pH and nutrient levels. Sometimes, but not always, the causal factor of the poor crop growth can be ascertained from the results of these tests.

Table 7.d.1. Plant part and stage of growth for sampling commonly grown crops in South Carolina.

Crop	Plant Part	Stage of Growth	# Samples
(1) Coastal bermuda	Upper 4-6" of plant.	During vegetative growth.	>15 handfuls
(2) Corn	Whole plant.	Less than 4" tall, cut 1" from soil surface.	15-20
(3) Corn	Leaf below the whorl.	From 4" tall to tasseling.	15-20
(4) Corn	Ear leaf.	At tasseling and before silks turn brown.	15-20
(5) Corn	Ear leaf.	At maturity.	15-20
(6) Cotton	Uppermost recently mature leaf, without petiole.	Early bloom.	>25
(7) Cotton	Uppermost recently mature leaf, without petiole.	Late bloom/maturity.	>25
(8) Soybean	Uppermost recently mature leaf.	At flowering.	>25
(9) Tall fescue	Upper 4-6" of plant.	During vegetative growth.	>15 handfuls
(10) Wheat	Whole plant.	Seedling to tillering, 1" from soil surface.	>25
(11) Wheat	Top 2-3 leaves with stem.	Jointing to flag leaf emergence.	>25
(12) Wheat	Flag leaf.	At boot stage.	>50

Table 7.d.2. Nutrient sufficiency ranges for crops based on plant part and stage of growth (From the WEB site: http://www.agr.state.nc.us/agronomi/saaesd/s394.htm). Plant part and stage of growth correspond to those listed in Table 7.d.1.

Crop	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
	---------- % ----------						---------- ppm ----------					
(1) Coastal bermuda	2.0-2.6	0.20-0.40	1.5-2.3	0.25-0.50	0.10-0.25	0.15-0.25	50-200	20-300	15-70	4-20	5-15	--------
(2) Corn	4.0-5.0	0.4-0.6	3.0-4.0	0.3-0.8	0.2-0.6	0.18-0.5	40-250	25-160	20-60	6-20	5-25	0.1-2.0
(3) Corn	3.0-4.0	0.3-0.5	2.0-3.0	0.25-0.8	0.15-0.6	0.15-0.4	30-250	20-150	20-70	5-25	5-25	0.1-2.0
(4) Corn	2.8-4.0	0.25-0.5	1.8-3.0	0.25-0.8	0.15-0.6	0.15-0.6	30-250	15-150	20-70	5-25	5-25	0.1-2.0
(5) Corn	2.5-3.5	0.25-0.4	1.6-2.5	0.2-0.8	0.12-0.5	0.12-0.4	30-250	15-150	16-50	4-20	3-20	0.1-2.0
(6) Cotton	3.0-4.5	0.2-0.65	1.5-3.0	2.0-3.5	0.3-0.9	0.25-0.80	50-250	25-350	20-200	5-25	20-80	--------
(7) Cotton	3.0-4.5	0.15-0.6	0.75-2.5	2.0-4.0	0.3-0.9	0.3-0.9	50-300	10-400	50-300	-----	15-200	--------
(8) Soybean	3.25-5.0	0.30-0.60	1.5-2.25	0.8-1.40	0.25-0.70	0.25-0.60	25-300	17-100	21-80	4-30	20-60	--------
(9) Tall fescue	2.8-3.8	0.26-0.4	2.5-3.5									--------
(10,11) Wheat	4.0-5.0	0.2-0.5	2.5-5.0	0.2-1.0	0.14-1.0	0.15-0.65	30-200	20-150	18-70	4.5-15	1.5-4.0	0.1-2.0
(12) Wheat	4.0-5.0	0.2-0.5	2.0-4.0	0.2-1.0	0.14-1.0	0.15-0.65	30-200	20-150	18-70	4.5-15	1.5-4.0	0.1-2.0

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