SOILS AND FERTILIZERS
MODULE 13
SOIL AND PLANT TISSUE ANALYSIS AS A GUIDE TO FERTILIZATION

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1. Why we fertilize.
   a. Fertilizer should be used to supply only that portion of the so-called <u>crop nutrient requirement</u> that cannot be supplied from the soil. Fertilizer is applied to the soil not to increase soil test levels, but to improve plant nutrition. Without a positive crop response to this added nutrition, there is little incentive to add fertilizer to the soil.
   b. Need to consider crop quality vs. crop quantity (e.g. a dark green lawn vs. dark green citrus trees).
   c. The soil may already contain enough of each of the essential plant nutrients (from previous cropping or from previous fertilizer and lime additions) to supply all needed nutrients for optimum crop growth. At other times, the soil may be low in one or more essential elements (leached due to rainfall, used by previous crops, etc.) and fertilizers or lime will be needed to produce optimum crop response. The nutrient status of the soil can be estimated through soil testing techniques that have been demonstrated to relate fertilizer additions to positive crop response.
   d. Benefits achieved by using a proper soil testing and fertilization system:
      i. The crop is exposed to adequate but not excessive fertility.
      ii. Only those nutrients that are actually needed to satisfy plant nutrition are ever added to the soil.
      iii. No damaging fertilizer salts are present to slow plant development.

2. Soil sampling variability
   a. Most of the variability in soil testing comes from the soil sampling process, since soils can be so variable across a field. Therefore, sampling errors should be minimized to obtain a representative soil sample from the management unit in question.
   b. The traditional way of sampling an area is to partition the acreage into management units, i.e. blocks of land that may need to be managed differently. This partition should take into account such parameters as soil series, soil fertility, drainage, and cropping patterns. Each management unit should be sampled separately, especially the "good" and "bad" units. The more modern way of sampling an area is to take samples in a grid pattern, identify the sampling sites with a geographic positioning system (GPS), and create data maps using a geographic information system (GIS).

3. Nutrient mobility
   a. The mobility of a nutrient in the soil is critical to the value of soil testing. <u>Mobile</u> nutrients, such as nitrate, can change concentration rapidly in the soil in response to fertilization or leaching. Soil testing for mobile nutrients as a basis for

making fertilizer recommendations at the beginning of a growing season is of little value under Florida's conditions of high rainfall and sandy soils.

b. On the other hand, immobile nutrients tend to remain in the soil profile. Such nutrients, including phosphorus and to a much lesser extent potassium (in sands), are retained through various means on surfaces in the soil, thereby resisting movement by leaching. Soil test values obtained for immobile nutrients can be linked to crop response and, therefore, to a fertilizer recommendation.

4. Types of soil sampling.
   a. Predictive soil sampling - Soil samples taken prior to planting a crop (should be taken no more than 4 to 6 weeks prior to planting). With proper calibration of the soil test, the contribution to the crop nutrient requirement from the soil for that particular immobile nutrient is estimated. It is from this sample that a prediction of crop fertilization needs is made for the coming growing season.
   b. Diagnostic soil sampling - Soil samples taken while the crop is actively growing. Such testing may be used to monitor soil nutrient status to insure adequate nutrient supply to the plant. Monitoring can be of value for both mobile and immobile nutrients, since one wants to know the nutrient status at the time of sampling (i.e. a "snap shot") and is not interested in predicting future nutrient supply.
   c. In order to diagnose reasons for poor plant growth, the following need to be considered in addition to a soil test:
      i. Stage of crop growth.
      ii. Plant tissue analysis.
      iii. Complete fertilizer, prior cropping, and pesticide records.
      iv. Weather records.
      v. Pest scouting.
      vi. Experience.
   d. Soil sampling by itself rarely provides enough information; additional information is needed as well.

5. Soil test calibration.
   a. Calibration is a fundamental process that makes soil testing meaningful for fertilizer recommendations. A soil test method must be calibrated with crop response to function as a fertilizer management tool. Calibration must be done for each soil extractant used.
   b. The calibration process: A particular soil test is calibrated by relating pre-plant soil test values to crop response to added fertilizer. Most universities use the calibration process to validate use of a particular soil-test extractant. Figs. 1 and 2 show examples (using generic data) of the calibration process.
   c. Interpretations of soil-test values: Interpretation is the process that verbally explains the relative meaning of a soil-test value. Interpretation scales usually consist of five levels ranging from **Very Low** to **Very High** (see below). By definition, the division between **Medium** and **High** is termed the **critical value**. Above this point there is no expected crop response to added fertilizer.

Current Mehlich-1 soil test interpretations used in the IFAS-wide Standardized Fertilizer Recommendation System.

	-------------------------------------- Rating --------------------------------------				
Element	Very Low	Low	Medium	High	Very High
	------------------ parts per million (mg/kg) in the soil -------------------				
P	< 10	10-15	16-30	31-60	> 60
K	< 20	20-35	36-60	61-125	> 125
Mg		< 15	15-30	> 30	

When a soil tests **Very Low**, one can expect less than 50% of the crop yield potential without addition of the deficient nutrient. A positive crop response to added fertilizer is highly probable.

When a soil tests **Low**, the expected crop yield is 50 to 75% of the potential maximum. A positive crop response to added fertilizer is probable.

When a soil tests **Medium**, the expected crop yield is 75 to 100% of the potential maximum, and response to fertilizer is probable.

When a soil tests **High** or **Very High**, it is unlikely that the crop will respond to added fertilizer. Adding fertilizer to soils in this range may provoke nutrient imbalances in the crop, contribute to excessive salt buildup in the soil, and contribute to environmental pollution through leaching of fertilizer from the soil profile.

6. Fertilization philosophies.
   a. Basic Cation Saturation Ratios: Says that there are ideal ratios of basic cations (Ca, Mg, and K) on the cation exchange complex of the soil at which maximum crop yields occur. If a soil test shows that the cation ratio is not ideal, rates of fertilizer a recommended in an attempt to adjust soil test results; usually the rates are very large. This philosophy is popular with commercial soil testing laboratories; the ratios are easy to calculate, and a fertilizer recommendation is almost always made for every soil test because the ratios almost never are what is considered "ideal."
   b. Buildup and Maintenance: Says that there are optimum or critical soil-test levels for each nutrient at which maximum yields occur. Fertilizers are used to adjust soil test results, i.e. extra is added above that which a crop needs to grow. Fertilizers are always added to replace nutrients used by the crop. Used by many commercial and a few Land-Grant university laboratories.
   c. Field Hydroponics: Says that all plant nutrients must be supplied by fertilizers; the soil acts only as a physical growth medium. The soil is assumed to be totally infertile. There are environmental concerns with this philosophy, as high fertilizer rates are normally used.
   d. Crop Nutrient Requirement: Says that each plant nutrient must be supplied in adequate but not excessive amounts to achieve optimum crop response. The

nutrient contribution from the soil is measured indirectly by a calibrated soil test. Fertilizers are used only to supplement the existing soil fertility. Used by many Land-Grant universities (including the University of Florida) and some commercial laboratories.

7. Usefulness of a soil and leaf tissue testing program.
   a. Monitor soil pH (single most useful parameter measured due to its effects on phosphorus and micronutrient availability).
   b. Monitor soil phosphorus levels to determine if P fertilization can be reduced or eliminated for a period of time.
   c. Monitor soil potassium levels to determine if the soil has the capacity to retain fertilizer K. If soil test K increases with time (not likely in sandy soil), fertilizer rate can be reduced.
   d. Use leaf tissue tests to evaluate N and K fertilizer programs; soil tests for N are of little or no value.
   e. Monitor micronutrient levels with leaf analysis.
   f. A collection of soil and leaf tissue data allows a grower to make more intelligent decisions regarding soil fertility management.
   g. A testing program can identify areas where additional fertilizer or soil amendments are needed to improve yield or quality, but can also indicate areas of excessive application.

8. Laboratory Procedures
   a. Water samples
      i. pH - most samples come from ground water that is stored within limestone substrata, thus it contain carbonates; this causes the pH to rise above 7 into the alkaline range.
      ii. Conductivity - gives an indication of the amount of salt that is dissolved in the water; relationship between conductivity and concentration (average conversion factor).
      iii. Can test for specific elements like sodium, calcium, magnesium, iron, or manganese (has implications in plugging of micro-irrigation systems).
   b. Soil samples
      i. Sample preparation - drying, followed by sieving or grinding.
      ii. Sample extraction - type of extractants that may be used:
         (1) Mehlich 1 (0.05 N HCl + 0.025 N H_2SO_4) UF/IFAS uses this.
         (2) Ammonium acetate (CH_3COONH_4), pH 4.8
         (3) Ammonium acetate, pH 7.0
         (4) Bray P1 (0.03 N NH_4F + 0.05 N HCl)
         (5) Mehlich 3
      iii. How the extractants work.
         (1) Phosphorus - Dissolution of sparingly-soluble P compounds in the soil, e.g. calcium phosphates, aluminum phosphates, and iron phosphates.
         (2) Calcium - Removal from cation exchange complex, and dissolution of solid Ca compounds.

(3) Magnesium and potassium - Removal from cation exchange complex, or dissolution of dolomite (Mg only).
(4) Soil pH - 2:1 water-to-soil ratio; mix together, let stand for 30 min, measure pH of soil suspension above the settled-out particles.

c. Plant samples
   i. Sample preparation - Washing (necessary for accurate Fe determination) and drying. Do not analyze for micronutrients in leaves if they have had a nutritional spray.
   ii. Ashing at 500 C.
   iii. Dissolution of ash in acid; analysis for nutrients other than N.
   iv. Digestion for total N.

d. Quality control.

9. Interpretation of results for citrus soil and leaf samples
   a. Soil samples - pH, P, Ca, Mg.
   b. Leaf tissue - N, P, K, secondary nutrients, micronutrients (if non-sprayed leaves).

Guidelines for interpretation of leaf analysis based on 4-to-6-month-old spring flush leaves from nonfruiting terminals.

Element	Deficient	Low	Optimum	High	Excess
N (%)	< 2.2	2.2 - 2.4	2.5 - 2.7	2.8 - 3.0	> 3.0
P (%)	< 0.09	0.09 -0.11	0.12 - 0.16	0.17 - 0.30	> 0.30
K (%)	< 0.7	0.7 - 1.1	1.2 - 1.7	1.8 - 2.4	> 2.4
Ca (%)	< 1.5	1.5 - 2.9	3.0 - 4.9	5.0 - 7.0	> 7.0
Mg (%)	< 0.20	0.20 - 0.29	0.30 - 0.49	0.50 - 0.70	> 0.70
Cl (%)	---	---	< 0.2	0.20 - 0.70	> 0.70*
Na (%)	---	---	---	0.15 - 0.25	> 0.25
Mn (ppm)	< 17	18 - 24	25 - 100	101 - 300	> 300
Zn (ppm)	< 17	18 - 24	25 - 100	101 - 300	> 300
Cu (ppm)	< 3	3 - 4	5 - 16	17 - 20	> 20
Fe (ppm)	< 35	35 - 59	60 - 120	121 - 200	> 200
B (ppm)	< 20	20 - 35	36 - 100	101 - 200	> 200
Mo (ppm)	< 0.05	0.06 - 0.09	0.10 - 1.0	2.0 - 5.0	> 5.0

*Leaf burn and defoliation can occur at Cl concentration of >1.0%