Soil and Plant Tissue Testing[1]

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Soil testing is the best tool for monitoring soil fertility levels and providing baseline information for cost-effective fertilization programs. This information allows for management actions that adjust soil fertility status in order to meet specific forage-nutrient requirements. Routine soil testing can identify nutrient deficiencies and inadequate soil pH conditions that may negatively affect forage production. Soil tests can also indicate nutrients that are present at adequate levels, providing the opportunity to eliminate unnecessary soil amendments.

A major limitation associated with soil testing is that it typically accounts for the plant-available nutrient pool present in the surface (4 to 6 inches) soil layer. However, the subsoil can be an important source of water and nutrients, particularly in perennial crop systems. In addition, some nutrients are highly mobile in the soil and can easily leach into subsoil, resulting in nutrient accumulation at deeper soil depths. Unlike soil testing, plant tissue analysis can account for the plant-available nutrient pools present at multiple soil depths, including deeper horizons. Because of the extensive root system in some plants, plant analysis is a complement to the soil test to better assess the overall nutrient status of a perennial forage system, while revealing imbalances among nutrients that may affect crop production.

Purpose of Tissue Testing

Plant tissue analysis involves the determination of nutrient concentrations from a particular part or portion of a crop, at a specific time and/or stage of development. The basic principle of plant analysis interpretation is that yield will be limited by critical nutrient concentrations for each specific crop. The critical level—defined as the nutrient concentration in a plant sample below which yield is significantly reduced—varies among forage crops. Since multiple factors can influence crop-tissue nutrient concentrations, tissue testing should be used with caution and in conjunction with a routine soil-testing program. Recent efforts in Florida have shown that when plant tissue analysis was used in combination with soil testing, there was improved predictability of P and K availability to plants (Silveira et al. 2011). Plant tissue analysis is currently being used in Florida to guide P fertilization of established bahiagrass (*Paspalum notatum* L. Fluegge) pastures. In Louisiana, Mondart et al. (1974) suggested that 90% of maximum bermudagrass (*Cynodon dactylon [L.]* Pers.) yields were obtained when average plant tissue P concentration was 2.0 g kg^{-1}. A critical lower limit of 2.6 g kg^{-1} P has been estimated for dallisgrass (*Paspalum dilatatum* Poir) (Kelling and Matocha 1990). When used in conjunction with soil testing, tissue analysis will improve our diagnostic toolbox for developing nutrient management programs that predict when crops need additional nutrients, while avoiding unintended impacts of excess fertilization on the environment.

Best Time to Test Soil and Plant Tissue

Although soil can be tested at any time, testing at the same time each year is recommended. Furthermore, soil and tissue sampling in early- to mid-Fall (mid-October to November–December) is ideal, because it provides ample

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time for lime to be applied (if needed) and to achieve effectiveness before the growing season in Florida. If soil pH needs to be adjusted, it is recommended to apply lime at least 3 to 4 months prior to the spring fertilization in order to allow time for the material to react in the soil. In recently fertilized hay fields, delay sampling at least four to six weeks so that recent fertilizer application has a chance to be utilized by the crop. Also, avoid taking soil samples when the soil is saturated with water, as this will give inaccurate results.

Plant tissue samples should be collected at the same time and from the same vicinity as soil samples. The plant part, maturity stage, and time of sampling are important factors that can affect plant nutrient composition. Tissue samples should be collected when the plant is actively growing, so careful planning is the key.

Soil and Plant Tissue Sample Collection

Soil and plant tissue testing results and interpretation are only reliable if the samples are collected properly. In other words, *test results are only as good as the sample taken*. It is very important to submit soil and plant tissue samples that are comprehensive of the area of interest so that test results are reliable and fertilizer recommendations can be made for the entire area. For soil testing, this can be accomplished by submitting a composite sample. A minimum of 15 to 20 subsamples (approximately 6 inches deep) should be collected per 40-acre field. Samples should be taken at random in a zigzag pattern over the entire area (Figure 1). Areas that are managed or cropped differently or have different soil types should be sampled separately. Similarly, areas that show clear problem signs (i.e., poor forage production, disease) should also be sampled and analyzed separately. Avoid sampling areas not typical of the total field, such as near water, feed, or shade.

Collecting a good, representative soil sample is well worth the time and effort it requires. Soil samples can be taken using a soil probe or a shovel. Consistency is important, so collect every sample as close as possible to the same depth. For each area or field sampled, place all the subsamples (15–20) in a clean plastic bucket and mix thoroughly. A handful (~1 pint) of soil should be sent to a reputable laboratory for analysis. If multiple samples are sent to the lab, pack them in sturdy containers to avoid cross-contamination among the samples. It is recommended that a routine soil test (pH, lime requirement, and available plant nutrients) be conducted at least every three years. The frequency of soil sampling will depend on several factors, including soil type, nitrogen application rate, nitrogen fertilizer source, and forage utilization (grazing vs. haying). In intensively-managed production systems that receive relatively high fertilizer inputs, annual soil and tissue testing is recommended.

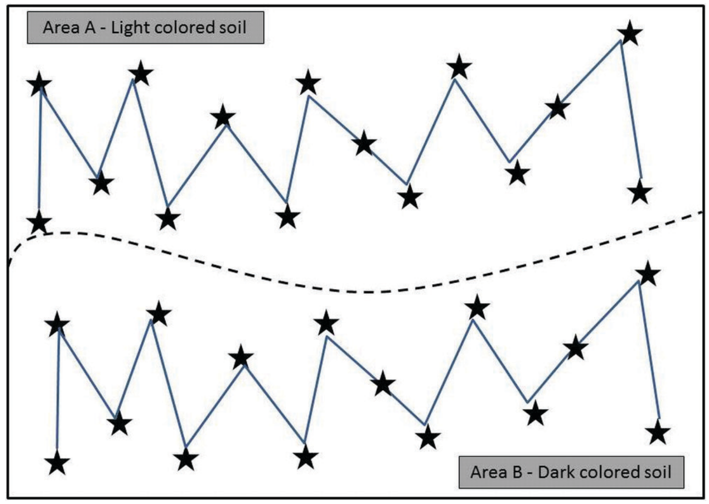

Figure 1. Schematic representation of soil sampling locations within a paddock. Each star represents a sampling location. Areas A and B (separated by dashed line) should be sampled and analyzed separately, because they are different soil types.
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Similar to soil samples, plant tissue samples must be representative of the field. The number of plants to sample in a specific area will depend on the general conditions of plant vigor, soil heterogeneity, and forage management. A truly representative sample can be obtained by sampling a large number of plants so that the sample represents the entire field. Collect at least 1 oz (30 g) of fresh material. Sampling is not recommended when plants are injured by insects and diseases. To avoid contamination, plants should not be sampled soon after spraying pesticides or herbicides. Care should be taken to minimize soil contamination on the sampled plant material. In addition, plants should not be sampled under temperature or moisture stress. Ideally, samples should be collected during a time of the day when climatic conditions are mild, generally early to mid-morning or early evening. The plant part, maturity stage, and time of sampling are also important factors that can affect plant nutrient composition. Forage grasses and hay fields should be sampled prior to seed head emergence or at the optimum stage for forage utilization. As the plant matures, nutrient concentrations decline, so it is critical that plants are sampled at the proper stage of maturity. Care should be taken to select the plant part that accurately reflects the nutrient status of the plant. *The top portion of the plant (the portion on which cattle would graze) should be sampled.* Do not sample seeds, because they are not useful for assessing nutrient status of forage crops and may introduce large errors in the report interpretation. If deficiency symptoms are suspected, plants showing these symptoms should be sampled and analyzed separately from "normal" or apparently healthy plants. After sampling, tissue should be placed in properly labeled paper bags and sent immediately to a reputable laboratory for analysis. Avoid plastic bags, because they can hold heat and moisture. Take precautions when handling your newly collected plant tissue. Because fresh plant material may start decomposing shortly after collection, send the plant material to the laboratory as quickly as possible. If you cannot mail the tissue samples immediately to the lab, then place them in a refrigerator until ready for shipping. For more information on bahiagrass tissue sampling and interpretation, refer to EDIS article SS475, *Tissue Analysis as a Nutrient Management Tool for Bahiagrass Pastures* at http://edis.ifas.ufl.edu/ss475, or contact your local county UF/IFAS Extension's livestock agent or other university personnel.

Sample Submission and Results Interpretation

Make sure you correctly fill out all forms and accurately label boxes and samples before sending to the laboratory, so you know exactly which samples apply to each area of interest.

A soil test generally includes the determination of pH, phosphorus, potassium, calcium, and magnesium. Micronutrients (e.g., zinc, copper, iron, and manganese), organic matter, and physical properties (e.g., percentage of sand, silt, and clay) can also be determined. Lime, phosphorus, and potassium application rates are based on soil test results. The only exception is nitrogen fertilization, which should not be based on soil test results. Nitrogen fertilization is based on crop management and expected yields. Caution should be exercised when interpreting fertilizer recommendations generated by commercial laboratories, because they typically use different soil-fertility approaches. For example, while UF/IFAS fertilizer recommendations are based on crop nutrient requirement, the fertilizer recommendations generated by commercial labs (particularly out-of-state) may be targeted to build up nutrient levels in the soil. However, given that most Florida soils are coarse-textured and have limited physical capability to retain nutrients, the nutrient "build-up" approach is not appropriate for both economic and environmental reasons.

The soil and tissue test report will indicate whether crops should respond to fertilization. Extensive research has been done to determine the relationships between available nutrients, fertilization application, and yield responses. For instance, if the soil test indicates that potassium levels are high, then the crops will not respond to additional potassium fertilization. Of greater importance than the actual nutrient concentration is the classification of the degree of nutrient sufficiency. The degree of nutrient sufficiency is reported as three categories: *low*, *medium*, or *high*. Table 1 is a typical representation of current interpretation of soil test results for agronomic crops in Florida. In addition to the soil test results, economic issues (e.g., fertilizer cost, hay prices) must also be considered when choosing the most adequate fertilization management strategy.

Current tissue testing interpretations are only valid for established bahiagrass (Table 2); thus, if the area is managed for other purposes—such as hay, sod, or seed production—a different interpretation approach should be used. *For established bahiagrass pastures,* tissue analysis has been recently incorporated into the revised IFAS fertilizer recommendations as a management tool to guide proper P fertilization. Revised IFAS recommendations state that tissue analysis should be performed when soil tests are low in P (less than 25 ppm of Mehlich-3 extractable P). Assuming the soil pH is within the optimal range for bahiagrass (around 5.5) and the tissue P concentration is below the critical concentration of 0.15%, then P fertilization is expected to improve bahiagrass production. Recommended P application rates vary from 25 lb P_2O_5/acre for the low- and medium-N input options (50 and 100 lb N/ac., respectively), up to 40 lb P_2O_5/ac. for the high-N option (160 lb N/ac.).

Once soil tests and/or plant tissue analyses have been conducted, soil amendment management decisions can be implemented to ensure efficient and effective fertilization strategies for the required forage production goals. The target or goals of production vary according to numerous factors—such as exclusive hay production, hay plus stocking, exclusive stocking by ruminants, desired stocking rate, and cow-calf and/or stocker production. The choice and selection of fertilizer sources and the rates and timing of applications are governed by availability and cost of product. The fertilization strategies are therefore driven by production for a targeted dry-matter response and by the need to sustain the pasture system. If you need further assistance with interpretation of soil test results or fertilization recommendations, consult with your local county UF/IFAS Extension agent or other university personnel.

References

Kelling, K. A. and Matocha, J. E. 1990. "Plant analysis as an aid in fertilizing forage crops." Pages 603–643 in: *Soil testing and plant analysis.* R. L. Westerman, ed. Soil Science of America, Madison, WI.

Mackowiak, C.L. Blount, A.R., Hanlon, E.A., Silveira, M.L. and Myer, R.O. 2013. *Getting the Most out of Bahiagrass Fertilization*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss469.

Mondart, C. L. Jr., Harris, H. E., Brupbacher, R. H. Jr., and Sedberry, J. E. 1974. *Influence of annual applications of phosphorus on the yield and chemical composition of common bermudagrass and on the chemical composition of a Bowie soil*. Louisiana Agric. Exp. Sta. Bull. No. 684.

Mylavarapu, R. S., Wright, D., Kidder, G. and Chambliss, C. G. 2013. *UF/IFAS Standardized Fertilization Recommendations for Agronomic Crops*. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss163.

Silveira, M. L., Obour, A. K., Vendramini, J. M. B. and Sollenberger, L. E. 2011. "Using tissue analysis as a tool to predict bahiagrass phosphorus fertilization requirement." *J. Plant Nutr.* 34: 2193–2205.

Table 1. Current Mehlich-3 soil test interpretation for agronomic crops in Florida (Mylavarapu et al. 2013).

Element	Low	Medium	High
	Part per million (ppm)		
Phosphorus (P)	≤ 25	26–40	> 41
Potassium (K)	≤ 25	26–40	> 41
Magnesium (Mg)	≤ 10	11–23	> 24

Table 2. Critical concentrations of N, P, and K in bahiagrass tissue (Mackowiak et al. 2013).

Element	Critical concentration (%)
Nitrogen (N)	< 1.5
Phosphorous (P)	< 0.15
Potassium (K)	< 1.2