Turfgrass Tissue Testing: Pros and Cons

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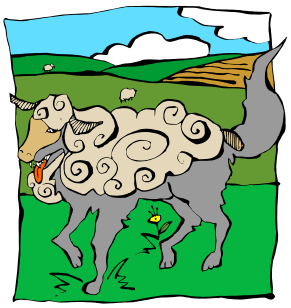
Bottom line: Making sure that turf is receiving optimal nutrition is one the most important activities that turf managers carry out. If the correct nutrients are applied at the right times and in the right amounts, turf health is maximized, while run-off, negative environmental impacts, high costs and high clipping yields are minimized. There are several different tools that are useful in nutrient decision making. Analysis of turf tissues as a means of determining fertility requirements has been popular in the past, but is plagued by sampling errors and by the fact that it does not detect some parameters that are important in turf health. For this reason, anaylsis of soil chemistry is usually a more useful indicator. If tissues analyses are conducted, however, it is important to distinguish between two methods. NIRS (near infrared reflectance spectroscopy) provides a rapid and accurate analysis of tissue nitrogen, but is not accurate for any other nutrients, while conventional wet chemistry provides somewhat better estimates of a wide spectrum of nutrients in turf tissues. Tissue analyses by any method can be useful, especially for investigating specific problems, but should always be used in conjunction with – and not instead of soil analyses.

What you see is what you get: or is it?



One of the reasons that turfgrass tissue testing is so popular is that it seems to make so much sense. After all, what could be more obvious than looking at the turf plant itself if you want to know which nutrients are lacking, which are present in sufficient concentrations, and which are too high? What better way to find out what the turf plant "needs"?

But appearances can be deceiving, and tissue testing is overall not as useful a tool for designing nutrition programs as it might seem. Or as we might hope. In this issue of PACE Insights, we will summarize the benefits and drawbacks of the two major types of tissue testing procedures, provide guidelines for sampling and interpreting tissue test data, and suggest that while tissue testing be a useful tool, it should only be used in conjunction with – and not instead of soil testing.

Why not tissue testing?

While tissue testing can provide an alternate, and at times useful view of turf nutrition and health, there are several reasons why the results achieved may at times be inconsistent, incomplete or just plain wrong. These include:

- Samples are frequently contaminated by dust, fertilizer or pesticide sprays, or by sand or soil. This will cause readings of some nutrients to appear higher or lower than they really are.
- The nutrient content of the foliage can vary depending on the growth rate of the plant. When the plant is growing rapidly, it produces many starches and structural compounds such as lignins, which have the effect of temporarily diluting out the nutrient composition of the plant. If you pulled tissue samples when the plant was undergoing a growth spurt, nutrient levels might appear artificially low.
- Nutrient levels in tissues may also vary depending on temperature, soil moisture and light intensity. For this reason, nutrient levels in tissue samples may vary from week to week, or even from day to day.
- Misleading nutrient deficiencies may show up in tissue tests that are not the result of true deficiencies. Instead, the lack of nutrients in tissues can sometimes be due to physical problems in the soil (compaction, anaerobic conditions, waterlogging, black layer, high salts) that interfere with the ability of roots to take up nutrients from the soil. There may in fact be plenty of nutrients in the soil, but the roots may be unable to take advantage of them. If this is the case, you would run the risk of applying unnecessary nutrients, or even risking toxicity, and the real problem – soil physical properties – would go unaddressed.

Figure 1. Contamination of tissue samples with sand, soil, pesticides or fertilizer granules (as seen below) should be avoided, as this will produce erroneous analytical readings.

- Accumulation of soil organic matter is an important parameter to monitor, since levels

above 6% can lead to decreased water and gas movement in the soil, which in turn can produce anaerobic soils and black layer. However, tissue tests cannot measure soil organic matter.

Some of these problems, such as sample contamination, can be solved by taking more care when collecting samples (see below). But the majority of the issues listed above are inherent in the concept of tissue testing.

The relationship between soil and tissue test results

When we compare the results of tissue testing with the results of soil tests taken from the same greens (Table 1), we see very little relationship between the two types of data. For this reason, most agronomists (see References section below) agree that soil testing provides a more accurate and consistent framework for developing a fertility program, and that tissue testing should not be used as a substitute for soil testing.

This isn't to say that tissue tests aren't useful. They can be especially helpful when a turf health problem arises, and you are attempting to investigate the source. Also, for those golf courses that have access to NIRS (near infrared reflectance spectroscopy) units, very rapid analyses of tissue nitrogen levels can be obtained; this can be useful for making fast decisions on nitrogen fertilization. A watch-out here, though. NIRS analyses, have been shown by several researchers (Carrow et. al., 2001; Rodriguez and Miller, 2000; Stowell and Gelernter, 1998) to be accurate only for measuring tissue nitrogen, and are ineffective for measurement of any other nutrients.

Does soil testing address all of the problems?

While we believe that regular soil testing (twice per year works for many superintendents) forms a good backbone for development of fertility programs, no one analytical method provides all of the information that you'll need. In addition to periodic soil testing, tissue testing can help pinpoint specific problems, as discussed above (for this reason, we have included a chart of tissue guidelines in Table 2). Visual observations (including monitoring of clipping yields as a way to assess nitrogen needs) and close attention to soil physical properties (compaction, infiltration, salt levels) are also critical.

Sampling procedure for tissue testing

Mowing: Clean out any old clippings or sand from the mower basket before mowing. Avoid collecting clippings soon after fertilizer or other chemical applications (Figure 1). Mow enough turf to fill the basket about 1/3 full.

Site selection: Select sites that represent the best and the worst performing turfgrass areas. This wide difference in turfgrass quality will help you develop a sense of the range of values in which good and poor turf grow.

Labeling: Label sample containers (paper bags, plastic bags, or any clean container that holds 1 quart of clippings) prior to mowing. Use a waterproof pen or marker. The label should include the location where clippings were collected (e.g., G 2 for green 2) and an indication of turfgrass quality (e.g., E = exceptional, A =average, and P = poor performing turf). Place one quart of clippings into the labeled container.

Washing: Using a clean bucket, wash each sample separately. Fill the bucket with water that is at least 4 times the volume of the clippings. Mix clippings into the water by hand or with a mixing spoon so that debris such as fertilizer granules or sand particles are washed off of the tissue and sink to the bottom. The tissue will float.

Drying: Find an area that is dry and not in a windy spot. Label pieces of newspaper to match labels on sample containers. Remove the clippings that are floating on the surface of the water and squeeze to get rid of excess water. Spread the washed clippings into a thin layer (less than 1 inch deep) on the newspaper to air dry. Do not use an oven or microwave. Allow the clippings to dry completely (in a dry room, overnight is usually sufficient). When dry, the tissues will blow away easily so be careful in handling them to prevent cross-contamination of samples. Once the tissue has dried, they are stable and will not decay.

Packaging and shipping: Place clippings into a new, clean appropriately labeled paper bag that is appropriately labeled, roll the bag to secure the tissues inside and place a rubber band around the bag to prevent loss of the sample. Ship to an analytical laboratory for analysis.

References

Carrow, R.N., D.V. Waddington and P.E. Rieke. 2001. Turfgrass Soil Fertility and Chemical Problems. Ann Arbor Press, MI.400 pp.

Christians, N. 1998. Fundamentals of Turfgrass Management. Ann Arbor Press, MI. 301 pp.

Marschner, H. 1997. Mineral nutrition of higher plants. 2nd edition. Academic Press, CA. 889 pp.

Rodriguez, I.R. and G.L. Miller. 2000. Using near infrared reflectance spectroscopy to schedule nitrogen applications on dwarf-type bermudagrasses. Agronomy Journal. 92:423-427.

Stowell, L.J. and W. Gelernter, 1998. Tissue Analyses: Guidelines and NIRS Revisited. PACE Insights, November, 1998.

Table 1. The poor relationship between soil and turf tissue analyses. When 20 different parameters were measured in 197 pairs of soil and tissue samples taken from golf course greens (analysis conducted by Brookside Laboratories New Knoxville, OH), only those measurements related to nitrogen and copper (see values highlighted in green) showed any correlation with one another – and even those correlations were weak. This conclusion was reached by calculating the **regression coefficient** (which is a measure of how closely related two sets of data are) and the **probability value** (a measure of the likelihood that the regression is a chance happening). A regression coefficient of 1 means that soil and tissue measurements were perfectly correlated, and a regression coefficient of 0 means that there was no relationship whatsoever. A high probability value (greater than 0.05) indicates that the correlation we're seeing is probably more due to chance than to an actual relationship, while a low probability value (less than 0.05) indicates that the correlation between soil and tissue values is significant, or probably NOT due to chance. To avoid including samples in the analysis that were contaminated with fertilizer, sand or other materials, only pairs of samples that reported less than 400 ppm iron in tissue analysis were used in these calculations.

Soil	Tissue	Regression Coefficient	Probability
Balance measurements			
Ca %	CA %	0.06	0.410
Mg %	Mg %	0.00	0.919
K %	K %	0.11	0.154
Threshold measurements			
NO_3	N %	0.31	0.001
NH_3	N %	0.10	0.319
NO_3:NH_4	N %	0.20	0.038
Total N	N %	0.26	0.006
N from Organic Matter (estimate)	N %	0.26	0.000
Phosphorous Bray II	P %	0.01	0.883
Phosphorous (easily extractable)	P %	0.03	0.678
Ca ppm	CA %	0.03	0.684
Mg ppm	Mg %	0.04	0.573
K ppm	K %	0.01	0.172
SO4 ppm	S %	0.05	0.572
Fe ppm	Fe ppm	0.08	0.284
B ppm	B ppm	0.00	0.403
Mn ppm	Mn ppm	0.02	0.784
Mn availability (MnAI)	Mn ppm	0.01	0.943
Cu ppm	Cu ppm	0.16	0.027
Zn ppm	Zn ppm	0.04	0.567

Reading Table 2

The tissue summary graphs, also known as "box plots", on page 4 can be used as rough guidelines for evaluating your results. The plots are based on data from good performing greens in Illinois (23 locations) and California (25 locations). The words in the central red column on page 4 indicates the state and the analytical procedure used. For example, the top box in each graph are wet chemistry results from Illinois (IL WET). Normal tissue values should fall within the limits of the horizontal lines extending from the box. And for the best performing turf, values should fall within the outlines of the box for each nutrient. Although we do not recommend using tissue analyses alone to make nutrient recommendations (results of soil analyses tend to provide much more detailed and useful information), they can be helpful in identifying areas with serious nutrient imbalances.

Table 2. Tissue nutrient values from good performing greens in Illinois (IL) and California (CA) determined by conventional wet chemistry (WET) and near infra-red reflectance spectroscopy (NIRS). While NIRS values appear to be accurate primarily for nitrogen, wet chemistry values provide a more accurate analysis of the nutrients below.