TISSUE TESTING: QUESTIONS AND ANSWERS

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HAVING the opportunity to monitor the cutting edge of technology in the golf course maintenance industry is an exciting part of the work of USGA agronomists. We are continually asked questions about new products and procedures, and we are among the first to see them in action. Unfortunately, not all questions have easy or direct answers. The question about the value and use of tissue testing falls into this category. Tissue testing is being performed more and more, and questions about this practice have grown more numerous and pointed. Following are some of the most often asked questions about tissue testing, along with some answers that provide a perspective on the potential value of this technology in the turfgrass industry.

In preparing these questions and responses, references were obtained through the Turfgrass Information File (TGIF), and university researchers throughout the country were interviewed for their views on this timely topic.

Question: What is tissue testing?

Answer: *Tissue testing* involves analysis of foliar tissue (grass clippings) for nutrient content, and should not be confused with *plant analysis*, which determines the elemental content of all the plant tissue (leaves and roots).

The goal of tissue testing is to better meet the nutritional needs of golf course turf. In theory, knowing the nutritional content of turfgrass tissue would allow the design of a more efficient fertility program to produce healthier and better quality turf. However, nutrient interactions occurring within the turfgrass plant (combined with varying environmental conditions) are not completely understood, and modifying a fertility plan based on tissue test results is difficult and is not recommended by most turfgrass scientists at this time.

Question: Are all tissue testing techniques the same?

Answer: No, they are not the same. Basically, there are two approaches that can be used: Wet Chemistry techniques and Near-Infrared Spectral analysis (NIRS).

Tissue Testing Methods
(Jones & Kalra, 1992)

Wet Chemistry
Atomic Absorption Spectrometer
ICP Plasma Spectrometer
DC Plasma Spectrometer

Other
Near-Infrared Spectral

Wet chemistry techniques utilize sophisticated laboratory equipment and dilution materials to determine nutrient concentrations. The Atomic Absorption spectrometer (a wet chemistry technique) can provide very accurate data, but the turnaround time for receiving results after submitting a sample may be as long as two weeks.

Recently, an effort has been made to adapt NIRS technology for analyzing the nutrient content of turfgrass tissue samples. Near-infrared spectral analysis can be done much more quickly and cost effectively than wet chemistry, and was first used to analyze forage grasses for protein content (Wilkinson & York, 1986). NIRS utilizes a spectrum of light in the near-infrared region. The instrument measures reflectance at specific bands or wavelengths of this light spectrum. A computer then uses this information to statistically predict the content of specific nutrient elements.

Unfortunately, many turf managers confuse the two methods. Wet chemistry analysis is a primary method of determining nutrient concentrations, while NIRS is a secondary method. In other words, a single wet chemistry lab (providing repeatable results) must be used to generate the database which then is used by NIRS technology. These data are stored in the computer and serve as a base from which tissue nutrient concentrations can be estimated. This process is ongoing.

The bottom line is that *wet chemistry* and *NIRS* techniques are different, and the terms should not be used interchangeably.

Question: Which method provides the most accurate results?

Answer: Wet chemistry techniques provide an accurate analysis of the nutrient concentrations within turfgrass leaf tissue (Jones & Kalra, 1992). On the other hand, available information and research literature do not support the accuracy of the newer NIRS procedure at this time. With the exception of nitrogen, correlation studies between NIRS and wet chemistry have produced weak to moderate relationships for many nutrient concentrations. NIRS provides results very rapidly, but unfortunately, interpreting the data is difficult and the accuracy of this technique currently is questionable.

Question: Can tissue analysis provide information about fertilizer needs that cannot be obtained from soil analysis?

Answer: Yes, but the information gained is difficult to interpret. Soil testing is the place to begin when designing a fertility program.

Many turf managers have the impression that plant uptake of nutrients is directly related to the amount of nutrients available in the soil. Research has shown that this is not always true. The relationship between nutrient supply in the soil and nutrient concentrations in the plant is strongest when nutrient supplies become so low that they limit the growth of the turf. Plants have internal mechanisms that allow them to control nutrient uptake to meet their needs when nutrient concentrations in the root zone are plentiful. Nutrient deficiency develops when demands are in excess of supply (Kussow, 1993). Therefore, adequate nutrition levels may exist in the soil, but plants, for a number of reasons, might not be taking up those nutrients. Tissue tests could be used to indicate nutrient deficiencies in the plant that do not actually exist in the soil. In some cases, adjusting the soil pH may be all that is needed to correct a nutrient availability problem.

Question: Do baseline tissue nutrient concentration levels exist for turfgrass?

Answer: Unfortunately, no. Baseline nutrient levels for turfgrasses do not exist. Baseline levels refer to nutrient concentrations within turfgrass plants that correspond to optimum development, growth, and appearance. The nutrient concentration levels established for forage grasses were first used as the standard for turf, but one could question the use of forage standards in making decisions about turfgrass fertilization!

The fact remains that nutrient levels in turfgrass vary considerably depending on species, cultivar, time of sampling, and management practices (Overman & Wilkinson, 1993). J. R. Jones (1980) summarized the literature and suggested sufficiency ranges for elemental tissue contents. These ranges, however, are not applicable in all situations (Turner, 1992; Turner & Hummel, 1992). For example, interpreting tissue test results for a polystand of turf (such as *Poa annua* and bentgrass) is even more difficult. Nutrient concentrations that are acceptable for bentgrass might not be acceptable for *Poa annua* or vice versa. Very few golf course putting greens consist of a single turf species. Even mixed stands of perennial-type and annual-type *Poa annua* could present a problem, as could blends of bentgrass cultivars. Much more research is needed.

Question: If I choose tissue testing as a tool to monitor my fertility plan, how frequently should tissue testing be performed?

Answer: Weekly testing would provide data that could be analyzed for possible trends. Maintaining weather records would also help. For instance, nitrogen will accumulate during cooler weather, while nitrogen depletion will take place during warmer weather. Nitrogen concentrations are dynamic. On one day it may be adequate and two days later it can be deficient. Also, other nutrient concentrations may be affected by nitrogen fluctuations, which may or may not affect turf quality. The more data generated, however, the greater the chance that strong correlations (with soil tests, time of year, weather, visual quality, playability, etc.) will exist. Two or three years of data collection may be necessary before this information is of value.

Question: What are some of the pitfalls commonly associated with tissue testing?

Answer: Difficulty in interpreting results is a significant pitfall. Cost is also a consideration. Testing can become expensive if many samples are analyzed. In addition, if test results indicate deficiencies of micronutrients and corrective treatments are made, these applications can be expensive. Also, micronutrients are required in small amounts and overapplication is a risk.

Representative tissue samples can be easily obtained thanks to clipping removal programs.

Question: Since micronutrients are required in very small amounts, how can I tell if the materials being applied are doing any good?

Answer: A common pitfall in turfgrass maintenance is the lack of test plots. Test plots not only provide areas to calibrate spray equipment, but also provide an excellent opportunity to visually examine turf quality differences following different treatments. Tissue testing will not accurately determine nutrient concentrations unless all of the material applied has been absorbed. Any residuals that remain on the leaf will cause inaccuracy. In fact, some fungicides can solubilize nutrients and allow for uptake into the plant. The practical approach is to utilize a test area before deciding to make blanket applications of micronutrients.

Question: Is there a governing body or an association that monitors the testing procedures being used by testing laboratories?

Answer: Yes, the *Council on Soil Testing and Plant Analysis* was formed in 1969 (Jones & Kalra, 1992). Its major objectives are:

1. To promote uniform soil testing and plant analysis methods, use, interpretation, and terminology.
2. To stimulate research on the calibration and use of soil testing and plant analysis.
3. To provide a forum and information clearinghouse for those interested in soil testing and plant analysis.
4. To bring individuals and groups from industry, public institutions, and independent laboratories together and share information.

A survey was sent to testing laboratories in the United States and Canada. The results indicated that a majority of the laboratories responding to the survey provide a wide range of services and utilize the latest available technology. Interestingly, not one of the nearly 200 laboratories responding to the survey (601 surveys were mailed) were using the NIRS technology to determine tissue nutrient levels. All were using wet chemistry techniques. The accuracy of NIRS has not been substantiated by research and thus is not recognized by the Council as a reliable testing method. However, NIRS is being used by a number of vendors nationwide, and this is where many of the concerns and questions from turf managers arise.

Question: Of what practical value is "tissue testing" in day-to-day golf course maintenance?

Answer: For tissue testing to be helpful in day-to-day turfgrass management, the results from tissue testing must be obtainable in a timely fashion. Regrettably, wet chemistry tissue testing takes time to complete, often days or weeks. Thus, if an immediate problem needs to be addressed, tissue testing would not be practical.

For tissue testing to be helpful as a diagnostic tool, it must provide results that are interpretable and also correspond well with soil tests. Much of the research examining soil nutrient levels to determine low, medium, and optimum ranges was performed more than 20 years ago. The fertility trends of that era, particularly for nitrogen, were higher than those rates commonly applied today, so soil test interpretations that are based on 1970s protocols may be erroneous.

It is fair to conclude that correlating soil test data with tissue nutrient concentrations is very difficult (Hall, 1974; Goss & Brauen, 1985; Spear & Christians, 1991) and misleading.

Question: Is fast and accurate tissue testing unobtainable by the turf manager?

Answer: There is new technology available that can provide rapid, accurate, and inexpensive results. Inductively Coupled Plasma-emission spectrometry (ICAP) is an advanced wet chemistry technique that can analyze a sample for a wide range of elements. An increasing number of testing laboratories are using ICAP, although the atomic absorption wet chemistry method is still the most frequently employed procedure (Jones & Kalra, 1992).

Also, NIRS technology is improving. New hardware, software, and a new and expanded data base are being developed. In time, this technology may have greater application in the turfgrass management industry.

Summary

Tissue testing may prove to be useful for monitoring nutritional fluctuations within turfgass. However, information on which to base a complete fertility program has not been developed (Christians, 1993). The usefulness of tissue testing is very site-specific due to variables such as soil pH, CEC, soil type, plant species, soil moisture, height and frequency of mowing, time of sampling, soil temperature, herbicide, fungicide or growth regulator applications, fertility regimes, topdressing schedules, and other cultural programs.

Tissue testing may be used to supplement soil test results but should not be considered as a replacement for soil testing. It is the consensus of all the scientists contacted while preparing this article that more research is needed to make tissue testing a standard tool on which to base fertility recommendations.

Tissue analysis has long been used in production-based agriculture to help achieve maximum yields (Smith et al., 1985). But turf management is not focused on maximum tissue yields. Quality is more important than quantity.

As with any new technique or management strategy, university research and field testing must be combined to document the usefulness and practical value of tissue testing. Establishing a strong foundation (cultural practices, sound water management, balanced fertility) is important before the full benefits of fine-tuning techniques such as tissue testing can be realized.

Many turf managers are integrating tissue testing into their management programs. It is one of many new tools being developed, all focused on helping the turf manager become more effective and efficient. New technology stimulates questions that are investigated, and this leads to better understanding and ultimately better management techniques.

Tissue testing results are no better than the sample taken. Samples should be free of weeds and other contaminants such as moss.

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