PLEASE FORWARD TO COURSE SUPERINTENDENT

Near Infrared Reflectance Spectroscopy (NIRS), Atomic Emission Spectroscopy (AES), and Automatic Nitrogen Analysis (ANA)

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Holy mackerel, how did we get ourselves in this deep? It's easier than you might imagine. Many of you recently participated in a tissue analysis survey that compared these techniques. The most popular method of tissue analysis requires a laborious chemical extraction and expensive analytical tools, such as atomic emission spectroscopy (AES) for the major and minor elements except nitrogen and an automatic nitrogen analyzer (ANA) for nitrogen. More recently, near infrared reflectance spectroscopy (NIRS) has captured the interests of the golf course industry because it promises to be a fast and simple way to monitor turfgrass tissue nutrient status that can be carried out in a golf course superintendents office. Unfortunately, NIRS technologies have fallen far short of delivery on this promise.

This issue of PACE Insights summarizes a portion of the recent tissue analysis survey that compared NIRS to the conventional analytical chemistry methods using the more accurate AES and ANA techniques. The study reveals that only nitrogen strongly correlates between the NIRS and ANA. Correlations between NIRS and AES were not significant. Based upon these results, NIRS should only be used to roughly estimate nitrogen status of turfgrass tissues and NIRS should not be used to evaluate the other major and minor nutrients.

Background: Analytical chemistry is an important discipline. It helps us understand plant nutrition and has become increasingly important in the effort to insure the safety of our food and water. There are a wide range of methods for identifying the chemicals and elements present in samples of turfgrass tissues, soils, food, and water. The three methods that will be compared in this report are near infrared reflectance spectroscopy (NIRS), atomic emission spectroscopy (AES), and automatic nitrogen analysis (ANA).

The AES and ANA methods are considered conventional even though the machines that are used in these analyses are sophisticated instruments. The basic difference between these three techniques is that AES and ANA measure the amount of each element in a sample, whereas the NIRS measures the amount of chemical bonds that are present in the sample. For example, measuring the amount of nitrogen (N) in a tissue sample using NIRS would result in "counting" the number of carbon (C) to N bonds and then assuming the number of C-N bonds is equivalent to the number of N atoms in the tissue. Because NIRS can accurately measure C-N bonds, NIRS has been widely used to determine the amount of protein in animal feeds.

Unlike NIRS, ANA systems analyze tissue samples by flash burning the sample, converting the nitrogen products of the burn to nitrogen gas, separating the nitrogen gas from the other gasses and then measuring the amount of nitrogen gas produced during ignition of the sample. AES methods require dissolution of the sample and injecting the sample into a high energy system, for example a plasma at 12,000° C, and measuring the amount of light that each element emits. The AES and ANA systems are more direct and less prone to interference compared to the NIRS system.

Materials and Methods: Tissue samples from 32 different golf course greens were collected by 16 golf course superintendents in Southern California. Immediately following receipt at PACE, each sample was first air dried and then oven dried at 80 C overnight. Dried samples were stored in paper bags

inside sealed ziploc bags prior to grinding. All samples were ground for 60 sec in a Braun coffee mill to produce a fine powder. Each sample was divided into two 10 g sub-samples and placed into two vials. One vial was shipped to Brookside Laboratories and the other to University of Arizona for analysis. The results below summarize the correlations found between the Karsten NIRS carried out by Charles Mancino and Alison Maricic, University of Arizona, and AES and ANA conducted by Brookside Laboratories, New Knoxville, OH.

Results and Discussion: Percent nitrogen (%N) was found to be significantly correlated between the NIRS and ANA techniques. None of the other elemental analyses were correlated between the NIRS and AES. Interestingly, the NIRS results were not correlated with ANA when plant %N levels were below 4.5%. Therefore, NIRS is only providing reliable results at %N levels above 4.5%.

Near infrared reflectance spectroscopy is a developing technology. Unfortunately, the basic mechanism of detection is based upon chemical bonds and not direct measurement of the elements in the sample. This mechanism of detection is prone to error when samples contain a wide range of substances, for example turfgrass tissues. Although NIRS and ANA nitrogen results were correlated, the NIRS was only accurate when the plant already contained high nitrogen levels (>4.5%). Further improvements in NIRS will be needed before this technology will find a practical application in turfgrass nutrient management.

Bottom line: Based upon the results of this survey, Near Infrared Reflectance Spectroscopy is not sufficiently accurate to assist golf course superintendents in managing turfgrass fertility.

Figure 1. Correlation between percent tissue nitrogen values (%N) determined by NIRS and ANA. Note the correlation is more precise at %N values greater than about 4.5%. Also note that the slope of the line (0.6) indicates that the NIRS system is only detecting about 60% of the N compared to the ANA system.

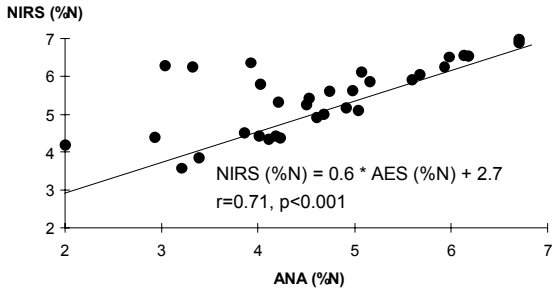

Table 1. Significant correlation table. The AES or ANA and NIRS values are significantly correlated if the probability that the interaction is due to chance is less than 5% (0.05). Only percent nitrogen (%N) by NIRS and ANA were significantly correlated.

Element	Correlation between[1] AES or ANA and NIRS
%N (nitrogen)	Significant
%P (phosphorous)	Not significant
%K (potassium)	Not significant
% Ca (calcium)	Not significant
%Mg (magnesium)	Not significant
%S (sulfur)	Not significant
B ppm (boron)	Not significant
Fe ppm (iron)	Not significant
Mn ppm (manganese)	Not significant
Cu ppm (copper)	Not significant
Zn ppm (zinc)	Not significant
Na ppm (sodium)	Not significant

[1]Nitrogen was evaluated using ANA and NIRS. All other elements were evaluated by AES and NIRS.