Tissue Analyses: Guidelines and NIRS Revisited

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Bottom line

The use of Near Infrared Reflectance Spectroscopy (NIRS) for analysis of plant tissues has the advantage of providing answers rapidly, and of providing accurate estimates of tissue nitrogen content. However, NIRS is not sufficiently accurate to provide accurate estimates of ten other key tissue nutrients. For this reason, standard wet chemistry methods are more reliable indicators of serious imbalances in turfgrass nutrition than is the NIRS method. It is also important to remember that tissue analyses by any method should always be used in conjunction with – but not instead of soil analyses.

Near Infrared Reflectance Spectroscopy systems have improved since we first reported on the accuracy of NIRS for turfgrass tissue analysis in comparison to wet chemical extraction and analysis in 1995 (PACE Insights, March, 1995 and 1995 PTRI Turgrass Research Report). At that time, the comparison between standard wet chemical methods and NIRS indicated that NIRS could fairly accurately estimate the nitrogen content of tissues, but did not provide accurate estimates of other key soil nutrients such as potassium, calcium, magnesium, iron, manganese, boron, copper, zinc and sodium. In 1998, a cooperative project was established to re-visit the value of NIRS vs. standard wet chemistry for use in making turfgrass fertility management decisions.

The 1998 project was a cooperative effort among 23 Illinois golf course superintendents (a complete list of cooperators and a detailed description of Materials and Methods will be published on the PACE-PTRI web site and PTRI annual report), Dr. Robert Carrow of the University of Georgia, Oscar Miles of The Merit Club, Arthur Cleason Professional Products, the PACE Turfgrass Research Institute, and the key instigator of the study, Steve Davis of AgrEvo. This *PACE Insights* will review the results of the 1998 study and will provide unique summary graphs that will help you determine if your turfgrass tissues are deficient, within normal ranges, or exceeding desired ranges for key nutrients.

Reading the NIRS – wet chemistry graphs: Figures 1 - 11 summarize the 98 samples of turfgrass tissues that were analyzed. Each circle on the graphs represents the results of a single tissue sample evaluated using wet chemistry and NIRS. If the results are identical using both methods, the data will be perfectly correlated, and the circles will all fall along a line that starts at x=0 and y=0 and passes through x=1 and y=1, x=2 and y=2 and so on. This perfect correlation would have an intercept (b) of 0.0, a slope (m) of 1.0, and a regression coefficient (R^2) of 1.0 with a probability (p) that the correlation is due to chance of 0.00. The equation that describes the interaction of x (wet chemistry) and y (NIRS) in this example of a perfect correlation would be: **y = mx +b or y = 1•x + 0**. The example above would be reported as: b=0.0, m=1.0, R^2=1.0, p<0.00.

Figures 1 –11 can be used to evaluate the accuracy of NIRS vs. wet chemistry by studying the values of R^2 and p for each of the 11 nutrients tested. For turfgrass management purposes, we can assume that NIRS is roughly as accurate as wet chemistry if the R^2 value is near or above 0.80 and the probability that the correlation is due to chance is below 0.05 (or 5%). Of the 11 nutrients studied, only the results illustrated in Figure 1 for nitrogen indicate that NIRS was as accurate as standard wet chemistry. None of the other nutrients were predicted accurately enough using NIRS, however.

Figure 1. Correlation between percent tissue nitrogen values determined by wet chemistry (WTNPER) and NIRS (IRNPER). Although the correlation is not perfect, it is very good indicating that NIRS provides accurate estimates of tissue nitrogen levels. b=0.46, m=0.82, R^2=0.78, p<0.00

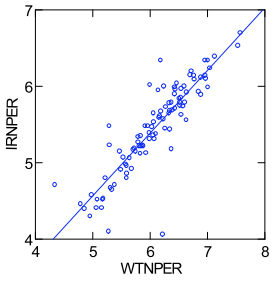


Figure 2. Unlike nitrogen, the NIRS percent phosphorous (IRPPER) is not sufficiently correlated with wet chemistry analysis of tissue percent phosphorous (WTPPER) to guide management decisions. b=0.50, m=0.28, R^2=0.19, p<0.00

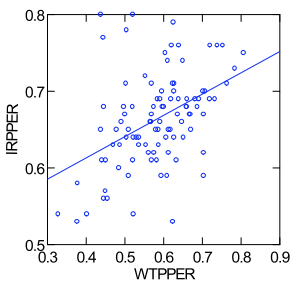


Figure 3. Correlation between NIRS tissue potassium percentage (IRKPER) and wet chemistry potassium percentage (WTKPER). The correlation is significant but not precise enough for management recommendations. b=1.16, m=0.51, R^2=0.28, p<0.00

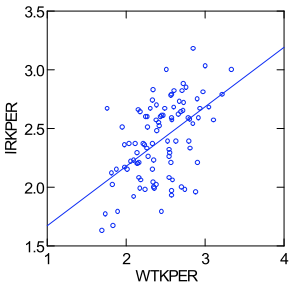


Figure 4. Correlation between NIRS tissue calcium percentage (IRCAPER) and wet chemistry calcium percentage (WTCAPER). The correlation is significant but not precise enough for management recommendations. b=0.46, m=0.27, R^2=0.09, p<0.00

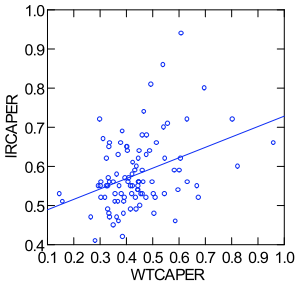


Figure 5. Correlation between NIRS tissue magnesium percentage (IRMGPER) and wet chemistry magnesium percentage (WTMGPER). The correlation is not significant. b=0.0, m=0.03, R^2=0.00, p<0.65

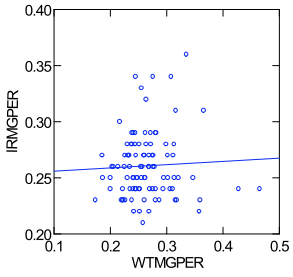


Figure 6. Correlation between NIRS tissue manganese ppm (IRMMNPPM) and wet chemistry manganese ppm (WTMNPPM). The correlation is not significant. b=124.21, m=0.00, R^2=0.00, p<0.86

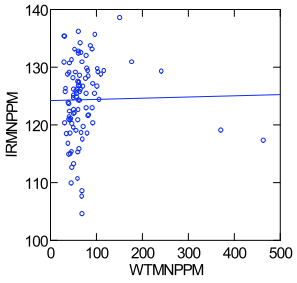


Figure 7. Correlation between NIRS tissue iron ppm (IRFEPPM) and wet chemistry iron ppm (WTFEPPM). The correlation is significant but not precise enough for management recommendations. b=222.47, m=0.84, R^2=0.54, p<0.00

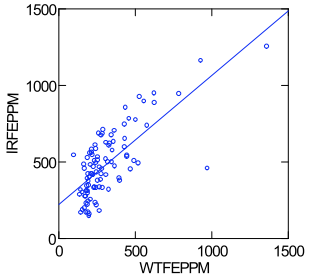


Figure 8. Correlation between NIRS tissue boron ppm (IRBPPM) and wet chemistry boron ppm (WTBPPM). The correlation is significant but not precise enough for management recommendations. b=6.77, m=0.12, R^2=0.04, p<0.0.04

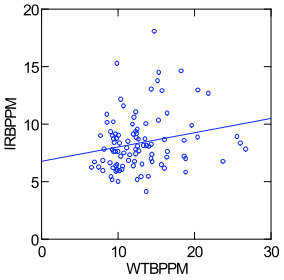


Figure 9. Correlation between NIRS tissue copper ppm (IRCUPPM) and wet chemistry copper ppm (WTCUPPM). The correlation is significant but not precise enough for management recommendations. b=21.86, m=0.15, R^2=0.29, p<0.00

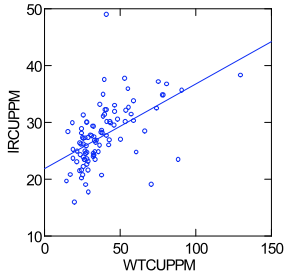


Figure 10. Correlation between NIRS tissue zinc ppm (IRZNPPM) and wet chemistry copper ppm (WTZNPPM). The correlation is not significant. b=70.90, m=0.00, R^2=0.00, p<0.84

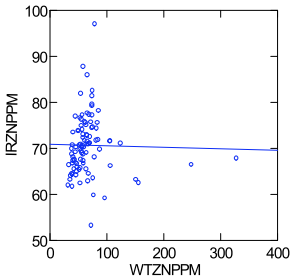
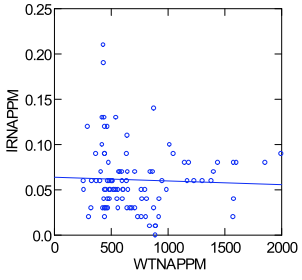
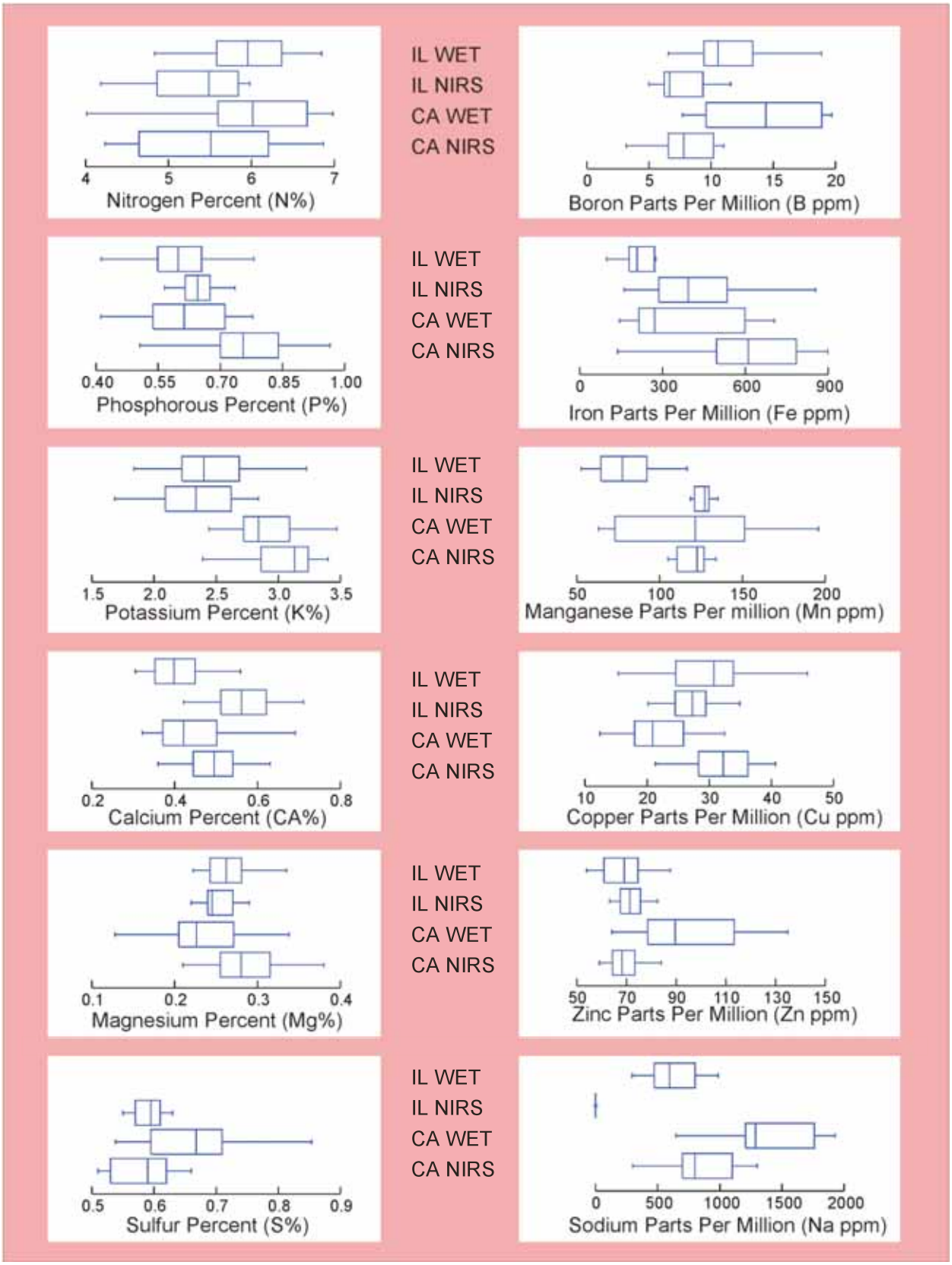


Figure 11. Correlation between NIRS tissue sodium ppm (IRNAPPM) and wet chemistry sodium ppm (WTNAPPM). The correlation is not significant. b=0.06, m=0.0, R^2=0.00, p<0.69



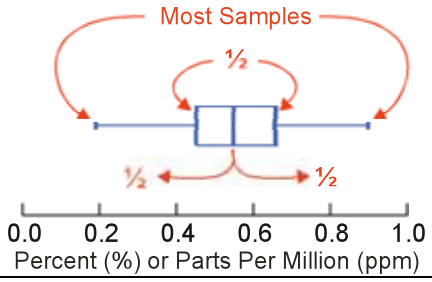
Tissue Nutrient Values from Good Performing Greens in Illinois (IL) and California (CA) Determined by Wet Chemistry (WET) and NIRS



Tissue Summary Graphs: The tissue summary graphs, also known as "box plots", on page 3 can be used as rough guidelines for evaluating your own tissue results. The plots are based on data from good performing greens in Illinois (23 locations) and California (25 locations), and they illustrate the nutrient values we obtained from golf courses in each state using standard wet chemistry (WET) and the NIRS method. The words in the central red column on page 3 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. Ideally, your tissue 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.

Figure 12. How to read box plots for evaluation of tissue analytical results. The vertical line in the box represents the median – the value at which half of the samples were higher and half were lower (about 0.55 in the example below). The box represents the range of values for the central ½ of the samples. The horizontal lines extending from the box, called whiskers, represent the range that most samples fell in; only a few "outliers" were reported outside the range of the whiskers. Sample values that fall within the limits of the box would be considered typical for good performing greens. Sample values falling outside the whiskers are atypical and probably represent either a deficiency or excess of that nutrient.



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