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Soil and Tissue Analyses: Do They Correlate?

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Balance your soil chemical components and you will have healthy turfgrass. This is a quote that we have heard many times. we support this approach but when attempts are made to find out if the soil chemistry values are related to the chemistry of the plant that is growing in the soil, disappointing results frequently occur. Over the past three years, PTRI has been collecting soil and tissue chemical data from paired analyses - tissues collected from the same golf course green where soil samples were collected. The results of statistical analyses were targeted at identifying any correlations between the soil and tissue values that would suggest a sound method for making soil fertility recommendations. The data is preliminary and more samples need to be included in the analysis before a concrete conclusion can be made. However, the current data suggests that most golf course greens contain a surplus of the major and minor elements. The only significant correlations between soil levels and tissue composition were soil nitrate and percent tissue nitrogen, soil magnesium and percent tissue magnesium, soil potassium and percent tissue potassium and soil sulfate and percent tissue sulfate.

Correlation is a method of determining whether the interaction of two factors are related or whether there is no interaction between the factors. For example, it is common knowledge that high nitrogen fertilization results in greater clipping yields than with lower nitrogen fertilization. But what about the other turf nutrients? Can a soil test result be used to help decide what amendments are needed and are the results predictable. What is the best way to determine how to adjust soils based upon test results? Are simple soil threshold values or are more complex soil balance methods?

To balance or not to balance, is one of the questions that continues to provoke discussion. When soil chemical balance is discussed, it usually refers to the ratios of the cations - positively charged elements, calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), and hydrogen (H) to one another. A general balance between these cations that is thought to produce healthy soils has persisted through the years and is listed in table 1 below. Percent refers to the percentage of the total extractable cations (TEC) that are extracted from the soil. In California, the primary reason that this technique is utilized is to help make recommendations that reduce sodium percentages in soil. Sodium levels above 6% of the TEC are considered stressful to turf. Figure 2 illustrates the balance between Ca and Na in the soil. The interplay between these two cations is easily evaluated and the correlation is statistically significant ($r = 0.43$, $p=0.001$).

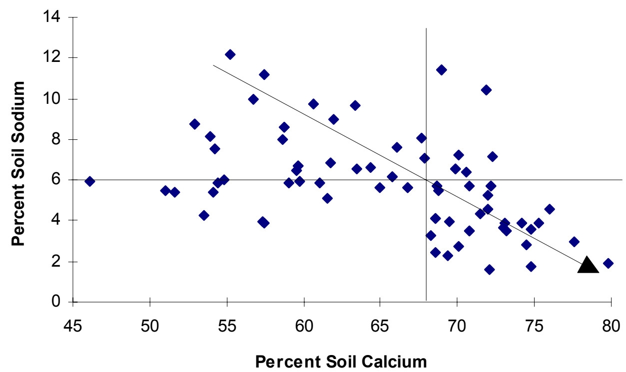
If the balance strategy were a valid method of adjusting soils to produce a plant response, there should be some positive correlations between cation soil percentages and tissue composition. In testing this hypothesis, only percent soil magnesium was directly correlated with tissue magnesium (Table 2).

Table 1. Approximate values for major cations that is frequently used to guide recommendations for soil amendments.

Cation	Percent
Calcium	68
Magnesium	12
Potassium	4
Hydrogen	10-15
Sodium	<3

Figure 1. Relationship between percent soil calcium and percent soil sodium. When soil

calcium exceeds 68% most samples report less than 6% sodium, the upper threshold for vigorous turf growth.



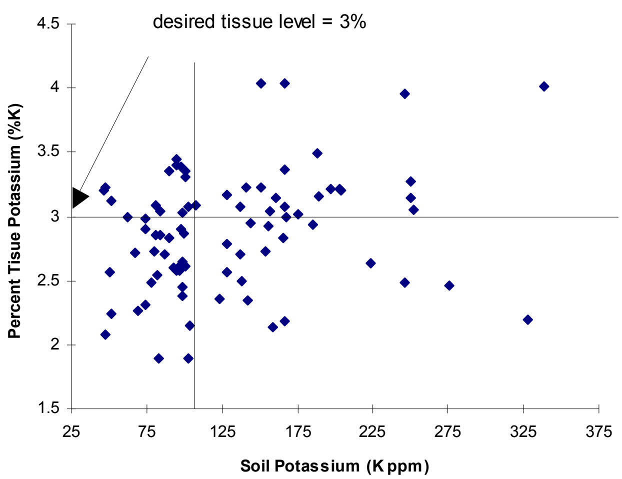
Sufficiency Thresholds are values that are used to trigger an application of a plant nutrient. If the soil test reports levels of an element that are below the threshold, applications of the element are recommended to bring the element into the desired range. In this case, the percentage composition is less important than the concentration of the nutrient. If we believed this strategy, there should be direct relationships between the concentration of the nutrient in with the concentration of the nutrient in the tissues. Using this strategy, nitrate, magnesium, potassium iron and sulfur demonstrated significant correlations between soil and tissue levels.

Potassium and magnesium are two of the soil elements that were found to be positively correlated with tissue levels. In both cases, the concentration of the element increased in the tissues with increases in soil. Magnesium but not potassium also demonstrated a positive correlation between percent magnesium and tissue concentration. A threshold might be determined for potassium that provides a high probability that the turf will be provided sufficient potassium. The a simple value, for example 110 - 200 ppm of soil potassium is the desired amount of this element for healthy growth. If the soil contains less than 110 ppm of potassium, potassium is recommended. If the soil contains potassium levels within the range, no additional potassium is needed.

Table 2. Results of correlation analysis using paired soil and tissue samples from golf course greens. The regression coefficient is a measure of the precision of the regression with a value of 1 being perfectly correlated. The probability value is a measure of the likelihood that the regression is a chance happening. Values less than 0.05, indicate a significant correlation between the soil and tissue values.

Soil	Tissue	Regression Coeff.	Probability
NO3	N %	0.34	0.04**
NH3	N %	0.09	0.59
Total N	N %	0.31	0.06
Phosphorous Bray II	P %	0.00	0.88
Phosphorous Easily	P %	0.01	0.93
Ca ppm	CA %	0.82	0.46
Ca %	CA %	0.00	0.42
Mg ppm	Mg %	0.28	0.01**
Mg %	Mg %	0.33	0.00**
K ppm	K %	0.26	0.02**
K %	K %	0.00	0.30
SO4 ppm	S %	0.23	0.04**
Fe ppm	Fe ppm	0.29	0.01**
B ppm	B ppm	0.10	0.37
Mn ppm	Mn ppm	0.00	0.25
Cu ppm	Cu ppm	0.02	0.86
Zn ppm	Zn ppm	0.28	0.25

Figure 3. Relationship between soil potassium (ppm) and tissue potassium (%). Even though the statistical analysis identified a significant correlation between these two factors, the correlation is not sufficient to provide a good basis for making recommendations. If the target is to grow turfgrass plants containing 3% potassium, there is not a clear soil potassium content that can be selected that will guarantee this level of tissue potassium. However, the data suggests that soils with potassium levels below 110 ppm (vertical line) appear to result in more plants with less than 3% potassium than soils.



Nothing seems to work very well even when the most sophisticated analytical procdures are followed. The problem that turfgrass managers are facing is not a lack of good information. The likely cause of confusion surrounding soil and tissue analyses is most likely a result of the good management practices of most superintendents. Figure 4 illustrates the interaction between soil nutrition and plant composition. The positive correlation only appears when the plants are limited for a particular nutrient. Once the soils have accumulated nutrients to surpass the sufficiency levels, the correlation disappears. The sufficiency stage allows the plant to acquire only the nutrients that are needed. If this is the case, it will be difficult to develop simple mathematical models that describe the interactions of the elements.

Is there a best way to evaluate soils and tissue samples? Yes, it entails field observations an use of soil balance and threshold stragegies. PTRI will continue to research the relationships between soil and tissue analyses.

Figure 4. Eample of plant accumulation of a nutrient from soil reserves as it relates to the abundance of the nutrient in the soil. Increasing accumulation will occur up to the point where more nutrient can not be acquired and assimilated into the plant tissues. Once the surplus level of a nutrient has been reached, there is no point in adding more of the nutrient.