Unlocking the Mysteries: Interpreting a Soil Nutrient Test for Sand-Based Greens

Reading and interpreting a soil nutrient test requires both knowledge of the testing methods and value of the information.

by JAMES E. SKORULSKI

SOIL NUTRIENT tests and their recommendations can be confusing and perhaps even intimidating. The confusion often arises from the methodology used to complete the tests, the terminology used in the test reports, and differing interpretation philosophies employed by the laboratories. Do not get discouraged. With a little work, you can better understand how tests are conducted, how the methodology used in the laboratory can affect the test results, and what information is most pertinent in managing fertilizer inputs for greens.

Extraction Methods

Much of the confusion and mystery surrounding soil nutrient tests arises from the multitude of extracting agents used by laboratories to determine concentrations of plant-available phosphorus (P), calcium (Ca), magnesium (Mg), potassium (K), micronutrients, and calculate total CEC (cation exchange capacity) of the rootzone mix. The two most common extracting agents used for P are the acidic Bray I, used when soil pH is below 7.2, and the alkaline Olsen, used when soil pH is higher than 7.2. The Morgan, Mehlich I, and Mehlich III are acidic extracting agents that also are used. The acidic agents will dissolve higher quantities of P from calcareous sands than may actually be available to the plant.

Neutral ammonium acetate (pH 7) is used by most soil laboratories to determine K, Ca, Mg, and Na cation concentrations on exchange sites and in soil solution. Laboratories located in the central and western states, where most soils are calcareous, may use ammonium bicarbonate or sodium bicarbonate agents. A number of laboratories choose to use more acidic ammonium acetate (pH<4.8), Mehlich I, or more universal Mehlich III (pH<2) extractants for cations. Note that using the acidic reagents on highly calcareous sands can overestimate Ca and Mg cations and the CEC value of those sands. This could adversely affect management decisions in salt-affected soils. The most commonly used extractant for micronutrients (Cu, Mn, Zn, and Fe) is DTPA. Some laboratories choose to use Mehlich III for micro-nutrients, but that extraction method is not well correlated with DTPA extractions.

Soil nutrient tests are especially critical for new sand-based greens to properly manage fertilizer programs and track the progress of those programs as the greens establish.

The fact that soil laboratories rely on different extraction agents accounts for some of the differences observed in test values and interpretations when a new laboratory is used. It is a good idea to know which extracting agents were used and decide if those agents are appropriate for your site. Laboratories base their nutrient target values and recommendations on the extractant they choose to use.

Paste Extractions

Laboratories usually use a water-saturated paste extraction to analyze salt concentration in the soil. The method involves saturating a soil sample with distilled water to form a paste. The salts dissolved in the water are determined by electrical conductivity (EC) or calculated as total dissolved salts (TDS). The saturated paste extraction technique is sometimes requested for cations with the idea that this form of extraction more closely mimics the soil water and is thus a more realistic estimate of available nutrients. The water paste extractions tend to provide lower nutrient values than other extraction methods, as they do not account for the cations bound to exchange sites or that are available as relatively soluble compounds. Saturated paste extracts may eventually be of use in sands with very low CEC. However, the lack of correlation data for turfgrass and the rapidly fluctuating state of the soil water limit the predictive value of this method at the present time.

Soil pH/Buffer pH

The soil pH values may be the most important information provided in the soil test. It is a measure of H ions in the soil solution and on available exchange sites. Hydrogen ions dominate the exchange sites in more inert acid silica sands, whereas Ca, Mg, and K will dominate sites in more alkaline or calcareous sands. The majority of laboratories determine soil pH using a 1:1 or 1:2 soil to distilled water mixture. Fewer laboratories use a 1:1 or 1:2 soil to water/salt mixture. Note that switching from water to a water/salt mixture can result in about a half point pH difference.

Sands with an acid pH are treated with a buffering solution to determine their buffer pH or acid index. The buffer pH value may or may not be included on the test report. The laboratory uses that value to develop liming recommendations. A lower buffer pH value means the soil has higher acid reserves and will require

Table 1 Nutrient Holding Capacity of Soil Based on CEC			
CEC	Potassium	Magnesium	Calcium
2	39*	35	318
5	109	91	649
10	139	161	1,298

*lb/A.

larger quantities of lime to raise the pH. Applications of calcitic limestone (25-30% Ca) are recommended to raise pH if calcium is considered deficient, whereas dolomitic limestone (20-25% Ca, 10-15% Mg) will be recommended when Mg is deficient. Sands with a pH>7.2 (alkaline and often calcareous) can also be tested for free calcium carbonate (free lime). That information is used for developing recommendations for acidification or reclamation programs for sodic and saline soils.

Cation Exchange Capacity

The cation exchange capacity (CEC) or total exchange capacity is usually provided on a test report. It reflects the potential ability of the sand or soil to exchange cations (Ca, Mg, K, Na, and H). The number provided on the report estimates the negative charges available to bind with cations. It is determined by saturating a sample with an exchanging or extracting agent, and is measured in milliequivalents per 100 grams of soil. CEC values will vary depending on the agent used to complete the test. The CEC of a sand rootzone is termed very low or low, usually ranging from 1 to 10 meq/100g soil (often 2-5), as compared to a loam soil that may range from 15 to 28 meq/100g soil. CEC generally increases in new sand-based greens as the organic matter content and pH increase. Peat, compost, small quantities of soil, or some inorganic amendments are often added to sands used in green construction to increase water retention and CEC.

A "very low" or "low" CEC value means there are fewer negatively charged exchange sites to bind with positively charged cations. Sand mixes will also have a lower buffering and nutrient-holding capacity (see Table 1) and fertility programs become more complex. Such systems require more light and frequent applications of N and K to minimize leaching potential.

Table 2 "Ideal" Base Saturation	
Ca	65-85%
Mg	10-20%
K	2-7%
Na	0-5%
H	0-5%
Ratios: Ca/Mg	< 6.5:1
Ca/K	< 13:1
Mg/K	< 2:1

Some laboratories base target nutrient ranges on the calculated CEC value.

Available Nutrients

Soil nutrient tests most often provide information on available P, Ca, Mg, K, and Na. Information on nitrate nitrogen can be requested, but is usually not provided because its levels change so rapidly. Information for nitrate-N and P will likely become more critical for environmental monitoring and "best management programs." Requests can be made to test for the availability of S, Fe, Mn, Cu, Zn, Mo, and B as well. The information is provided in pounds per acre or parts per million (multiply ppm by 2 too convert to pounds per acre). The test report may or may not provide specific target ranges for nutrients, in addition to fertilizer recommendations.

Lime and fertilizer recommendations are based on the soil pH and sufficiency level of available nutrients (SLAN), which is the traditional means of predicting the total quantity of plant-available nutrients. Many laboratories report calculated percent saturation of Ca, Mg, K, and Na on exchange sites. This is not the total quantity of cations that are available in the soil solution. Laboratories using the base cation saturation ratio (BCSR) approach develop recommendations by ranking the calculated percent cation saturation with an "ideal base saturation" (see Table 2), based on research in agricultural forage crops. Laboratories develop nutrient target values and subsequent fertilizer recommendations from the SLAN or BCSR interpretation alone or from a combination of the two methods.

The arguments as to which method is more effective are being debated by scientists and superintendents alike. The SLAN method is the more proven, traditional approach that will provide an accurate assessment of nutrient and fertilizer needs in putting greens. Percent base saturation and the ratios between Ca, Mg, and K will adjust closely to the "ideal" when pH problems are corrected and fertilizer applications are made to eliminate specific cation deficiencies.

The BCSR information can be a helpful tool to avoid any gross imbalances between cations and to track the effects of your fertility programs on the soils over time. It is also helpful for tracking Na levels on the exchange sites in salt-affected soils. However, it is not advised to become overly concerned with trying to meet the "ideal ratio," especially if pH is in a desirable range. Such efforts may result in unnecessary fertilizer applications and lead to nutrient deficiencies and an undesirable pH.

So what should you look for in regard to target values for the P, Ca, Mg, and K in sand-based greens? Target ranges developed through the SLAN approach will be effective for P and the cations. Request those values along with subsequent liming and fertilizer recommendations from the laboratory conducting the test. Remember, however, that limited exchange sites in a sand-based system will not make it possible to meet the sufficiency target values for potassium, and more frequent and light applications will be required to meet the turf's needs. Calcium deficiencies are very rare in the field. Adjusting soil pH to optimal levels should provide all the Ca required by the turf. Mg deficiencies are more likely to occur in systems built with calcium carbonate type sands. Strive to meet the Mg target values generated from SLAN interpretations and monitor BCSR data to avoid a deficiency.

Total salinity and Na saturation are also concerns in saline, sodic, or saline-sodic soils or when water quality issues exist. Total dissolved salts (TDS) and electrical conductivity (EC) are measures of soil salinity. Note that TDS (ppm) = EC (mmhos/cm) × 640. Exchangeable sodium percentage (ESP) and sodium adsorption ratio (SAR) are measures used to determine the potential for sodium to influence soil structure and permeability. Request total salinity, ESP, SAR calculations, and concentrations of toxic ions (B, Na, Cl, and SO_4) if you are dealing with salt-affected soils. A more thorough discussion of this topic can be found in *Salt-Affected Turfgrass Sites* (see references below).

Micronutrients

The practicality of recommendations for micronutrients is also questionable in most cases. Micronutrients are usually extracted in the laboratory with the chelating agent DTPA. Mehlich I and Mehlich III extraction may also be used to extract certain micronutrients. There have been no actual micronutrient deficiencies reported for turf in the field with the exception of Fe and Mn, which can be deficient in certain parts of the country. Soil tests may also report that a micronutrient is *excessively high*, which can raise unnecessary concerns in the field, where such toxicities are very rare. A tissue test can be conducted if a micronutrient deficiency or toxicity is suspected in the field. Micronutrient deficiency or toxicity problems will be more of a concern at extreme soil pH levels.

Conclusion

The soil nutrient test is a very useful tool for managing fertility programs for your greens. It can also be misleading if extracting agents are unknowingly changed or the test results are not interpreted correctly. It is wise to choose one soil-testing laboratory that uses extractants that are appropriate for your soil type, and to use that laboratory consistently to better correlate the test values with turfgrass response and performance under your conditions.

Remember that the test only provides a "snapshot" of the nutrient status of the sand rootzone and that concentrations of specific nutrients will fluctuate rapidly, especially when CEC is low. Therefore, use the tests as a basic roadmap for your fertility practices and concentrate on the most important information of soil pH and liming recommendations, and the availability of P, K, Ca, and Mg in the rootzone. Those with salt-affected soils must also be cognizant of total dissolved salts and exchangeable sodium percentage values. It is also a good idea to test effluent or any irrigation water of questionable quality on a regular basis to better understand its influence on soil fertility.

Finally, take the time to learn more about the soil testing process, and do not be afraid to ask questions or to get an unbiased opinion when recommendations are not clear. Sometimes as managers we wish to make things more complex than is necessary. This is one case where keeping it as simple as possible will provide the best results.

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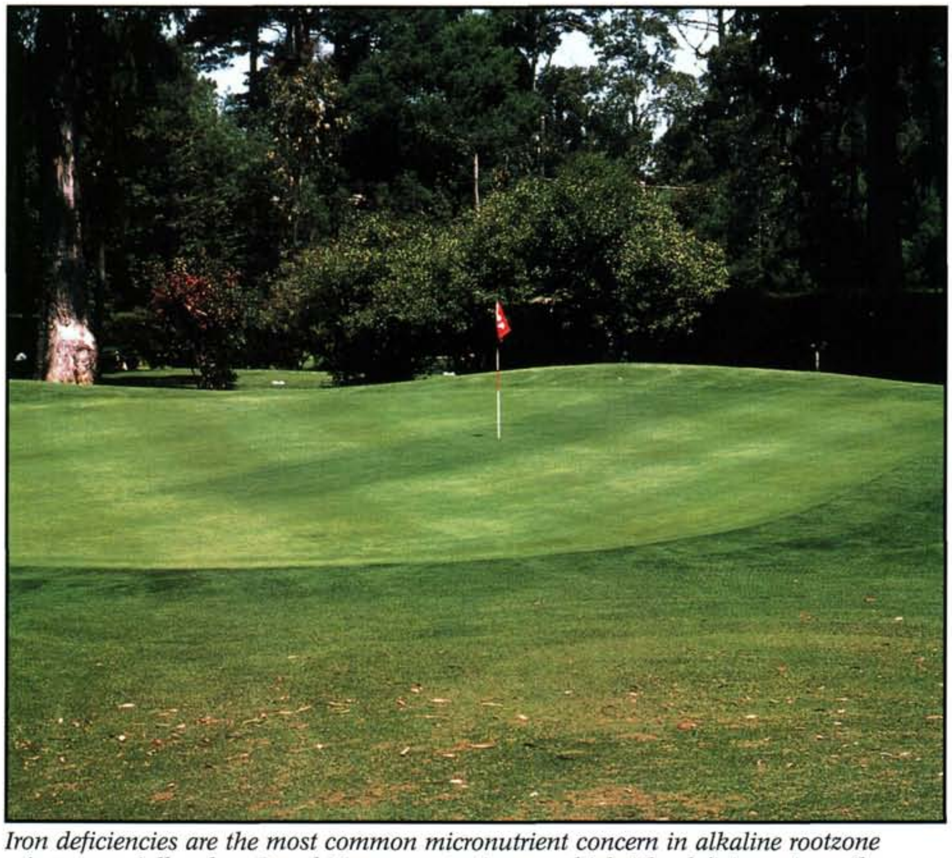
JIM SKORULSKI *is a Green Section agronomist who visits golf courses throughout the New England states and eastern Canada.*



Iron deficiencies are the most common micronutrient concern in alkaline rootzone mixes, especially when P and Mn concentrations are high. The deficiency is easily corrected with an iron sulfate or chelated iron product.