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Simplifying Soil Test Interpretations for Turf Professionals

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Many consider soil testing a cornerstone of turf fertilization. Soil tests estimate nutrient availability, drive management recommendations and provide peace of mind when making decisions about fertilization. While soil tests can be useful, their results are frequently over-analyzed and over-interpreted. Sometimes soil test results can be more confusing than helpful. It doesn't have to be so difficult. The goal of this publication is to explain which soil test values are important and which values can be ignored. It is designed to be a reference and not a comprehensive guide to soil testing.

Consistency is Key

Consistency is essential for soil test results to be useful and comparable from year to year. For example, changing soil sampling depth from 3 to 6 inches will drastically change soil test results. Four inches is good for golf turf and six inches is recommended for lawns and athletic fields. To further ensure consistency, routinely use a lab you trust Different laboratories using the same testing methods can produce different soil test results.

There are many different types of soil testing methods. Some laboratories will offer many, but others may offer just a few. Pick a laboratory that offers the methods you want to use. The Mehlich-3 soil test method is preferred for turf. It is works across a range of soil pH values (unlike the Bray-1 or Olsen). It extracts nutrients in the soil solution and on cation exchange sites, and it provides an estimate of plant available phosphorus. Some fertility consultants call these results 'total nutrients' and nutrients in a saturated paste extract (nutrients only the soil solution) 'available nutrients.' This distinction is merely a sales tactic, as the saturated paste extract method drastically underestimates nutrient availability – a great way to sell more fertilizer.

Best Practices

Pick a consistent sampling depth, lab, and soil test method.

Interpreting Soil Testing Results

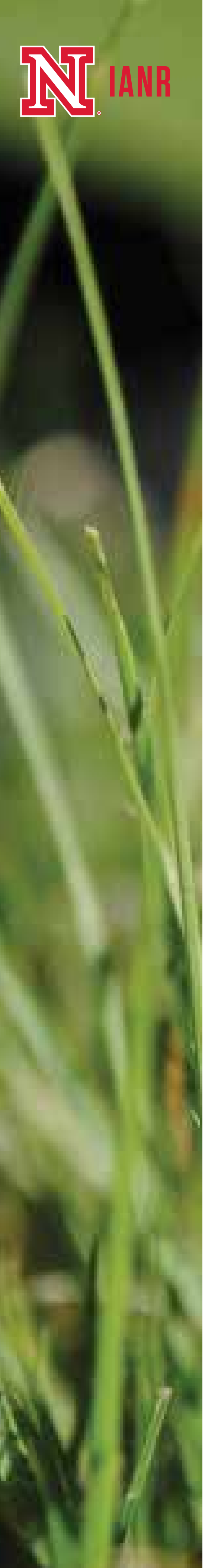
A soil test report has three parts: results, interpretations and recommendations (Fig. 1). Results are the actual values produced in the laboratory. They are typically in either ppm or lbs/acre (divide lbs/acre by 2 to convert to ppm). The results express the level of plant-available nutrients in the soil. Interpretations generally define nutrients as 'Low,' 'Medium' or 'High,' and recommendations specify how much fertilizer to apply. While some interpretations and recommendations on test reports can be ignored because they are unnecessarily complex, confusing, or not science-based, some amount of interpretation is still required to make sense of test results. It takes a great deal of research to develop soil test interpretations for turf, and those findings are specific to the particular soil test method and the location of the research. While research findings are very specific, they can help generate reliable soil test interpretations. The following soil test interpretations are derived from scientific studies and are useful to turfgrass fertility management.

Phosphorus

Desired Range: 25 to 50 ppm Mehlich-3

Phosphorus (P) is an essential plant nutrient, but can also cause water quality problems by promoting eutrophication of lakes and streams. The goal of P fertilization is to supply enough to sustain healthy turfgrass growth yet minimize environmental risk. Soil test calibration studies1 and Minimum Levels for Sustainable Nutrition2 (MLSN) guidelines suggest that soil test P levels remain above 7 to 21 ppm Mehlich-3 P (Fig. 2). To ensure a margin of safety, turf managers should strive to keep soil test P levels between 25 and 50 ppm.

Turf soils below 25 ppm should receive starter fertilizer to increase soil test phosphorus levels. Turf stands with soil test P levels between 25 and 50 ppm should also receive light maintenance application of phosphorus annually (1/8 – 1/4 lb. of P2O5 per lb. nitrogen (N) applied annually3) Monitor soil test P levels over time and adjust the P:N fertilizer ratios to keep your soil between 25 and 50 ppm. No P is required when soil test P levels are above 50 ppm, but P may slowly decline over time due to plant uptake and soil fixation. Therefore, frequent soil testing (1 to3 years) is recommended to monitor this decline and



determine when maintenance P applications are needed.

Soil Organic Matter Content

Desired Range: No recommended range

Accumulation of organic matter in the soil is a necessary consequence of turfgrass management. Fertilization, irrigation, and sound cultural practices encourage root and shoot production which contribute to soil organic matter4. There is not a goal for soil organic matter (SOM) content because it varies with a number of factors. A new sand-based golf putting green, for example, will have very low SOM levels while a lawn soil amended with rich compost will have much greater SOM levels. Both situations are normal. SOM levels also tend to increase as a new turf stand ages. After several decades, the turf ecosystem will stabilize and SOM won't change as much.

Monitor changes in SOM from year-to-year as a way to assess your agronomic program. Rapid buildup of SOM, especially from thatch accumulation, is a sign of excessive fertilization or irrigation and infrequent cultivation. Consider measuring the thickness of the thatch and write it on the soil test report for reference. If SOM does not change or only slightly increases year-to-year, this indicates the ecosystem is stable and good agronomics are being employed. Continue to monitor thatch accumulation when taking soil samples and adjust topdressing accordingly. A large decline in SOM could be the result of aggressive cultivation during the previous year.

Potassium

Desired Range: 40 to 80 ppm Mehlich-3

Potassium (K) is a salt that is mainly used to control water content within the turf plant. Unlike P, soil test calibration studies for K are generally less conclusive. Research shows that turf can have acceptable visual quality across a wide range of soil test K levels5. This observation has been echoed in the MLSN guidelines which examined K fertility levels across thousands of soil samples2. This makes determination of a critical point challenging. Recent research has indicated that leaf tissue K greater than 2.0% can help control anthracnose in annual bluegrass but also encouraged snow mold in annual bluegrass and creeping bentgrass5. Therefore, managers should apply K early in the season and then lean off K into the fall and winter.

Like P, K requirements are influenced by N fertilization. Sites with soil test K levels lower than 40 ppm should apply slightly more K than N annually. Turf sites with soil test K levels between 40 and 80 ppm should aim to apply 0.75 to 1.0 lb. of K_2O per lb. N applied. Turf grown on sandy soils needs to be on the higher side of that range. If returning clippings you can be on the lower side of the range. Apply K in the spring and lightly throughout the summer. Be careful with high rates of KCl in summer (>1.0 lb.) because it has a high salt index. Avoid application of K in the fall. Turf sites with greater than 80 ppm soil test K do not require K fertilizer.

Soil pH

Desired Range: 5.5 to 8.0

Soil pH influences soil nutrient availability and soil plant and microbial communities. It is commonly measured from saturated paste extract (ratio of soil to water varies with the lab). Turfgrasses are fairly pH insensitive because they excrete chelating molecules from their roots to help extract soil nutrients that would otherwise be rendered unavailable by high or low pH. Cold or warm soils can sometimes cause root dysfunction which can lead to micronutrient deficiency in early spring and mid-summer on high pH soils6.

Application of lime is recommended if soil pH is less than 5.5 to optimize nutrient availability and reduce the risk of aluminum toxicity. Consult the soil test report for lime recommendations. At high soil pH, consider use of acidifying fertilizers such as ammonium sulfate or elemental sulfur to reduce soil pH. It is possible to slowly reduce soil pH in weakly buffered soils while other soils – especially calcareous sands – are highly buffered and resist pH change. Application of micronutrient fertilizers may improve turfgrass color when hot or cold soil temperatures reduce the plant's ability take up micronutrients.

Soil Salinity and Sodicity

Soil salinity: Species dependent, <3 dS/m

Exchangeable sodium percentage: <15%

Salt problems are generally more of an issue in the arid Southwestern US but problems can occur in Nebraska. Risk is greatest during dry growing seasons on turf irrigated with water high in salts. A saline soil has high amounts of salts (Na, K, Ca, Mg, etc.) which reduce the plant's ability to take up water. Salinity can be reduced by leaching salts from the soil with heavy irrigation. Addition of gypsum ($CaSO_4$) will not improve soil salinity problems, and actually can make them worse since gypsum itself is a salt. Soil salinity is measured via electrical conductivity of the saturated paste extract (ECe). Cool-season turfgrasses can tolerate salinity up to 1.5 dS/m ECe7. Bluegrasses are more sensitive than other Nebraska turfgrasses. They will begin to struggle when salinity exceeds 1.5 dS/m ECe. Other grasses struggle when ECe exceeds 3.07. Deep irrigation leaches salt from in the soil.

A sodic soil has a high proportion of sodium (Na) relative to other cations (Ca, Mg, and K). Sodium causes clay particles to disperse which destroys soil structure and reduces permeability.
Applications of gypsum are recommended to displace Na in sodic soils. Sodicity is not a concern in sandy soils (including sand-based golf and sports turf) because they have minimal clay content and lack a well-defined soil structure. Gypsum will not improve soil physical properties on sandy soils and is not recommended. Soil sodicity is measured via exchangeable soil percentage (ESP). Some labs report sodicity as SAR of the soil saturated paste extract. However, SAR is more appropriate for water test results. Soil is classified as sodic when the exchangeable sodium percentage exceeds 15%. Fine-textured soils with ESP values approaching 15% should be treated with gypsum to displace sodium in the soil at 30 to 100 lbs. per 1000ft2. This practice is not recommended for sand-based soils which inherently lack soil structure.

Things to Ignore

Soil test reports typically have a wealth of other results, interpretations and recommendations. Typically, anything other than the factors described above can be ignored because there is little scientific proof to support those recommendations. For example, most test reports offer base cation saturation ratios (BCSR). It stems from a theory proposed in the 1940s that an 'ideal' ratio of Ca, Mg and K in the soil would promote plant growth. Since then, that theory has been consistently proven to be incorrect, including in turf (Fig. 3). Turf plants selectively take up nutrients as needed regardless of the ratio of those nutrients in the soil8. It doesn't make sense to apply nutrients that don't elicit a plant response.

Soil test values, interpretations, and recommendations for N, sulfur (S) and micronutrients should also be discounted. Nitrogen and S have complex and dynamic nutrient cycles in soil. Levels for N and S can change more rapidly than P and K. Soil test results for those nutrients likely changed between sampling and the time the soil test report was received. Micronutrients and S are also problematic because it's rare to observe deficiencies in turf. Without calibration data of turf response to a nutrient, it's impossible to accurately develop soil test interpretations. The best way to manage S and micronutrients is to be flexible and let your eyes and experience determine if they are needed. Apply a small amount of product to the turf and watch for a response. If there is no response then why apply the product?

Simplified Soil Testing

Soil testing can be both helpful and simple. The key is to know what is important and what values can be ignored. Be consistent in sampling methods, sample from similar areas each year, and use the same soil testing method/lab. The Mehlich-3 is a great method that both works across a wide range of soils and has calibration data to guide interpretations. The most useful information is found in the results section of the report. Look for phosphorus, potassium, soil organic matter and soil pH. Soil salinity/sodicity values can also be useful if there is a history with those problems. Soil testing can be a valuable decision-making tool for turf nutrient management, but it is only as useful as you make it. How you sample and what you do with the information is ultimately up to you.

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Figures

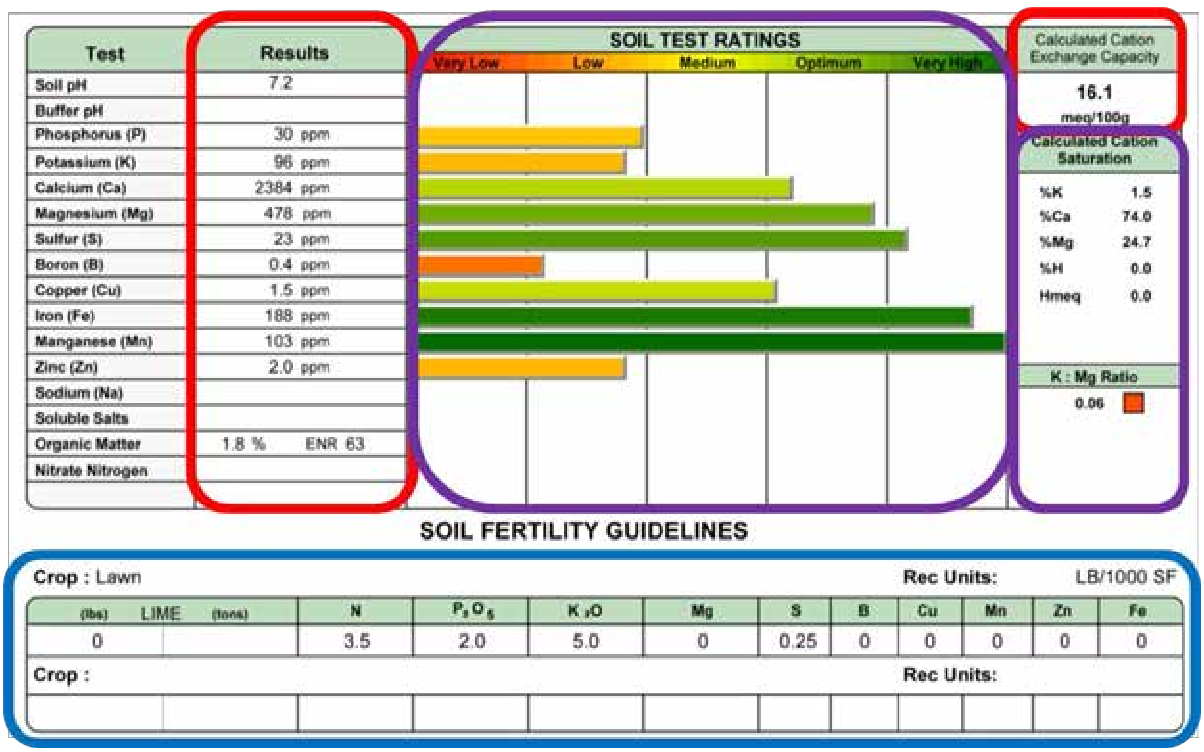

Figure 1. Soil test reports consist of three parts. Results (red) are the nutrient values produced by the laboratory. Interpretations (purple) and recommendations (blue) are included to make sense of the values in the results section.

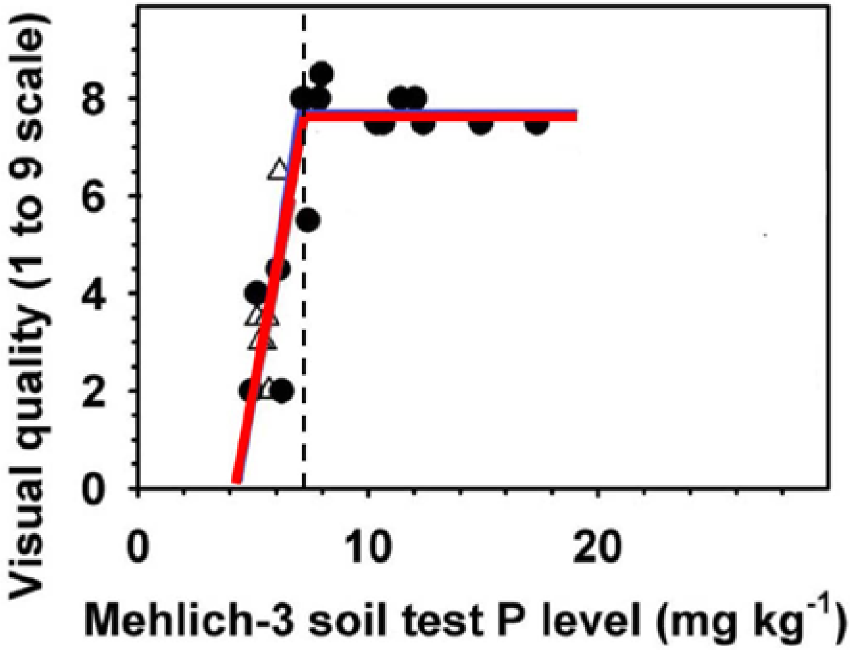

Figure 2. Soil test calibration studies are used to relate results with discussion and recommendations. In this study, putting green visual quality was maximized when Mehlich-3 soil test-P reached 7 ppm. That critical level is then increased to provide a margin of safety across a range of growing environments.

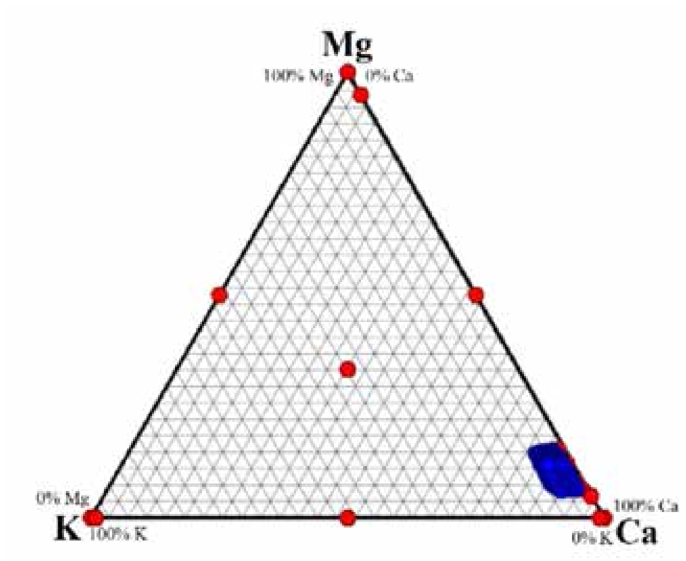

Figure 3. Base cation saturation ratios (BCSR) are frequently found on soil test reports. While they are prevalent, they are not correlated with turfgrass growth and performance. St. John et al. (2007) showed that turf grown across a range of BCSRs (red dots) performed the same as turf grown on soils containing the 'ideal' BCSR (blue dots).

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Soil Testing Quick Reference Guide

Soil Sampling: 4-6" depth from representative areas of similar management
Soil Testing Lab: Exclusively use one trusted soil testing laboratory
Soil Testing Method: Mehlich-3 – pH independent method

Soil test results interpretation and recommendation

Soil Test Result	Desired Value	Soil Test Result	Annual Fertilizer Recommendation
Phosphorus (P)	25-50 ppm[a]	Less than 25	>0.25 lbs. P_2O_5 per lb. N applied[b]
		25-50	0.25 lbs. P_2O_5 per lb. N applied[b]
		Greater than 50	No P fertilizer required
Soil organic matter (SOM)	No recommended range	Much greater than previous year	Reduce inputs (nitrogen and water) Increase cultivation and topdressing
		Slightly greater or same as previous year	Some increase is normal in new turf stands - continue good management.
		Much less than previous years	Likely the result of aggressive cultivation and/or reduced inputs
Potassium (K)	40-80 ppm[a]	Less than 40 ppm[1]	>1 lb. K_2O per lb. N applied[b]
		40-80 ppm[1]	0.75 to1 lb. K_2O per lb. N applied[b]
		Greater than 80 ppm	No K_2O required
Soil pH	5.5-8.0[c]	Less than 5.5	Consider lime application
		6.0-8.0	No remediation required
		Greater than 8.0	Consider use of acidifying fertilizer; potential micronutrient limitation
Salinity	< 3 dS/m[c]	Less than 1.5 dS/m	Low salinity risk
		1.5 to 3.0 dS/m	Bluegrasses sensitive, leach soil
		Greater than 3.0 dS/m	Most turfgrasses sensitive, leach soil
Sodicity (native soils only)	< 5% ESP	Less than 5% ESP	Low sodium risk in fine-texture soil
		5-15% ESP	Consider gypsum treatment to improve permeability of native soils
		Greater than 15%	Sodic soil, treat native soils with gypsum
All other nutrients (Ca, Mg, S, N, Fe, etc.)	No reliable/science-based soil test interpretations for these nutrients		Confirm deficiency with tissue testing or small applications to turf to verify fertilizer response

[a] Mehlich-3 soil test method

[b] Demand for P and K fertilizer is affected by nitrogen fertilizer, soil type/environment, and clipping management. For example, turf on a native soil, clippings removed, and fertilized annually with 4 lbs of nitrogen/1000 ft^2 would need about 1 lb of phosphorus (P_2O_5) and 3 lbs of potassium (K_2O)/1000 ft^2 to sustain soil test levels. Returning clippings reduces those P and K requirements by 50%. These ratios are good starting values and may need to be adjusted to sustain soil test P and K levels at any particular location. More information can be found here: http://goo.gl/0wrnmB.

[c] Saturated soil paste extract method