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Utilizing Soil Tests in Nutrient Management for Sports Fields

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Reviewed by 2015 STMA Information Outreach Committee

Soil Testing Leads to Informed Decision Making Regarding Nutrient Applications

The basis for sound nutrient management and water quality protection programs in turf management revolves around soil testing. A "Basic Soil Test" will typically provide information on soil pH and the levels of the macronutrients phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca) (Figure 1).

However, a basic soil test may vary from state-to-state or lab-to-lab (Figure 2), including analyses such as cation exchange capacity (CEC) and organic matter. A "Complete Soil Test" will include soil pH, the macronutrients provided in the standard soil test as well as sulfur (S), and the micronutrient levels for iron (Fe), zinc (Zn), copper (Cu), manganese (Mn) and sodium (Na) (Figure 3). Again, specifics may vary depending on your location (i.e. in regions were boron (B) is typically deficient, this micronutrient may be included in the analysis). These tests will document the available nutrient levels and often provide recommendations based on the nutrient levels recorded (Figure 1). By nature of its constant fluctuations from plant available to unavailable forms and back, nitrogen (N) levels are not provided in soil test results unless you live in a very dry region. However, soil tests will likely provide a general recommendation for nitrogen levels based on turf species and its use.

Currently there are two approaches to interpreting soil test results—the sufficiency level of available nutrients (SLAN) approach and the basic cation saturation ratio (BCSR) approach. In general, the SLAN testing procedure provides the most accurate assessment of plant-available nutrients in the soil, while the BCSR method is considered to be a 'maintenance level' approach that considers a soil's cation exchange capacity (CEC) in its determination of soil nutrient status. Most turf scientists support the SLAN approach because it has been validated from many decades of research on a variety of soil types and crops, including turfgrass.

In addition to the interpretation approaches, different extraction methods are used for various nutrients. In some areas of the country the Mehlich-1 extractant is typically used, while other laboratories use the newer Mehlich-3 method. In addition to standard nutrient extraction procedures, additional techniques such as the Saturated Paste Extraction method that is highly effective in measuring sodium adsorption ratios (SAR) and total soluble salts (TSS) may be used, but provides very different standard nutrient extraction levels than Mehlich-1 or -3 extractions. Even soil scientists continue to debate the pros and cons of all of these testing procedures. From a sports fields managers perspective, contact your county or state extension specialist to identify the appropriate testing methods and optimum laboratories in your region. For consistency, it's best to use the same lab each year.

MICHIGAN STATE UNIVERSITY

MICHIGAN STATE UNIVERSITY
SOIL AND PLANT NUTRIENT LABORATOR
EAST LANSING, MICHIGAN 48824-1325
(517) 355-0218

SOIL TEST REPORT FOR:	CONSULTANT
ALEC KOWALEWSKI 1611 RIVER TERRACE EAST LANSING MI 48823	

SOIL NUTRIENT LEVELS				Below Optimum	Optimum	Above Optimum
[1]Soil pH	8.7	Lime Index				
[2]Phosphorus (P)	4	ppm				
[3]Potassium (K)	120	ppm				
[3]Magnesium (Mg)	223	ppm				

ADDITIONAL RESULTS:					Optional Tests:						
[3]Calcium (Ca) (ppm)	CEC (meq/100 g)	% of Exchangeable Bases			Micronutrients (ppm)					Organic Matter %	Nitrate-N ppm
		K	Mg	Ca	B	Cu	Mn	Zn	Fe		
3694	20.6	1.5	9.0	89.5							

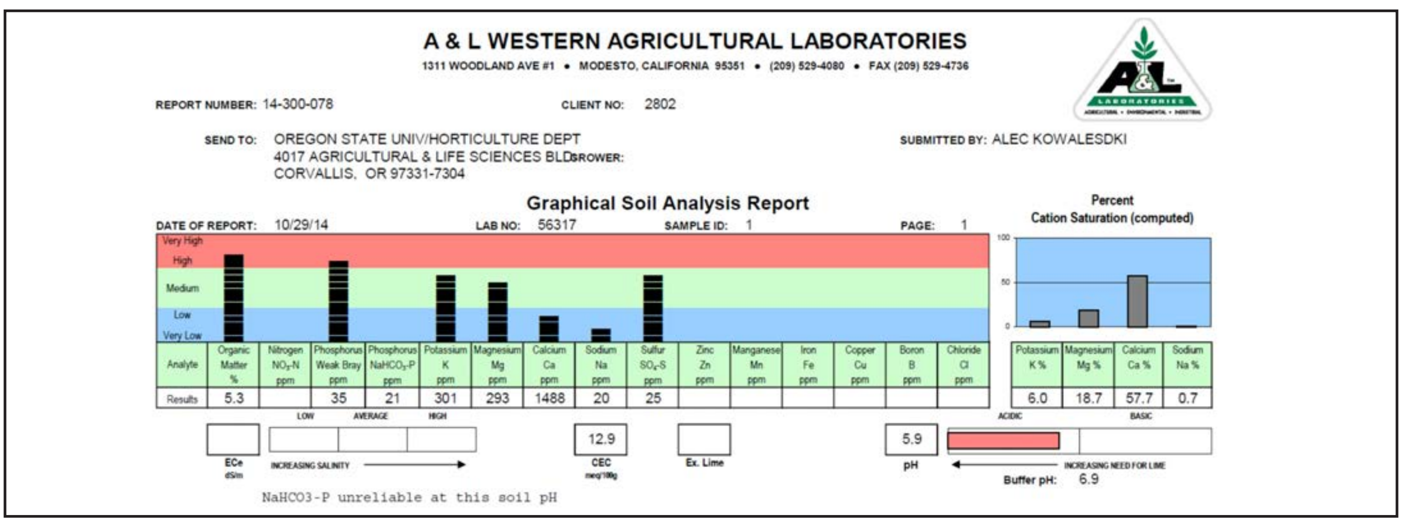
RECOMMENDATIONS FOR: ***Turf, low maintenance***

Limestone: NONE

NUTRIENT NEEDS:

Nitrogen (N)	Phosphate (P_2O_5):	Potassium (K_2O):
1-2 lb/1000 sq ft	1.9 lb/1000 square feet	NONE

Figure 1: A "Basic Soil Test" will typically provide information on soil pH and the levels of the macronutrients phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca), general N fetilizer recommendations, and finally P and K recommendations based on soil test results.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REPORT NUMBER: 14-300-078 CLIENT NO: 2802

SEND TO: OREGON STATE UNIV/HORTICULTURE DEPT
4017 AGRICULTURAL & LIFE SCIENCES BLD GROWER:
CORVALLIS, OR 97331-7304

SUBMITTED BY: ALEC KOWALESDKI

Graphical Soil Analysis Report

DATE OF REPORT: 10/29/14 LAB NO: 56317 SAMPLE ID: 1 PAGE: 1

Analyte	Organic Matter %	Nitrogen NO_3-N ppm	Phosphorus Weak Bray ppm	Phosphorus $NaHCO_3$-P ppm	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Chloride Cl ppm
Results	5.3		35	21	301	293	1488	20	25						

Percent Cation Saturation (computed)

Potassium K %	Magnesium Mg %	Calcium Ca %	Sodium Na %
6.0	18.7	57.7	0.7

ECe dS/m | LOW AVERAGE HIGH INCREASING SALINITY | CEC meq/100g 12.9 | Ex. Lime | pH 5.9 | ACIDIC BASIC INCREASING NEED FOR LIME | Buffer pH: 6.9

NaHCO3-P unreliable at this soil pH

Figure 2: A Basic Soil Test may vary from state-to-state or lab-to-tab, including analysis such as secondary macronutrients, micronutrients organic matter, and cation exchange capacity (CEC).

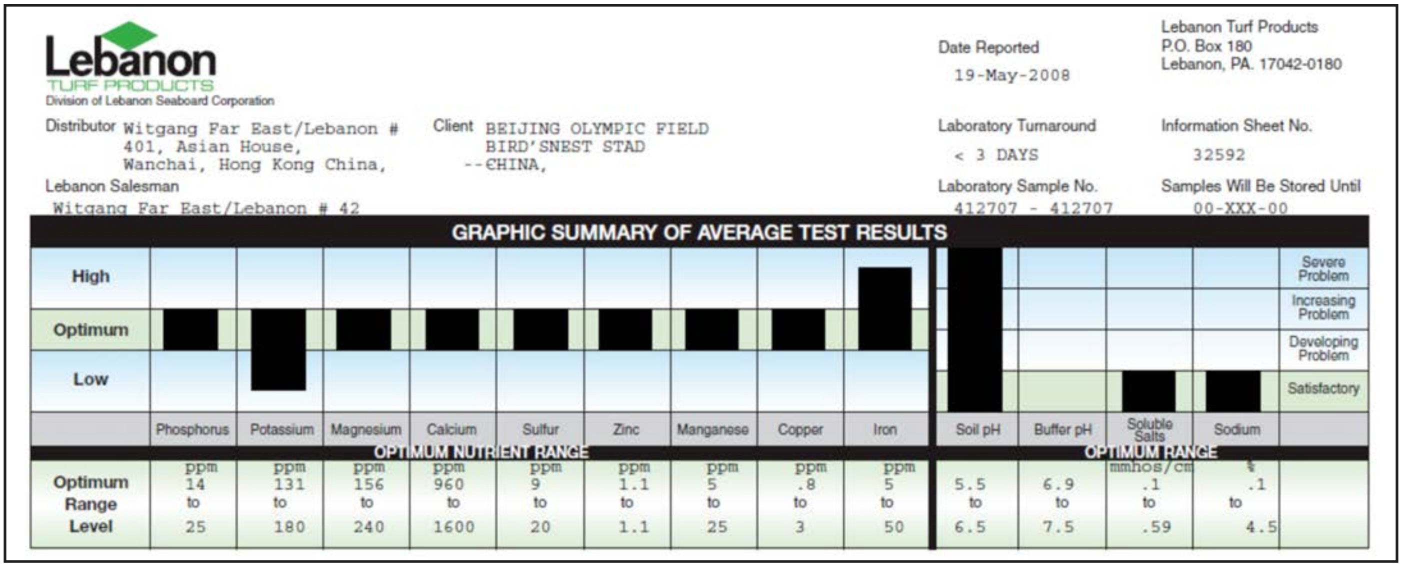

Figure 3: A "Complete Soil Test" will include soil pH, the macronutrient; phosporus (P), pottasium (K), magensium (Mg), calcium (Ca), sulfur (S), and micronutrients; iron (Fe), zinc (Zn), copper (Cu), manganese (Mn) and sodium (Na).

Soil Sampling

Soil tests should be conducted on sand-based soils at least once per year. Sand-based systems have reduced nutrient and water holding capacity as compared to heavier textured soils (high in silt and clay). The need for testing sand-based soils is further exaggerated if clippings are removed. Native soil fields high in silt and clay should be tested every 3 to 4 years because the relatively high CEC within these soils buffers them against rapid changes.

Although soil samples can be taken at any time of the year, it is recommended to take samples in advance of planting or fertilization. 'Off-season' sampling is common in many locations, as this allows time to get results and apply lime and nutrients in advance of the next growing season. Since standard lime sources can take months to fully react with soil, liming should be done well in advance of the next growing season in order to optimize nutrient availability. Soil sampling should not be done for at least two months after fertilization or liming.

When collecting soil samples, the field should be divided into logical components for sampling (for example the infield and outfield of baseball, north half and south half of football or soccer fields). Each designated area should have its own sample collected. A stainless steel soil probe (standard diameter of 0.6 in.) is an ideal tool for sampling, but any type of spade or digging instrument can work (Figure 4). Sub-samples should be collected in a random pattern across the area to a 4 inch depth, removing the grass mat from the top of the sample. Typically, 10-15 sub-samples per area provide a representative sample of the soil and enough material for the testing procedure (approximately ½ pint). The sub-samples should be mixed together in a plastic bucket and the final sample taken from the bucket and placed in the testing box or bag provided by the soil testing lab.

The value of the soil test report received from the lab is only as good as the quality of the sample. A soil test of a 'problem site' (such as a previous fertilizer or chemical spill) can provide valuable information on site-specific problems and/or how to remediate that area. Problem areas should be sampled separately.

All soil test sample submission forms request additional information that improves the value of the test. Most ask a description of the soil (sand, clay, modified, native) and a brief history of recent fertilization and liming (if known). The form will also provide the opportunity for soil test data in addition to the standard pH and nutrient tests conducted. Test results can include cation exchange capacity, soil organic matter content, and total soluble salts. The additional tests will likely require a supplemental fee.

Figure 4: Collect 10 to 15 soil samples to a 4 inch depth using a soil probe, remove the thatch before placing the individual samples into a plastic bucket, and then mix the samples together for a composite sample.

Interpreting Soil Test Results

Labs report results as either parts per million (ppm), pounds per acre, or as a predictive index. Most laboratories report a rating indicating the relative status for each nutrient, such as:

Very Low:	A plant response is most likely if the indicated nutrient is applied. A large portion of the nutrient requirement must come from fertilization.
Low:	A plant response is likely if the indicated nutrient is applied. A portion of the nutrient requirement must come from fertilization.
Medium:	A plant response may or may not occur if the indicated nutrient is applied. A small portion of the nutrient requirement must come from fertilization.
High:	Plant response is not expected. No additional fertilizer is needed.
Very High:	Plant response is not expected. The soil can supply much more than the turf requires. Additional fertilizer should not be added to avoid nutritional problems and adverse environmental consequences.

Soil pH, Lime and Sulfur

Perhaps the most important piece of information from a soil test is the soil pH. The chemical reactions in the soil that result in nutrients transforming between plant available and/or unavailable forms are governed primarily by pH. The optimum soil pH that maximizes nutrient availability is slightly acidic (6.2 to 6.8 are typical ranges in most sports field soils) (Figure 5). Extremes in soil pH in either direction (acidic or basic conditions; low or high pH, respectively) can result in either nutrient deficiencies or toxicities. For instance, when a soil is strongly acidic (<5.0-5.5) many pesticides can lose effectiveness and plant growth is limited by aluminum toxicity. When soils are basic (well above a pH of 7.0, also known as alkaline), micronutrients such as Mn and Zn are limited.

Lime will typically be recommended when soil pH drops to or below 6.0. If the pH is greater than 6.0 the macronutrients, N, K, S, Ca, and Mg will not be limited and therefore lime is not recommended. The effects of a typical lime application will last two to three years for a native soil field and up to a year on a sand-based field. When choosing lime materials it is important to keep in mind the properties of common products. Agricultural limestone is composed entirely of calcium carbonate ($CaCO_3$), is generally finely ground and is relatively soluble. If used repeatedly for liming it could eventually lead to a deficiency in Mg. Dolomitic limestone, on the other hand, contains both $CaCO_3$ and magnesium carbonate [$CaMg(CO_3)_2$], and therefore is the appropriate choice when acidic conditions coupled with a Mg deficiency have been identified. Dolomite is slower to react in soil than agricultural lime, but is generally longer lasting than an equivalent amount of agricultural lime. Regardless of the formulation, apply liming products several months ahead of field use to allow time for more complete soil reaction. Note: In different parts of the country agricultural limestone may be dolomitic in nature depending on the source of materials. Be sure to check the properties of the product prior to use.

If the pH is well above the ideal range (>7.0), then application of sulfur is sometimes recommended to help lower the pH. However, sulfur has been linked to development of black layer on sand-based fields. It is also important to consider that at a high pH there can be deficiencies in P and the micronutrients Fe, Mn, Cu, Zn and B. Calcareous soil have inherently high pH levels, but often support sufficient turfgrass growth because P is typically included in the regular fertility program and micronutrients are inherently required at low levels. In alkaline conditions, consider adding micronutrients to balance deficiencies before adding sulfur to lower the soil pH. Also, if you suspect a micronutrient deficiency, get the soil tested for the various micronutrients before applying fertilizer.

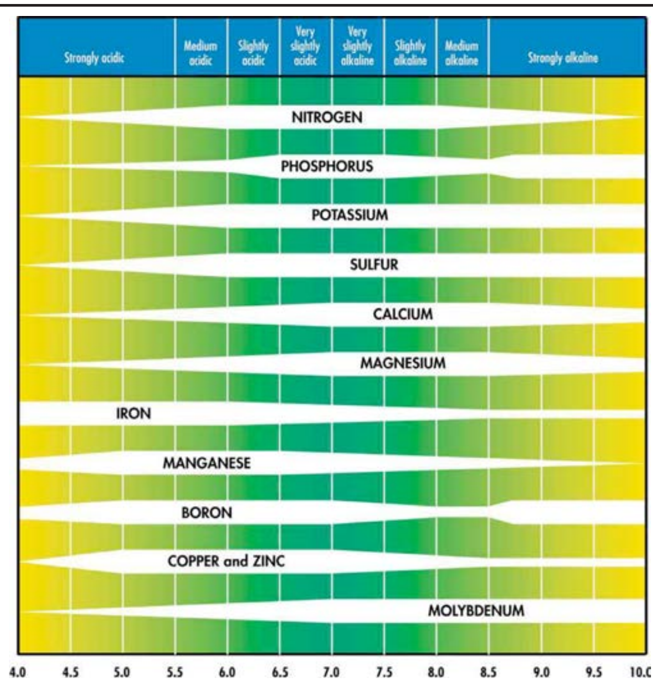

Figure 5. Relative soil nutrient availability as influenced by pH for the 11 essential soil nutrients, with the primary macronutrients being nitrogen (N), phosphorus (P), and potassium (K), secondary macronutrients being sulfur (S), calcium (Ca), and magnesium (Mg), and micronutrients being iron (Fe), manganese (Mn), boron (B), copper (Cu) and zinc (Zn). Image courtesy of Jeff Langner.

Nutrients:

Primary Nutrients: Within the primary nutrients, N is required by the plant at the greatest levels, followed by K, and finally P. Nitrogen plays a critical role in turfgrass shoot growth and density, root growth, wear tolerance and recuperative rates. While N is the most important nutrient, as previously stated, levels are not typically reported on a soil test due to rapid fluctuations within the soil and plant. Generally speaking, N should be applied during periods of active growth, i.e. the spring and fall for cool-season turfgrass, and summer months for warm-season turfgrass. Soil test recommendations will often include general N rates; however, N rates vary substantially from species to species and intensity of field use. Therefore, consult county and state extension specialists for specific recommendations.

Benefits of adequate K include drought, heat, cold and disease tolerance. The benefits of P include quicker seedling establishment, heathy root development and dense turfgrass. A medium level or optimum level of soil K, quantified using the extractable Mehlich-3 procedure, is 180 to 220 parts per million (ppm). The optimum soil P level, again quantified using the extractable Mehlich-3 procedure, is 27 to 54 ppm. It is important to note that while optimum levels of K and P will improve turfgrass density, root growth and stress tolerance, above optimum levels will not provide added benefits.

	-----------------Optimum Soil Level (ppm)-----------------		
Extraction Method	Mehlich-1	Mehlich-3	Ammonium Acetate
Potassium (K)	36-88	180-220	75-235

	-----------------Optimum Soil Level (ppm)-----------------				
Extraction Method	Morgan	Bray-1	Olsen	Mehlich-1	Mehlich-3
Phosphorus (P)	10-20	16-30	12-28	18-37	27-54
Region	Northeast and Northwest	Midwest	Western	Southeast	

To achieve adequate levels of N, K and P throughout the year select a complete fertilizer with high levels of N, medium levels of K and low levels of P; 10:1 N to P ratio. An example of a complete fertilizer ratio that achieves this formulation is 30N-3P-15K (it is important to note that fertilizer labels present the nutrients in this order; N-P-K). In 11 of the 50 United States (Illinois, Maine, Maryland, Michigan, Minnesota, New Jersey, New York, Vermont, Virginia, Washington, and Wisconsin) synthetic fertilizers containing P cannot be applied unless a soil test documents P as deficient or below optimum soil conditions. Phosphorus is a known catalyst for accelerated eutrophication. These restrictions and environmental concerns stress the importance of regular soil testing.

Secondary Nutrients: Medium levels of calcium and magnesium, quantified using the extractable Mehlich-3 procedure, are 360 to 750 ppm and 54 to 140 ppm, respectively. Calcium and magnesium are normally added to the soil through the application of limestone. As previously stated, calcium carbonate is the preferred liming material for offsetting a Ca deficiency, but when Ca and Mg are both deficient the preferred product is dolomite.

Macronutrient	-----------------Optimum Soil Level (ppm)-----------------		
Extraction Method	Mehlich-1	Mehlich-3	Ammonium Acetate
Calcium (Ca)	200-350	360-750	360-750
Magnesium (Mg)	20-30	54-140	140-250
Sulfur (S)	NA*	15-40	30-60

**Not applicable (NA)*

Micronutrients: Micronutrients (Zn, Mn, Mo, Cu, Fe, and B) are typically present in the soil at adequate levels if the soil pH is in its proper range. As the pH begins to become alkaline, micronutrients may become limited. In alkaline situations consult the soil test. If micronutrients become deficient, consider getting the soil tested for micronutrients and pH and possibly apply a micronutrient package and sulfur to lower excessively high soil pH levels. It is important to note that if indiscriminate or excessive amounts of micronutrients are applied, phytotoxicity to the desired turfgrass can occur.

Micronutrient	Optimum Soil Level (ppm)
Manganese (Mn)	30-50
Iron (Fe)	25-50
Zinc (ZN)	5-8
Boron (B)	1.3-2.0
Copper (Cu)	1.5-3.0
Molybdenum (Mo)	0.2-0.4

Organic Matter

Soil organic matter (SOM) is the percentage by weight of the soil that consists of decomposed plant and animal residues. When maintained within the adequate range, 0.5 to 2.5%, organic matter will improve the overall soil tilth or soil quality, increase nutrient and water holding capacity in sand-based fields, and improve aeration and soil structure on native soil fields. However, SOM can rapidly accumulate on sand-based fields and as little as 3% SOM will begin to compromise the drainage capacity of a sand-based field, subsequently resulting in reduced rooting and increased disease activity. Core cultivation and vertical mowing should be used to maintain the SOM on sand-based fields below 3%. Increased microbial activity on native soil fields has a tendency to maintain SOM within adequate ranges reducing the need for cultivation to manage organic matter.

Cation Exchange Capacity

Cation Exchange Capacity (CEC) gives an indication of a soil's ability to hold some nutrients against leaching. Native soils in many areas have CEC's ranging from 3 to 100 milliequivalents/100g. Sand on the other-hand will not exceed 5 meq/100g. The CEC of sand-based fields will increase as SOM increases, however, as previously stated; drainage will be compromised as SOM increases. From a manager's perspective, sports fields with a CEC at or below 5 meq/100g will require frequent fertilization and irrigation to maintain high quality turfgrass.

Utilizing Soil Tests in Nutrient Management for Sports Fields

Summary

Soil tests provide the foundation for a field's annual nutrient plan. Testing sand-based fields once a year and native soils every 3-4 years keeps field nutrients at desirable levels and keeps the field manager informed on field health. Use the same lab each time to stay consistent and get to know how the soil is tested and how the lab makes recommendations. If a consultant or sales representative is taking and testing the soil sample and making recommendations based on the results, be aware of bias. If turfgrass managers have a better understanding of the soil testing process, they can interpret the results and create an annual nutrient management plan themselves.