Taking the Confusion Out of Soil Testing

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Why Do We Soil Test?

• Estimate plant available nutrients

• Monitor changes in soil nutrients

• Peace of Mind
Emphasis on Available Nutrients

Total Soil Nutrients vs Available Soil Nutrients

Plants only use soluble nutrients

\[ \text{H}_2\text{PO}_4^- \]

“Labile P” + H\textsubscript{2}O
P Can Bind to Soil and Become Unavailable

- Not Related to CEC
- Labile vs Nonlabile Nutrients

![Diagram showing the binding of P to soil and its availability]

- Available P: \(H_2PO_4^-\)
- "Nonlabile P": \(OH\)
Cation Exchange Capacity

Mg$^{2+}$

Ca$^{2+}$

Mg$^{2+}$

H$^+$

K$^+$
Nutrients can bind to soil via cation exchange capacity (CEC).

Soil tests estimate nutrients in the soil solution and labile nutrients.

What the plant ‘sees’
We Can Test for Everything but N

Primary & Secondary

• Nitrogen (N)
• Phosphorus (P)
• Potassium (K)
• Calcium (Ca)
• Magnesium (Mg)
• Sulfur (S)

Micronutrients

• Iron (Fe)
• Manganese (Mn)
• Molybdenum (Mo)
• Zinc (Zn)
• Boron (B)
• Chlorine (Cl)
• Copper (Cu)
• Nickel (Ni)
“There is a tendency to place undue emphasis upon the value of chemical soil tests.

This is true of some technical workers as well as salesmen.

These methods have a promising future but their present usefulness is limited by imperfect [methods] and for a lack of definite correlation with field experience”

--O.J. Noer, in ABC of Turf Culture, 1928
“Soil analyses – these are of practically no value. No one living can tell what they mean”

--Bulletin of the USGA Green Section, 1925
Keys to Soil Testing Success

1. Proper field sampling
   To obtain representative sample

2. Proper test selection
   Several extractants to choose from

3. Proper calibration and interpretation
   Making sense of the numbers
Proper Sampling
Collecting a Representative Sample

• Take a Composite Representative Sample

• Consistent Sampling Depth and Time of Year

• Consistent Soil Testing Lab or Method
Proper Sampling

• Representative Areas
  – Mineral soils vs. Sand or constructed soils
  – Areas built at different times
  – Areas cut out of forest vs. old agricultural land
  – Areas of drastically different soil type
How Deep?

Where the roots are
### How Deep?

<table>
<thead>
<tr>
<th>Depth</th>
<th>Mehlich 3 Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>ppm</td>
</tr>
<tr>
<td>0 – 1</td>
<td>205</td>
</tr>
<tr>
<td>0 – 2</td>
<td>138</td>
</tr>
<tr>
<td>0 – 6</td>
<td>74</td>
</tr>
</tbody>
</table>

33% decrease in soil P with addition of 1 inch of soil!
Guidelines for Sampling Depth

- Lawns, Fairways, Athletic Turf
  - 6 inches
- Golf greens and tees
  - 4 inches
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Soil test selection

- Bray-1, Bray-2
- Mehlich-1, Mehlich-3
- Olsen
- Morgan
- Ammonium acetate
- Water or 0.01 M calcium chloride
Soil test selection

• Low pH Soils (<7)
  – Bray-1, Bray-2
  – Mehlich-1, Mehlich-3
  – Morgan, Modified Morgan
  – Neutral ammonium acetate (pH 7)
• High pH Soils (>7)
  – Olsen
  – Buffered ammonium acetate (pH 8.5)
• Alternative
  – Water or 0.01 M calcium chloride
Laboratory Analysis

- Dry and grind
- Add chemical extractant
- Shake soil and extractant
- Remove liquid and analyze
Analyze the Nutrients
Soil Extraction Method

• Different test methods produce different results

• Ask the lab which method they use

• Be consistent with method
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Without Soil Test Calibration Our Results are Meaningless Numbers

Takes a lot of work and money to calibrate soil tests
• How to calibrate soil tests for turf?
  – Growth?
  – Quality?
  – Tissue Content?
Phosphorus Soil Test Calibration
Grass Doesn’t Need Much Phosphorus

![Graph showing the relationship between visual quality and soil test P levels.](image)
Potassium Research at Cornell Univ.

- L-93 creeping bentgrass on calcareous sand root zone
- Seven annual rates of $K_2O$
  - 0, 3, 6, 10, 13, 16, 19 lbs/M
  - Mehlich-3 K was very low (<50 ppm) in the 0 tmt
- No difference in color, quality, or ball roll over 2 years
- Greater rooting found between 4 and 8 inches in low K plots
Bray-1 Soil Potassium (ppm)

Leaf Potassium Content (%)

Level between “low” and “very low” in many soil test reports

Commonly cited sufficiency level in turf tissue
Soil Test Interpretation

• Very little research on soil test calibration has been conducted
  – Especially for Secondary and Micronutrients

• Different labs/distributors give different recommendations because of different data, or different philosophies
Soil Test Interpretation

• Two main philosophies:
  – Sufficiency Level of Available Nutrients (SLAN)
    • Feed the Plant
  – Base Cation Saturation Ratio (BCSR)
    • Feed the Soil
Base cation saturation ratio

• “Ideal” ratios of the major exchangeable cations

• CEC central to use of BCSR
Cation Exchange Capacity

$\text{Ca}^{2+}$

$\text{Mg}^{2+}$

$\text{H}^+$

$\text{K}^+$
Development of the BCSR concept

- The “Ideal” Soil
  - 65 to 85% Ca
  - 6 to 12% Mg
  - 2 to 5% K
  - Remaining $H^+$, $NH_4^+$
Original concept was based on the SLAN approach

- Alfalfa in NJ

- Alfalfa exhibits “luxury consumption” of potassium

- Need to maximize growth, but minimize excess K uptake
BCSR Philosophy Expanded Beyond NJ

• Very common in soil testing

• Values essentially the same as the early work on Alfalfa

• Assumes the ‘Ideal’ soil is in New Jersey
BCSR Not Supported by University Researchers

1. Ignores differences in nutrient needs among plants
2. Assumes uniform distribution of nutrients in soil
3. Scientific literature does not support the claims
4. Results in inefficient use of resources
#1: BCSR Ignores the Plant

- “...plants have the mechanism to select the ions in a mutual ratio favorable for their growth and development.” (Steiner, 1980)

- Ca, Mg, K uptake channels and carriers are independent
#1: BCSR Ignores the Plant

- Different plants prefer different soil pH
- BCSR results in a very narrow range of pH 6.0 – 6.5.
- Many turf managers attempt to favor bentgrass over annual bluegrass by modifying root zone pH
#2: BCSR Assumes Uniform Nutrient Distribution

- Testing in top inch will give a vastly different Ca/Mg ratio than testing to a depth of 3 or 6 inches.

- Which is “right”? 
#3: Scientific Research Doesn’t Support BCSR

**RED DOTS:** Saturation of soils used in study

Range required by BCSR
#4: Inefficient Use of Resources

- Expensive and time consuming application that do not improve turfgrass health

- Confirm soil test interpretations with tissue testing and small scale applications

- Plenty of micronutrient recommendations despite lack of soil test calibration
PACE Turf Minimum Level for Sustainable Nutrition

Minimum Levels for Sustainable Nutrition

Soil Guidelines

Minimum Level for Sustainable Nutrition (MLSN) is a new, more sustainable approach to managing soil nutrient levels that can help you to decrease fertilizer inputs and costs, while still maintaining desired turf quality and playability levels. The MLSN guidelines were developed in a joint project between PACE Turf and the Asian Turfgrass Center. All soil analyses were conducted at Brookside Laboratories, New Knoxville, OH.

| MLSN Soil Guideline |  
|---------------------|---|
| pH                  | >5.5 |
| Potassium (K ppm)   | 35  |
| Phosphorus (P ppm); pH<7.5, Mehlich 3 | 18  |
| Phosphorus (P ppm); pH<7.5, Bray 2 | 25  |
| Phosphorus (P ppm); pH>7.5, Olsen | 6   |
| Calcium (Ca ppm)    | 360 |
| Magnesium (Mg ppm)  | 54  |
| Sulfur as sulfate (S ppm) | 13  |
| Sodium (Na ppm)     | <110 |
| Electrical conductivity (EC dS/m) | <2  |
| Total Nitrogen (N ppm)* | <3  |

Managing sodium and salts: In locations where poor quality irrigation water makes it difficult to meet the guideline of <110 ppm sodium or <2 dS/m salts, MLSN guidelines and overall management practices may need to be modified on a site-specific basis. For more information on salinity and sodium management, see Carrow RN and Duncan R., 1998. Salt affected turfgrass sites: assessment and management. Sleeping Bear Press, 173 pp.

*N requirements are best determined based on turf growth potential, which incorporates site-specific weather and turf type to calculate nitrogen demand (Gelernter and Stowell, 2005. Golf Course Management, p. 108-113, March, 2005). The values provided above can be used in the absence of growth potential data.

How the guidelines were developed

From a database of over 16,000 soil samples, we selected 1500 that were classified as having:

- not poor performing turfgrass
Soil Testing Take Home Message

• Use soil testing to monitor changes in available soil nutrients over time

• Consistent sampling depth, time, and lab analysis method is essential

• Good calibration studies are lacking
  – Be cautious of interpretations with no calibration
  – Confirm with tissue testing and small scale applications
Thank You

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