1. Introduction of new products, technologies, and approaches will continue --- good, bad, or ugly.
   - Examples --- soil amendments, biostimulants, microbial additives, water treatments, etc. – are all products in these categories good?
2. How can we make wise decisions about which new products/technologies/concepts will help versus:
   - which will be a cost without a benefit (does not help);
   - may distract from real problems;
   - may hinder or increase problems.

Maximizing Limited Budgets- Rational Decisions About Products and Field Management - Class Overview

1. Identifying/Seperating Primary, Secondary, and Non-Existent Problems – KEY: management starts with recognizing a problem; then we select products and technologies to prevent or alleviate the problem.
2. Specific Areas of Confusion
3. Basic Guidelines – to determine what products or technologies to use within IPM, BMP, or EMS management decisions.

Management Strategy

1. Start/Focus on the basics. Mowing, fertilization, irrigation, drainage, cultivation, pest control.
2. Identify Specific Primary Problems. Management always starts with accurately identifying problems.
3. Develop written short/long term plans for each primary problem. Attempt to alleviate or minimize primary problems. Examples of soil compaction versus wear.
4. Then, determine the specific need and role for any new product or technology:
   - Will it do a better job in alleviation of a problem?
   - Will it help to assess a problem or monitor a problem?

#1. Identify Problems: Types

- **Primary** Problems
- **Secondary** Problems
- **Non-existent** Problems – just because someone says or believes that there is a problem does not mean that it exists.

Primary and Secondary Problems

- **Primary Problems**—the most basic or underlying field problem. These are “site-specific” since each site is unique.
- **Secondary Problems**
- **Non-existent Problems**

Example on Fine-Textured Sports Fields:
- Surface soil compaction = lack of macropores (> 0.10 mm diameter) and high soil strength.
Primary and Secondary Problems

• **Secondary Problems**—a problem that arises out of the primary problem (i.e., is caused by the primary problem). These are also symptoms of the primary problem.

• **Example**: Lack of macropores (large pores) results in
  --poor water movement.
  --poor gas exchange from soil to atmosphere.
  --limited rooting.

Secondary Problems/Symptoms: Example of Soil Compaction (primary problem)

- Waterlogged condition and poor drainage
- Anaerobic soil
- Hard soil when dry
- Irrigation scheduling problems
- Water runoff
- Poor rooting
- Greater Poa annua, goosegrass, knotweed
- More Pythium and brown patch when wet
- More dollar spot and rust when dry Greater wear injury
- Poor surface stability and smoothness.
- Rutting, divots
- Turf decline
- Job loss

Common Primary Problems: Sports Fields

### Fine-Textured Fields
1. Lack of Macropores
2. Excessive fines
3. Soil compaction
4. Wear
5. Surface contouring–surface drainage
6. Poor irrigation uniformity

### Sandy Soil Fields
1. Low water retention
2. Poor irrigation uniformity
3. Localized dry spot
4. Surface layering – OM, fines
5. Wear
6. Fertilization – low CEC, nutrient content

Domed or High Wall Stadiums

- Low light

Soil Compaction + Wear + Surface Stability

Surface stability, Drainage/contouring, Soil compaction.
Primary Problems: Sand-Based Rootzones

1. **Excess OM in surface 2.0 zone.** Too many micropores (capillary, water retention pores).
2. **Insufficient micropores in profile** = low water holding capacity.

Symptoms or Secondary Problems: Excessive OM in Surface 0-2 inch Root Zone

**Moist Conditions**
- Saturated or near saturated in surface
- Low oxygen zone
- Root dieback and shallow rooting
- Soft, not firm
- Poor surface stability
- Root-rot diseases such as take-all are favored
- Winterkill favored if excessive moisture.
- Less effective fungicide activity

**Dry Weather Cycles**
- Prolonged dew and moist surface
- Black layer beneath the OM zone
- Nutrient challenges

**Management To Correct Problems**

What do I manage? – the symptoms, secondary problems, or the primary problem?

- When **secondary problems** are occurring and causing adverse symptoms, then the secondary problems(s) must be **dealt with on an immediate basis**.
- But the long-term approach is to attempt to alleviate, prevent, or minimize the **primary problem**. Then, the secondary problems do not occur or are minimized.
Non-Existent Problems

Non-Existent problem = a problem that exists only because someone says or thinks it is a problem. Are these problems— all the time, sometimes, hardly ever??

- My high sand (or fine-textured) sports field lacks adequate microbial populations.
- My turf needs supplemental vitamins, amino acids, hormones.
- My turf needs sugar applications.
- My water needs to be acidified.
- My water needs treatment with a magnetic device.

Grids For Assessing Problems

“Problems” Are Assessed Depending On The Overall Goal— There Are Multiple Goals or Grids to view problems. For example:

1. Turf Quality/Performance
2. Soil Conditions for Growth
3. Climatic Conditions
4. Playability of Area
5. Safety
6. Environmental (EMS)

Note: Once specific problems are identified, then products, technologies, and approaches are chosen to alleviate or prevent the problem.

Turfgrass-Soil-Atmospheric-Man “System”

Climatic
- Surface Playability/Use
- Player Safety

Man – Management
- Stakeholder Expectations – Environmental Issues (EMS)

Turfgrass Plant and Site

Soil Physical Properties
Soil Chemical Properties
Soil Biological Properties

Three Types of Problems: Primary, Secondary, and Non-Existent

Sports Fields: Turf Quality Assessment

Turf Cover/Quality of Field
- Turfgrass species and cultivar – adapted to wear, soil compaction, pest stress, climatic conditions.
- Quality – turf uniformity, shoot density, color, striping
- Degree and nature of traffic injuries—wear, soil compaction, divots
- Bare ground, weeds coverage, type of weeds
- Degree of mat or thatch layer
- Percent of permanent grass vs. over-seeded grass

Sports Fields: Soil Conditions for Growth Assessment

Physical
- Excessive fines – lack of macropores
- High soil strength (hard)
- Soil Compaction
- Excess Moisture status
- Soil Oxygen status
- Layers
- Low Infiltration
- Drainage – surface and subsurface
- Too sandy – low soil moisture, LDS
- OM layer at surface, thatch

Chemical
- Fertility
- pH
- Saline/sodic

Biological
- Soil diseases
- Insects
- Earthworms
- Microbial activity, population etc.

Sports Fields: Climatic Assessment

1. Irrigation/Water Uniformity
   - Rate of water application
   - Head to head coverage
   - Uniformity of delivery
   - Malfunctioning sprinklers
   - Correct nozzles
   - Head and valve box levels for safety

2. Runoff – field and surrounds
   - Dry areas
   - Wet areas

3. Light/shade
   - Low light in large stadiums – often their number one problem.
   - Tree shade

4. Air Drainage.
Sports Fields: Playability and Safety Assessment

Surface Characteristics -- Playability
- Surface stability
- Traction (torsion machine)
- Surface hardness (Clegg hammer)
- Soil compaction (penetrometer)
- Surface soil moisture
- Any minor or major depressions (is surface level)
- Grass height
- Grass resistance to tearing
- Thatch/mat

Safety
- Surface Characteristics related to safety – many are the same as for playability.
- Goals, fences, etc
- Sprinkler height
- Surround

EMS (www.epa.gov)

- An Environmental Management System (EMS) is a set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency.
- Plan Planning, including identifying environmental aspects and establishing goals
- Do Implementing, including training and operational controls
- Check Checking, including monitoring and corrective action
- Act Reviewing, including progress reviews and acting to make needed changes to the EMS.

Environmental Management Systems (EMS) Consideration/Problem Areas

1. Turfgrass and Landscape Plant Selection – adapted for use, pests, climate
2. Water-Use Efficiency/Conservation
3. Irrigation Water Quality Management – salts, nutrients, other constituents
4. Pesticides: Water Quality Protection
5. Nutrients: Water Quality Protection
6. Sediments: Water Quality Protection
7. Stormwater Management – flood control, water quality, water reuse.
8. Soil Sustainability/Quality/Health. OM, microbial populations, erosion control, any degradation factor.

Environmental Management Systems (EMS) Consideration/Problem Areas (continued)

9. Wildlife Habitat Management
10. Wetland/Stream Mitigation and Management
11. Aquatic Biology, Lake/Pond Management
12. Climatic Management – temperature, C sequestration, firewise landscaping, etc.
13. Energy Management
14. Waste Management
15. Maintenance Facility EMS aspects.
16. Clubhouse EMS aspects – includes pool, tennis courts, equestrian, grounds, etc

Athletic Field: Assessment (Australian Study)
Player Safety, Field Characteristics, Turf Quality

- Uniformity of Turf Cover*
- Density of Turf Cover*
- Turf Type and Weed Types
- Bare Ground Assessment* – percent, surface uniformity/evenness, wear patterns
- Grass Height
- Soil Texture and Clay Type
- Soil Profile Description – layers, horizons, zones
- Penetrometer Resistance/Compaction* and Layers
- Soil Hardness/Resiliency* – Clegg Hammer
- Traction*

*Involved in Player Safety.

Athletic Field: Assessment (AU study, continued)
Player Safety, Field Characteristics, Player Quality

- Soil Moisture – surface 4.0 inches during dry-down
- Irrigation Distribution/Water Audit – system adjustments
- Drainage – subsurface, surface drainage, contouring patterns (flat field, crowned, pocketed, etc.)
- Thatch
- Soil Fertility
- Irrigation Water Quality
- Soccer Goal Pegging/Installation*
- Fences*, etc.

*Involved in Player Safety.
#2. Areas of Confusion or Challenge

1. Items Identified By the Audience,
2. Product Labels and Ingredients,
3. Organic Soil Amendments,
   - Soil Microbial Additives or Enhancement
   - Biostimulants – hormonal, non-hormonal based.
4. Inorganic Soil Amendments (Non-Sand)
5. Fertilization/Nutritional Aspects
6. Water Treatment
7. Selection of Cultivation Devices

1. Areas Identified by Audience

2. Product Labels/Ingredients

Comment on General Claims: Any Soil Amendment or Additive

1. Essentially anything you add to the soil can “theoretically” alter soil physical, chemical, and biological properties. Examples: two products I could sell you and claim proprietary rights to not put on the label what is in it, but I could claim positive changes in all 3 soil properties.

2. “The Real Question” is not whether theoretically a product changes these properties, BUT whether it is significant in magnitude, duration, consistency, and cost effective.

Product Labels/Ingredients

Full disclosure on the package of:

- Product ingredients. Does the label disclose details on the nature of the ingredients?---active and “inactive”. What is the chemistry of the active ingredient.
- N and Fe content is especially important, since the responses may be from N or Fe rather than the advertised “active” ingredients. An “inactive” or “unlisted ingredient” that has known effects on plant growth should not be considered “inactive” and should be listed with concentration.
- Consider this rule: I will not accept any material even for trial unless the above information is provided.

Product Labels/Ingredients

- Insist on rate of application information – not just gallons per acre of total product; but lbs per acre of “active ingredient”.
- Does the product rate make sense related to the problem – example, if a Ca source added to increase pH (acid soil) or displace Na on the soil CEC sites (sodic soil), is the rate at 1 gallon per acre or 430 – 860 lbs per acre?
- Cost per lb of active ingredient --- can this be calculated?
- Does the product formulation make sense for the need. Foliar applied vs. foliar uptake.
Why These Guidelines?
• Common sense
• Remember that for a “soil amendment”, theoretical claims of improved soil physical, chemical, and biological changes can be made without reference to the magnitude of response.
• Products should be targeted to alleviation of a specific problem, and at the rate needed.
• These guidelines will eliminate many questionable products (now and in future), but allows legitimate new products and concepts to be introduced --- based on science and not pseudo-science.

3. Organic Soil Amendments or Additives

What Are Organic Soil Amendments or Additives?
• Anything that is organic in nature added to the soil.
• Most common organic additives are: compost material or organic fertilizers.
• But, many other organic-based materials may be promoted to apply to turfgrass situations for specific purposes. Examples are.....

Organic Soil Amendments/Additives:
A diverse group of materials
• Organic fertilizers
• Organic composts—surface applied
• Organic soil amendments or composts—worked into the soil
• Humates
• Humic Acids---granular, liquids
• Biostimulates—seaweed meal/extracts, hormones (cytokinin)
• Microbial additives—to increase microbial population
• MO additives to suppress diseases
• MO additives to control thatch
• Carbon sources---molasses, sugars

Proposed Benefits of OM Soil Amendments (depends on the material)
1. Microbial Additives/Enhancers---by direct inoculation or from carbon source. For one of these purposes;
   • Improve soil structure by microbial production of musilages.
   • Thatch decomposition by inoculation with organisms that degrade organic matter or by enhancing the earthworm population.
   • Disease suppression via inoculation with non-pathogenic organisms.
2. Biostimulants. Provide homanal responses. —auxin, cytokinins, hormone-like materials

Proposed Benefits of OM Additives (depends on the material)
3. Improved Soil Structure/water retention ---directly from the OM additions usually at 5-15 % volume.
4. Enhanced CEC—by CEC associated with OM. In sand with 1-3 % OM content (230-690 lbs OM) generally has CEC of 2-6.
5. Chelation of micronutrients by humic substances in OM.
Thatch Reduction and OM or MO Additives

1. Microclimate of Thatch Makes A Difference.
   • No wide fluctuations in environmental conditions – i.e., consistent weather.
   • Presence of Organic carbon/organic matter – i.e. thatch.
   • Good soil moisture (50-100 % field capacity)
   • Good oxygen status/aeration.
   • pH > 5.5
   • Soil or thatch temperatures 50F to 104F
   • Inorganic nutrients

2. Approaches – grow product in the soil; add the product frequently; apply in a manner to maintain more consistent conditions (core aerate, integrate into core holes, topdress and fill holes).

3a. Soil Microorganism Additives or Enhancement

Types:
• MO in liquid, slurry, or granular carriers; or inoculated onto organic composts.
• Materials to enhance MO growth – sugars

Claims or Purposes:
• Improve soil structure – therefore better drainage, root growth, etc.
• Decompose thatch.
• Suppress a particular disease
• Provide hormones, vitamins, amino acids, essential growth factors, other

NUMBER OF MICROBES IN SOIL

NO./GRAM OF SOIL
(SIZE OF NAVY BEAN) "VOLUME"

• BACTERIA 100,000,000-1,000,000,000
• ACTINOMYCETES 10,000,000-100,000,000
• FUNGI 100,000-1,000,000
• ALGAE 10,000-100,000

High Sustained MO Populations Are Favored By the “Microclimate” They Live In:

• No wide fluctuations in key environmental conditions. As these do change a particular microbial population may dramatically change.
• Organic carbon/organic matter (food source) – clippings, roots, etc.
• Soil moisture (50-100 % field capacity)
• Oxygen status/aeration. Aerobic MO populations are the most active in OM decomposition. Good drainage is important.
• pH > 5.5. Especially important for bacteria.
• Soil or thatch temperatures 50F to 104F
• Present of inorganic nutrients (N, P, K, S, etc. and Micronutrients)

Natural Microbial Populations

• Are microorganisms already present in mature turf systems?? Yes, they most often are present in appreciable quantities – due to a favorable microclimate and food source.
• Are readily available organic sources (sugars) and more resistant OM already present in turf systems as a food source for MO?? Yes, an actively growing turf will excrete about 20-30 % of soluble sugars produced each day from photosynthesis into the surrounding soil. Other OM comes from dead turfgrass and soil MO organic additions.

When are MO Populations Likely To Be Limited?

1. Site with very little organic matter prior to establishment, especially if:
   • No plant cover present for several weeks.
   • Site has been very dry for long period.
   • After soil sterilization
2. If the microclimate of the surface thatch, mat, or soil is not conducive to good MO activity – whether natural or introduced. Especially important are soil pH and aeration.
Thatch

Poorly drained soil

Sustaining MO Populations

- For natural or introduced MO populations to be sustained, their microclimate must be favorable.
- In a greenhouse (controlled climate), this is possible; but in the field, it is much more complex.
- Attempts to sustain an added MO population — repeated applications via sprays, irrigation system, granular applications.
- Add readily degradable carbohydrates to increase the MO population — best results in arid, low OM, bare soils for a short period of time; but little or no results in turf covered soil.

Organics For Thatch Control and Disease Suppression: UGA Studies

1. Sometimes (< 5% of measurements) thatch would be statistically less for a treatment — but not consistent over time. Note: Recent study at Clemson by McCarty reported rather consistent results which may be due to method of application – core aerate, apply material into holes, fill holes with sand (GCM, October 2006).
2. Sometimes (<10% of measurements) a particular disease would be suppressed — usually dollar spot and most likely due to the N in the product enhancing growth. But, not consistent overtime with rate or product.

Do you want a definite answer? Here it is.....

“SOMETIMES THEY WORK, OTHER TIMES THEY DON’T”

3b. Biostimulants

- A natural plant extracts and synthetic chemicals that have hormonal properties — i.e. they seem to provide some +/- growth response. But, they are not essential nutrients (fertilizers).

Biostimulants: Types Claimed to Give Hormonal Response

1. Natural plant extracts/meals and synthetic chemicals that have hormonal properties — i.e. they seem to provide some +/- growth response. Examples: cytokinins, auxins, GA, seaweed extracts/meal, yucca plant extracts
2. Humates/Humic materials with hormone-like activity.
**BUT, KEEP IN MIND… IN ADDITION TO THE “ACTIVE INGREDIENTS” MOST BIOSTIMULANTS CONTAIN PLANT NUTRIENTS (N, Fe)**

**BE SURE THAT THE “POSITIVE” RESPONSE SEEN IS IN FACT DUE TO THE “ACTIVE INGREDIENT(S)” AND NOT SIMPLY A NUTRITIONAL RESPONSE.**

**CYTOKININ-BASED BIOSTIMULANTS**
- Cytokinin-Synthetic
- Kelp Extract
- Seaweed
- Sea Kelp
- Yucca Extracts

**Common Biostimulant is Cytokinin**
- Cytokinins are synthesized in roots but most is translocated to the shoots. Unhealthy roots or lack of roots reduce cytokinin activity.
- Cytokinins (hormone) often give growth stimulation when plant roots are under root stress or recovering from stress, especially salinity, low oxygen, high temperatures (CS).
- Cytokinins may give response during establishment when roots are limited.

**Hormones**
- Abscisic acid (ABA)
- Auxins (indoleacetic acid, IAA)
- Ethylene
- Gibberellins (gibberellic acid, GA)
- Cytokinins/cytokinin-like

**a Primarily growth promoters**
**b Primarily growth inhibitors**

**HUMATE-BASE BIOSTIMULANTS**
- Humic Acid
- Fulvic Acid
What Are Humate/Humic Acids Additives

Humates should refer to mined humic substances but is often used to mean for any humic substance. Humic acid substances contain some humic acid content. **Sources:**

- Humates from natural deposits
- Composted sewage sludges, other sources
- Some sea plants, harvested and composted.
- Liquid extraction from humic substances, often also contain the non-humic fraction.
- Soil organic matter.

Proposed Benefits Humates

1. **Hormonal responses** ("biostimulate") — auxin, cytokinins
2. **Nutrients/Fertilizer** — naturally present or added.
3. **Chelation** of micronutrients
4. **Enhanced CEC** — sand with 1-3 % OM content (230-690 lbs OM) generally has CEC of 2-6.

Compounds in Organic Composts and Humates

1. **Non-humic Substances** (minor in mined humates) — such as simple organics (simple sugars, amino acids) and intermediate complex substances (polysaccharides, proteins, lipids).
2. **Humic Substances** — very complex organic compounds. Divided into
   - Humic acids. Alkali soluble
   - Humin. Not soluble in water or alkali.

Nature of Soil OM Turf Soils

1. **20-40 % Nonhumic**
2. **60-80 % Humic (Humus) Substances** — consisting of humic acids, fulvic acids, and humin.
   - 2 % OM by weight in the surface 4 inch layer of soil = **460 lbs of OM** per 1000 ft².
   - 2.0 lb N per 1000 ft² by Milorganite (6% N) equals **33 lbs OM** added per 1000 ft².
   - Typical OM addition (dry weight) by Kentucky Bluegrass lawn per year as roots is **130 lb per 1000 ft²**.
   - "Net increase" in OM is estimated at 0.1% SOM per year or 35 lbs SOM per 1000 sq. ft (Qian and Koski, 2002)

Biostimulants: Types Claimed to Give Non-Hormonal Response.

1. **Microorganisms or microbial extracts** --- vitamins, amino acids, essential growth factors, other
2. **Carbon sources**. Such as molasses.

OTHER MATERIALS SOMETIMES CALLED BIOSTIMULATES

- **AMINO ACIDS**
- **ENZYMES**
- **VITAMINS**
- **PROTEINS**

Which of these are made by the plant? Which are already in the soil from soil OM and within microorganisms?
CARBON SOURCES

• CARBOHYDRATES (MOLASSES, SUGAR)
  • What about the daily sugars that the plant makes and then excretes about 25-30 % into the rootzone?

4. Inorganic Soil Amendments – Sand Substitutes

Sand Substitutes – Claims

Various inorganic materials are sometimes added to mixes primarily to provide:
  • In sand soils: moisture retention; prevention/alleviation of localized dry spots; and for some materials to increase CEC.
  • In heavy soils: to increase macropore space; pore continuity; better aeration; infiltration and percolation. Improved moisture retention and aeration conditions from sand substitutes (SS) relative to sands arise from the internal porosity (i.e., pores inside the SS particles) of the sand substitute unless total volume of sand + SS is > 85 % and particle bridging occurs to open up macropores between sand sized particles (sands + SS).

Inorganic Sand-Substitutes

<table>
<thead>
<tr>
<th>Material</th>
<th>DE</th>
<th>CC</th>
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</thead>
<tbody>
<tr>
<td>Vermiculite (No)</td>
<td></td>
<td></td>
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<tr>
<td>Perlite (No)</td>
<td></td>
<td></td>
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<tr>
<td>Pumice (No)</td>
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<tr>
<td>Sinterid Fly Ash (No)</td>
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<tr>
<td>Clay</td>
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<tr>
<td>Axis (DE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenschoice (CC)</td>
<td></td>
<td></td>
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<tr>
<td>Isolite (DE, CC)</td>
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<tr>
<td>Lassennite (Volcanic ash/amorphous silica, diatoms) ASTM C-131 ??</td>
<td></td>
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<tr>
<td>Profile (CC)</td>
<td></td>
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<tr>
<td>Perm02Pore (CC)</td>
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<tr>
<td>PSA (DE)</td>
<td></td>
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<tr>
<td>Terragreen (CC)</td>
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<tr>
<td>Turface (CC)</td>
<td></td>
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<tr>
<td>Zeolites</td>
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<td></td>
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<tr>
<td>Others</td>
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</tr>
</tbody>
</table>

DE = Diatomaceous earth
CC = Calcined clays
No = amendments not used due to poor particle strength/stability

Sand Substitutes: Issues

- Moisture Retention vs. Moisture Release
- Weathering Stability
- Mechanical Stability
- Percent by volume to achieve significant moisture retention/release, CEC, aeration porosity, other other attribute desired. Percent required should be based on soil physical lab analyses with SS mixed into the sand/OM media – example 5, 10, 15 %.
- Will too much cause problems? Remember that some SS add considerable internal micropores (capillary porosity) – excess moisture retention, limit rate of salt leaching, etc.
- Does it preferentially hold Na – none do that I am aware of, but some do preferentially hold K.
- Total soluble salt leaching from micropores when water quality is not good, especially at high use rates ??
ASTM Tests: Sand Substitutes

- **ASTM C 88-99a.** Standard Test Method for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulfate. American Society for Testing and Materials. This test method covers the testing of aggregates to estimate their soundness when subjected to weathering action. < 12% degradation.

- **ASTM C 131-03.** Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine. American Society for Testing and Materials. This test method covers a procedure for testing sizes of coarse aggregate smaller than 37.5 mm (1 1/2 in.) for resistance to degradation using the Los Angeles testing machine. < 40.

Calcined Clays

Calcined clay is a hard, porous mineral derived by calcining (heating to just below the melting point, usually about 1300–1800°F) a clay material to remove water and stabilize it both physically and chemically.

These are also called porous ceramics; however, a material can be classified as a porous ceramic as long as it contains some calcined clay.

Examples of 100% calcined clays (porous ceramics) are Profile, Greenschoice, Turface, and Terragreen. Isolite contains diatomaceous earth plus clay and is not calcined. Thus, it is classed as porous ceramic but not a pure calcined clay.

Diatomaceous Earth

Diatomaceous earth is an inorganic material that is derived from diatoms; deposits of fossil diatoms which are primarily SiO₂.

Examples are Axis and PSA. Axis is calcined and PSA is kiln fired but not at a temperature high enough for calcining.

Lassenite Soil Amendment

- “The Lassenite Pozzolan deposit, which is primarily amorphous silica, originated 26 million years ago when nearby volcanoes erupted and the volcanic ash was deposited into freshwater lakes. These freshwater lakes contained large amounts of protozoa called diatoms. The skeleton of this tiny organism is extremely porous and absorbent which allows for the efficient movement of air and water available to turf and plants.”

Zeolite

- Increase CEC permanently.
- Use on sites with low CEC (<2.5 cmol/kg) due to low clay and OM content.
- Favors K retention, but not Na.
- Aids in reducing wide fluctuations in nutrients with leaching irrigation and rain.
- Zeolite with CEC of 150 cmol/kg requires about 225 lbs per 1000 sq. ft. mixed in surface 4.0 inches to raise CEC 1 cmol/kg. Total target CEC in surface 4 inches is 2.5—3.0 cmol/kg.

Zeolites – mined, natural ones.

The chemical formula for clinoptilolite, a common natural zeolite is: (Na₃K₃)(Al₄Si₁₃)O₉6 • 24H₂O.

Atoms or cations (i.e., charged metal atoms) within the second set of parentheses are known as structural atoms, because with oxygen they make up the rigid framework of the structure. Those within the first set of parentheses are known as exchangeable ions, because they can be replaced (exchanged) more or less easily with other cations in aqueous solution, without affecting the aluminosilicate framework. This phenomenon is known as ion exchange, or CEC.
Selection of Rootzone Mix: Sand Substitutes

**Original mixes**
- 0 to 15% by volume
- 0 to 10% by weight

**Topdressing mix**
- 0 to 30% by volume
- 0 to 15% by weight

**Benefits Claims**
- **Sand soil**: moisture retention, prevent/alleviate localized dry spot, some increase CEC (Zeolite can increase CEC substantially)
- **Heavy soil**: better aeration, infiltration/percolation, alter soil texture

---

**Physical Properties of the Rootzone Mix**

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Recommended Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Porosity</td>
<td>35%-55%</td>
</tr>
<tr>
<td>Air-filled Porosity (at 40 cm tension)</td>
<td>15%-30%</td>
</tr>
<tr>
<td>Capillary Porosity (at 40 cm tension)</td>
<td>15%-25%</td>
</tr>
<tr>
<td>Saturated Conductivity</td>
<td>Minimum of 6.0 inches per hour</td>
</tr>
<tr>
<td>Organic Matter Content (by weight)</td>
<td>1%-5% (ideally 2%-4%)</td>
</tr>
</tbody>
</table>

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**5. Fertilization Related**

- **Situations Causing Nutrition Problems**
  - **Low CEC soils** – sandy, low OM soils, low clay content
  - **Poor rooting depth and viability** – often associated with excess OM in surface zone.
  - **Ultra pure irrigation water** (EC < 0.30 dS/m; 192 ppm)
  - **Lower quality irrigation water**: reclaimed water, saline ground water, seawater blends, water recycling.
  - **Water treatment additions**: acid injection
  - **Soil amendments additions**: gypsum, others
  - **Leaching**: rainfall and for salt control
  - **Pancaking of several of above.**

- **Not Understanding Soil, Water, Tissue Tests**
  - **Problem areas**:
    - Use of high rankings to create unneeded nutrient recommendations;
    - Use of dilute saturated water paste data to make nutrient recommendations;
    - Not using “saturated paste extract” for assessing salt-affected soils.
    - Improper extractant.
    - Too much emphasis on BSCR method.
    - Professional turf manager must be able to deal with these issues.
    - See Sept 03, Jan 04 Golf Course Mange.
Foliar Fertilization

Spoon Feeding = light, frequent applications of fertilizer. Excellent practice;
- To enhance nutrient-use efficiency.
- For saline irrigation water and low CEC soils for all nutrients.

But:
- Does Spoon Feeding = Foliar Feeding = Fertigation. Does not have to be foliar but can use light, frequent applications of granular fast/slow release fertilizers.
- Does Foliar Application = Foliar Uptake.

Foliar Feeding

- **Defined:** Low rate of nutrients applied to the foliage or leaves using < 1-2 gal water per 1000 sq. ft. Nutrients are water soluble and not suspensions.
- **Uptake** through the cuticle pores (hydrophycin, negative charged) more than cracks and stomata. Inside the leaves, nutrients pass directly into cells through the cell wall and plasma membrane; or enter the apoplasm (space between cells) and then may be transported in the xylem (up) or phloem (up, downward).
- Uptake most rapid with same **forms** taken up by roots. Large molecules do not pass.

Foliar Applied: Nutrient Mobility

1. **Are all nutrients taken up?**
   - Hot, dry conditions limit uptake.
   - Mowing of leaves before uptake—if clippings are returned to the soil, they become available; but not if removed.
   - Uptake is rapid in only certain forms

2. **Are all nutrients translocated downward?**
   - Mobile---N, P, K, Mg, Cl, Na
   - Somewhat Mobile---S, Cu, Mo, Zn, B
   - Immobile---Ca, Fe, Mn, Si. Ca and Mn must be “targeted” to site of need.

Targeted Calcium Applications

- Ca applied to replace Na on soil CEC. Rate 440 – 880 lb Ca/acre to soil.
- For Ca deficiency in leaves due to Ca displacement/stripping, Ca should be foliar in a form that is foliar taken up. Rate 4.4 – 8.8 lb Ca/acre.
- For Al/Mn toxicity (pH < 5.0) or Na toxicity to roots, Ca must be applied to root area at high liming rates.
- Pay attention to Ca form, rate, cost per pound of Ca --- use common sense.

Calcium product release & movement in the soil & plant

- **Fast Release/Solubility** (foliar application for **foliar uptake**). These are **liquids**.
  - **Calcium nitrate** – yes
  - **Calcium chloride** - yes
  - **Calcium gluconate/heptogluconate**
  - **Calcium complexed with sugar alcohols**

- **Intermediate Release/Solubility** (foliar application does not mean foliar uptake for suspension products) (**root uptake** or removal with clippings).
  - **Calcium sulfate** (gypsum); Calcium thiosulfate

- **Slow Release/Solubility** (foliar application not foliar uptake for these **suspensions**). (root uptake or removal with clippings).
  - Calcium hydroxide / oxide; lime or Dolomite; Calcium carbonate (lime) & powdered coral; Calcium silicate
Situation: Low CEC/OM Content

Combination of low CEC sands + rapid OM decomposition (little OM contribution to CEC) + irrigation water that is too pure (EC < 0.30 dS/m) + high rain fall = limited nutrient retention and high leaching of many nutrients.

- Roots may be present but not nutrients—but nutrient deficiencies ultimately limit rooting.
- N, K, Mg, Ca, S, P, Mn, Zn, Fe
- Multiple nutrient deficiencies possible.
- Other problems--- hydrophobic areas, turf more prone to wear and drought.

Situation: Low OM Content (continued)

- All nutrients should be spoon-fed.
- N fertilization not responsive if other nutrients are limited.
- Try zeolite. Zeolite with CEC of 150 cmol/kg requires about 225 lbs per 1000 sq. ft. mixed in surface 4.0 inches to raise CEC 1 cmol/kg. Total target CEC in surface 4 inches is 2.5—3.0 cmol/kg.
- Why not use a porous ceramic? 3-5X rate.
- Add over time with topdressing at 30 % by volume + 70 % sand.
- Use good stable zeolite—mechanical, weathering stability

6. Water Treatments

1. Bicarbonate Removal by acidification. Yes, if Na is high relative to Ca and Mg in the water.
2. Magnetic devices or similar. No.

Bottomline --- Na removal requires Ca addition plus leaching, leaching, leaching. Water acidification alone doesn’t help.

Most Important Reasons For Cultivation

1. Number One Reason = Create Temporary Macropores (> 0.10 mm diameter) for the purposes of:
   - Improved infiltration and percolation --water
   - Improved gas exchange--oxygen
   - Improved rooting—roots
2. Second most important reason is to reduce soil strength.

7. Selection of Cultivation Devices
### Additional Reasons For Cultivation

- Reduce soil compaction
- To modify the soil (with topdressing)
- For overseeding/renovation Break up soil layers
- Improve resiliency
- As a tool for thatch control
- Improve penetration of chemicals

### Developing Turfgrass Cultivation Programs

1. Identify primary (basic) soil physical and chemical problems
2. Select the best method(s) to correct problems
3. Determine the frequency of cultivation
4. Determine the appropriate times of application
5. Evaluate the effectiveness of your program

### 8. Management Style

#### Basic Agronomics vs. Search for the Silver Bullet

For maintenance of a good soil/plant nutritional program, the most important aspects are:

- Soil chemical properties are primary – CEC level, nutrient balance, nutrient levels, pH, salt control
- Soil physical problems are also important – especially excessive OM or any factor that limits water movement.
- Soil biological activity or biostimulates—least important since good turf = good conditions for MO activity.
- Which of these do I emphasize in my programs – time, money, focus?? Use common sense.

### #3. Questions to Ask About a Product/Technology

1. Is the product **needed**?
2. **Active ingredient** – is it listed on label, how much (oz per Acre). Is it a realistic rate.
3. Are there better **alternatives**?
4. Is the positive response from the product or an added material?
5. What about magnitude, duration, **consistency of response**?
6. Are valid, unbiased **test results** available?
7. Should I try this on a **trial area** or basis?
8. Do the **benefits** justify the **costs**?

### Questions to Ask About a New Product/Technology

1. **Is this product needed in my situation?**
   - Does the product specifically address a problem that is important?
   - Does the product provide anything not already present in the soil such as humic acids, humus, microorganisms, etc.
   - Produced by the plant such as hormones.
### Questions to Ask About a New Product/Technology

#### 2. How Much Active Ingredient Is Applied?
- Is the specific active ingredient noted?
- How much active ingredient is actually applied per acre or 1000 sq. ft.
- How much active ingredient do alternative products apply and how much is needed to get an expected response.
- Example, some Ca products may only apply < 1% of needed.

#### 3. Are there better “alternatives”?
- Example: pH reduction of alkaline soils to provide better nutrition versus adding the deficient nutrients.
- Example: acidification of irrigation water to prevent calcite formation and possible sealing of sands.
- Adding MO rather than producing a microclimate to favor natural populations.

#### 4. Is the positive response from the product or an added material?
- Example: N, Fe, or colorants added for a “greening” effect.
- Am I looking for the “silver bullet” of turfgrass management?
- Don’t forget the basics - grass selection, mowing, irrigation, fertilization, pest control.

#### 5. What is the...?
- **Magnitude** of response?
  - 80 to 100%
  - 40 to 60%
  - 0 to 20%
- **Duration** of response?
- **Consistency** of response?

#### 6. Are valid, unbiased “tests results” available?
- Is the product performance based on:
  - Sales/company claims.
  - Testimonials.
  - Scientific results from University and/or unbiased laboratories.
- Are you the product testing facility?
- Ask “will you put in writing exactly what this product will do in my situation and why that response occurs?”

#### 7. Should I try this on a trial area or basis?
- Have a control (check)
- Have replications
- Randomize
- Determine ahead of time what you expect based on product claims. Do these occur?
Questions to Ask About a New Product/Technology

8. **Do the “benefits” justify the “costs”?**
   - Are benefits sufficient to justify the expense?
   - Would I purchase this product from my bank account if I was the owner?