Cation Ratios And Soil Testing Methods For Sand-Based Golf Course Greens

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This research is focused on basic cation nutrition of sand-based greens. Specifically, we are looking at soil testing techniques for measuring exchangeable basic cations and cation exchange capacity (CEC), and we are also looking at Basic Cation Saturation Ratios (BCSR) for creeping bentgrass. Most of our progress this past year was made evaluating soil testing techniques.

Soil Testing Procedures:
Some soil testing methods dissolve calcium carbonate and/or gypsum; thus, reporting high readings for exchangeable calcium, which may lead to erroneous interpretations of CEC and basic cation ratios. On soils with large proportions of clay and organic matter, this dissolution problem usually has a small affect on the results, but in the high-sand, low-organic-matter, calcareous root zones used for turf, the dissolution of calcium carbonate can greatly influence the results. There are two ways to approach this problem of dissolution. The first solution can be to prevent the calcium carbonate or gypsum from dissolving during the soil testing procedure. Ways to prevent the dissolution include raising the pH and/or lowering the salt concentration of the extracting solution, or by choosing different extraction solutions that have less reactivity with $CaCO_3$ or $CaSO_4$. The second answer to dissolution is to be aware that dissolution is occurring and correct for this amount. One correction method measures the carbonate and sulphate concentration in the soil extracts and relates those concentrations to dissolved $CaCO_3$ and $CaSO_4$, respectively (Suarez, 1996). The concentrations of dissolved $CaCO_3$ and $CaSO_4$ are related to calcium and are subtracted from the total calcium measured in the extract.

We started by raising the pH of the industry standard ammonium acetate pH 7 (NH_4OAc) procedure. Raising the pH of the ammonium acetate solution from 7.0 to 8.1 reduced the Ca concentration of the soil extracts an average of 33% (Table 1). We also evaluated a procedure that makes corrections for the dissolved $CaCO_3$ and/or $CaSO_4$. The technique uses ammonium chloride (NH_4Cl) as the extracting solution (Suarez, 1996). The NH_4Cl procedure measured an average 16% less Ca than the NH_4OAc pH 7.0 extraction procedure (Table 1).

We also evaluated the effect of calcium carbonate on several different soil test procedures by testing samples with increasing levels of $CaCO_3$. We mixed silica samples with either lab-grade $CaCO_3$ or a local calcareous sand. The results from 5 different soil test techniques are presented in Graphs 1 and 2. When using reagent grade $CaCO_3$, the dissolution of $CaCO_3$ plateaued for each extraction technique. The Mehlich 3 leveled off around 10-15% $CaCO_3$ content (Data not shown), whereas the NH_4OAc pH 8.1 and NH_4Cl methods leveled off around 0.5% and the NH_4OAc pH 7 leveled around 2%. Clearly the different techniques influence the solubility of $CaCO_3$. When using sand instead of lab grade $CaCO_3$, the Ca concentrations were not as high and did not plateau either. Not as much Ca was dissolved when using sand as the $CaCO_3$ source. The differences in Ca concentration between the two types of $CaCO_3$ sources could be attributed to particle size and purity. The lab grade $CaCO_3$ was a finely ground pure powder whereas the sand had a much larger particle size and the individual particles of $CaCO_3$ probably contained impurities, both of which probably caused a reduced dissolution rate. It is also possible that the sand we used did not actually have 11% $CaCO_3$ like we measured. We measured the calcium carbonate concentration of the calcareous sand by gravimetric loss upon treatment with acid. Perhaps the loss in weight we measured was due to more than just reaction of the $CaCO_3$ with acid. We are doing further evaluations of these procedures in the winter of 2004/2005.

We have been using DOWEX cation exchange resin to mimic sand. DOWEX is a sulfonated polystyrene/ DVB matrix resin that has a known cation exchange capacity. We intend to 'load' the resin with different ratios of cations and perform several soil tests with different techniques and hopefully determine which method extracts the correct ratio and concentration of cations. In our experiments to date, we apparently have not correctly prepared the DOWEX for analysis. The DOWEX was prepared for analysis by washing it with a weak HCl solution, equilibrating it with a solution containing Ca and Mg overnight, rinsing with distilled water, and air drying. The results from these experiments had very high levels of Ca and Mg compared to the calculated CEC of the DOWEX and also had very low pH. Therefore, we believe the DOWEX samples were not rinsed with enough distilled water to remove any free Ca/Mg solution and due to the low pH, the DOWEX samples were not properly equilibrated with the Ca/Mg solution to remove enough of the H ions from the exchange sites. We are doing more work to establish the correct preparation procedures for DOWEX analysis.

Basic Cation Saturation Ratio Theory
The BCSR theory states that proper and healthy growth is achieved when the basic cations exist within certain percentages of the cation exchange capacity (CEC). It states that calcium (Ca) should be 65-85% of the CEC, magnesium (Mg) should be 6-12%, and potassium (K) should be 2-5%. Recently we have seen an increased use of the BCSR theory with sand-based greens and athletic fields. The validity of applying this theory to sand-based greens is in question.

While research has been conducted applying the cation saturation theories to agronomic crops established on soils with large proportions of clay, silt and organic matter and relatively high cation exchange capacities, little research has been completed applying these methods to turfgrass established on sandy, low CEC media. The objective of this research is to determine the effectiveness and validity of the BCSR theory for use with sand-based turfgrass systems.

Future Plans:
We plan to finish the soil test experiments for exchangeable basic cations and for cation exchange capacity this year. We are continuing the studies designed to use exchange resins to mimic sands for soil test evaluation and correlation. Recently we visited with other soil

scientists around the US and have discovered some new techniques that we are planning to add to the experiment. We are still modifying the DOWEX protocol to improve its effectiveness for use in the soil test experiments.

We are working with a statistician to redesign the BCSR experiments in the greenhouse. We are hoping to use a 'mixture statistical design' to compare ratios of Ca, Mg, and K in a single study, rather than using three independent studies looking at Ca:Mg, Ca:K, and Mg:K. The basis of the 'mixture design' is to maximize results, while minimizing the number of treatments. We plan to have the greenhouse experiment started this winter and replicated in the spring.

References:

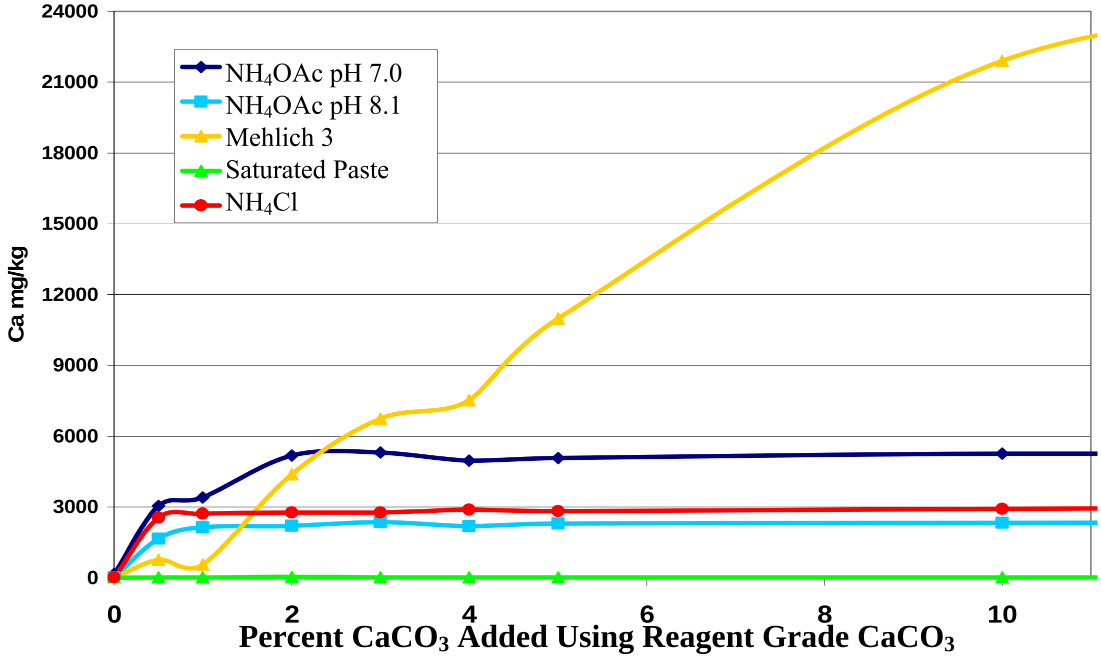
Suarez, D.L. 1996. Beryllium, magnesium, calcium, strontium, and barium. p. 575-601. *In* Sparks, D.L. (ed.) Methods of soil analysis: Chemical methods. Part 3. SSSA, Madison, WI.

Table 1. Average Ca concentration affected by soil test method of 19 soil samples with soil types ranging from sand to silt-loam.

Method	Ca (mg/kg)
Mehlich 3	3100 a†
NH4OAc pH 7.0	2774 ab
NH4Cl	2328 c
NH4OAc pH 8.1	1853 d

†Means with the same letter are not significantly different according to Tukey's multiple comparison error rate. ($p \leq 0.05$)

Graph 1. Ca concentration from silica sand samples that had increasing levels of reagent grade $CaCO_3$.



Graph 2. Ca concentration from silica sand samples that had increasing levels $CaCO_3$ from local calcareous sand.