# Chapter 8.

## Summary and research needs.

If soil nutrient analyses from a particular site are always conducted with the same extraction procedure, the results will probably represent the changes in nutrient availability indices from that site. When samples from different sand rootzones are compared to derive sufficiency ranges, however, there is increased variability in the extracted nutrients when common extracting solutions such as 1 *M* $NH_4OAc$, Mehlich 3, and Morgan are used. The variability is caused by extraction of an unknown fraction of non-exchangeable cations, and it makes the results more difficult to interpret.

A recurring observation in our work has been the disconnect between turfgrass performance and the current sufficiency ranges for extractable nutrients. We found that creeping bentgrass growth and performance were acceptable even at levels of soil nutrients classified as low. Furthermore, leaf nonacid cation contents were regularly within proposed sufficiency levels when creeping bentgrass was grown in sands classified as low in the corresponding nonacid cation.

The 0.01 *M* $SrCl_2$ extraction procedure can be used to extract the nonacid cations that are actively exchangeable with the soil solution. Water soluble nonacid cations appear to provide a useful index of nutrient availability in a range of sands under greenhouse growing conditions.

We have identified extraction procedures that offer significant improvements over the current technology. Most importantly, a dilute salt solution such as 0.01 *M* $SrCl_2$ extracts all the actively exchangeable cations in sand samples with CEC < 60

$mmol_c\ kg^{-1}$. The procedure appears to be suitable for assessing the nonacid cations in sands ranging in pH from less than 5 to more than 8. The 1 *M* $NH_4OAc$, Mehlich 3, and Morgan tests were not suitable for extraction across such a range of soil properties.

Although we have made advancements in the understanding of nutrient analysis and nonacid cation bioavailability in sand rootzones, there are studies that should be considered to expand the utility of soil nutrient analyses of turfgrass sites.

First, the 0.01 *M* $SrCl_2$ and 1:5 $H_2O$ procedures should be used to evaluate nonacid cation, P, and micronutrient bioavailability in a wider range of sands that vary in pH, organic matter, and mineralogy. The extractable nutrients from the soil should be considered in their relationship to grass yield, turfgrass performance, and leaf nutrient content. The importance of measuring grass yield in response to changes in soil nutrient levels cannot be overstated. The turfgrass industry has often considered yield to be secondary to turfgrass quality or performance, but the yield data are important because they give a direct measurement of plant growth response to nutrients. Although we do not want to maximize yield, we do not want to minimize it either, and it is essential that we understand the growth response to available and applied nutrients.

The 0.01 *M* $SrCl_2$ and 1:5 $H_2O$ procedures should also be evaluated under field conditions in sands of varying types. It is necessary to confirm whether variable irrigation practices and environmental conditions will influence the nutrients extracted by these procedures to such a degree that they are no longer predictive of plant-available nutrients.

Finally, a series of experiments should be conducted to determine the soil nutrient levels at which maximum turfgrass yield is achieved for fixed N rates. Soils selected for these experiments must be representative of turfgrass sites as a whole, and the data must be generated for different turfgrass species. However, these calibration studies should not be done until a suitable universal extractant for turfgrass sites has been identified. It is clear that the 1 *M* $NH_4OAc$, Mehlich 3, and Morgan tests are not suitable for all soil types, but the suitability of the 0.01 *M* $SrCl_2$ test is not yet established, and the 1:5 $H_2O$ procedure shows great promise under greenhouse conditions, but we are not sure of results to be expected in the field.