CUTT

# Understanding the Exchange:

## Turfgrass Nutrient Management and Cation Exchange Capacity

*Cation exchange capacity is important to plants because it affects nutrient uptake by plants, leaching of certain nutrients, and buffering of soil pH.*

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Cation exchange capacity, or CEC, is the amount of cations a soil can hold. Cations that are most important to turf include hydro-gen, calcium, magnesium, potassium, ammonium and sodium. Cation exchange sites include the surfaces of clay size particles and organic matter. The amount of CEC is dependent on the amount and nature of the clay and organic matter. Some clays have a lower CEC value like the highly weathered kaolinite which have a CEC of 3-15 cmol/kg (me/100 g of soil). Other clays like montmorillonite, which have more exchange sites, can have CEC values up to 150 cmol/kg. Fresh organic matter that is not highly decomposed has a low CEC; whereas, as highly decomposed organic humus can have a high CEC value (>150 cmol/kg).

CEC is important to plants because it affects the process of:

- Nutrient uptake by plants
- Leaching of certain nutrients
- Buffering of soil pH

### Nutrient Uptake by Turf

Nutrients that are cations, like calcium, magnesium and potassium, are supplied to plants either from the soil solution or stored in the soil on CEC sites. The source of the nutrients may be from fertilizers, nutrients found naturally in the soil, or "recycled" nutrients through the decomposition of dead turf. In soil with a low CEC, such as a sandy soils with little or no clay or organic matter, the nutrients are supplied to the plant via the soil solution. Sandy soils with low CECs must be fertilized more frequently than soils with high CEC (especially if water soluble fertilizers are used) because the soil has little or no ability to retain or store cations on CEC sites.

Let's look at what is known about how CEC influences nutrient uptake in turfgrass (basically very little). We have had several graduate students at Cornell University that have studied nutrient uptake as it relates to CEC in sand based systems, in this case experimental sand greens profiles. Dr. Arthor Huang (Cornell University Ph.D. 1992) found that 16 to 22 % more of the fertilizer nitrogen was accumulated in the creeping bentgrass clippings when CEC was increased from 0.1 to 10 cmol/kg. Petri Anton (Cornell University M.P.S. 2000) found that more nitrogen, potassium, phosphorus and magnesium was recovered in bentgrass clippings when CEC was increased from 0.3 to 10 cmol/kg.

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# Cation Exchange Capacity

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## Nutrient Leaching

The leaching of nutrients is bad for several reasons. First, nutrients that are leached are not available for plant use, which means your fertilizer dollar was wasted. Second and more importantly, nutrients that are leached can results in groundwater contamination and possibly surface water contamination if the groundwater feeds surface water resource. CEC can reduce nutrient (cations) leaching by absorbing the nutrients when first applied then slowly releasing the cations as the plant removes them from the soil solution. Some cations are more prone to leaching such as single positively charged cations like potassium, sodium, hydrogen and ammonium. On the other hand, divalent (2 plus charges) cations (like calcium and magnesium) are held more tightly and leach much less from the soil.

In some cases leaching of cations is a good thing, especially if the cations are sodium and hydrogen. Sodium can directly injure turf or destroy the structure of the clay in a soil if sodium dominates the CEC sites. When lime is added the calcium (and/or magnesium) ions replace the hydrogen on the CEC sites and the soil pH will rise.

## pH Changes

The pH of the soil is determined by the amount of hydrogen found in the soil water. The amount of hydrogen in soil water is directly related to the amount of hydrogen on the CEC sites. At very low pH (<5.5) the amount of hydrogen in the soil water is also a function of the amount of aluminum on the CEC sites.

At the same pH, soils with a higher CEC value will require more lime to raise pH or sulfur to lower the pH than soils will lower CEC. When we apply lime to raise pH we are lowing the hydrogen ion concentration of the soil water by replacing hydrogen on the CEC sites with calcium (or magnesium if it is dolomite lime) and allowing the hydrogen ions to leave the soil, thus raising the pH. The difference in the amount of lime it takes to raise the pH from soil to soil can vary greatly and is related to CEC. If we have a clay soil with a high CEC it can take as much as 10 times more lime to raise the pH the same amount than a sand soil with a very low CEC.

## CEC and Turf Growth

To increase the CEC of a soil one adds materials like clay, organic matter or other soil amendments like natural zeolites and calcine clays. Obviously if one adds clay, organic matter or other soil amendments, many other soil properties are modified like the water holding capacity, saturated hydraulic conductivity, compaction susceptibility, and fertility (both in the form of macro and micro nutrients). Therefore, to study just the impact of CEC on grass growth requires one to adjust or correct for the other changes in soil properties. To study the affect of CEC on grass growth Petri Anton chose to study a soil with a very low CEC (sand) which would most likely show the greatest effect of increasing CEC on turf growth. Sand greens profiles were amended with reed sedge peat and two natural zeolites. The CECs were 0.3, 2, 4, 6, 8 and 10 cmol/kg. To get a CEC of 6 cmol/kg, 40 per cent of the mix, by volume, was peat and the two natural zeolites. Some other natural zeolites have higher CEC values and would require much less to increase the CEC.

As CEC increased up to 300%, shoot growth of creeping bentgrass increased only 17%. Improvement in growth was attributed to better uptake of nutrients and less leaching of nutrients. We would speculate that for soils having a high initial CEC, increasing the CEC by amendments of clay, organic matter or zeolites may have the same or less effect since they already have good nutrient holding capacity

Since materials that are used to increase CEC also modify many other properties, there is likely a much greater benefit to grass growth than nutrient fate as affected by CEC. For example, Dr. Huang found by increasing the CEC from 0.1 to 10 cmol/kg by adding a natural zeolite to sand, increased water use efficiency of creeping bentgrass 30 to 60%, depending on the nitrogen application rate. The more nitrogen applied the greater the water use efficiency to produce growth. Therefore, the goal of adding soil amendments to improve turf health benefits more than just plant nutrition.

*Marty Petrovic*

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