Research

Because water availability is becoming one of the most serious problems affecting the population, more golf courses are using reclaimed water to irrigate turf. Photo: Toro

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Minimizing damaging effects

Amino acid-based products positively influence low-quality golf course irrigation water

Water availability is one of the most serious problems affecting the world population, especially in arid and semiarid regions where long droughts can jeopardize development. Because of this increasing concern, water management for irrigation has evolved to optimize this resource for agriculture. For more and more golf courses, this evolution has led to the use of reclaimed water.

However, if the advantages of using recycled water are clear from a conservation perspective, the suitability of the water for irrigation purposes can be a nightmare for golf course superintendents. The extra chemical components and heavy metals in the water can damage the turfgrass, requiring more management of the water, soil and plant. (Y.L. Qian 2005)

Water quality depends on the type and concentration of substances in it. In most cases, reclaimed water contains a high dissolved salt content that potentially can be toxic to turfgrasses (R. Emmons 2000). These salts are generally chlorides of sodium and magnesium, sulphates and bicarbonates of calcium and magnesium, sodium carbonate, nitrates, ammonium, etc.

Basically, the buildup of salinity in the root zone can affect the turf performance in four critical manners (R.R. Duncan 2000):

- High salt concentrations generate low soil water potentials, leading to a drought stress that reduces the ability of plants to absorb water and nutrients. In this condition, turfgrass exhibits typical symptoms of drought stress (growth inhibition, photosynthesis reduction, desiccation) while the soil still appears moist.
- There are ions that cause specific ion toxicity. They include Na+, Cl-, $CO_3$2-, HCO_3-, pH (H+ and OH- ions) and heavy metals.
- The presence of a high amount of some substances in proportion to others can induce nutrient imbalances inside the plant.
- High sodium concentrations might alter the structure of soils because of the so-called sodium permeability hazard.

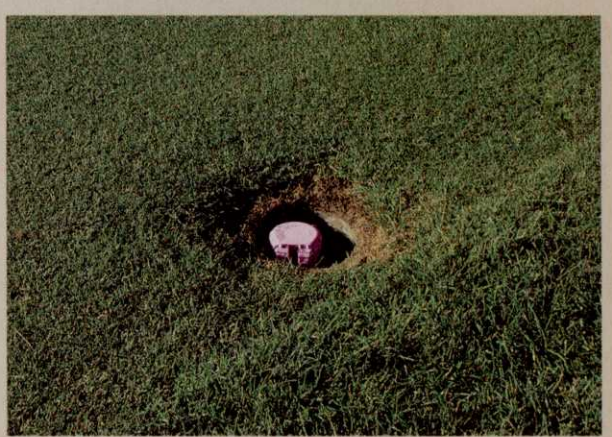
Symptoms of turfgrass affected by high salt concentrations include:

- growth reduction by inhibiting physiological processes such as nutrient uptake and assimilation;
- loss of color due to degradation of pigments like chlorophylls (e.g., yellowing, browning or purpling);
- wilting caused by the loss of water availability;
- leaf curling, and;
- leaf firing or desiccation (M. Huck 2000).

One of the classic methods that superintendents use to minimize salinity stress is to excessively irrigate to leach the salts. Also, it's important to strictly control the nutrients that the course receives through fertilization and not compound the problem. For this reason, constant soil and water analyses must be conducted in order to have updated information about turf conditions.

MITIGATING SALT DAMAGE

Yet, turfgrass salt damage can be mitigated by amino acids, which are the precursors of proteins and, either solely or conjointly, play a role in numerous biological processes. Some of their functions include the stimulation of root development, stomata opening and cell membrane permeability.



By using reclaimed water, which has high salt content, the buildup of salinity in the root zone can effect turf performance. Photo: Rain Bird

Amino acids also are precursors of hormones, nucleic acids and other important organic compounds such as chlorophylls. They play a role in osmoregulation, and some of them have complexing capacity with metal nutrients. Additionally, they have a function in the protection of cellular macromolecules and as scavengers of free radicals because of the antioxidant activity of some (M.M.F. Mansour 2000).

Because of their diverse functions, the additional application of amino acids is a complement for plants to save energy for their production and acts as a biostimulant of physiological processes.

The application of amino acids might be particularly helpful under stressful situations, when maximizing energy conservation, reduc-

The advantages of using reclaimed water are clear from a conservation standpoint but can be a nightmare for golf course superintendents. Photo: Toro

ing water loss and using reserves to maintain vital functions as part of the defense mechanism of plants. This becomes true especially in the case of salt stress (V.K. Ray 2002).

For preventing drought stress caused by the high salt content, plant resistance to salinity strongly depends on its osmotic regulation capacity at a cellular level. This regulation is mediated by the accumulation of amino acids and other compatible solutes, which helps to retain water inside the cell and prevents the dehydration of the entire plant (C. Di Martino 2003).

On the other hand, the complex capacity of amino acids can help the soil to retain nutrients (particularly mobile ions such as potassium, magnesium, nitrate, iron and manganese), otherwise lost by frequent leaching (H.D. Aschmead 1986). This complex capacity also is useful with the undesirable presence of any heavy metal in a high amount. Amino acids can buffer their flux by chelating them, which can prevent the heavy metal toxic effect (S.S. Sharma 2006).

However, one of the most harmful effects caused by salinity is probably due to the high concentration of sodium. Excess sodium is likely to cause damage in the soil structure and inside the plant. In the case of soil damage, sodium can displace potassium and calcium from soil exchange sites. Calcium ions are the building blocks that enhance the structural integrity of the clay fraction in the soil profile, hence its loss causes clay dispersion and, consequently, poor soil aeration (R.R. Duncan, 2000). That's why it's necessary to have an application of a calcium source in soils affected by salinity.

Additionally, once inside the plant, a high proportion of sodium can displace calcium in the cell walls and membranes of root tissues and cause root deterioration. In these situations, cells' contents often start to leak; above all, a potassium leakage occurs (M. Huck 2000). Considering potassium's high mobility and its propensity of loss, a regular potassium application might also be needed to maintain a nutritional balance in the turf plant (R.R. Duncan, 2000).

Because of the special requirements of salinity-affected turf, the application of potassium or calcium along with amino acids also can be beneficial thanks to the aforementioned properties of amino acids. In fact, numerous field trials have shown that the application of amino acids enhances the uptake and mobility of macronutrients, probably because of the stimulation of membrane permeability and root development under salinity conditions.

However, perhaps the most appreciable aspect of the effects of an amino acid-based product application refers to the visible part of the turf plant. One of the greatest concerns of golf managers is probably green color loss of the turfgrass. Environmental stresses such as salinity, drought, cold, heat and so on can cause a physiological imbalance inside the plant, which leads to an oxidative stress.

In these cases, organic cellular structures start being destroyed as a result of potent "reactive oxygen species" that induce the degradation of chlorophylls (yellowing), for example, and the reduction of photosynthesis. In these cases, the plant resorts to amino acid reserves in order to synthesize new proteins and metabolites that will alleviate the oxidative damage and recover the photosynthetic machinery (A. Kumar 2005).

ADD TO FERTILIZATION

In conclusion, on top of the already well-known practices that golf course superintendents implement to minimize the impact of salinity and nutrient imbalances caused by irrigating with recycled water, amino acid-based products can be excellent tools to help turf withstand the stress caused by this practice. Amino acid reserves will allow the plant to overcome stress and provide energy for growth or survival under modified conditions.

However, because of the difficulty in recovering from salinity damage once turf begins to deteriorate, it will always be best to approach the problem before damage is visible. That's why the application of an amino acid-based product is recommended in a fertilization program as a supplement for turf maintenance and as well as a precautionary measure in case of any incoming stress circumstance. GCI

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Superintendents can use rotors specifically designed for use with nonpotable water. Photo: Rain Bird

References

-Y.L. Qian & B. Mecham, Long-term effects of recycled wastewater irrigation on soil chemical properties on golf courses fairways, Agronomy Journal 97 (2005): 717-721

-R. Emmons, Turfgrass Science and Management, Ed.Thomson Learning, Delmar, (2000).

-R.R. Duncan, Understanding water quality and guide lines to management, USGA Green Section Record 38 (5) (2000): 14-24

-M. Huck et al., Effluent water: Nightmare or dream come true?, USGA Green Section Record 38 (2) (2000): 15-29

-M.M.F. Mansour, Nitrogen containing compounds and adaptation of plants to salinity stress, Biologia Plantarum 43 (4) (2000): 491-500

-V.K. Ray, Role of amino acids in plant responses to stresses, Biologia Plantarum 45 (4) (2002): 481-487

-C. Di Martino et al., Free amino acids and glycine betaine in leaf osmoregulation of spinach responding to increasing salt stress, New Phytologist 158 (2003) 455-463

-H.D. Aschmead, Foliar feeding of plants with amino-acids chelates, Noyes Publications (1986)

-S.S. Sharma & K-J. Dietz, The significance of amino acids and amino acid-derived molecules in plant responses and adaptation to heavy metal stress, Journal of Experimental Botany 57 (4) (2006): 711-726

-A. Kumar & A. Bandhu, Salt tolerance and salinity effects on plants: a review, Ecotoxicology and Environmental Safety 60 (2005): 324-349

Making the most of water shortages

Water availability is a growing threat to all golf courses throughout the country. It seems that every time people pick up a newspaper or turn on the TV news, they read or hear about water bans, shortages or unavailability that challenges the way superintendents maintain golf courses.

Although evapotranspiration-based controllers commonly are cited as one of the best water savings tools, they're not the only solution for water and cost savings.

Despite the availability of reclaimed water, the suitability can be called into question because of the potential for extra chemical inputs such as heavy metals. As such, the turf professional might be required to spend more time managing the irrigation process itself as well as the soil and the turf.

Reclaimed water, or the use of lightly treated recycled water, is an option. This method takes rain water and water used in households or commercial facilities and recycles it for reuse in turfgrass irrigation. It reduces discharge of wastewater into streams and oceans and is less costly and uses less energy than potable water.

These variables can be overcome by using soil inputs that not only help offset salts and other substances stemming from reclaimed water, but might also assist in the growth and vitality of turf.

The use of effluent water and other low-quality water will continue to grow as fewer courses are allowed to use potable sources. This article focuses on how superintendents can use amino acid products to make the best of a difficult situation and still produce quality course conditions.

BUSINESS APPLICATION

There's a need to grow healthier turf with poor-quality water, yet creating better playing conditions with lower-cost and fewer inputs. Amino acid products appear to help buffer the negative impacts of the damaging components of this type of water.

FIELD ASSESSMENT

The application of amino acids might be particularly helpful under stress situations by aiding in energy conservation, reducing water loss and helping the turf to maintain vitality. Contact John Walsh, editor (jwalsh@gie.net) with your experiences.

FUTURE OPPORTUNITY

Effluent water and less-than-desirable water will be the primary irrigation source for many courses in the future. Amino acid-based producs can be excellent tools to help turf withstand the stress caused by reclaimed water use. This technology is one option for dealing with the issue. GCI