WHAT DOES TURFGRASS SALINITY TOLERANCE REALLY MEAN?

The most complex and confusing abiotic environmental stress that can be imposed on turfgrass ecosystems is salinity. And there are multiple salinities depending on soil and water pH as well as composition of critical salt ions/compounds: sodium, chlorides, sulfates, bicarbonates, and magnesium. Superimpose changing environmental conditions and site specific soil ecosystem differences, and management becomes a challenge. These salts are a growth regulator, a potential toxin, and a soil + plant accumulator. Bicarbonates and their cation complexes are not absorbed by plants and thus are primarily soil accumulators.

The other major component for any plant with or without some level of salinity tolerance is the genetic capability to activate one or more tolerance mechanisms in the field, whether it is a golf course or sports field or other recreational turfgrass site. There are approximately 1000 genes involved in salt tolerance mechanism(s) activation. Some genes are up-regulated (switched on), while other genes are down-regulated (switched off). A majority of the genetic activation occurs in the root and crown regions of the plant.

The salinity impact on plants is twofold: foliar absorption of the salt ion complex from saline irrigation water, salt spray or storm surge inundation, and direct root uptake of soil accumulated salts. The genetic and physiological salinity tolerance mechanisms vary among turfgrass species and cultivars in dealing with the overall salt impact on the plant. Nutritional and hormonal imbalances interact with specific grass sufficiency requirements, photosynthesis, and growth responses. Plant growth rates are usually reduced as salt concentrations accumulate internally in the turfgrass, depending on specific genetic salt tolerance level of the cultivar. Growth rates can be reduced 50-75%+ on less salt tolerant grasses.

Several genetic and physiological tolerance mechanisms potentially contribute to specific species and cultivar tolerance activation:

1. Plant tissue tolerance: compartmentalization of sodium, chlorides, magnesium, and sulfates. For example, (a) translocation of chlorides (which are highly mobile internally in the turf plant) to growing points, such as leaf tips where the chloride-ladened leaf tip is mowed off. (b) Translocation of sodium into old organs (such as older leaves or through salt glands on the underside of leaves) or partitioning into the vacuoles (and away from the cellular photosynthetic machinery with minimal reduction on growth rates plus allowing for protein and enzyme synthesis). (c) Synthesis of counteractive solutes such as osmolytes, which is induced by potassium. (d) Internal cellular water turgor pressure maintenance, which is also induced by potassium.
2. Avoidance: (a) restricted root uptake (such as sodium)--regulated initial uptake of the salt ion and then exclusion of further root absorption. (b) regulated translocation of salt ions from roots to shoots and sequestration in older leaves or vacuoles. (c) Thick wax load on leaves and stolons that sequesters specific salt ions, such as sodium, and minimizes their absorption through the cuticle (sodium is a good example). (d) Increased succulence (elevated internal cell water content in an effort to dilute the salt concentration effects). (e) Osmotic adjustments through increased solute production (such as ectoine, glycine betaine, proline, trehalose, and other solutes) that are induced by potassium. (f) Intercellular water turgor pressure maintenance regulated by potassium.

Many grass germinating seeds or juvenile rooting sprigs during initial establishment do not have the salt tolerance mechanisms activated. And overall, salt tolerance in the juvenile plant stage is different than the salt tolerance mechanism activity in the mature plant stage. Nutritional and hormonal balances are critical maintenance strategies for sustaining tolerance mechanism activities in the turf plant. Long term salt management also must be focused on minimizing salt complex accumulation in soil profiles.

Comparison of some turfgrass species

All turfgrass species and cultivars absorb salt ions normally by root uptake from the soil and foliar absorption from sprinkler irrigation of saline water. The degree of salinity impact on the turfgrass plants varies by species, and the impact on a specific cultivar is governed by the level of genetic tolerance and the capability to perform in the salt-challenged ecosystem long term. The ultimate question regarding genetic and physiological high salt tolerance is: Is the species and specific cultivar actually a true halophyte?

The cool season and warm season grasses will generally foliarly and root absorb all of the salts: total dissolved or soluble salts, sodium, chlorides, sulfates, and magnesium (when exposed to ocean venues with high magnesium concentrations). Bicarbonates and their cation complexes are not foliarly absorbed. Growth rate reductions can range from 50-75% slower growth in those cultivars that have low genetic salinity tolerance.

General salinity tolerance rankings (taking into consideration that different cultivars within each species can range from susceptible to moderately tolerant). The most salt tolerant turfgrass (SLT) related truly halophytic turfgrass species include seashore paspalum, alkaligrass, and the saltgrasses. The next SLT group includes fairway/ Western wheatgrass and kikuyu. Additional non-halophytic groups with decreasing overall SLT include zoysiagrass, St. Augustinegrass, tall fescue, perennial ryegrass, slender creeping red fescue, common bermudagrass, hybrid bermudagrass, creeping bentgrass, and Kentucky bluegrass. The lowest SLT group includes carpetgrass, centipedegrass, annual bluegrass, colonial bentgrass, and roughstalk bluegrass. A list of specific cultivars by species with some level of salt tolerance has been documented (Carrow and Duncan, 1998 & 2012; Duncan, Carrow, and Huck, 2009).

The zoysiagrasses have salt glands generally on the underside of the leaves and will exude salts through those glands. This tolerance mechanism requires an energy expenditure on the part of this traditionally slow growing species, and as both the salt load in the irrigation water and the salt accumulation in the soil increases, the ability to handle the increased root and foliar absorption via the salt gland exudation can challenge the sustainability of the plant.

The bermudagrasses (*Cynodon* spp.) vary considerably in overall genetic salt tolerance. One recent study in Australia (T. Van Tran et al., 2018) has documented six genotypes as exhibiting similar halophytic responses comparable to two seashore paspalum cultivars in laboratory research, but field verification will need to be conducted to determine their SLT response over years and interactive saline ecosystems. Most of the ultradwarf hybrid bermudagrasses have shown minimal SLT responses in sports field situations.

Seashore paspalum evolved on sand dunes exposed to ocean water and rainfall for both moisture and nutritional survival. This grass readily absorbs chlorides, and since it was exposed to about 19,000 ppm chlorides, the tolerance level is exceptionally high compared with other turfgrasses. Chlorides are translocated rapidly to the growing points such as leaf tips where any concentrations can be mowed off the turf plant. Chlorides are highly mobile in the soil and will migrate with the wetting front down through the soil profile with acceptable water infiltration and percolation rates to the drainage lines.

Paspalum was exposed to over 10,500 ppm Na during evolution and has a dual mechanism to handle sodium concentrations: a) strict regulation on root uptake, absorbing a controlled concentration, and then excluding further uptake, thereby leaving sodium to accumulate in soil profiles. b) exclusive sequestration of sodium from irrigation water or salt spray in waxes on the leaves and stolons, thereby minimizing the concentration of sodium that actually enters the plant cells.

The grass was exposed to about 2700 ppm sulfates in ocean water during evolution and, as a result, has very high tolerance to that salt/nutrient; paspalum is a luxury consumer of sulfates in the irrigation water and the soil. Paspalum was exposed to over 1300 ppm magnesium from ocean water during evolution and also is a luxury consumer of that salt ion/nutrient. Seashore paspalum was exposed to about 35,000 ppm total dissolved salts in ocean water during evolution and thus has a very high genetic tolerance to that level of total salinity in water.

The question is often asked: With those high ocean water salinity tolerance concentrations, can that water source be used to irrigate seashore paspalum? The answer is: Even though the grass might tolerate the total salinity impact, the soil accumulation of the salt complex cannot sustain even seashore paspalum long term, and the soil ecosystem would eventually become toxic and overwhelm the total salt tolerance mechanisms in the grass. An additional question: Does seashore paspalum require salinity to grow? The answer is 'no'; the grass is buffered to withstand irrigation saline water quality ranging from normal rainfall to periodic ocean water exposure.

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