Don't get salt stress from measuring salinity

STOP! DON'T TURN THE PAGE! Living close to the coast is not the only place where a turfgrass manager needs to be concerned about salinity. Irrigation water and soils can be influenced by salts in more ways than you think: (a) in arid environments where there is not adequate rainfall to leach salts through the soil profile; (b) in cold climates where snow is melted from roads by salt deicers; (c) in the High Plains and in coastal regions, where water from naturally occurring saline aquifers is used for irrigation; (d) using treated effluent as a water source; (e) saltwater intrusion into naturally freshwater wells; and yes, (f) using irrigation water from tidally influenced creeks and rivers, or on the East Coast, from an intracoastal waterway. Convinced? Good! After reading this article you will be able to easily navigate the sea of salinity units that are commonly used. If want more information WHY you should monitor salinity, see **SportsTurf** May 2012 page 32.

Let's start off by defining "salinity." Salinity is a measure of the salts dissolved in water (or a soil). Before we get into the many reporting units for salinity, it is important to understand how salinity is typically measured.

MEASURING SALINITY

You may have heard of using refractometers to measure salinity. Refractometers measure the change of direction or bending of the light as it passes from air to water. When we first began to measure salinity, it was common to use a refractometer. While still used, precise refractometers come with a hefty price tag. Furthermore, they are not automated, thus cannot be deployed to determine salinity continuously.

And that leaves us with the following two techniques commonly used to measure salinity:

1. The first involves *using a conductivity meter to measure the electrical conductivity (EC) of a solution* in the field. The electrical conductivity of a solution is a measure of the total dissolved solids (TDS) within the solution. These dissolved solids are generally made up of inorganic and organic compounds that have passed through a 2 micrometer (μm) sieve. TDS is typically a measure of the concentration of *salts* that have dissociated (split) in the water to form both positively (cations) and negatively (anions) charged ions. The idea behind using EC as a measure for salinity is that the more salts present, the more electricity conducted, and the higher the EC reading.

2. The second method, *measuring TDS directly*, can only be performed in a laboratory and is generally the method by which laboratories report your salinity value. To measure TDS, a specific volume of sample is weighed, filtered through a 2 μm sieve to remove any particulate, gently dried until all water has evaporated, and the remaining salts/solids in the sample weighed. The dry weight of salts remaining divided by the original weight of the evaporated sample tells us the sample salinity.

Salinity Conversion Table
μ = micro, m = milli 1 μmhos/cm = 1 μS/cm 1000 μS/cm = 1 mmhos/cm = 1mS/cm = 1 dS/m
ppt = part per thousand, ppm = part per million 1 g/kg = 1 ppt = 10,000 ppm = 1.0%
ppm = dS/m x 550 (water with high proporation NaCl) ppm = dS/m x 700 (hydroponic solutions, other salts dominant)

THIS TABLE makes it easy to convert reported salinity units to those you are familiar with:

REPORTING SALINITY

How does TDS relate to EC and what can both measurements tell us about the salinity of a given water sample?

Salinity is discussed with many different units. It is common to see salinity expressed as a concentration (from the direct TDS measures) – such as 35 g dissolved salt / kg sea water = 35 ppt (part per thousand) = 35,000 ppm (part per million) = 3.5%. For irrigation purposes, many labs report salinity as TDS. Values below 500 ppm are generally not of any concern; values between 500-2000 ppm are considered an "increasing" concern and should be monitored, and > 2000 ppm are considered a severe problem.

To get a TDS or concentration measure of salinity, you have to submit an irrigation sample to an analytical laboratory and wait for results. If you need a more immediate measure of irrigation water salinity in the field, using a conductance meter to measure EC is an accurate and inexpensive (once the meter is purchased) method. While there is not exact relationship between EC and TDS, there is an approximate relationship. In water with a higher proportion of sodium chloride (water typical to SC) to get to ppm multiply the dS/m reading by 550; for other water sources (like hydroponics solutions) multiply the dS/m reading by 670 or 700 to convert to ppm. For the most part, turfgrass managers would use the 550 conversion factor.

EC is generally reported in deciSiemens/meter (dS/m), milliSiemens/cm (mS/cm), or millimhos per centimeter (mmhos/cm), which are numerically equivalent to each other. Here is a piece of trivia for you: as mentioned above, EC is a measurement of conductivity that is commonly measured in mmhos/cm. The opposite of conductivity is resistivity, which is measured in ohms. Ohms spelled backwards is mhos! When using an EC meter to determine relative salt levels, the recommended EC range of irrigation water is generally <0.75 dS/m for seedlings, or propagation areas and 0.75 – 3.0 dS/m for general irrigation purposes. If concentrations are less than 0.5 dS/m or greater than 3.0 dS/m, severe problems can occur. ■

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▶ **GRADUATE STUDENT NORMA FLOR** screens zoysiagrass for large patch response in a growth chamber. Photo: Kevin Kenworthy, University of Florida

The future of turfgrass research

LIKE MOST COMPANIES and individuals in today's economy, turfgrass breeders are expected to do increasingly more with less . . . more in the way of developing increasingly sustainable varieties in a climate that is *literally* changing . . . with less funding due to budget cuts in both public and private sectors. And it is clear that continued drought in some areas is having a lasting effect on how breeders view the future.

Given all of this, where will we see turfgrass breeding headed, how will it be funded and how will it affect turfgrass sod producers? To gain some insight, *Turf News*, the publication of Turfgrass Producers International, asked a number of turfgrass breeders in both public and private sectors a few questions. *Turf News* wishes to thank the following individuals for responding:

- Keenan Amundsen, University of Nebraska
- Ambika Chandra, Texas A&M
- Doug Brede, Jacklin Seed of the J.R. Simplot Co.
- Milt Engelke, Professor Emeritus, Texas A&M
- Bingru Huang, Rutgers University
- Melodee Fraser, Pure Seed Testing
- Kevin Kenworthy, University of Florida
- Brian Schwartz, University of Georgia
- Eric Watkins, University of Minnesota
- Joseph Wipff, Barenbrug USA, Inc.

Where do you think we will see turfgrass breeding moving forward? Will it be focused on particular traits and, if so, which traits?

Chandra: A lot more needs to be done. The changing climate, including extreme temperatures and recurring droughts, as well as the shortage and increasing cost of potable water plus evolving pathogens and insects, require continued work for more sustainable turfgrass production systems.

Different turfgrass species have their unique sets of strengths and weaknesses. Depending on intended use, region of adaptation and consumer preference, breeders are focusing on improving different traits in different species. Ball roll, divot recovery, thatch management, shade and traffic tolerance, for example, may be of more importance to golf course superintendents whereas shade tolerance, drought and disease/insect resistance may be more valuable to homeowners.

Growing grasses in the transition zone presents its own challenges, especially in dealing with extreme temperatures. Regardless, everyone wants a grass that looks and feels good, and that they do not have to mow as often. Therefore, dwarf varieties with higher establishment and recovery rates are very desirable.

Engelke: Consumers pay more for water on a per gallon basis than they do for oil. Therefore, we must focus on drought tolerance and low water consumption. The South already has been dealing with a long-lasting drought and some communities are reaching the stage where no watering will be allowed.

We also need to look at salt tolerance. Salinity becomes a problem when we do not have rain for extended periods. In this case, salt rises to the surface and concentrates in the crown of the plants and kills either the plant or the soil. Turfgrass then no longer has moisture or oxygen needed to grow. In these types of conditions, even halophytic plants can die.

At the same time, those who say that turfgrass uses too much water must be reminded of the many benefits of turfgrass, such as soil stabilization, cooling attributes, and the purification of water through grass's filtering effects.

Wipff: Water use efficiency; improved ability to use less than optimal quality water and effluent water; improved salinity tolerance; faster establishment; and reduced overall maintenance requirements will continue to be highly desired and sought after traits.

Another often overlooked trait and not widely considered by the end-user is the need for improved seed yields. Without higher seed yield and a strong dollar return per acre of seed production, the turfgrass seed industry will continue to find difficulty competing for production acres with food, forage, energy, and other high value crops.

Amundsen: The big traits of concern these days are based on water issues, especially given last year's widespread drought. Drought tolerance and water use efficiency are key. Other traits of interest include salt tolerance, cold and heat tolerance, disease and insect resistance, and nutrient use efficiency.

Breeding programs continue to focus on traits that are important for the turf industry (e.g, canopy density, color, uniformity, mowing tolerance, wear tolerance, recovery from damage), but there has been more focus toward biotic and abiotic stress tolerance over the past few decades and these traits will be at the forefront of breeding efforts in the next couple of decades.

I believe the next big advancement will come from the implementation of genetic tools that will allow us to evaluate and advance populations of plants more efficiently and cost effectively .This is not necessarily an advance in turfgrass breeding specifically, but new technology should allow us to maximize increasingly limited resources for turf improvement.

Huang: We will see more work on improving traits for stress resistance, and for more efficient use of water and fertilizers.

Brede: The plant breeding process is not linear.

We do not sit around a boardroom trying to imagine the next great trait. Instead, plant breeding is a random process requiring the breeder to be vigilant when something great comes along. We never really know what the next great thing will be. We have to wait for the plants to tell us.

Nonetheless, each breeder carries a mental list of the top 10 most wanted traits, such as bluegrasses that germinate faster, tall fescues that resist brown patch disease, bunch grass species that show a tendency to creep, grasses that need fewer inputs and anything that yields more seed per acre for the seed grower (and thus makes seed of that variety less expensive).

Kenworthy: I think that we will see more niche grasses developed for regions, with traits that have resistance to particular strains of the same pathogen, and more drought tolerance. My zoysia program, for example, is focused on large patch disease, and in bermudagrass, we are seeing more of a focus on tolerance or resistance to sting nematode.

Schwartz: I believe that turfgrass breeders will look at alternative species that fit niche situations and markets rather than a "one-size-fits-all" approach. You may see specific cultivars of popular species (like bermudagrass) that are developed for certain situations and not widespread adaptation. Specific trait development will probably depend on the application. But, we all are trying to improve drought tolerance.

With regard to golf greens, I am looking for nematode tolerance and reduced maintenance requirements. For home lawns, I am looking for reduced maintenance requirements.

Speaking of alternative species, will we see more work being focused on them?

Chandra: There is potential in exploring native grasses that have evolved to be genetically adapted to their native environments and associated stresses. But, they may not necessarily have desirable turfgrass quality traits such as high tiller density, dwarf stature, dark green color and so on. Texas bluegrass, bahiagrass, curly mesquite and blue gramas are just a few examples of the grasses on which breeders are working.

Engelke: Existing breeding programs have limited resources to fully exploit the existing genetic diversity available in any one species. Too often, because of those limited resources, we tend to see major efforts in any one species be limited to a fairly narrow genetic base. Subsequent varietal releases tend to look alike without fully exploiting a broader genetic base.

Going to an alternate species, while it may present opportunities for "low hanging fruit" to be harvested, is not as likely to have long-term ramifications as more in-depth scientific endeavors with major species already being studied. We must look for greater diversity, as well as discourage the idea that grass must be green all year long at any cost.

Amundsen: As the buffalograss breeder at the University of Nebraska, my view is certainly biased toward the use of non-traditional species. I think there are opportunities for buffalograss, poverty oatgrass, the gramas, salt grass, alkali grass, prairie junegrass, some of the wheatgrasses and other natives.

There may also be opportunities for non-conventional uses of traditional species, such as using alternative bentgrass species for lawns. With many of the native species, regional adaptation is a distinct advantage, so the market will likely be tailored to certain species in certain regions.

Schwartz: I can only speak for warm-season grasses. There is currently a big push to develop new zoysiagrasses. Seashore paspalum has really taken off, especially in the international market. Some breeders are selecting turf-types out of species that are often considered weeds. These types of projects are usually very long-term and require a lot of work and patience.

Brede: There is always some breeding work going on with new species, but

the track record for novel species over the last 25 years has been dismal. The typical response most breeders get when they present a brand new species to a salesperson is "But my customers aren't asking for that." I think we will see a handful of novel turfgrasses hit the market in the next decade, but none will gain a sizable market share nor will they be around very long if salespeople do not actively promote them.

What do you see as the next major breakthrough?

Chandra: The use of major advances in molecular biology, such as genome sequencing. The development of trait-specific molecular markers in marker-assisted breeding will enhance the speed and efficiency of progeny selection and, thus, the cultivar development process.

Turfgrasses are genetically complex and are challenging to manipulate since they are perennials and, in most cases, open-pollinated and have higher polyploids.

Several new and powerful tools of molecular biology have been developed and are available to us. The adoption of these tools in turfgrass genomics research is in its infancy (unlike major agronomic crops) mainly due to the lack of or limited funding. The turfgrass industry's interest and future funding would significantly enhance our ability to tap into the advances of molecular biology for turfgrass research.

Schwartz: Because some mutations happen spontaneously in nature that can lead to herbicide resistance, I think we may see non-genetically modified herbicide resistant turfgrasses.

Kenworthy: I think we will see improved drought tolerance and pest tolerance in varieties. This will help to make the turfgrass manager's job easier and make the turfgrass industry more sustainable (by reducing some use of pesticides, for example).

Amundsen: We continue to see significant, albeit incremental, gains in overall turf performance. Recent advances, such as rhizomatous tall fescue are interesting, but the major breakthroughs will likely come from host resistance or tolerance to stresses. The quality we have is pretty good and the challenge for most breeders will be developing new varieties that can maintain that quality with fewer inputs.

Wipff: There is great need for improved turfgrasses for the renovation and improvement of high use 'park and rec' fields. These characteristics would include faster germ and establishment, significantly improved traffic tolerance and recovery.

Brede: For several years now, there have been several vegetatively propagated varieties designed specifically for sod production. We have not seen a similar phenomenon with seeded types, but I believe we are close to seeing some specialized for sod production.

Will we see some warm-season grass varieties becoming more cold tolerant?

Huang: I am collaborating with Chinese scientists to perform mutation and genetic transformation work to improve cold tolerance in warm-season species. This work is in progress, but we cannot share details at the moment.

Chandra: Absolutely. As long as warm-season turfgrass breeders have access to a germplasm source with cold tolerance in the gene pool/germplasm collection, they can work on improving cold tolerance. There is increased interest in the use of warm-season turfgrasses in northern states mainly because of their enhanced wear tolerance and higher water-use efficiency (compared to cool-season turfgrass species).

One effort in this direction is a USGA-funded project where Texas A&M AgriLife Research, Kansas State University (Jack Fry and Megan Kennelly) and Purdue University (Aaron Patton) are collaborating on the development of cold-tolerant zoysiagrass cultivars with large patch disease resistance. There are also a few bermudagrasses being tested on golf courses as far north as Pennsylvania.

Schwartz: I believe that the breeding programs in Oklahoma and North Carolina will continue working on grasses that can be grown farther north. In Tifton, GA, this is a difficult goal to reach on our own. But, we have established plots in central Illinois and Indiana during the last year that will hopefully allow us to identify warm-season grasses that do well in both northern and southern locations.

Amundsen: I think we will continue to see gains in cold tolerance of warm-season grasses and heat tolerance of cool-season grasses, but there are limits to the range of adaptation of most species. As you move away from the zone of adaptation for a species into environments less favorable, some outliers will survive and tolerate a given stress. Since these outliers represent only a small fraction of the diversity for the species, there are genetic limitations to further advancing the species in less desirable regions.

The best approach probably lies with inter-generic hybridization to move certain turf traits into more widely adapted species, or move adaptation traits into better performing turf species. This is a challenge because there are limits in compatibility among species which would require a sizeable investment to make significant gains.

Fraser: While improvements in cold tolerance or winter survivability are goals for warm-season turfgrass breeders, one objective is to increase the portion of the year that those grasses are green. A warm-season turfgrass may have very good cold tolerance and winter survivability, but that may be because it has long winter dormancy. Cultivars that green up earlier in spring and have good fall color retention, along with winter survivability, will help expand the use of warm-season turfgrasses.

Wipff: There are a number of warm-season grasses currently available that are significantly cold tolerant. But, with colder climates typically come longer winters, shorter days, reduced summer temperatures and significantly longer winter dormancy. Prolonged winter dormancy generally precludes warm-season grasses from being used on a widespread basis. Most sod producers already seek out varieties that offer reduced dormancy and early spring green-up.

There is some concern that dwarf turfgrass varieties are unable to adequately compete with weeds. What are the pros and cons of dwarf varieties?

Fraser:The advantage of dwarf varieties is that their growth habits are very well suited for turf. A very low, very dense growth habit can be beneficial for many uses. Some disadvantages could be that some dwarf plants might have shallower root systems or slower growth rates. Plants with these characteristics might be less tolerant to drought stress, establish more slowly, recover more slowly from injury or be less competitive with weeds.

The good news is that there is usually variation in these traits which allows us to select plants that have beneficial characteristics that we can use in the development of new varieties.

Chandra: Dwarf varieties are generally slow to grow and spread. Therefore, during the establishment stage, weeds may have a competitive edge. Recovery from damage (mechanical, disease/insect, drought, etc.) in dwarf varieties may be slow, again allowing room for weeds to emerge.

Once fully grown-in, however, dwarf varieties are actually better than non-dwarf varieties. In addition to reduced mowing requirements, dwarf varieties have superior turfgrass quality, especially in term of higher shoot density that makes it difficult for weeds to creep in.

Dwarf varieties retain more leaf tissue below the low mowing height. This is the machinery for photosynthesis and, therefore, dwarf varieties maintain higher carbohydrate reserves, making them stronger than non-dwarf varieties.

There is a trade-off between dense, dwarf varieties and their rate of establishment/recovery. Some species respond better to trade-off manipulations than others, and turfgrass breeders work to balance these attributes.

Schwartz: Dwarf warm-season grasses (specifically bermudagrasses) are currently the only option for maintaining acceptable golf greens. While less aggressive, I have never seen a non-dwarf Bermudagrass variety make a putting green.

In the future, there may be dwarf zoysiagrasses that can be mowed low enough to be planted on golf greens and also have shade tolerance and dense rhizomes that would allow them to grow successfully off of a golf green.

It seems that more breeders are submitting materials to the Grass Variety Review Board than for Plant Variety Protection (PVP). What are the advantages and disadvantages of doing this?

Chandra: The purposes of the Grass Variety Review Board (GVRB) and the Plant Variety Protection Act (PVPA) are very different and should not be confused. The GVRB provides a third-party screening process which is administered by the Association of Official Seed Certifying Agencies (AOSCA) to evaluate the scientific merits, genetic purity and novelty of new varieties based on adequate data provided by plant breeders.

The GVRB ensures that new varieties meet the eligibility requirements of AOSCA's genetic seed certification standards. Recommendations made by the GVRB are considered by the state seed/plant certification agencies, permitting inclusion of the new variety into their state certification program.

Plant Variety Protection (PVP), on the other hand, provides plant-patent type protection to sexually-reproducing varieties for 20 years from the certificate's date of issue. This gives the breeder/company rights to exclude others from sexually reproducing the variety; or selling or distributing it without any prior agreement/contracts in place with the breeder/company. To be eligible for a PVP certificate, the breeder/company must show that the new variety is unique (new and distinct), uniform and stable.

Some companies/breeders decide to apply only to the GVRB. This is a decision each company makes based on the market and utility of the new variety.

Wipff: Many newer entries are not capable of meeting PVP standards for exhibiting distinctive turf characteristics whereas the guidelines for GVRB approval focus on seed certification only. Unfortunately, the GVRB does not evaluate the merits/distinctiveness of the entry and many "look alike" varieties will flood the market.

Ultimately, the disadvantages to the industry are the reduction and hindrance of turf innovation. At a time when significant gains in turf research are required to sustain a healthy, vibrant industry, GVRB paves the path towards mediocrity and similarity.

How is patenting varieties (vs. PVP) going to change the future of turfgrass breeding?

Engelke: Breeders must be able to protect their varieties with intellectual property rights. If others do not respect these rights, we will not have turfgrass breeding programs with any kind of stability or longevity. And, if intellectual property rights are not respected, we will not see continued funding to support turfgrass development.

Chandra: Plant patents and plant variety protections should not be confused. PVP provides protection to sexually-reproducing varieties (seeded turfgrass varieties). Plant patents, on the other hand, provide protection of asexually reproducing varieties (vegetatively propagated sod or apomictically produced seed).

Schwartz: Plant and utility patents definitely change what and whose plant material you can or cannot use as parents in your breeding program. It will likely lead to individual programs collecting or breeding their own germplasm pools or, in some instances, may lead to collaborations where a turf breeder licenses a patented variety from another breeder for use in their program. Time will tell.

Wipff: Patenting a turfgrass allows that the unique, distinctive characteristics of a variety are protected from theft, whereas with the current PVP system of registration, only the name is protected. At five times the monetary cost of a PVP, patented turfgrasses readily identify those research programs that are focused on proven innovation, true improvement and the willingness to protect them.

Is there anything else that you would like to share with turfgrass sod producers about your particular research interests or about turfgrass breeding in general?

Schwartz: I am not only looking for grasses that have end-user benefits, but also work with several sod producers in my state to conduct the final stage of research at their farms to look for grasses that they can profitably grow. By giving them enough of a potential future release, we have been able to determine if the establishment, lifting, sod strength and regrowth are satisfactory. If we can save money on the production side, we can increase farm profitability even if prices fall to the level of older varieties.

Chandra: We have several ongoing breeding projects, including the development of St. Augustinegrass cultivars with improved drought and disease resistance (funded by the Turfgrass Producers of Texas); development of seeded zoysia grass varieties (USGA funded); and development of cold tolerant and large patch disease resistant zoysiagrasses (USGA funded).

We also are developing hybrid bluegrasses (Texas bluegrass x Kentucky bluegrass) adapted to the southern US (funded by NGTurf; funding expired April 2012); and a multi-state project for the development of drought and salinity tolerant grasses for suitable turfgrass production in the southern US (funded by USDA-NIFA Specialty Crops Research Initiative).

We work closely with producers to help find solutions and develop cultivars that meet their needs and generate profits in their businesses.

Wipff: Ultimately the market needs to bear the cost of innovation. Unfortunately, most professional and non-professional end-users are not willing to pay for innovation or investigate the advantages gained by purchasing improved turfgrasses. Be it a penny a square foot or a nickel a pound, far too many end users are willing to 'go cheap' and bear the consequences.

Whether seed or sod, the amount of planning, effort, installation and planting dollars, water, fertilizer, etc. required to grow and establish a square foot or a pound is virtually the same regardless of the quality of sod or seed. For both situations, the only extra cost to be incurred is the investment in quality, innovation and long term performance. ■