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Evaluating Cool-Season Turfgrasses for Salinity Tolerance

Rutgers University scientists continue to unravel this important trait for future turfgrass cultivars.

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During the summers of 2007 and 2008, 21 Kentucky bluegrass cultivars, 22 perennial ryegrass cultivars, and 15 bentgrass cultivars were evaluated for salt tolerance by treating them with a salt solution three times per week.

OBJECTIVES

- Evaluate salinity stress tolerance of cultivars of several turfgrass species, including perennial ryegrass, creeping bentgrass, and Kentucky bluegrass, using a combination of greenhouse and field screening techniques.
- Begin studies to understand the physiological basis for salt tolerance among these cool-season turfgrass cultivars.
- Develop recommendations of salt-tolerant cultivars for turfgrass managers.
- Initiate inheritance studies of salt tolerance.

Start Date: 2007

Project Duration: Three years

Total Funding: $75,000

Water conservation is a necessary and responsible practice, especially in high-water-using urban landscapes and golf courses. As water restrictions and conservation efforts become more commonplace in the coming years, the use of alternative water sources (effluent, reclaimed, gray, or even seawater) will become more prevalent. Unfortunately, these alternative water sources can contain high levels of total dissolved salts. Although there are cultural practices that can help mitigate problems associated with high salt concentrations, the genetic control of salinity tolerance in turfgrasses has not been thoroughly investigated. Additionally, if alternative water sources are going to be used successfully on turfgrass areas, the need for identifying turfgrasses with salinity tolerance is necessary.

The goal of this project is to evaluate and screen commercial cultivars of perennial ryegrass, creeping bentgrass, and Kentucky bluegrass cultivars for salinity tolerance, and initiate inheritance and physiological studies. Using overhead irrigation, a unique greenhouse and field screening techniques for salinity tolerance developed at Rutgers will be compared for their ability to evaluate salinity tolerance in cool-season turfgrasses.

Cultivars of perennial ryegrass, creeping bentgrass, and Kentucky bluegrass are being tested under both greenhouse and field conditions. Two greenhouse screening runs were conducted on eight clones of five perennial ryegrass cultivars (Paragon GLR, Palmer III, Applaud, Brightstar SLT, and Nui) at four salinity levels (0, 5, 10, and 15 dS/m). Significant differences were observed among salinity treatments, with the highest salinity treatments causing the most injury to perennial ryegrass plants. Significant differences were also observed among clones. Four clones of Palmer III and one clone of Applaud exhibited the highest percent green ratings compared to clones of other cultivars.

Two greenhouse screening runs were also conducted on 21 Kentucky bluegrass cultivars at four salinity levels (0, 3, 6, and 9 dS/m). The cultivars exhibiting the highest percent green ratings were Eagleton, Liberator, and Cabernet. The cultivars and selections with the lowest percent green ratings were a Texas × Kentucky bluegrass selection, A03TB-246, Baron, and the Kentucky bluegrass selection A03-84.


Overhead irrigated salt chambers were built and used to apply salt water to trays containing plants.

Two greenhouse runs were also conducted on five clones from nine bentgrass cultivars (007, Tyee, Seaside II, Shark, Declaration, L-93, Penncross, Kingpin, and Penn A-4) at four salinity levels (0, 4, 8, and 12 dS/m). Clones within cultivars had variable percent green ratings. The clones exhibiting the highest percent green ratings were one clone each of 007, Tyee, Seaside II, Penn A-4, and L-93. The clones with the lowest percent green ratings were two clones of Shark and one clone each of Penn A-4, L-93, and Kingpin. In all experiments, percent green ratings correlated very well with clipping yields and shoot and root dry weights taken at the end of the 10-week treatment period.

A field study to evaluate cultivars of perennial ryegrass, Kentucky bluegrass, and creeping bentgrass was established in the fall of 2006. Twenty-one Kentucky bluegrass cultivars, 22 perennial ryegrass cultivars, and 15 bentgrass cultivars were established. They were evaluated for salt tolerance in the summer of 2007, 2008, and 2009 by treating the plants with a salt solution (EC=10 dS/m) using overhead irrigation three times per week throughout the summer.

By the end of the season in 2007, the soil EC reached levels above 3 dS/m, which caused significant stress on the turfgrass plants. Significant differences were observed among cultivars and selections under field conditions. Liberator, Eagleton, Diva, Rhythm, and Argos had the highest percent green leaf tissue under these conditions, while the experimental selection (A03-84) and Julia had the least.

Significant differences were found among cultivars under field conditions. Additionally, the field results were found to be strongly correlated to greenhouse salt chamber results. This indicates that greenhouse and field screening can be used interchangeably as effective screening tools for salinity tolerance.

Two hundred fifty clones of perennial ryegrass were also established in the fall of 2007 and treated with either a salt solution with an EC of 10dS/m or irrigated with regular water in order to determine heritability of

Significant differences in salt tolerance were found among cultivars and selections under field conditions, but the results were not strongly correlated to greenhouse salt chamber results. Heritability estimates indicate that salt tolerance, as an inheritable trait, can be effectively passed on to progeny in an effective breeding and selection program.

Kentucky bluegrass cultivars treated with salt solution (EC = 9 dS/m) after 10 weeks showing significant differences in cultivar responses to saline stress. The cultivars exhibiting the highest percent green ratings were Eagleton, Liberator, and Cabernet.

salinity tolerance. Initial broad-sense heritability was estimated to be approximately 0.78, indicating that a large proportion of the variation could be attributed to genetic effects. Narrow-sense heritability studies have also been established and will be calculated after the data have been analyzed. Through this research, we hope to identify the critical factors influencing salinity tolerance under field conditions in order to develop efficient selection techniques for improving salinity tolerance in cool-season turfgrasses.

SUMMARY POINTS

- Significant differences were observed in clones of five perennial ryegrass cultivars treated with four different salinity levels (0, 5, 10, and 15 dS/m) under greenhouse conditions.
- Four clones of Palmer III and one clone of Applaud exhibited the highest percent green ratings compared to clones of Paragon GLR, Brightstar SLT, and Nui.
- Significant differences were observed in 21 Kentucky bluegrass cultivars treated with four different salinity levels (0, 3, 6, and 9 dS/m) under greenhouse conditions. The cultivars exhibiting the highest percent green ratings were Eagleton, Liberator, and Cabernet. The cultivars and selections with the lowest percent green ratings were a Texas × Kentucky bluegrass selection, A03TB-246, Baron, and the Kentucky bluegrass selection A03-84.
- Significant differences were observed in clones of nine bentgrass cultivars treated with four different salinity levels (0, 4, 8, and 12 dS/m) under greenhouse conditions. Variable responses among clones were observed. The clones exhibiting the highest percent green ratings were one clone each of 007, Tyee, Seaside II, Penn A-4, and L-93. The clones with the lowest percent green ratings were two clones of Shark and one each of Penn A-4, L-93, and Kingpin.
- Twenty-one Kentucky bluegrass cultivars, 22 perennial ryegrass cultivars, and 15 bentgrass cultivars were established in a field trial in the fall of 2006 to evaluate for salinity tolerance under field conditions. Data were collected in 2007, 2008, and will continue through 2009.
- Initial broad-sense heritability of salinity tolerance in perennial ryegrass was estimated to be 0.78 from replicated clones.

RELATED INFORMATION

http://turf.lib.msu.edu/ressum/2008/41.pdf

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CONNECTING THE DOTS

An interview with DR. STACY BONOS *regarding her research.*

Q: *The goal of improving the salt tolerance of these widely used cool-season turfgrass species certainly is worthy. What was the impetus for this study?*

A: At one time or another, many turfgrass managers have experienced water-use issues such as drought restrictions. In the arid western U.S., annual precipitation is limited, while in the eastern U.S., storing the often abundant but inadequately distributed precipitation is a problem. Thus, drought conditions can occur in all climates. Alternative water sources can be used to alleviate some drought conditions, and turfgrass areas are the perfect environment in which to use alternative water sources that would reduce the demand for high-quality potable water for irrigation. However, these sources are often high in total soluble salts, resulting in salt stress injury and poor turf quality. The identification of turfgrass cultivars that can tolerate irrigation with alternative water sources, while maintaining safe, acceptable quality, would result in a community and industry more accepting of voluntary utilization of alternative water sources.

Q: *Do you think that enough genetic variation exists in these cool-season grasses to increase their salt tolerance to rival some of the warm-season grasses, such as seashore paspalum or inland saltgrass?*

A: Warm-season grass halophytes such as seashore paspalum and inland saltgrass have evolved to tolerate high salt conditions for thousands or hundreds of thousands of years. The remainder of the species that we use for turf (both warm-season and cool-season grasses) are not traditionally found in the same types of natural environments where we find seashore paspalum and inland saltgrass. As a result, the cool-season grass species that we are currently breeding do not have the same level of salt tolerance as the warm-season halophytes. That being said, our studies have indicated that it is possible to dramatically improve the salinity tolerance of cool-season grasses compared to existing cool-season germplasm. As we continue to expose cool-season grasses to high levels of salt, we will be able to identify elite material that is able to tolerate higher and higher salt concentrations. Although it will be a challenge to approach the level of tolerance that exists for seashore paspalum and inland saltgrass, our research indicates that traditional breeding techniques will make gradual but marked improvements in salt tolerance for the cool-season grasses in our breeding program.

Q: *Are your salt treatments (up to 15 dS/m) reflective of "typical" effluent water? To use effluent water as the primary source of irrigation, how salt tolerant do turfgrasses have to be?*

A: No, effluent water is typically only 3-5 dS/m. However, when effluent water is used regularly, it can cause salts to build up in the soil, especially under drought conditions and in western regions where rainfall is limited. There is just not enough rainfall or freshwater irrigation to leach the salts through the soil profile. This results in salinity stress on the plants. By using water with a higher concentration of salts, as we are using for our field and greenhouse screening systems, we are speeding up the process. This allows us to attain a higher salinity level in the soil more quickly so that we can reach a level that is stressful to plants and subsequently screen cultivars and germplasm.

Q: *Besides genetics, what other factors affect salt tolerance of turfgrasses? Is it possible to isolate the effects of salt from potentially confounding factors like heat and drought? What is your approach to do so?*

A: Under field conditions, there are a lot of confounding factors that can influence salinity tolerance. These include, but are not limited to, soil conditions, fertility, mowing height, and drought and heat stress. Specifically, if plants are under heat or drought stress, they will be more susceptible to salinity stress. In the greenhouse, the plants are all growing in the same soil medium in one experimental unit. We can control the temperatures and maintain adequate moisture so that the plants are not under heat or drought stress during the salinity experiments. This has helped to isolate the effects of salinity from the other stresses so that we can obtain a true estimation of salinity tolerance.

Q: *Although this project involves screening commercial cultivars, do you think long-range improvements of these species might come from crosses with other species (e.g., Texas bluegrass) or the molecular genetics approaches being used to improve heat tolerance of creeping bentgrass?*

A: I think this is an example where molecular genetic approaches will be extremely useful. Improving salinity tolerance in cool-season turfgrasses using traditional approaches is somewhat difficult compared to other traits because of the time, effort, and resources involved in inducing the stress. There has been some research conducted on the genetic control of salinity tolerance in *Arabidopsis* and other model species that can be applied to cool-season turfgrass. As the individual genes and pathways are elucidated in the model crops, we can look for similar genes and pathways in cool-season turfgrasses. We plan to explore these approaches in the future to more efficiently develop cultivars with improved salinity tolerance.

Q: *From your preliminary estimates of heritability, does it seem that salt tolerance is a trait that can be easily transferred to progeny?*

A: Heritability estimates separate the effects of genetics and the effects of the environment on complex traits. The environmental conditions that the plants are exposed to can influence salinity responses; however, our research found heritability estimates to be relatively high. This indicates that there is a strong genetic effect on salinity tolerance in perennial ryegrass. In our controlled cross experiments, the progeny from tolerant × tolerant crosses were more tolerant than the crosses with susceptible plants. This is promising, because it indicates that selection should result in progeny with improved salinity tolerance.

Q: *Are you convinced that salt tolerance of creeping bentgrass, Kentucky bluegrass, and perennial ryegrass can be significantly improved? If so, when might superintendents likely see new improved salt-tolerant cultivars on the market?*

A: Yes, I am convinced that these species can be significantly improved for salinity tolerance because significant genetic variation exists within each of these species. Slight improvements have been made in perennial ryegrass and will probably be available in the marketplace in three to five years. More dramatic improvements will take several more years of selection before they would be available. In the meantime, we are screening commercially available cultivars for salinity tolerance to provide cultivar recommendations of the most salt-tolerant cultivars that are currently available.

Q: *How well do the preliminary results of your greenhouse and field studies match? In other words, are the most salt-tolerant varieties, as shown in your greenhouse tests, performing best in salinity field tests?*

A: Yes, the top-performing cultivars in the greenhouse are also the better-performing cultivars under field conditions. This indicates that the greenhouse and field screening techniques are similar enough that they may be able to be used interchangeably. This is an important finding, as greenhouse screening affords more space for trials in a highly controlled environment and can supplement screening procedures in the off-season. This will ultimately increase the efficiency and productivity of the breeding project.

JEFF NUS, PH.D., *manager, Green Section Research.*