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Physiological Mechanisms for Developing Improved Drought Tolerance in New Bermudagrasses

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Objectives:

1) Characterize drought tolerance in a collection of new bermudagrass germplasm consisting of commercially available cultivars and experimental materials in both field and controlled environment conditions.
2) Determine the role of physiological mechanisms in providing the levels of drought tolerance found in these grasses by assessing important aspects of plant tolerance including the accumulation of compatible solutes, stomatal regulation, anti-oxidant metabolism, and growth and carbohydrate relations.

Start Date: 2017

Duration: 2 years

Total Funding: $9,800

Drought is a major abiotic stress which leads to damage and decline in turfgrasses throughout the world. These damages include reduced growth and quality, wilting and leaf firing, and eventual plant death. These damages are due to a number of factors including cellular dehydration, the production of reactive oxygen species, and loss of function of cellular membranes and proteins in key metabolic pathways. The ability to thrive in water limited conditions is controlled by the interaction of many complex features including drought avoidance traits such as rooting and water usage, and drought tolerance traits such as osmotic adjustment and anti-oxidant metabolism. New cultivars of hybrid bermudagrasses are constantly being developed, with improved drought tolerance being a major trait of interest. However, drought tolerance mechanisms of new lines, and how they compare of older cultivars is poorly understood. Physiological characterization of traits involved in drought tolerance have not been well documented in many bermudagrasses. Furthermore, much of the work that has been performed has used 'Tifway' as the drought tolerant line, despite the cultivar being released over 50 years ago, and new germplasm may utilize drought tolerance mechanisms differently than previous releases. Understanding which traits are contributing to enhanced drought tolerance will help in the development of new lines with increased abiotic stress tolerance as well as help determine the underlying regulation of stress tolerance mechanisms.

The aim of the current project is to characterize drought tolerance in a collection of bermudagrass to better understand key mechanisms affecting performance in water limited environments. This is to be accomplished through both field trials and growth chamber studies. A collection consisting of 3 commercial cultivars, 'Celebration', 'Tifway' and the recently released 'TifTuf', and 3 experimental lines will be used in both field and growth chamber studies. Field studies are being performed under automatic rain-out shelters to prevent rainfall from reaching plots during the drought period when irrigation is with-held. During field trails plants are assessed using NDVI, digital image analysis, relative water content to measure leaf hydration status, membrane stability via electrolyte leakage, osmotic adjustment, and CO_2 flux using an infrared gas analyzer. Growth chamber studies will further characterize drought tolerance mechanisms by measuring shoot and root characteristics, anti-oxidative capacity, and the accumulation of important compatible solutes such as proline, glycine betaine and sugars.

Plots were planted in the spring of 2017 in a randomized complete block, with 4 reps of each cultivar: 'Celebration', 'TifTuf', 'Tifway', and 3 experimental lines. To date, the 2017 field trial has been completed and data are currently being analyzed. The 1st drought trial lasted 7 weeks of plants receiving no irrigation under an automatic rain-out shelter. Significant declines due to drought were found in all lines, as seen by turf quality ratings, however the degree of drought induced damages were significantly different between lines (Fig. 1). The greatest differences in drought were seen at 35 days without water, after which fewer significant differences were found between cultivars. At this point 'TifTuf' had a relative water content of 78%, but values had declined in most other cultivars ('Celebration' 63%, 'Tifway' 65%, 'UGB-208' 64%, 'UGB-70' 67%, 'UGB-42' 71%). A similar trend can be seen with membrane stability measurements, where the percent relative damage in 'TifTuf (23%), and 'UGB-42' (22%) were significantly lower than in 'Tifway' (29%), 'Celebration'(33%), or 'UGB-208' (32%). The cultivar 'TifTuf' was consistently one of the top performing lines, and is likely utilizing a combination of mechanisms for enhanced drought tolerance. Experimental lines such as 'UGB-42' also performed well under drought. These lines maintained canopy color as assessed by NDVI (Fig. 2A), maintained leaf hydration levels (Fig. 2B), had reduced membrane damage (Fig. 2C), and maintained photosynthesis levels (Fig. 2D). The experimental line 'UGB-42' however did not perform as consistently in every trait as 'TifTuf'. For example 'UGB-42' maintained NDVI and leaf water content compared to other lines during drought, but experienced significant declines in photosynthesis.

Future and ongoing work include a growth chamber study to be performed in the winter of 2018, and additional field trials. Plants have been transplanted into pots for establishment in the greenhouse to be used for in depth analysis of key drought tolerance mechanisms in controlled environment growth chambers. Growth chamber studies will quantify root characteristics, anti-oxidant metabolism and the accumulation of important compatible solutes, beyond what has been performed in the field and confirm drought tolerance results. Additionally, fall color and dormancy data are being collected on field plots. A repeated drought trial will be performed in the summer of 2018 to replicate the previous round of drought performed in 2017. Completion of this work will help give additional insight into drought tolerance mechanisms in bermudagrasses, and hopefully assist turfgrass breeders in selecting for key abiotic stress tolerance traits in future cultivars.

Summary Points:

- Significant differences in drought tolerance levels were found among commercial cultivars and experimental lines.

- Top performing lines in the 2017 field trial included the cultivar ‘TifTuf’ and the experimental line ‘UBG-42’
- ‘TifTuf’ had high performance in all measured traits, while other lines such as ‘UGB-42’ maintained leaf water content but had declines in photosynthetic rates, indicating multiple mechanisms may be involved in tolerance be utilized differently.
- Drought tolerance mechanisms will be further explored in controlled environment studies and in a repeated field trial in 2018

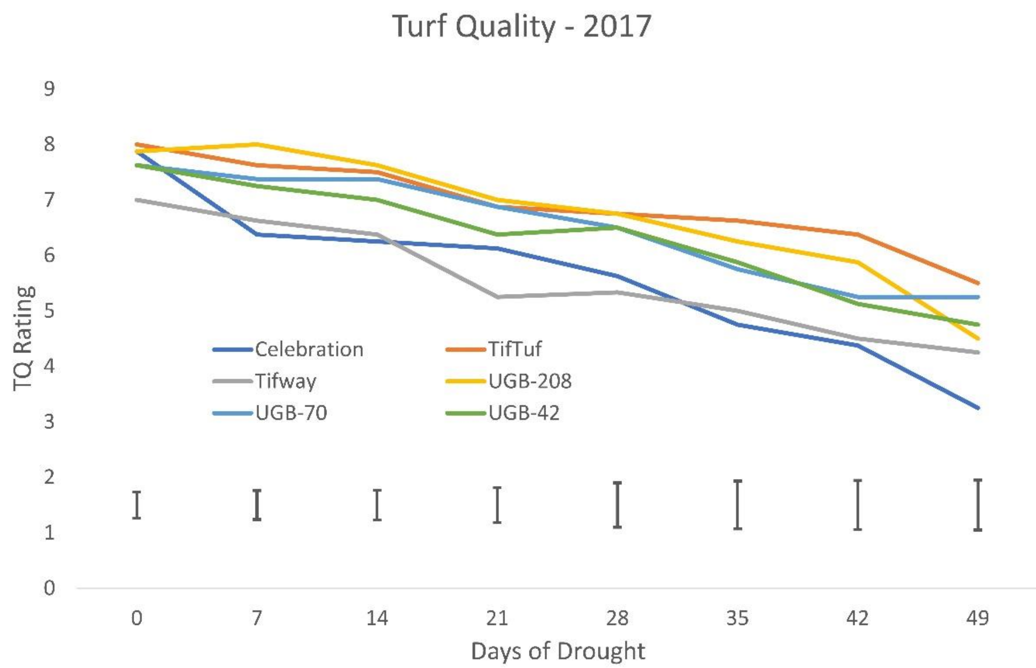

Figure 1. Decline in Turf quality ratings over the 7 week drought trial in period 2017. Bars represent LSD values at $p < 0.05$

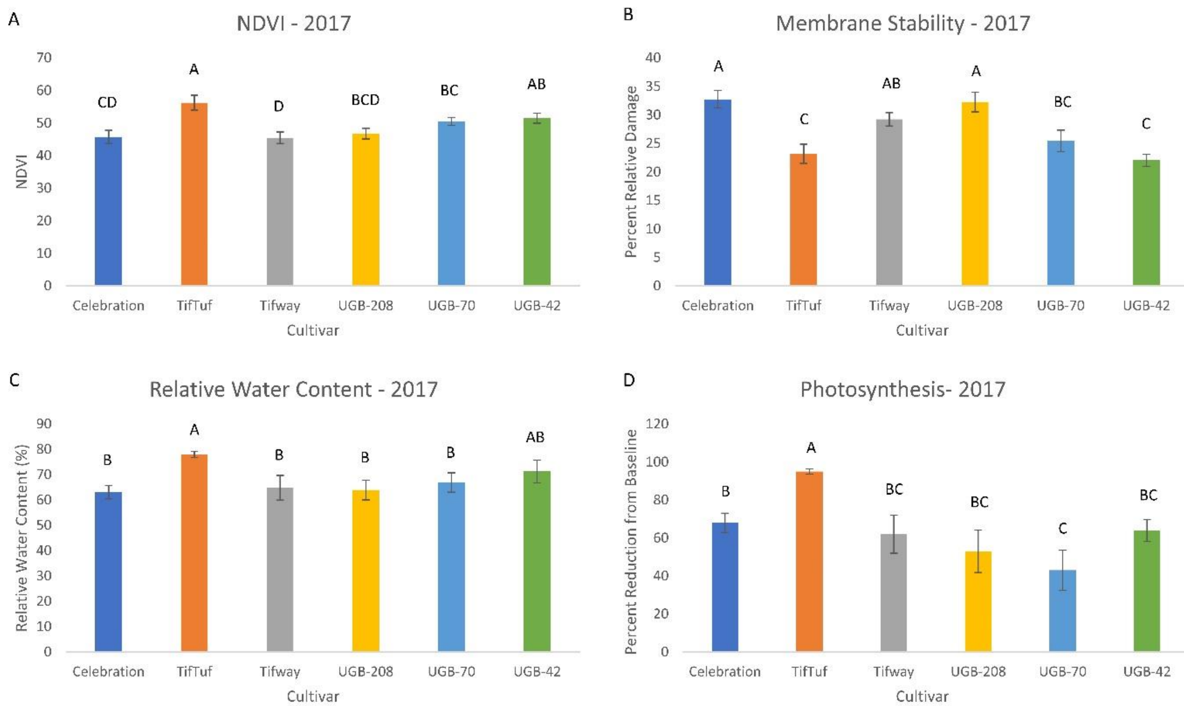

Figure 2. Comparison of lines at 5 weeks of drought stress for (A) NDVI, (B) membrane stability measured by electrolyte leakage, (C) leaf hydration levels determined by relative water content, and (D) percent reductions in photosynthesis as compared to non-stress control. Bars represent standard error, and letters represent LSD groupings at $p<0.05$ with cultivars containing the same letter being in the same statistical group.

2017 Bermudagrass Drought trial

'TifTuf' 'Celebration'

Figure 3. Side by side comparison of 'TifTuf' and 'Celebration' during the 2017 drought trial. These cultivars represent one of the top and bottom performers respectively during the trial.