TITLE: Comparison of the heat and drought tolerances of a Texas bluegrass hybrid compared with Kentucky bluegrass and tall fescue: A growth chamber study

OBJECTIVES: 1) Investigate the effects of high temperature and drought stresses on photosynthesis in a Texas bluegrass hybrid (Thermal Blue), Kentucky bluegrass (Apollo), and tall fescue (Dynasty); 2) Compare electrolyte leakages among species of leaf cell membranes after exposure to irrigation deficits and high temperature; higher electrolyte leakages indicate cell membrane breakdown and thus, lower tolerance to stresses; 3) Determine the effects of heat and drought stresses on visual quality; and 4) Evaluate heat and drought tolerances of the 3 cool-season turfgrasses.

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Introduction

Kentucky bluegrass (*Poa pratensis* L.) is a cool-season grass that is commonly used on fairways and roughs of golf courses in the U.S. Tall fescue (*Festuca arundinacea* Schreb.), also a cool-season grass, is sometimes used in roughs. In some areas of the U.S. these grasses are subjected to frequent drought, which results in either heat and drought symptoms or high irrigation rates in order to maintain acceptable quality. Kentucky bluegrass commonly goes dormant and loses color during periods of high temperature and drought. Tall fescue has good drought resistance, but some superintendents prefer the finer texture that Kentucky bluegrass offers.

New Texas bluegrass (*Poa arachnifera* Torr.) hybrids, which are genetic crosses between Kentucky bluegrass and native Texas bluegrasses, have the appearance of Kentucky bluegrass but may be able to withstand higher temperatures and extended drought without going dormant, and may maintain their green appearance during all but extreme conditions. In warm-season climates such as the South, Texas bluegrasses stay green all year long. Furthermore, Texas bluegrass hybrids may use significantly less water than other cool-season species while maintaining their green color. The latter is important given the increasing competition for water and the rising costs of irrigation.

At least one hybrid of Texas bluegrass (Reveille) has demonstrated disease resistance to leaf rust, powdery mildew, and summer patch, although it shows susceptibility to brown patch especially when over-fertilized. Reveille has also shown resistance to fall armyworms and white grubs, and tests have revealed it performs poorly in saline soils. Observations of other Texas bluegrass hybrids have suggested that disease resistance and susceptibility is similar to Kentucky bluegrasses.

Texas bluegrass (Reveille) is advertised as a “multi-use cool season grass for the Eastern Seaboard, Transition zone, arid West, and Southern U.S.” that has similar water requirements as common bermudagrass. Tests with Reveille revealed no significant decline in visual quality ratings when irrigation was decreased from 2/3 to 1/3 of openpan evaporation (in Texas; James Read, personal communication). This suggests that Texas bluegrass is a high quality, low water use, and high heat tolerant turfgrass that may be well suited for golf course fairways and roughs in some parts of the U.S, including the transition zone.

Despite the promising role that Texas bluegrass may play on U.S. golf courses, there is little scientific data available about its qualities under the various forms of management and stress that it would be subjected to on golf courses. For example, the effect of different mowing heights on the drought- and heat-tolerance characteristics of Texas bluegrass is unknown. Some parts of the transition zone are subjected to extreme cold during winter months, and the cold hardiness of Texas bluegrass compared to Kentucky bluegrass has not been evaluated. It is also uncertain how it compares in quality to Kentucky bluegrass under various irrigation regimes and deficits.

Materials and Methods

Three turfgrass species were planted in 36 polyvinylchloride (PVC) tubes (10 cm diam.,60 cm high) filled with mixture of sand and topsoil (1:1,v:v) in a greenhouse for 4.5 months. The three species included 1) a Texas bluegrass hybrid (Thermal Blue); 2) Kentucky bluegrass (Apollo); and 3) tall fescue (Dynasty). The tubes were transferred to and acclimated in growth chambers at optimum temperature (22^{o}C day (14 h), 15^{o}C night (10 h)) for 2 weeks. Turfgrasses were then exposed for 48 days to high temperature (35/25^{o}C, 14/10 h day/night) and optimum (22/15^{o}C, 14/10 h day/night) under water-deficit (60% ET replacement) and well-watered (100% ET replacement) irrigation regimes. Experimental design was split-plot. Whole plots were temperature treatments (individual growth chambers) in a randomized complete block design. Species/cultivar and irrigation were subplots. Net photosynthesis and respiration was measured with a Li-6400 (Licor) equipped with a custom surface chamber; total photosynthesis (Pt) was estimated as the sum of net photosynthesis and respiration. A conductance meter (YSI Model 32) was used to measure electrolyte leakage.

Results and Discussion

Total Photosynthesis (Pt):

High temperature & drought stress combination caused a rapid decline in Pt among species; Pt in Thermal Blue was generally higher towards end of study (Fig. 1A). In well-watered, high temperature treatments, Pt was consistently and significantly higher in Thermal Blue than in Dynasty beginning on day 24 and in Apollo on day 42 (Fig. 1B). In optimum temperature, drought stressed treatments, Pt declined among species and differences were not significant (Fig. 1C).

Living Leaf Electrolyte Leakage (EL):

High temperature & drought stress combination caused EL to increase among species and EL was significantly higher in Apollo and Dynasty than in Thermal Blue late in the study (Fig. 2A). High temperature had no effect on EL in well-watered Thermal Blue, but EL increased significantly in well-watered Apollo and Dynasty (Fig. 2B). Drought stress in optimal temperature treatments had no significant effect on EL among species (Fig. 2C).

Visual Quality:

High temperature & drought stress combination reduced visual quality among species. Visual quality in Thermal Blue was significantly higher than in Dynasty and Apollo late in the study (Fig. 3A). In well-watered, high temperature treatments the visual quality of Thermal Blue was significantly higher than Dynasty and Apollo (Fig. 3B). In optimum temperature, drought stressed treatments, visual qualities declined among species and differences were not significant (Fig. 3C). The higher visual quality of Thermal Blue in high temperature treatments is illustrated in Figure 4.

Conclusions

In well watered, high temperature treatments, Thermal Blue exhibited significantly higher Pt and visual quality and significantly lower EL than Apollo and Dynasty. High temperature and drought combination caused a reduction in Pt and visual quality among species although Thermal Blue was generally higher in both Pt and visual quality late in the study. High temperature and drought combination caused EL to increase among species although EL was significantly higher in Apollo and Dynasty than in Thermal Blue late in the study ($P<0.05$). In optimum temperature, drought-stressed treatments, Pt and visual quality declined and EL was unchanged with no significant differences among species. Thus, no significant differences in drought tolerance were found among species. In general, Thermal Blue exhibited higher heat tolerance than Apollo and Dynasty in a growth chamber study.

Abbreviations:

ET: Evapotranspiration; Pt: Total photosynthesis (estimated as the sum of canopy photosynthesis and plant respiration); and EL: Electrolyte leakage.

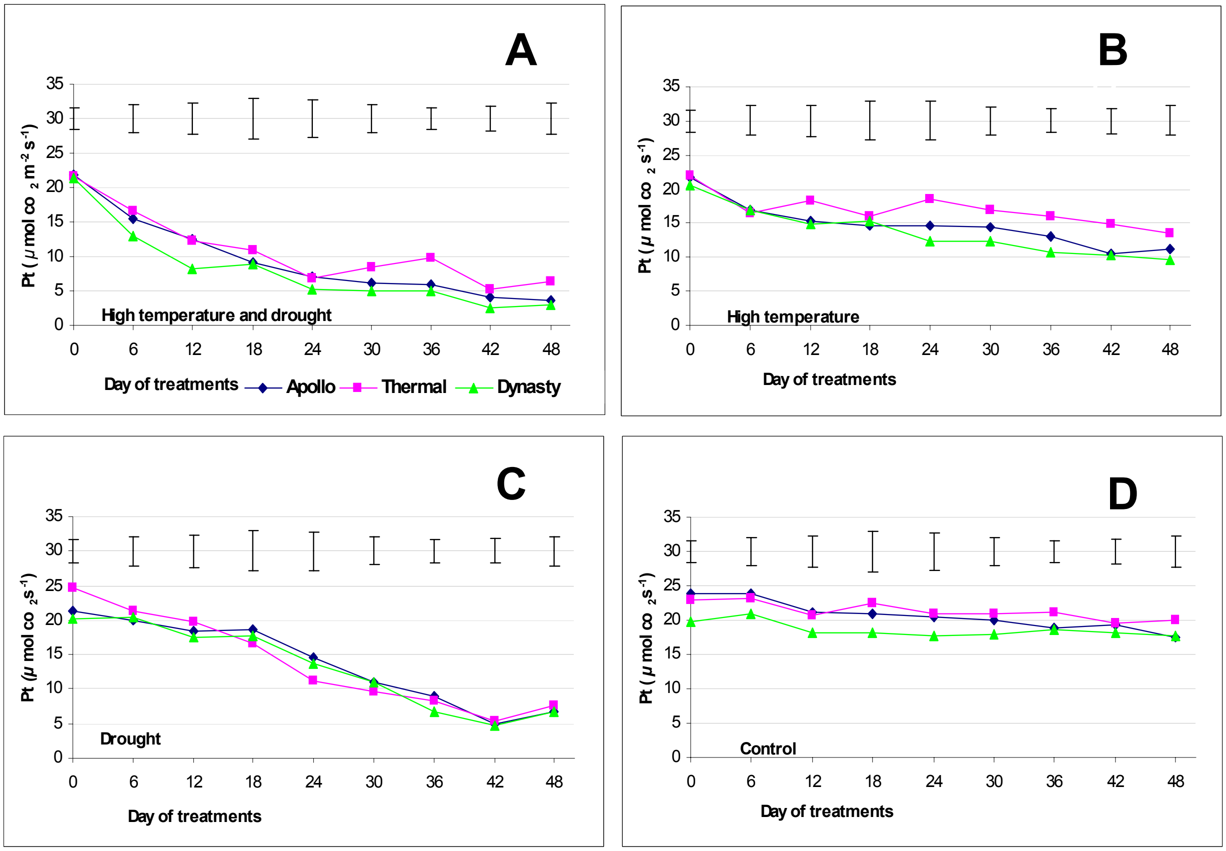

Figure 1. Effects of high temperature and drought on total photosynthesis (Pt) in Apollo, Thermal Blue, and Dynasty. Vertical bars indicate LSD values (P=0.05) among treatments on a given day following treatment initiation (Day of treatments).

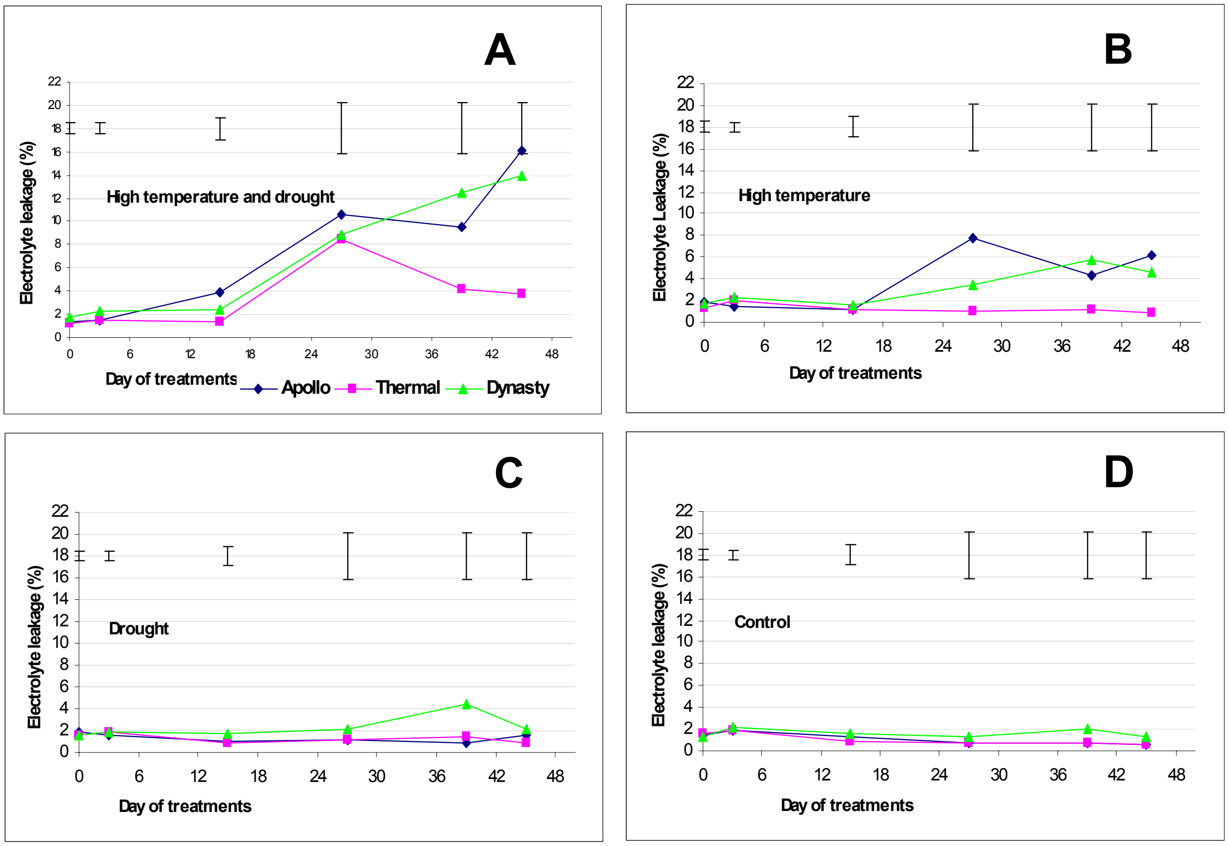

Figure 2. Effects of high temperature and drought on electrolyte leakages in Apollo, Thermal Blue, and Dynasty. Vertical bars indicate LSD values (P=0.05) among treatments on a given day following treatment initiation (Day of treatments).

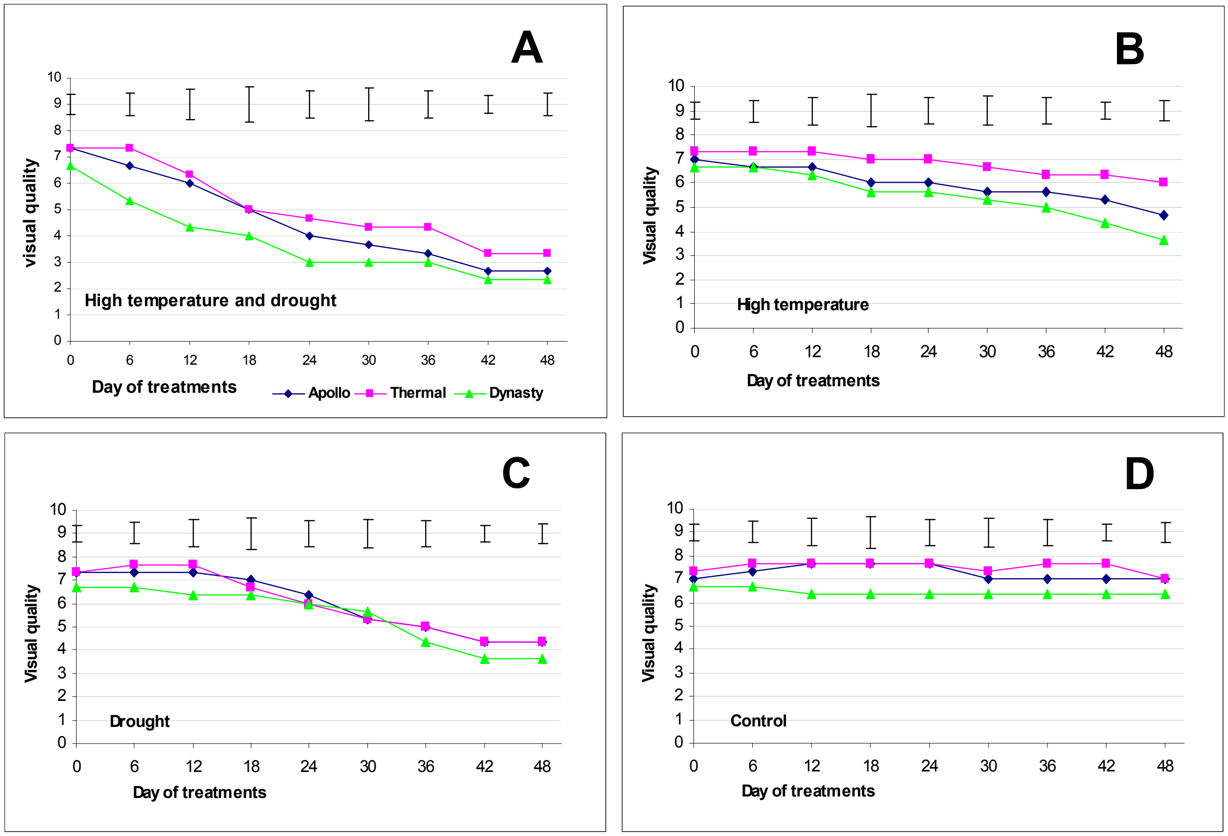

Figure 3. High temperature and drought effects of Apollo, Thermal Blue, and Dynasty on their visual qualities. Ratings are on a scale of 1 to 9: 9 = best, 6 = minimally acceptable, and 1 = poor. Vertical bars indicate LSD values (P=0.05) for treatment comparisons as a given day of treatments.

Figure 4. Visual appearance of Apollo (KBG), Thermal Blue (TB), and Dynasty (TF) in the 1st replication after 36 days of temperature and irrigation deficit treatments. Front row is high temperature and back row is low temperature treatment. From left to right in both front and back rows: KBG (60% evapotranspiration [ET]); KBG (100% ET); TB (60% ET); TB (100% ET); TF (60% ET); and TF (100% ET).