TESTING AND SELECTING DROUGHT RESISTANT COMMON BERMUDAGRASS GENOTYPES

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TESTING AND SELECTING DROUGHT RESISTANT

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Abstract: Bermudagrass (*Cynodon dactylon* (L.) Pers.) is a perennial warm-season turfgrass that is widely used in the central and southern part of the United States. The drought performance of 67 experimental selections made from the normally seed-propagated cultivars 'Yukon', 'Riviera' and ' OKS 2004-2' bermudagrass, with two cultivars ‘Celebration’ and ‘Premier’ serving as standards. Field research plots were established at the Oklahoma State University Turfgrass Research Center in Stillwater, OK in 2012 in a randomized complete block design with four replications. Plots were evaluated in the field during and following a one month drought treatment period in 2012 and 2013. Plots received no water from irrigation or natural rainfall during the treatment period. Right after the drought period, plots were irrigated to allow grass recovery and the recovery rate was measured. Parameters measured included turf quality, leaf firing, normalized difference vegetation index, soil volumetric water content, and digital image analysis. Based on data collected in 2012 and 2013, two experimental genotypes, ‘1x9’ and ‘20x7’, showed significant improvement in field drought performance compared to all other entries and performed better than the highly drought resistant standard Celebration.

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CHAPTER I

LITERATURE REVIEW

Drought

Drought is an extended and abnormal period of atmospheric and soil water deficit (Dracup et al., 1980). Drought conditions can cause lack of moisture in the plant root zone (Youngner, 1985). Drought can cause environmental damage worldwide, can have deadly effects on plants, and has aroused widespread attention. The United States has also met challenges from drought conditions. In the 1930s, the Dust Bowl impacted the entire Great Plains region, from the Rio Grande River to Minnesota and Montana, and even extended into Canada. Oklahoma also was influenced deeply and severely. In some years, precipitation was well below normal causing significant crop and soil losses. The 1930s Dust Bowl caused heavy losses and was considered the most devastating drought in the history of the United States (Donald, 1979). To measure long-term meteorological drought, Wayne Palmer developed the Palmer Drought Severity Index (PDSI) in 1965 (Alley, 1984). The PDSI maps were published by the National Oceanic and Atmospheric Administration (NOAA) to monitor drought situations. More than half of the American mainland may face different levels of drought at any given time, including Oklahoma. At any given time of the year, many parts of Oklahoma may be under drought conditions (National Drought Monitor, 2013).

Water Conservation

Water covers seventy-one percent of the earth's surface. However, only three percent is fresh water and not all of that is useable for humans. Lots of fresh water exists in the Arctic and Antarctic regions. Only 0.003 percent of total water is considered as useable fresh water, and among it approximately 80 percent is used in agricultural irrigation (Muthena, 2011). Zoldoske (2003) reported that 2.9% of all irrigation water in the United States is used in landscape and 1.5% is used on golf courses. Considering that most landscaped areas and golf courses are located in urban areas, water conservation is necessary. With proper water use and improved irrigation management, large amounts of treated fresh water can be saved and cost can be reduced. About 80-90% of a turfgrass plant's weight is comprised of water (Beard, 1989). When a lack of water causes negative effects on grass growth and development, drought or water deficit damage occurs in the plant (Youngner, 1985).

Drought Resistance in Plants

For plants, water deficit can cause significant decreases in overall plant vegetative growth and may increase mortality rates (Touchette et al., 2007). Plants respond to drought stress with different processes as the length of the drought condition increases. Passioura (1996) published a general list of important processes that occur in plants as drought persists. He described phenomena occurring over time that influenced drought tolerance in plants. When drought stress occurs, plants will trigger stomatal movement and cause protein alteration. If drought lasts for hours, plants may produce heat shock proteins or dehydrins, alter leaf orientation, wilt, undergo osmotic adjustment, and/or produce abscisic acid (ABA). After one to two days, plants may initiate seedset, flowering, and cellular “hardening” caused by the induction of housekeeping genes. After several days of drought, plant responses may include canopy leaf senescence and root system development. When the condition continues for several weeks to months, processes affected will include vernalization, time to flowering, and grain filling. (Passioura, 1996)

Drought resistance is the plant’s ability to prevent dehydration or tolerate dehydration in plant tissues through a series of mechanisms; including drought avoidance, drought tolerance, and drought escape (Levitt, 1980; Kim et al., 1988).

Drought escape is a strategy usually observed in annual and ephemeral species in arid areas. They decrease or suspend active vital movement during a drought period and escape from water deficits by adjusting their life cycle (Beatley, 1974). In higher plants, drought tolerance and drought avoidance are major mechanisms for drought resistance. Drought avoidance is a plants ability to maintain water levels through morphological and physical mechanisms, such as changes in stomata, changes in leaf area and anatomy, and altered leaf orientation. Drought avoidance allows sufficient water absorption and reduction in water use (Beard, 1973). Drought tolerance is a plants response to water deficit through biochemical and physiological processes, such as osmotic changes that result from affecting the concentrations of carbohydrates, inorganic ions, and organic acids, and adjustment of cellular and/or tissue elasticity (Levitt, 1980).

C3 plants vs. C4 plants

Plants can be classified as C3 plants or C4 plants, according to their photosynthetic pathways (Maherali et al., 2003). The C3 plants use the Calvin cycle to fix carbohydrate. The first product of this pathway is 3-phosphoglyceric acid (PGA), which is a three carbon compound, hence the name 'C3'. Grasses that are categorized as C3 species are also called cool-season species. Many of them are widely used as turfgrass. For example, tall fescue (*Festuca arundinacea* Schreb.), Kentucky bluegrass (*Poa pratensis* L.), perennial ryegrass (*Lolium perenne* L.) and creeping bentgrass (*Agrostis stolonifera* L.) (Turgeon, 2005). Prior to performing the Calvin Cycle, C4 plants perform the photosynthetic dicarboxylic acid cycle from which the first product is oxaloacetate, a four carbon compound (Hull, 1992). C4 grasses are also known as warm-season grasses. Popular C4 turfgrass species include zoysiagrass (*Zoysia japonica* Steud) centipedegrass (*Eremochloa ophiuroides* (Munro) Hack), and bermudagrass (*Cynodon dactylon* (L.) Pers) (Kim et al., 1988). Compared with C3 plants, C4 plants can use CO_2 more efficiently and perform better when the CO_2 availability is low. Deficiency of water can cause a vapor pressure decrease, which can lead to stomatal closure and this can hamper air exchange. Former research shows the C4 pathway works better than C3 when CO_2 availability is reduced. Also, C4 grasses are considered to have better leaf nitrogen use efficiency (Wilson and Haydock, 1971). The ability of C3 and C4 grasses to grow deeper roots in response to drying soils is varies. Some C4 grass species distribute roots deeper into the soil profile. (Doss et al., 1960; Evans, 1978) So generally speaking, C4 plants have better drought resistance then C3 plants (Turgeon, 2005).

A Brief Introduction Bermudagrass and its Distribution

Bermudagrasses are a group of warm-season perennial grass species and widely used as turfgrass. They are monocots and belong to the Poaceae family. Bermudagrasses are adapted to the humid and semi-arid tropical and sub-tropical climate regions all over the world. The common name 'bermudagrass' is used in the United States, while some other countries use the common name 'couchgrass' (Beard, 1973). There are 9 species and 10 botanical varieties in the genus *Cynodon* (Harlan et al., 1970). The common bermudagrass taxon *C. dactylon var. dactylon*, African bermudagrass (*C. transvaalensis*) and interspecific hybrids between these two species (*C. dactylon* X *C. transvaalensis*) are the most important warm-season grasses to the turfgrass industry (Beard, 1973; Taliaferro, 2003; Taliaferro et al. 2004a).

Bermudagrass is a diverse species and can be found on six continents. Taliaferro reported that Africa or Southeast Asia is the center of origin of genus *Cynodon* (Taliaferro et al. 2003). In the Southern United States, bermudagrassses are very important turfgrasses and are widely used in full-sun areas. The Natural Distribution map for Bermudagrass published at the USDA Plants website shows they can be found in across the Southern U.S (USDA, 2013).

Growth Habit of Bermudagrass

Bermudagrasses can propagate by both seed and vegetatively. They can spread by seeds, tillers, rhizomes, and stolons. Thus, bermudagrasses have excellent recuperative ability and wear tolerance (Turgeon, 2005). Their growth habit is prostrate which helps bermudagrasses tolerate low mowing heights (Beard, 1973). There are variations among cultivars, but most common bermudagrasses can adapt to mowing heights as low as 1.27 cm (0.5 inches) or 2.54 cm (1.0 inches). Some particular cultivars tolerate mowing as low as 0.28 cm (0.125 inches). The most suitable soil pH for bermudagrass growth is between 6.0 - 6.5 (Higgins, 1998), but they are adapted to soil pH ranging from 5.5 to 8.5 (Christians, 2006).

Bermudagrass Response to Drought Stress

As described before, plants may survive drought through a series of physiological responses. When water is limited, bermudagrass can increase soluble carbohydrates, free amino acids, amides, and bound water, undergo osmotic adjustment, induce dehydrin proteins, produce ABA, and develop deep root systems (Levitt, 1980; Huang et al., 1997; Huang, 2004; Su et al., 2013). Turfgrass may close stomata to decrease transpiration to save water during dry periods. However, stomatal closure will hamper photosynthetic activity. When the respiration rate is greater than the photosynthetic rate, carbohydrate production is reduced. Therefore, carbohydrate reserves become essential for plant growth and survival. Available plant carbohydrates are influenced by total nonstructural carbohydrate concentration (Smith, 1969). Carbohydrate concentration changes are also believed to be involved in osmotic adjustment processes (Levitt, 1980). Dehydrin-like proteins in bermudagrasses are believed to contribute to drought tolerance by helping to maintain physiological integrity of cells and protecting other proteins (Bray, 1993; Close, 1996; Hu et al., 2010). Also, ABA may enhance drought avoidance by adjusting stomatal closure (Huang, 2004). Plants may avoid drought damage by distributing roots deeper into the soil profile. Hays (1991) measured roots characteristics of 10 bermudagrass genotypes at different soil depths, 30-60 cm, 60-90 cm, 90-120 cm and 120-150 cm. He reported there was a significant correlation between root distribution and turf quality with coefficients of determination of r^2= 0.72, 0.86, 0.80, and 0.81, respectively (Hays et al., 1991).

Drought Resistance of Bermudagrass

Bermudagrasses have excellent heat and drought resistance. These properties make them very competitive grasses in hot and/or dry regions (Turgeon, 2005). Kim et al. (1998) showed the ranks of warm-season turfgrass species based on their drought resistance (shoot recovery) and leaf firing. He compared St. Augustinegrass (*Stenotaphrum secundatum* (Walt.) Kuntze), seashore paspalum (*Paspalum vaginatum* Sw), buffalograss (*Bouteloua dactyloides* (Nutt.) J.T. Columbus*; synonym Buchloe dactyloides* (Nutt.) Englem), bahiagrass (*Paspalum notatum* Flugge), centipedegrass, zoysiagrass and bermudagrass for drought resistance. The most widely used cultivars of each species were chosen and measured for their performance. The results showed bermudagrass had relatively low leaf firing and high drought resistance among these widely used warm-season turfgrass species. (Kim et al., 1988)

Carrow (1996) conducted a study which ranked a series of popular turfgrasses by drought performance. He evaluated the wilting and leaf firing of grasses under drought stress. The ranking was as follows: common bermudagrass = 'Tifway' bermudagrass > 'Raleigh' St. Augustinegrass = common centipedegrass > 'Rebel II' tall fescue > 'Kentucky 31' tall fescue > 'Meyer' zoysiagrass. According to this research, the two most drought resistant turfgrasses within the seven cultivars were both bermudagrasses (Carrow, 1996).

Certain cultivars of bermudagrass are more drought resistance than others. Baldwin et al. (2006) reported a ranking of six bermudagrass cultivars according to their performance under drought stress in a greenhouse. Their results showed that the cultivar 'Celebration' had the best drought resistance among 'SWI-1012', 'Arizona Common', 'Tift No.3', Tifsport', 'Aussie Green' and Celebration. Chalmers et al. (2008) also published a drought resistance evaluation. They evaluated 25 turfgrass species widely used in Texas, which included eight bermudagrass cultivars, 'Celebration', 'Common', 'GN-1', 'Grimes EXP', 'Premier', 'Tex Turf', 'TifSport' and 'Tifway'. Results indicated that bermudagrasses, along with buffalograsses, had good drought resistance and among the bermudagrass cultivars studied, 'Celebration' had relatively high drought resistance, while 'Premier' was more drought sensitive.

Goals and Objectives

The goal of this research project was to identify cold tolerance and drought resistant common bermudagrass germplasm that could be used to develop superior cultivars for use in Oklahoma and the U.S. transition zone.

The objective of this research was to:

1. Evaluate and rank the field drought performance of 67 experimental bermudagrass genotypes.

Research hypothesis:

1. There are statistically significant differences in experimental genotypes of bermudagrass for their field drought performance.

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CHAPTER II

TESTING AND SELECTING DROUGHT RESISTANT COMMON BERMUDAGRASS GENOTYPES

Abstract

Bermudagrass (*Cynodon dactylon* (L.) Pers.) is a perennial warm-season turfgrass that is widely used in the central and southern part of the United States. We evaluated the drought performance of 67 experimental selections made from the normally seed-propagated cultivars 'Yukon', 'Riviera' and ' OKS 2004-2' bermudagrass, with two cultivars ‘Celebration’ and ‘Premier’ serving as standards. Field research plots were established at the Oklahoma State University Turfgrass Research Center in Stillwater, OK in 2012 in a randomized complete block design with four replications. Plots were evaluated in the field during and following a one month drought treatment period in 2012 and 2013. Plots received no water from irrigation or natural rainfall during the treatment period. Right after the drought period, enough water was irrigated to allow the grass recovery and recovery rate was measured. Parameters measured included turf quality, leaf firing, normalized difference vegetation index, soil volumetric water content, and digital image analysis. Based on data collected in 2012 and 2013, two experimental genotypes, ‘1x9’ and ‘20x7’, showed significant improvement in field drought performance compared to all other entries and performed better than the highly drought resistant standard Celebration.

Key words

Bermudagrass, drought resistance, evaluation, turf quality, leaf firing, soil volumetric water content, normalized difference vegetative index, digital image analysis, and drought performance.

Introduction

Bermudagrass [*Cynodon dactylon* (L.) Pers. *var. dactylon*] is a perennial warm-season turfgrass that can propagate by seed, rhizomes, and stolons. Bermudagrasses have excellent recuperative ability and wear tolerance (Turgeon, 2005) and are suitable for low mowing heights (Beard, 1973). Bermudagrasses also have excellent heat and drought tolerance. They are adapted to humid and semi-arid tropical and sub-tropical climate regions. These properties make bermudagrass a very competitive grass in hot and/or dry regions (Turgeon, 2005).

However, bermudagrass in general is sensitive to cold weather. Bermudagrass shoots stop growing when air temperatures drop below 16 ℃ (60 ℉) and when temperatures drop below 10 ℃ (50 ℉), discoloration may happen. Cold climates limit the use of bermudagrasses despite their wide distribution. (Emmons, 1995). Bermudagrass visual turf quality is reduced by dead leaf tissue when freezing induced dormancy occurs, reducing playability and ornamental value. To improve the cold adaptation of bermudagrass, researchers at Oklahoma State University (OSU) are currently testing and selecting bermudagrass genotypes with improved cold tolerance (Wu et al., 2013).

Approximately 75-85% of the weight of a turfgrass plant is comprised of water (Beard, 1985). When a lack of water causes negative effects on grass growth and development, drought damage occurs (Youngner, 1985). Because water is vital for turfgrass growth and survival, almost all golf course turf needs supplemental irrigation. Water is a precious natural resource and is limited in many regions. Therefore, using water efficiently is important in turfgrass management. Development of bermudagrasses with improved drought performance is essential for water conservation in turfgrass areas. The goal of this project was to develop bermudagrass cultivars with improved drought resistance for adaptability in Oklahoma and the U.S. transition zone. The objective of this research was to determine and evaluate the field performance of 67 experimental bermudagrass genotypes and two standards under acute drought and to compare and rank the field drought performance of the 67 experimental genotypes.

Materials and Methods

Plant Materials

A total number of 67 experimental selections and two standard cultivars were used for this research (Table 1). Forty-nine experimental selections were from the OSU bermudagrass breeding and development program. They were believed to have improved cold hardiness (Wu et al., 2013). In the summer of 2009, 210 selections from Riviera and 210 selections from Yukon were field established at the Landscape and Horticulture Center of the University of Illinois at Urbana – Champaign (40’05” N. Lat., 88’14” W. Long.). Spring green-up was observed in April 2010. The top 98 genotypes were selected and transplanted to the OSU Agronomy farm in 2011. Forty-nine genotypes were selected that were considered to exhibit faster establishment during the very dry summer of 2011, including 12 genotypes from Yukon and 37 genotypes from Riviera. These experimental genotypes were coded as: ‘1x9’, ‘2x10’,’ 2x14’,’ 2x7’, ‘4x20’, ‘5x6’, ‘6x1’, ‘6x2’, ‘8x11’, ‘8x16’, ‘8x19’, ‘9x19’, ‘11x12’,’ 11x15’, ‘11x18’, ‘12x15’, ‘12x20’, ‘12x21’, ‘12x6’, ‘12x7’, ‘12x8’, ‘13x2’, ‘13x8’, ‘13x9’, ‘14x15’, ‘14x18’, ‘14x6’, ‘14x7’, ‘15x2’, ‘16x17’, ‘16x19’, ‘16x4’, ‘16x6’, ‘17x10’, ‘17x7’, ‘18x14’, ‘18x15’, ‘18x18’, ‘18x19’, ‘18x3’, ‘18x6’, ‘19x10’, ‘19x16’, ‘19x6’, ‘19x7’, ‘20x16’, ‘20x2’, ‘20x6’, ‘20x7’. The coding system shows their positions in the nursery block. The first digit is row number while second digit is column number. For example, 8x16 was a plant from row 8 and column 16.

Also included in this experiment were 18 genotypes that were tested to have improved leaf firing resistance based on the work of Thapa (2011). During that study bermudagrass materials were exposed to a drought period of 93 days and individual tillers showing improved leaf firing resistance were marked for later removal at the end of the experiment for clonal propagation (Thapa, 2011). Based on the results of Thapa's experiment, 18 individual bermudagrass tillers were chosen from seeded lines based on their improved leaf firing resistance or drought tolerance, including 5 selections from Yukon, 8 selections from Riviera, and 5 selections from OSU experimental line OKS 2004-2. These genotypes were coded as: '7-1-1-4', '7-2-1-2', '7-2-2F-2', '7-2-3F-4', '7-2-4F-2', '7-4-1-3',' 7-4-2F-2', '7-4-3F-4', '8-2-1-4', '8-2-2F-1',' 8-2-3F-3', '8-5-1-1', '8-5-2F-2', '20-2-1F-4', '20-2-2F-3', '20-4-1F-1', '20-4-2F-2', '20-4-3F-4'. The first letter of the label is the parent seeded cultivar from which the selection arose, 7=Riviera, 8=Yukon and 20 =OKS 2004-2. The second letter designates the drought tube replication number from which the selection was made. The third number of the label designates a unique selection made out of a certain tube within a certain cultivar. The fourth number represents replication of identical material and F means fired tillers. The genotypes that did not contain F means their tillers did not leaf fire during the dry down cycle experiment. The 'Celebration' and 'Premier' have been commercially sold and are used in this study as standard cultivars. Based on previous research, Celebration bermudagrass was found to have excellent drought resistance while Premier bermudagrass was found to have poor drought resistance (Chalmers, 2008).

In preparation for transplanting to the field in spring 2012, all materials were clonally propagated in greenhouse trays from November 1, 2011 to May 15, 2012. Mealy bugs were detected in the greenhouse and treated with imidacloprid (Merit 75 WP insecticide, Bayer Environmental Science, Durham, North Carolina) and permethrin (Permethrin E-Pro Termiticide/lnsecticide, Envincio LLC, Spartanburg, North Carolina) at labeled rates. No symptom of mealy bug damage was observed during the field experimental period.

Growth condition

Field research plots were established at the OSU Turfgrass Research Center, located 1.6 km west of Stillwater, OK (36° 07’ 06” N, 97° 06’ 10” W). The former crop at the site was bermudagrass which was killed with glyphosate and tillage in 2010. For weed control, the post-emergent broad spectrum herbicide glyphosate was applied one week prior to establishment and the pre-emergent herbicide oxadiazon granular formula (Ronstar G generic, Quality Turf and Ornamental Product, Pasadena, Texas) was applied at 196 kg ha^{-1}one day after the transplanted for weed control. Voluntary bermudagrass plants and weeds also were removed manually throughout the establishment period. A soil sample was taken on May 10th, 2012. The soil test results showed the texture was 75% sand, 13.8% silt, and 11.3% clay, which classifies as a “Loamy Sand” according to the USDA soil textural triangle (USDA, 2013). The soil pH was 6.6. According to soil test recommendation and N fertility maintenance (Qian et al., 1997), a total of 245 kg N $ha^{-1}$was applied during of 2012 and 2013. Phosphorus (P) and Potassium (K) were applied at rate of 73.5 kg ha^{-1}in total of 2012 and 2013. No symptoms of element deficiency were observed during the study.

Plot design and field establishment

This study used a randomized complete block design with four replications of each treatment. The total plot area was 438 m^2(10 m wide and 43.75 m) long. Individual plot size was 1 m x 1 m with 0.25 m bare soil borders between plots to separate different entries (Table 2). Eight plugs of each genotype were planted in plots on May 16th, 2012. Holes were drilled with a plywood template before planting materials to ensure the plugs were distributed evenly in plots.

During the grass establishment stage, an automatic irrigation system was used to irrigate in a range of approximately 0.32 cm of water per day. The research site was located 0.4 km west of an observation station of the Oklahoma Mesonet System. Based on reference evapotranspiration data calculated by the Penman-Monteith method (Allen et al., 1998) and published by Mesonet daily, irrigation was adjusted to ensure irrigation at 100% ET for warm-season turf during the establishment stage. Plots were mowed at 5.1 cm height with a rotary mower and clippings were removed away from the plots. No mowing was applied during the drought treatment period. During the recovery period, the mowing height was adjusted to 6.4 cm and brought down to 5.1 cm to avoid scalping damage.

Treatment

When the bermudagrass plots were well established and uniform, drought treatment was applied to all 276 research plots. One day prior to drought treatment, the research plots were well-watered with 1.5 cm of irrigation. Following this final irrigation, the irrigate system was turned off and the plots were not watered during the drought period. In 2012, one 694 m^2 size tarp (Covermaster, Rexdale, ON, Canada) was used as rain cover during the drought treatment period to prevent natural precipitation and create a drought condition. The drought testing stage lasted four weeks from July 30th to August 25th, 2012.

In 2013, three smaller waterproof tarps (Blue 40-ft x 60-ft Plastic Tarp) were used to cover the plots during rain, and each was 18 m length and 12 m wide, which made it easier to cover the plots by one person. The last day that the plots were irrigated before drought treatment was July 3rd, 2013. However, a series of rain events happened between July 10th and August 14th, 2013. Since covering the plots too long could introduce stress other than drought and potentially damage the research plots, the plots were uncovered and expose to rain during this period. Therefore plots irrigation ceased completely on August 14th and lasted 32 days until September 16th, 2013.

No mowing, fertilizer or pesticide was applied to plots during the drought treatment period both in 2012 and 2013. Roundup was applied to the plot surroundings and to the borders to prevent contamination. Plots were irrigated, fertilized, mowed and maintained as normal after the drought period to evaluate drought recovery.

Parameters

Parameters collected to evaluate the performance of bermudagrass included subjective data turf visual quality (TQ), leaf firing (LF), and objective data normalized difference vegetative index (NDVI) and digital image analysis (DIA). Turfgrass visual quality was rated on a scale of one to nine based on the National Turfgrass Evaluation Program criteria, where 1 = dead or dormant turf, 6 = acceptable turf visual quality, and 9 = excellent turf (Morris, 2007). Leaf firing is a visual rating for plant drought symptoms and measures the browning of grass leaves. Leaf firing was also rated on a scale of 1 to 9, where 1 = total LF and 9 = no LF (Chalmers, 2008). Normalized difference vegetative index (NDVI) was measured by a GreenSeeker sensor (N Tech Industries Inc., Ukiah, CA) on a scale of zero to one, where a number closer to one indicates a greener plot. The equation to calculate NDVI ratio as follows: $\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{VIS})}{(\mathrm{NIR} + \mathrm{VIS})}$, where NIR = spectral reflectance measurements acquired in near-infrared for a given pixel, VIS = spectral reflectance measurements acquired in the visible (red) range for a given pixel (Deering, 1975). Thus, the NDVI value is a ratio without a unit. Digital photographs were taken with a 90 cm x 90 cm camera stand and DIA was analyzed via SigmaScan software to calculate percent living coverage (Richardson, 2001; Karcher and Richardson, 2003). Soil volumetric water content

(SVWC) of each plot was measured by a Stevens POGO portable soil sensor (Stevens, Portland, OR). The SVWC were rated to show the accumulation of drought stress in soil and the probe used was 5 cm. The TQ, LF, NDVI, digital image and SVWC were recorded weekly throughout the drought treatment and the recovery period.

Statistical analysis

The experimental design was a randomized complete block with sixty-nine genotypes and four replications. Analyses were conducted on SVWC, TQ, LF, NDVI and DIA data using Statistics Analysis System (SAS) software for Window v.9.1 (SAS Institute, 2002). Analysis of variance (ANOVA) was analyzed by procedure "PROC GLM". For all the parameters, there was a significant year by treatment interaction, thus data were analyzed by year. Similarly, within each year there was a significant date by treatment interaction, thus data were analyzed by date. When genotype means were separated, Fisher's least significant difference (LSD) was applied to test at the 95% significant probability level. The DIA results were analyzed as a percentage of green leaves (pixels) so they were transformed by the formula ASSRDIA = ARSIN(SQRT(DIA/100)), which gave the arcsine square root of DIA. The range of arcsine square root of DIA was from 0 to 1.57.

Results and Discussion

Soil volumetric water content (SVWC)

Figures 1 and 2 show the soil volumetric water content means for the research plots in 2012 and 2013. The SVWC of field capacity was approximately 20%. After one week of drought treatment, the means of SVWC measurements had decreased to 8.6% in 2012 (Aug 7th), and 6.3 %

in 2013 (Aug 22nd). At the end of the drought treatment period, the means of SVWC decreased to 4.3% in 2012 (Aug 21st) and 2.9% in 2013 (Sep 12th). Figures 1 and 2 also show SVWC values following the drought treatment period (recovery period) where the plots were well watered. The plots SVWC were raised back to field capacity and had means of SVWC higher than 20% in both 2012 and 2013 after rewatering.

Turfgrass visual quality (TQ)

Means of TQ for each genotype in the 2012 drought treatment period are reported in Table 3. Prior to the drought treatment, all bermudagrass entries had acceptable TQ means, ranging from 6.00 to 8.25. At one week after the drought treatment (WAT), there were 25 entries out of 69 that appeared in the top LSD group. This included the good drought resistant standard Celebration, and the poor drought resistant standard Premier, and the following experimental selections: 8x16, 8x19, 20x7, 20x16, 16x17, 19x16, 19x6, 16x19, 17x10, 12x21, 14x15, 12x20, 13x8, 12x7, 1x9, 20x2, 17x7, 7-2-1-2, 19x10, 14x7, 20x6, 7-4-1-3, and 11x15. At two WAT, there were nine entries out of 69 that appeared in the top LSD group, included the following genotypes: 16x17, 8x16, 20x7, 12x21, 20x2, 8x19, 19x16, 1x9, and 16x19. After three WAT, there were 11 entries out of 69 are appeared in the top LSD group, included the following genotypes: 8x16, 16x17, 20x7, 12x21, 20x2, 1x9, 19x16, 14x7, 16x19, 17x10 and 8x19. TQ means were ranging from 2.00 to 5.75. No entry had acceptable TQ ratings after three weeks of acute drought. The standard Celebration was in the second top group while Premier was in the fifth statistical group. Experimental selections 8x16 and 16x17 were no different than 20x7, 12x21, 20x2, 1x9, 19x16, 14x7, 16x19, 17x10 and 8x19, but had higher TQ than the remaining 58 entries.

Drought treatment data of 2013 are reported in Table 5. Prior to the drought treatment, TQ means ranged from 5.25 to 8.00. The experimental genotype 2x14 was the only entry that had a TQ rating below 6. At one WAT, there were 51 entries listed in the top LSD group, including the following genotypes: 11x12, 1x9, 11x18, 7-2-1-2, 7-2-2F-2, 20x6, 13x8, 7-4-1-3, 20x2, 16x17, 18x6, 18x3, 15x2, 19x6, 8x16, 8x11, 12x6, 17x10, 17x7, 14x18, 7-1-1-4, 7-2-3F-4, 7-2-4F-2, 20-2-2F-3, 12x20, 7-4-3F-4, 18x19, 13x9, Premier, 11x15, 20-2-1F-4, 12x7, 7-4-2F-2, 16x4, 20x16, 8-2-2F-1, 14x6, 14x15, 19x16, 19x10, 18x15, 8-5-1-1, 20x7, 18x18, 8-2-3F-3, 8x19, 16x19, 5x6, 6x1, 18x14, and 9x19. At two WAT, there were 40 entries out of 69 that appeared in the top LSD group, included the following genotypes: 1x9, 16x19, Celebration, 2x7, 13x9, 8x16, 9x19, 16x17, 20x16, 20x7, 17x10, 14x7, 8-2-2F-1, 7-2-2F-2, 7-4-2F-2, 6x1, 11x15, 19x10, 7-4-1-3, 14x18, 8x11, 12x6, 18x15, 17x7, 19x7, 11x12, 12x21, 16x4, 7-2-1-2, 5x6, 2x10, 14x6, 20-2-1F-4, 15x2, 19x16, 11x18, 7-4-3F-4, 6x2, 19x6, and 18x3. After three WAT, there were seven entries out of 69 appeared in the top LSD group, included the following genotypes: 1x9, Celebration, 16x17, 14x7, 8x16, 20x7, and 12x21. After four WAT, means of TQ were ranging from 1.25 to 4.25. No entry had acceptable TQ ratings at the end of drought treatment period in 2013. There were seven entries out of 69 that appeared in the top LSD group, included the following genotypes: 1x9, 19x7, Celebration, 12x21, 20x7, 16x7, and 19x10. Experimental selection 1x9 was no different than 19x7, Celebration, 12x21, 20x7, 16x7, and 19x10, but had higher TQ than the remaining 62 entries.

Normalized difference vegetative index (NDVI)

Means of NDVI for each genotype in the 2012 drought treatment period are reported in Table 7. Prior to the drought treatment, means of NDVI ranged from 0.716 to 0.857. At one WAT, there were 39 entries out of 69 that appeared in the top LSD group. This included the good drought resistant standard Celebration, the poor drought resistant standard Premier, and the following experimental selections: 16x17, 8x16, 16x19, 19x6, 20x7, 12x20, 7-4-1-3, 7-4-2F-2, 1x9, 13x8, 12x8, 14x15, 13x9, 17x10, 18x3, 8x11, 9x19, 20x16, 19x16, 20x6, 20x2, 7-4-3F-4, 14x7, 20-2-2F-3, 7-2-4F-2, 19x7, 8-2-2F-1, 12x7, 18x15, 11x15, 7-2-1-2, 16x6, 17x7, 8x19, 20-2-1F-4, 11x18, and 7-2-3F-4. At two WAT, there were 14 entries out of 69 that appeared in the top LSD group, included the following genotypes: 16x17, 8x16, 1x9, 16x19, 20x7, 20x2, 18x3, 9x19, 14x7, Celebration, 19x16, 17x10, 19x6, and 8x11. After three WAT, there were 25 entries out of 69 which appeared in the top LSD group, included the following genotypes: 16x17, 20x7, 16x19, 20x2, 8x16, 14x7, 9x19, 1x9, 18x3, 19x16, Celebration, 12x21, 17x7, 8x11, 7-4-1-3, 19x6, 19x10, 8x19, 16x4, 12x6, 17x10, 14x15, 12x20, 12x8, and Premier. Experimental selection 16x17 was no different than 20x7, 16x19, 20x2, 8x16, 14x7, 9x19, 1x9, 18x3, 19x16, Celebration, 12x21, 17x7, 8x11, 7-4-1-3, 19x6, 19x10, 8x19, 16x4, 12x6, 17x10, 14x15, 12x20, 12x8, and Premier, but had higher NDVI than the remaining 44 entries.

Drought treatment NDVI data from 2013 are reported in Table 9. Prior to the drought treatment, means of NDVI ranged from 0.406 to 0.834. At one WAT, there were 36 entries listed in the top LSD group, included the following genotypes: 16x19, 8-2-2F-1, 19x6, 13x9, 7-4-1-3, 6x1, 19x7, 16x17, Premier, 7-4-2F-2, 17x10, 7-2-1-2, 7-2-2F-2, 12x6, 7-4-3F-4, 2x7, 2x10, 11x18, 14x18, 1x9, 7-2-3F-4, 8-2-1-4, 8-5-1-1, 8x16, 12x20, 18x15, 11x12, 12x7, 20x7, 19x10, 15x2, 11x15, 14x6, 14x15, 17x7, and 13x2. At two WAT, there were 50 entries out of 69 that appeared in the top LSD group, included the following genotypes: 19x7, 16x19, 16x17, 1x9, 13x9, 7-4-2F-2, 8-2-2F-1, 19x6, 20x7, 7-4-1-3, 17x10, Celebration, 6x1, 8x11, 8x16, 11x15, 9x19, 19x10, 20x16, 7-2-1-2, 12x6, 2x10, 16x4, 14x7, 8-2-1-4, 11x12, 14x15, 17x7, 14x6, 7-2-2F-2, 7-4-3F-4, 18x18, 15x2, 18x15, 11x18, 2x7, 20-2-1F-4, 12x7, 19x16, Premier, 14x18, 20x2, 18x3, 16x6, 20x6, 7-1-1-4, 20-2-2F-3, 7-2-4F-2, 5x6, and 7-2-3F-4. After three WAT, there were 19 entries out of 69 are appeared in the top LSD group, included the following genotypes: 1x9, 20x7, 19x7, 16x19, Celebration, 16x17, 12x6, 13x9, 14x7, 19x10, 17x10, 9x19, 14x18, 8x11, 20x16, 14x6, 20x2, 8x16, and Premier. After four WAT, there were eight entries out of 69 that appeared in the top LSD group, included the following genotypes: 20x7, Celebration, 1x9, 19x7, 19x10, 12x21, 14x18, 14x7. Genotypes 20x7 and Celebration were no different than, 1x9, 19x7, 19x10, 12x21, 14x18, 14x7, but had higher NDVI than the remaining 61 entries.

Digital image analysis (DIA)

Means of DIA for each genotype in the 2012 drought treatment period are reported in Table 11. Prior to the drought treatment, means of DIA ranged from 1.451 to 1.547. At one WAT, there were 46 entries out of 69 that appeared in the top LSD group. This included the good drought resistant standard Celebration, the poor drought resistant standard Premier, and the following experimental selections: 7-2-1-2, 13x8, 20x6, 8x16, 7-4-1-3, 18x3, 19x6, 1x9, 12x8, 14x15, 19x16,11x18, 12x20, 12x6,20x16, 8-2-2F-1, 11x15, 14x6, 7-2-3F-4, 7-4-3F-4, 20x7, 20x2, 17x7, 18x19, 20-2-2F-3, 16x19, 19x7, 12x7, 9x19, 8-2-1-4, 20-2-1F-4, 7-2-4F-2, 16x6, 19x10, 13x9, 17x10, 2x10, 18x15, 7-4-2F-2,8x19, 16x17, 2x7, 14x7, and 12x21. At two WAT, there were 35 entries out of 69 that appeared in the top LSD group, included the following genotypes: 8x16, 20x2, 20x7, 1x9, 16x17, 16x19, 18x3, 12x21, 19x16, Celebration, 13x8, 19x6, 17x7, Premier, 14x7, 9x19, 19x10, 20x16, 8x19, 17x10, 11x15, 12x8, 12x20, 7-4-1-3, 13x9, 18x19, 20x6, 8-2-2F-1, 8x11, 19x7, 14x15, 12x6, 16x4, 16x6, and 12x7. After three WAT, there were 29 entries out of 69 are appeared in the top LSD group, included the following genotypes: 20x2, 1x9, 16x17, 12x21, 14x7, 17x10, 8x16, 9x19, 20x7, 16x19, Celebration, 19x16, 17x7, 18x3, 19x6, 8x19, 20-4-2F-2, 19x10, 12x6, 12x8, 16x4, 11x15, 16x6, 7-4-1-3, 12x20, Premier, 14x15, 19x7, and 8x11. Experimental selection 20x2 was no different than, 1x9, 16x17, 12x21, 14x7, 17x10, 8x16, 9x19, 20x7, 16x19, Celebration, 19x16, 17x7, 18x3, 19x6, 8x19, 20-4-2F-2, 19x10, 12x6, 12x8, 16x4, 11x15, 16x6, 7-4-1-3, 12x20, Premier, 14x15, 19x7, and 8x11, but had higher DIA than the remaining 40 entries.

Drought treatment DIA data from 2013 are reported in Table 13. Prior to the drought treatment, means of DIA ranged from 1.360 to 1.561. At one WAT, there were 54 entries listed in the top LSD group, included the following genotypes: 1x9, 19x6, 16x19, 12x6, 7-2-2F-2, 7-2-1-2, 14x6, 17x7, 13x9, 8-2-2F-1, Premier, 16x17, 7-4-2F-2, 11x12, 6x1, 7-4-1-3, 19x7, 15x2, 18x15, 13x8, 20x16, 14x18, 12x7, 8x16, 8-5-1-1, 11x18, 7-4-3F-4, 18x3, 14x15, 9x19, 19x10, 16x4, 7-2-3F-4, 12x20, 7-2-4F-2, 19x16, Celebration, 11x15, 8-2-1-4, 14x7, 20x7, 2x7, 18x6, 18x18, 17x10, 2x10, 13x2, 20x2, 20-2-1F-4, 5x6, 18x14, 12x8, 20-4-1F-1, and 6x2. At two WAT, there were 32 entries out of 69 that appeared in the top LSD group, included the following genotypes: 1x9, Celebration, 16x17, 16x19, 8-2-2F-1, 20x7, 12x6, 19x7, 14x7, 7-4-2F-2, 9x19, 11x12, 8x16, 14x6, 19x6, 12x21, 20x16, 13x9, 14x18, 13x8, 19x10, 19x16, 20-2-1F-4, 20x2, 7-4-1-3, 17x10, 2x7, 7-2-1-2, Premier, 8-2-1-4, 18x3, and 18x18. After three WAT, there were 32 entries out of 69 are appeared in the top LSD group, included the following genotypes: 1x9, Celebration, 16x17, 16x19, 8-2-2F-1, 20x7, 12x6, 19x7, 14x7, 7-4-2F-2, 9x19, 11x12, 8x16, 14x6, 19x6, 12x21, 20x16, 13x9, 14x18, 13x8, 19x10, 19x16, 20-2-1F-4, 20x2, 7-4-1-3, 17x10, 2x7, 7-2-1-2, Premier, 8-2-1-4, 18x3, and 18x18. After four WAT, there were 25 entries out of 69 that appeared in the top LSD group, included the following genotypes: 19x7, 1x9, 12x21, 19x10, 14x7, Celebration, 15x2, 9x19, 12x6, 20x2, 16x17, 18x15, 20x7, 18x3, 20x6, 19x16, 16x19, 8x19, 14x18, 11x15, 12x8, 7-4-1-3, 14x6, 17x10, and 13x9. Experimental selection 19x7 was no different than 1x9, 12x21, 19x10, 14x7, Celebration, 15x2, 9x19, 12x6, 20x2, 16x17, 18x15, 20x7, 18x3, 20x6, 19x16, 16x19, 8x19, 14x18, 11x15, 12x8, 7-4-1-3, 14x6, 17x10, and 13x9, but had higher DIA than the remaining 44 entries.

Leaf firing (LF)

Means of LF for each genotype during the 2012 drought treatment period are reported in Table 15. Prior to the drought treatment, there was no leaf firing in any genotype. At one WAT, there were 39 entries out of 69 that appeared in the top LSD group. This included the good drought resistant standard Celebration, the poor drought resistant standard Premier, and the following experimental selections: 16x17, 8x16, 20x7, 20x16, 19x16, 13x8, 17x10, 19x6, 12x20, 20x2, 19x10, 14x15, 12x21, 16x19, 7-2-1-2, 20x6, 20-2-2F-3, 12x7, 19x7, 12x8, 11x15, 1x9, 18x19, 16x6, 7-4-1-3, 14x18, 7-4-3F-4, 8x19, 17x7, 7-2-4F-2, 13x9, 14x7, 8x11, 20-4-3F-4, 7-2-2F-2, 20-2-1F-4, and 18x3. At two WAT, there were 22 entries out of 69 that appeared in the top LSD group, included the following experimental selections: 16x17, 20x7, 8x16, 1x9, 20x2, 19x16, 14x7, 16x19, 8x19, 19x6, 9x19, 12x21, 17x10, 14x15, 13x8, 20x16, 7-4-1-3, 14x18, 12x20, 16x4, 13x9, and 11x15. After three WAT, there were 15 entries out of 69 are appeared in the top LSD group, included the following experimental selections: 16x17, 20x7, 8x16, 1x9, 20x2, 14x7, 19x16, 8x19, 16x19, 19x6, 14x15, 12x21, 9x19, 17x10, 7-4-1-3. Experimental selection 16x17 was no different than 20x7, 8x16, 1x9, 20x2, 14x7, 19x16, 8x19, 16x19, 19x6, 14x15, 12x21, 9x19, 17x10, and 7-4-1-3, but had higher DIA than the remaining 54 entries.

Means of LF for each genotype during the 2013 drought treatment period are reported in Table 16. Prior to the drought treatment, there was no leaf firing in any of the genotypes. At one WAT, there were 56 entries listed in the top LSD group, included the following genotypes: 7-2-2F-2, 13x9, 20x7, 1x9, 12x6, 14x18, 11x18, 20x16, 14x6, 7-4-3F-4, 16x19, 8-5-1-1, 17x7, 16x17, 2x7, 19x7, 18x15, 16x4, 14x15, 7-4-1-3, 6x1, 7-2-1-2, 12x20, 12x7, 18x6, 11x15, 8-2-1-4, 8-2-2F-1, 20-2-1F-4, 19x10, 7-1-1-4, 9x19, 5x6, 6x2, 20x2, 2x10, 11x12, 17x10, 8-2-3F-3, 19x6, 7-4-2F-2, 8x11, 19x16, 15x2, 13x8, 8x16, 18x19, 12x21, 7-2-3F-4, Celebration, 18x14, 14x7, Premier, 7-2-4F-2, 16x6, and 12x8. At two WAT, there were 32 entries out of 69 that appeared in the top LSD group, included the following genotypes: 1x9, 16x19, Celebration, 8x16, 20x7, 2x7, 9x19, 16x17, 19x7, 2x10, 8-2-2F-1, 7-2-2F-2, 7-4-2F-2, 20x16, 14x7, 13x9, 12x6, 6x1, 7-2-4F-2, 19x10, 7-4-3F-4, 7-4-1-3, 7-2-1-2, 14x15, 14x6, 18x15, 20-2-1F-4, 12x21, 11x12, 11x15, 6x2, and18x3. After three WAT, there were 11 entries out of 69 are appeared in the top LSD group, included the following genotypes: 1x9, Celebration, 12x21, 20x7, 14x7, 16x17, 8x16, 19x7, 9x19, 16x19, and 19x10. After four WAT, there were eight entries out of 69 that appeared in the top LSD group, and included the following genotypes: 1x9, Celebration, 20x7, 12x21, 19x10, 19x7, 14x7, 16x17. Experimental selection 1x9 was no different than Celebration, 12x21, 14x7, 16x17, 19x10, 19x7, and 20x7, but had higher DIA than the remaining 61 entries.

Recovery after drought stress

The parameters TQ, NDVI and DIA were measured during the recovery period where plots were re-watered immediately following the drought treatment period each year. In 2012, irrigation and recovery was initiated on August 26th. There were four rating dates. Means of TQ for each genotype in 2012 drought treatment period are reported in Table 4. At one week after recovery (WAR), there were 16 entries out of 69 that appeared in the top LSD group, included the following experimental selections: 20x2, 12x21, 8x16, 1x9, 16x19, 20x7, Premier, 16x6, Celebration, 19x6, 8x19, 12x20, 16x17, 12x6, 9x19, and 14x15. At two WAR, there were 26 entries out of 69 that appeared in the top LSD group, included the following experimental selections: 1x9, 8x16, Premier, 19x6, 20x7, 14x15, 12x21, 18x3, 12x6, 16x19, 20x2, 19x16, 12x20, 13x8, 11x15, Celebration, 9x19, 19x10, 7-2-1-2, 6x2, 8-5-1-1, 8x19, 7-2-2F-2, 17x7, 7-2-4F-2, and 11x18. After three WAT, there were 35 entries out of 69 are appeared in the top LSD group, included the following genotypes: 8x16, 1x9, 13x8, Celebration, Premier, 20x2, 11x15, 19x6, 12x6, 16x19, 14x15, 19x16, 16x6, 20x7, 12x20, 17x7, 12x21, 18x3, 19x10, 14x7, 11x18, 6x2, 20x16, 8-5-1-1, 7-4-1-3, 7-2-2F-2, 9x19, 16x17, 16x4, 8x19, 14x6, 7-2-1-2, 7-2-4F-2, 12x7, and 5x6. After six WAT, there were 43 entries out of 69 are appeared in the top LSD group, included the following genotypes: 16x6, 1x9, 11x18, 12x15, 7-2-2F-2,19x6, 17x7, 18x3, 13x8, 19x16, 7-2-4F-2, 8-5-1-1, 6x2, 11x15, 8x16, 7-4-1-3, 20x2, 13x9, 14x15, 5x6, 12x20, 16x19, Premier, 9x19, 12x6, 7-2-3F-4, 19x10, 7-2-1-2, 12x7, 20x16, 20x7, 14x7, 8-5-2F-2, 12x21, 6x1, 20-4-2F-2, 7-4-2F-2, Celebration, 20-4-1F-1, 2x10, 8-2-1-4, 16x4, and 14x6. In the end of recovery period, the means of TQ were ranging from 4.75 to 8.00.

Means of NDVI for each genotype in 2012 drought treatment period are reported in Table 8. At one WAR, there were 33 entries out of 69 that appeared in the top LSD group, included the following genotypes: 20x2, 1x9, 16x19, 8x16, Premier, 12x21, 20x7, 14x15, 17x7, 18x3, 12x20, 12x6, 5x6, 8x19, Celebration, 16x6, 9x19, 7-4-1-3, 19x6, 19x16, 16x17, 8-2-1-4, 11x18, 14x7, 13x9, 11x15, 16x4, 19x10, 18x19, 13x8, 17x10, 7-2-4F-2, and 8-5-1-1. At two WAR, there were 45 entries out of 69 that appeared in the top LSD group, included the following genotypes: Premier, 18x3, 16x19, 1x9, 20x2, 11x18, 17x7, 14x15, 13x8, 5x6, Celebration, 12x6, 8x16, 19x6, 7-2-4F-2, 9x19, 12x20, 7-4-1-3, 19x10, 13x9, 16x6, 20x7, 7-2-2F-2, 6x2, 11x15, 8-5-1-1, 16x4, 12x15, 7-2-1-2, 20x16, 8-2-1-4, 12x7, 19x16, 20-4-2F-2, 7-4-2F-2, 7-2-3F-4, 8-5-2F-2, 18x18, 8x19, 14x6, 2x10, 12x21, 6x1, 16x17, and 14x7. After three WAT, there were 42 entries out of 69 are appeared in the top LSD group, included the following genotypes: Premier, 16x19, 18x3, 13x8, Celebration, 11x18, 5x6, 14x15, 7-2-4F-2, 17x7, 1x9, 12x6, 20x2, 6x2, 13x9, 19x6, 7-2-2F-2, 12x15, 19x10, 12x20, 7-4-1-3, 8x16, 20-4-2F-2, 9x19, 16x6, 11x15, 16x4, 12x7, 20x16, 20x7, 8-5-1-1, 7-2-3F-4, 7-2-1-2, 8-2-1-4, 19x16, 14x6, 2x10, 7-4-2F-2, 18x18, 12x21, 8-5-2F-2, and 6x1. After six WAT, there were 43 entries out of 69 are appeared in the top LSD group, included the following genotypes: 7-2-2F-2, 18x3, 16x19, 12x15, Premier, 11x18, Celebration, 6x1, 1x9, 6x2, 5x6, 7-2-4F-2, 7-2-1-2, 20x16, 12x6, 13x9, 13x8,8-5-1-1, 17x7, 20-4-2F-2, 7-2-3F-4, 7-4-2F-2, 11x15, 14x15, 8-2-1-4, 8x16, 18x15, 9x19, 19x10, 7-4-1-3, 19x16, 12x20, 12x7, 16x4, 14x6, 18x18, 13x2, 19x6, 2x7, 16x6, 11x12, 18x14, 20x2, 7-4-3F-4, 20-4-1F-1, 2x10, 20x7, and 8-5-2F-2. In the end of recovery period, the means of NDVI were ranging from 0.449 to 0.844.

Means of DIA for each genotype in 2012 drought treatment period are reported in Table 12. At one WAR, there were 24 entries out of 69 that appeared in the top LSD group, included the following genotypes: Premier, 19x6, 12x21, 8x16, 12x20, 17x7, 13x8, 20-4-2F-2, 16x6, 5x6, 14x7, 20x2, 13x9, 7-2-4F-2, 9x19, 7-2-1-2, 11x15, 11x18, 7-4-1-3, 12x6, 14x15, 16x19, 1x9, and 18x19. At two WAR, there were 44 entries out of 69 that appeared in the top LSD group, included the following genotypes: 18x3, Premier, 19x6, 8x16, 7-2-1-2, 7-4-1-3, 13x8, 11x18, 14x15, 12x20, 14x7, 12x21, 18x18, 5x6, 16x19, 17x7, 19x16, 9x19, 7-2-4F-2, 1x9, 7-2-3F-4, 11x15, 20x16, 16x6, 12x7, 13x9, 11x12, 18x19, 20x2, 20-4-2F-2, 14x18, 12x6, 20x7, 20-4-1F-1, 19x10, 7-2-2F-2, 14x6, 8-2-1-4, 12x15, 2x10, 8-5-1-1, 19x7, 6x2, and 8x19. After three WAT, there were 39 entries out of 69 are appeared in the top LSD group, included the following genotypes: Premier, 8x16, 18x3, 11x18, 20x2, 12x21, 7-4-1-3, 1x9, 20-4-2F-2, 12x20, 19x6, 18x19, 13x9, 19x16, 14x15, 8-5-1-1, 5x6, 20x7, 17x7, 7-2-2F-2, 7-2-4F-2, 7-2-3F-4, 14x6, 16x6, 14x7, 12x6, 7-2-1-2, 9x19, 16x19, 11x15, 13x8, 20-4-1F-1, 12x15, 18x18, 13x2, 7-4-2F-2, 19x10, 18x6, and 12x7. After six WAT, there were 35 entries out of 69 are appeared in the top LSD group, included the following genotypes: Premier, 13x2, 11x12, 19x6, 20-4-2F-2, 18x18, 13x8, 17x7, 7-2-3F-4, 14x6, 7-4-1-3, 12x7, 7-2-2F-2, 20-4-1F-1, 5x6, 13x9, 7-2-1-2, 20x7, 14x7, 11x18, 20x2, 14x15, 12x20, 8x16, 8-2-1-4, 19x10, 7-2-4F-2, 16x6, 18x6, 7-4-2F-2, 18x3, 9x19, 8-5-1-1, 7-4-3F-4, and 1x9. In the end of recovery period, the means of DIA were ranging from 1.077 to 1.503.

In 2013, irrigation and recovery was initiated on September 17th. There were three rating dates. Means of TQ for each genotype in 2013 drought treatment period are reported in Table 6. At two WAR, there were 13 entries out of 69 that appeared in the top LSD group, included the following genotypes: 20x7, 1x9, Celebration, 19x7, 12x21, 8x16, 19x16, 14x7, 8x19, 19x10, 20x2, 17x10, and 14x18. After four WAT, there were 13 entries out of 69 are appeared in the top LSD group, included the following genotypes: 1x9, 19x7, Celebration, 20x7, 19x16, 12x21, 20x2, 19x10, 8x16, 20x6, 12x6, 20x16, and 18x3. After five WAT, there were 15 entries out of 69 are appeared in the top LSD group, included the following genotypes: 1x9, 19x16, 19x7, 20x16, 20x7, 12x21, 19x10, Celebration, 16x17, 17x10, 14x6, 18x3, 14x7, 11x15, and 14x18. In the end of recovery period, the means of TQ were ranging from 2.00 to 6.25.

Means of NDVI for each genotype in 2013 drought treatment period are reported in Table 10. At two WAR, there were eight entries out of 69 that appeared in the top LSD group, including the following genotypes: 20x7, Celebration, 1x9, 19x7, 19x10, 12x21, 14x18, and 14x7. After four WAT, there were 14 entries out of 69 are appeared in the top LSD group, including the following genotypes: 20x7, 1x9, 19x7, 17x10, 12x21, Celebration, 14x7, 19x16, 11x15, 20x6, 20x16, 19x10, 8x19, and 11x18. After five WAT, there were 20 entries out of 69 are appeared in the top LSD group, and included the following genotypes: 20x7, 1x9, 17x10, 19x7, 12x21, Celebration, 14x18, 18x3, 19x16, 14x7, 19x10, 20x2, 14x6, 11x15, 11x18, 18x15, 20x16, 16x17, 17x7, and 20x6. At the end of recovery period, the means of NDVI were ranging from 0.279 to 0.693.

Means of DIA for each genotype in 2013 drought treatment period are reported in Table 14. At two WAR, there were ten entries out of 69 that appeared in the top LSD group, and included the following genotypes: 1x9, 20x7, 12x21, 19x7, Celebration, 19x16, 14x7, 8x19, 19x10, and 14x18. After four WAT, there were 18 entries out of 69 are appeared in the top LSD group, and included the following genotypes: 1x9, 19x7, Celebration, 12x21, 20x7, 19x16, 14x7, 20x2, 17x10., 14x18, 20x16, 19x10, 17x7, 20x6, 16x17, 14x6, 18x3, and 16x19. After five WAT, there were 22 entries out of 69 are appeared in the top LSD group, and included the following genotypes: 1x9, 20x7, 19x7, 19x16, Celebration, 12x21, 20x16, 17x10, 16x17, 14x7, 18x3, 17x7, 16x19, 19x10, 14x18, 11x15, 18x18, 14x6, 20x2, 20x6, 18x15, and 12x6. At the end of recovery period, the means of DIA were ranging from 0.635 to 1.495.

Discussion

In this study, 69 bermudagrass entries (Table 1) were evaluated based on TQ, LF, NDVI and DIA for two year's drought performance and recovery. Table 17 shows a rank made out of the performance of drought treatment period and recovery period in both years. Entries were ranked base on number of times that the entry's mean appeared in the top statistical ranking group at the p=0.05 level. There were 49 total groups of data and the entry 1x9 appeared in the top group 47 times, while bottom performance entries 2x14 and 4x20 did not appear in the top group at all. Also, the entry 20x7 appeared in the top statistical group 46 times. Both 1x9 and 20x7 appeared in the top LSD group more times than the good drought performance standard Celebration which appeared 38 times. The genotype 12x21 was similar in ranking with Celebration while the poor drought performance standard Premier appeared in the top group a total of 22 times throughout the study.

Throughout the study, the two subjective parameters bermudagrass TQ and LF had a significant positive correlation ($P < 0.0001$), where: $TQ = 0.4156 + 0.751\ (LF)$, $N = 2484$, with $r^2 = 0.9020$. LF was considered as an important parameter to test drought tolerance in turfgrass research (Ebdon and Kopp, 2004). When LF was compared with the two objective readings, NDVI and DIA, they both had a significant positive relationship ($P < 0.0001$). The relationships were $LF = -0.59+12.219\ (NDVI)$, $N=2484$, with $r^2=0.8646$, and $LF = -0.5121+0.0824\ (DIA)$, $N=2484$, with $r^2=0.7232$.

The hypothesis that there are statistical significant differences among the experimental genotypes for their field drought performance was accepted. The genotype 1x9, a progeny of

Yukon, and the genotype 20x7, a progeny of Riviera, appeared in the top statistical group a higher number of times compared to the high drought performance than standard Celebration. Future work will evaluate root growth parameters under well-watered conditions and drought of 1x9, 20x7, Celebration, and Premier. In addition, the carbohydrate partitioning of each of the four entries will be compared during well-watered and drought conditions. This future work will evaluate mechanisms of drought resistance for each entry.

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Table 1. Sixty-nine bermudagrass experimental selections and standard cultivars tested for field drought performance in Oklahoma.

Bermudagrass Entries	Notes
1x9	OSU Experimental
2x10	OSU Experimental
2x14	OSU Experimental
2x7	OSU Experimental
4x20	OSU Experimental
5x6	OSU Experimental
6x1	OSU Experimental
6x2	OSU Experimental
8x11	OSU Experimental
8x16	OSU Experimental
8x19	OSU Experimental
9x19	OSU Experimental
11x12	OSU Experimental
11x15	OSU Experimental
11x18	OSU Experimental
12x15	OSU Experimental
12x20	OSU Experimental
12x21	OSU Experimental
12x6	OSU Experimental
12x7	OSU Experimental
12x8	OSU Experimental
13x2	OSU Experimental
13x8	OSU Experimental
13x9	OSU Experimental
14x15	OSU Experimental
14x18	OSU Experimental
14x6	OSU Experimental
14x7	OSU Experimental
15x2	OSU Experimental
16x17	OSU Experimental
16x19	OSU Experimental
16x4	OSU Experimental
16x6	OSU Experimental
17x10	OSU Experimental

17x7	OSU Experimental
18x14	OSU Experimental
18x15	OSU Experimental
18x18	OSU Experimental
18x19	OSU Experimental
18x3	OSU Experimental
18x6	OSU Experimental
19x10	OSU Experimental
19x16	OSU Experimental
19x6	OSU Experimental
19x7	OSU Experimental
20x16	OSU Experimental
20x2	OSU Experimental
20x6	OSU Experimental
20x7	OSU Experimental
7-1-1-4	OSU Experimental
7-2-1-2	OSU Experimental
7-2-2F-2	OSU Experimental
7-2-3F-4	OSU Experimental
7-2-4F-2	OSU Experimental
7-4-1-3	OSU Experimental
7-4-2F-2	OSU Experimental
7-4-3F-4	OSU Experimental
8-2-1-4	OSU Experimental
8-2-2F-1	OSU Experimental
8-2-3F-3	OSU Experimental
8-5-1-1	OSU Experimental
8-5-2F-2	OSU Experimental
20-2-1F-4	OSU Experimental
20-2-2F-3	OSU Experimental
20-4-1F-1	OSU Experimental
20-4-2F-2	OSU Experimental
20-4-3F-4	OSU Experimental
Celebration	Good drought performance standard†
Premier	Poor drought performance standard†

† Chalmers et al., 2008

Table 2. Bermudagrass drought trial plot plan (Block 16)

NORTH

101	8x16	136	2x10	201	14x15	236	2x14	301	7-4-1-3	336		401	8-2-2F-1	436	19x7
102	20x7	137	11x15	202	Premier	237	13x9	302	11x18	337	7-2-1-2	402	5x6	437	18x6
103	18x6	138	7-2-2F-2	203	8x16	238	19x6	303	8-2-2F-1	338	11x12	403	16x19	438	8x16
104	13x2	139	12x15	204	12x7	239	7-2-1-2	304	6x1	339	19x6	404	13x9	439	9x19
105	12x20	140	14x15	205	19x7	240	12x15	305	12x8	340	12x7	405	12x15	440	14x7
106	7-2-3F-4	141	8-2-3F-3	206	7-4-3F-4	241	20-4-3F-4	306	14x15	341	13x8	406	7-2-3F-4	441	7-4-1-3
107	18x14	142	20x16	207	20-2-2F-3	242	8-5-1-1	307	8-5-2F-2	342	18x18	407	13x2	442	8-5-2F-2
108	8-2-1-4	143	8x19	208	7-2-4F-2	243	11x12	308	7-2-4F-2	343	14x18	408	20x2	443	12x6
109		144	18x3	209	2x10	244	12x8	309	18x6	344	13x2	409	8-5-1-1	444	1x9
110	6x1	145	14x6	210	16x6	245	18x6	310	20-2-2F-3	345	19x16	410	2x10	445	8-2-1-4
111	12x21	146	20-4-3F-4	211	20x7	246	17x7	311	18x19	346	20-2-1F-4	411	7-4-2F-2	446	17x10
112	12x8	147	20x6	212	20-4-1F-1	247	14x7	312	18x14	347	20-4-1F-1	412	20-2-2F-3	447	6x1
113	7-4-1-3	148	20-2-2F-3	213	18x15	248	8x19	313	2x14	348	20x6	413	19x6	448	2x7
114	17x7	149	18x15	214	13x8	249	8-2-1-4	314	17x10	349	16x6	414	14x6	449	8x11
115	16x17	150	2x7	215	16x4	250	9x19	315	17x7	350	7-2-2F-2	415	20-2-1F-4	450	20x16
116	8x11	151	19x10	216	7-2-2F-2	251		316	16x4	351	12x6	416	16x4	451	20-4-2F-2
117	17x10	152	8-5-2F-2	217	18x19	252	7-1-1-4	317	12x15	352	12x20	417	7-4-3F-4	452	16x17
118	16x4	153	8-5-1-1	218	8-2-3F-3	253	16x17	318	9x19	353	7-4-3F-4	418	12x8	453	7-2-1-2
119	19x6	154	7-2-1-2	219	7-4-2F-2	254	20x2	319	13x9	354	20-4-3F-4	419	Celebration	454	12x7
120	14x7	155	20x2	220	11x18	255	8-5-2F-2	320	14x7	355	4x20	420	19x10	455	11x18

121	15x2	156	19x16	221	Celebration	256	7-4-1-3	321	11x15	356	8x19	421	18x14	456	11x15
122	4x20	157	18x19	222	20-4-2F-2	257	18x18	322	18x3	357	6x2	422	7-1-1-4	457	7-2-2F-2
123	7-4-3F-4	158	19x7	223	1x9	258	15x2	323	8x11	358	Premier	423	18x19	458	14x15
124	14x18	159	12x7	224	12x6	259	12x21	324	5x6	359	20x16	424	18x3	459	
125	9x19	160	16x6	225	7-2-3F-4	260	20x6	325	8-5-1-1	360	16x17	425	2x14	460	12x20
126	12x6	161	11x12	226	17x10	261	20-2-1F-4	326	Celebration	361	7-2-3F-4	426	20-4-1F-1	461	8-2-3F-3
127	1x9	162	20-4-2F-2	227	11x15	262	19x16	327	8x16	362	16x19	427	20x7	462	18x15
128	16x19	163	6x2	228	8-2-2F-1	263	12x20	328	12x21	363	15x2	428	19x16	463	8x19
129	8-2-2F-1	164	7-1-1-4	229	18x14	264	20x16	329	18x15	364	20x7	429	14x18	464	20-4-3F-4
130	20-2-1F-4	165	18x18	230	8x11	265	14x6	330	2x7	365	1x9	430	20x6	465	16x6
131	13x9	166	Premier	231	14x18	266	4x20	331	2x10	366	19x7	431	11x12	466	Premier
132	13x8	167	20-4-1F-1	232	2x7	267	13x2	332	8-2-3F-3	367	19x10	432	12x21	467	18x18
133	5x6	168	11x18	233	6x1	268	19x10	333	7-4-2F-2	368	14x6	433	15x2	468	4x20
134	Celebration	169	2x14	234	18x3	269	16x19	334	20-4-2F-2	369	20x2	434	17x7	469	6x2
135	7-4-2F-2	170	7-2-4F-2	235	5x6	270	6x2	335	8-2-1-4	370	7-1-1-4	435	7-2-4F-2	470	13x8

Figure 1. Soil volumetric water content (SVWC) Means for research plots in 2012.

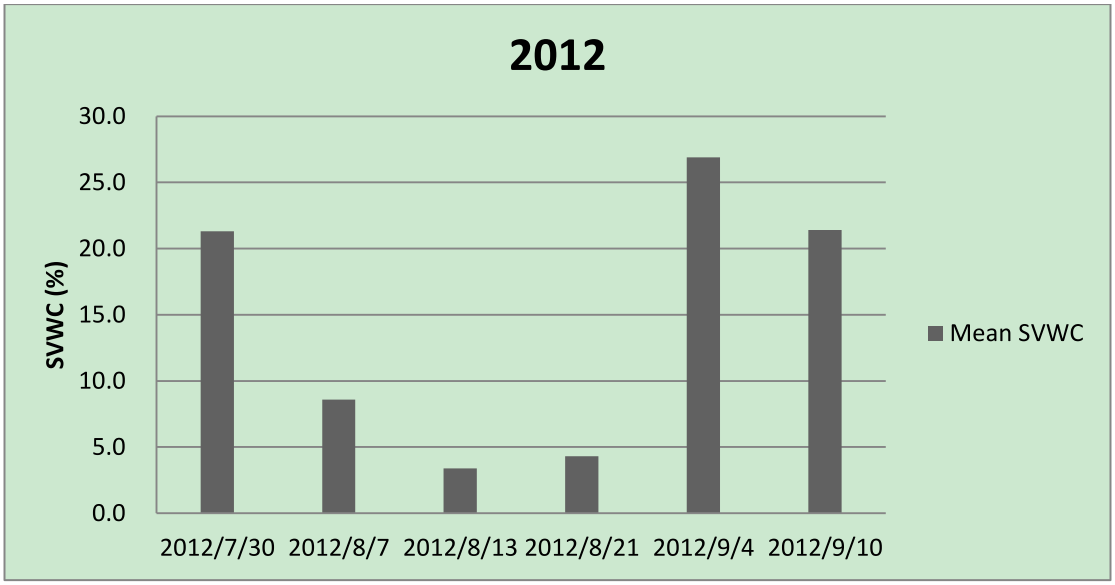

Figure 2. Soil volumetric water content (SVWC) Means for research plots in 2013.

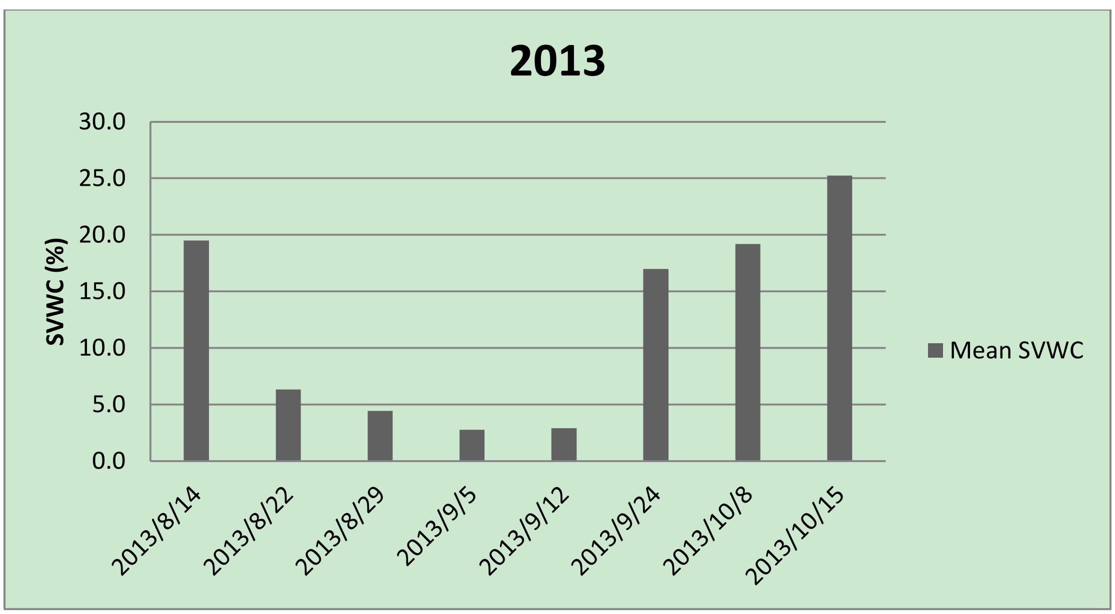

Table 3. Mean turfgrass visual quality for sixty-nine bermudagrass entries during the drought treatment period 31 July – 20 August in 2012.

Bermudagrass Entry	Turf Visual Quality†							
	2012							
	31-Jul	Group‡	7-Aug	Group	13-Aug	Group	20-Aug	Group
11x12	6.25	gh	3.50	j-m	2.75	h-k	2.75	g-j
11x15	7.25	cde	6.00	a-f	4.25	c-g	4.00	b-g
11x18	7.00	def	5.00	d-j	3.25	f-k	3.00	f-j
12x15	8.00	ab	4.00	h-l	3.00	g-k	2.75	g-j
12x20	7.75	abc	6.25	a-e	4.25	c-g	3.50	d-i
12x21	7.50	bcd	6.50	a-d	5.00	a-d	5.00	abc
12x6	7.00	def	4.50	f-l	3.25	f-k	3.00	f-j
12x7	7.50	bcd	6.25	a-e	3.75	d-i	3.50	d-i
12x8	7.00	def	5.25	c-i	3.25	f-k	3.25	e-j
13x2	6.50	fgh	3.00	lm	2.50	ijk	2.50	hij
13x8	8.00	ab	6.25	a-e	4.50	b-f	4.00	b-g
13x9	7.25	cde	5.50	b-h	4.00	c-h	3.75	c-h
14x15	7.50	bcd	6.25	a-e	4.25	c-g	4.00	b-g
14x18	7.00	def	5.50	b-h	3.25	f-k	3.25	e-j
14x6	7.50	bcd	5.50	b-h	4.00	c-h	3.75	c-h
14x7	7.50	bcd	6.00	a-f	4.50	b-f	4.50	a-e
15x2	7.00	def	4.75	e-k	3.00	g-k	2.75	g-j
16x17	7.75	abc	7.00	ab	6.00	a	5.75	a
16x19	7.75	abc	6.75	abc	4.75	a-e	4.50	a-e
16x4	6.75	efg	4.75	e-k	3.75	d-i	3.75	c-h
16x6	7.25	cde	5.75	b-g	3.50	e-j	3.50	d-i
17x10	7.50	bcd	6.75	abc	4.50	b-f	4.50	a-e
17x7	7.00	def	6.00	a-f	4.25	c-g	4.00	b-g
18x14	7.25	cde	4.50	f-l	2.75	h-k	2.50	hij
18x15	7.50	bcd	5.00	d-j	3.75	d-i	3.25	e-j
18x18	6.75	efg	4.50	f-l	3.25	f-k	3.00	f-j
18x19	7.50	bcd	5.75	b-g	3.50	e-j	3.50	d-i
18x3	7.75	abc	5.75	b-g	4.25	c-g	4.25	b-f
18x6	7.00	def	3.75	i-l	2.50	ijk	2.50	hij
19x10	7.50	bcd	6.00	a-f	4.00	c-h	3.50	d-i
19x16	7.50	bcd	6.75	abc	5.00	a-d	4.75	a-d
19x6	7.75	abc	6.75	abc	4.25	c-g	4.25	b-f
19x7	7.25	cde	5.00	d-j	3.50	e-j	3.50	d-i
1x9	7.50	bcd	6.25	a-e	5.00	a-d	4.75	a-d
20-2-1F-4	7.25	cde	5.50	b-h	3.75	d-i	3.25	e-j
20-2-2F-3	7.50	bcd	5.75	b-g	3.50	e-j	3.25	e-j

20-4-1F-1	7.25	cde	4.25	g-l	2.50	ijk	2.25	ij
20-4-2F-2	6.75	efg	3.25	klm	2.25	jk	2.25	ij
20-4-3F-4	7.00	def	4.75	e-k	3.50	e-j	2.75	g-j
20x16	7.50	bcd	7.00	ab	4.25	c-g	3.75	c-h
20x2	8.00	ab	6.00	a-f	5.00	a-d	5.00	abc
20x6	7.25	cde	6.00	a-f	3.75	d-i	3.25	e-j
20x7	7.75	abc	7.00	ab	5.25	abc	5.25	ab
2x10	7.00	def	5.25	c-i	3.50	e-j	3.25	e-j
2x14	6.00	h	2.00	m	2.00	k	2.00	j
2x7	7.00	def	4.25	g-l	2.75	h-k	2.50	hij
4x20	7.50	bcd	3.25	klm	2.50	ijk	2.50	hij
5x6	6.50	fgh	3.75	i-l	3.00	g-k	2.75	g-j
6x1	7.50	bcd	4.00	h-l	3.00	g-k	2.75	g-j
6x2	7.50	bcd	5.00	d-j	3.75	d-i	2.75	g-j
7-1-1-4	6.25	gh	4.00	h-l	3.00	g-k	3.00	f-j
7-2-1-2	7.75	abc	6.00	a-f	3.75	d-i	3.25	e-j
7-2-2F-2	7.75	abc	5.25	c-i	3.25	f-k	2.75	g-j
7-2-3F-4	8.00	ab	5.25	c-i	3.25	f-k	2.50	hij
7-2-4F-2	7.75	abc	5.00	d-j	3.25	f-k	2.50	hij
7-4-1-3	7.25	cde	6.00	a-f	4.50	b-f	3.50	d-i
7-4-2F-2	7.00	def	4.75	e-k	3.50	e-j	3.25	e-j
7-4-3F-4	7.25	cde	5.50	b-h	3.50	e-j	2.50	hij
8-2-1-4	7.25	cde	5.00	d-j	3.75	d-i	3.50	d-i
8-2-2F-1	7.00	def	4.75	e-k	3.25	f-k	2.75	g-j
8-2-3F-3	7.50	bcd	4.25	g-l	3.00	g-k	2.50	hij
8-5-1-1	7.75	abc	5.25	c-i	3.25	f-k	3.00	f-j
8-5-2F-2	7.50	bcd	4.75	e-k	3.25	f-k	3.25	e-j
8x11	7.00	def	5.25	c-i	3.50	e-j	3.25	e-j
8x16	7.75	abc	7.50	a	5.75	ab	5.75	a
8x19	7.50	bcd	7.00	ab	5.00	a-d	4.50	a-e
9x19	7.25	cde	5.00	d-j	4.00	c-h	3.75	c-h
Celebration	7.00	def	6.50	a-d	4.50	b-f	4.00	b-g
Premier	8.25	a	7.00	ab	3.25	f-k	3.25	e-j

† Turf visual quality was rated on a 1 to 9 scale where 1 = dead or dormant turf, 6 = acceptable turf visual quality and 9 = excellent turf.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 4. Post-drought stress mean turfgrass visual quality for sixty-nine bermudagrass entries during the recovery period 4 September – 1 October in 2012.

	Turf Visual Quality†							
Bermudagrass Entry	2012							
	4-Sep	Group‡	10-Sep	Group	17-Sep	Group	1-Oct	Group
11x12	4.00	k-o	5.50	g-k	6.50	c-g	7.00	b-e
11x15	6.00	c-h	7.25	a-e	7.75	ab	7.75	ab
11x18	5.25	f-k	7.00	a-f	7.50	abc	8.00	a
12x15	4.75	h-m	6.00	e-j	6.75	b-f	8.00	a
12x20	6.75	a-e	7.50	a-d	7.75	ab	7.75	ab
12x21	7.75	a	7.50	a-d	7.50	abc	7.25	a-d
12x6	6.50	a-f	7.50	a-d	7.75	ab	7.75	ab
12x7	5.00	g-l	6.50	c-h	7.00	a-e	7.50	abc
12x8	4.50	i-m	5.00	i-m	5.00	ijk	5.25	hi
13x2	4.25	j-n	4.75	j-m	5.50	g-j	7.00	b-e
13x8	5.75	d-i	7.50	a-d	8.00	a	8.00	a
13x9	5.25	f-k	6.75	b-g	6.75	b-f	7.75	ab
14x15	6.50	a-f	7.75	abc	7.75	ab	7.75	ab
14x18	4.75	h-m	6.00	e-j	6.50	c-g	6.75	cde
14x6	4.75	h-m	6.75	b-g	7.00	a-e	7.25	a-d
14x7	6.00	c-h	6.75	b-g	7.50	abc	7.50	abc
15x2	4.00	k-o	5.00	i-m	5.50	g-j	7.00	b-e
16x17	6.50	a-f	6.50	c-h	7.00	a-e	6.50	def
16x19	7.25	abc	7.50	a-d	7.75	ab	7.75	ab
16x4	5.50	e-j	6.25	d-i	7.00	a-e	7.25	a-d
16x6	7.00	a-d	6.75	b-g	7.75	ab	8.00	a
17x10	5.50	e-j	6.25	d-i	6.50	c-g	6.75	cde
17x7	6.00	c-h	7.00	a-f	7.75	ab	8.00	a
18x14	4.00	k-o	5.50	g-k	5.75	f-j	6.75	cde
18x15	4.25	j-n	5.25	h-l	5.50	g-j	6.50	def
18x18	5.00	g-l	6.00	e-j	6.75	b-f	7.00	b-e
18x19	6.00	c-h	6.75	b-g	6.75	b-f	7.00	b-e
18x3	6.25	b-g	7.50	a-d	7.50	abc	8.00	a
18x6	4.75	h-m	5.50	g-k	5.75	f-j	7.00	b-e
19x10	5.50	e-j	7.00	a-f	7.50	abc	7.50	abc
19x16	6.25	b-g	7.50	a-d	7.75	ab	8.00	a
19x6	6.75	a-e	7.75	abc	7.75	ab	8.00	a
19x7	5.00	g-l	6.00	e-j	6.00	e-i	6.50	def
1x9	7.25	abc	8.25	a	8.00	a	8.00	a
20-2-1F-4	3.50	mno	4.75	j-m	4.75	jkl	5.75	fgh
20-2-2F-3	4.00	k-o	5.00	i-m	5.25	h-k	6.25	efg

20-4-1F-1	4.25	j-n	5.75	f-k	6.00	e-i	7.25	a-d
20-4-2F-2	4.75	h-m	5.50	g-k	6.25	d-h	7.25	a-d
20-4-3F-4	3.75	l-o	5.25	h-l	5.25	h-k	6.50	def
20x16	5.75	d-i	6.75	b-g	7.25	a-d	7.50	abc
20x2	7.75	a	7.50	a-d	8.00	a	7.75	ab
20x6	3.75	l-o	4.75	j-m	4.75	jkl	4.75	i
20x7	7.25	abc	7.75	abc	7.75	ab	7.50	abc
2x10	5.00	g-l	6.25	d-i	6.50	c-g	7.25	a-d
2x14	3.00	no	4.00	lm	4.25	kl	5.75	fgh
2x7	4.00	k-o	5.50	g-k	6.25	d-h	7.00	b-e
4x20	3.00	no	4.50	klm	4.75	jkl	5.50	ghi
5x6	5.50	e-j	6.50	c-h	7.00	a-e	7.75	ab
6x1	4.50	i-m	5.50	g-k	6.25	d-h	7.25	a-d
6x2	5.25	f-k	7.00	a-f	7.25	a-d	7.75	ab
7-1-1-4	3.75	l-o	5.50	g-k	6.00	e-i	6.50	def
7-2-1-2	5.00	g-l	7.00	a-f	7.00	a-e	7.50	abc
7-2-2F-2	4.75	h-m	7.00	a-f	7.25	a-d	8.00	a
7-2-3F-4	4.50	i-m	6.75	b-g	6.75	b-f	7.50	abc
7-2-4F-2	5.25	f-k	7.00	a-f	7.00	a-e	8.00	a
7-4-1-3	5.75	d-i	6.50	c-h	7.25	a-d	7.75	ab
7-4-2F-2	4.50	i-m	5.50	g-k	5.50	g-j	7.25	a-d
7-4-3F-4	4.00	k-o	5.75	f-k	5.75	f-j	6.75	cde
8-2-1-4	4.75	h-m	5.75	f-k	6.25	d-h	7.25	a-d
8-2-2F-1	3.50	mno	5.00	i-m	5.25	h-k	6.25	efg
8-2-3F-3	2.75	o	3.75	m	3.75	l	4.75	i
8-5-1-1	5.75	d-i	7.00	a-f	7.25	a-d	7.75	ab
8-5-2F-2	4.75	h-m	6.25	d-i	6.75	b-f	7.50	abc
8x11	4.00	k-o	5.25	h-l	5.75	f-j	6.25	efg
8x16	7.50	ab	8.00	ab	8.00	a	7.75	ab
8x19	6.75	a-e	7.00	a-f	7.00	a-e	7.00	b-e
9x19	6.50	a-f	7.25	a-e	7.25	a-d	7.75	ab
Celebration	6.75	a-e	7.25	a-e	8.00	a	7.25	a-d
Premier	7.25	abc	8.00	ab	8.00	a	7.75	ab

† Turf visual quality was rated on a 1 to 9 scale where 1 = dead or dormant turf, 6 = acceptable turf visual quality and 9 = excellent turf.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 5. Mean turfgrass visual quality for sixty-nine bermudagrass entries during the drought treatment period 15 August – 12 September in 2013.

Bermudagrass Entry	Turf Visual Quality† 2013									
	15-Aug	Group ‡	22-Aug	Group	29-Aug	Group	5-Sep	Group	12-Sep	Group
11x12	8.00	a	7.00	a-e	4.25	a-f	3.00	d-h	2.50	d-g
11x15	7.75	ab	7.00	a-e	4.50	a-e	3.25	c-g	2.75	c-f
11x18	8.00	a	7.25	a-d	4.00	a-f	2.50	f-i	2.25	e-h
12x15	7.25	bcd	6.25	def	2.75	fg	2.25	ghi	2.00	f-i
12x20	7.75	ab	6.75	b-f	3.50	c-g	2.25	ghi	2.25	e-h
12x21	6.75	de	6.25	def	4.25	a-f	4.00	a-d	3.75	ab
12x6	7.75	ab	7.25	a-d	4.25	a-f	3.75	b-e	3.00	b-e
12x7	7.75	ab	7.00	a-e	3.75	b-g	3.00	d-h	2.25	e-h
12x8	7.00	cde	6.25	def	3.25	d-g	3.00	d-h	2.50	d-g
13x2	7.00	cde	6.00	ef	3.00	efg	2.25	ghi	2.00	f-i
13x8	8.00	a	7.00	a-e	3.25	d-g	1.75	i	1.75	ghi
13x9	7.75	ab	7.75	ab	5.25	ab	3.25	c-g	2.50	d-g
14x15	7.50	abc	7.25	a-d	3.75	b-g	2.75	e-i	2.25	e-h
14x18	7.75	ab	6.75	b-f	4.50	a-e	3.50	b-f	3.25	bcd
14x6	7.50	abc	7.25	a-d	4.00	a-f	3.00	d-h	2.75	c-f
14x7	7.00	cde	7.25	a-d	4.75	a-d	4.25	abc	3.25	bcd
15x2	8.00	a	7.00	a-e	4.00	a-f	2.75	e-i	2.25	e-h
16x17	8.00	a	7.50	abc	5.00	abc	4.25	abc	3.50	abc
16x19	7.50	abc	7.25	a-d	5.25	ab	3.75	b-e	2.75	c-f
16x4	7.75	ab	7.50	abc	4.25	a-f	2.50	f-i	2.25	e-h
16x6	7.25	bcd	6.50	c-f	3.75	b-g	3.00	d-h	2.50	d-g
17x10	7.75	ab	6.75	b-f	4.75	a-d	3.50	b-f	2.75	c-f
17x7	7.75	ab	7.50	abc	4.25	a-f	2.75	e-i	2.75	c-f
18x14	7.50	abc	6.50	c-f	3.25	d-g	2.25	ghi	2.00	f-i
18x15	7.50	abc	7.25	a-d	4.25	a-f	3.00	d-h	3.00	b-e
18x18	7.50	abc	5.75	f	3.25	d-g	2.50	f-i	2.00	f-i
18x19	7.75	ab	7.00	a-e	3.25	d-g	2.75	e-i	2.25	e-h
18x3	8.00	a	6.50	c-f	4.00	a-f	3.00	d-h	2.50	d-g
18x6	8.00	a	6.75	b-f	3.00	efg	2.00	hi	2.00	f-i
19x10	7.50	abc	6.25	def	4.50	a-e	3.75	b-e	3.50	abc
19x16	7.50	abc	7.00	a-e	4.00	a-f	3.50	b-f	2.75	c-f
19x6	8.00	a	7.00	a-e	4.00	a-f	2.25	ghi	2.25	e-h
19x7	7.00	cde	7.00	a-e	4.25	a-f	3.75	b-e	3.75	ab
1x9	8.00	a	8.00	a	5.50	a	5.00	a	4.25	a
20-2-1F-4	7.75	ab	6.50	c-f	4.00	a-f	2.25	ghi	2.00	f-i
20-2-2F-3	7.75	ab	6.25	def	3.50	c-g	2.75	e-i	2.25	e-h
20-4-1F-1	6.50	e	5.75	f	3.75	b-g	2.00	hi	1.75	ghi
20-4-2F-2	6.50	e	5.75	f	3.00	efg	2.00	hi	2.00	f-i
20-4-3F-4	7.25	bcd	6.00	ef	3.00	efg	2.00	hi	1.50	hi

20x16	7.75	ab	6.75	b-f	5.00	abc	3.25	c-g	2.75	c-f
20x2	8.00	a	7.25	a-d	3.75	b-g	3.50	b-f	2.75	c-f
20x6	8.00	a	7.00	a-e	3.25	d-g	3.00	d-h	2.75	c-f
20x7	7.50	abc	7.75	ab	4.75	a-d	4.00	a-d	3.50	abc
2x10	7.00	cde	6.75	b-f	4.25	a-f	2.50	f-i	2.00	f-i
2x14	5.25	f	4.50	g	2.25	g	1.75	i	1.25	i
2x7	7.00	cde	6.75	b-f	5.25	ab	2.75	e-i	2.00	f-i
4x20	7.00	cde	5.75	f	3.00	efg	1.75	i	1.50	hi
5x6	7.50	abc	6.25	def	4.25	a-f	2.50	f-i	2.00	f-i
6x1	7.50	abc	7.50	abc	4.50	a-e	2.25	ghi	2.00	f-i
6x2	7.25	bcd	6.50	c-f	4.00	a-f	2.25	ghi	2.25	e-h
7-1-1-4	7.75	ab	6.75	b-f	3.50	c-g	2.50	f-i	2.25	e-h
7-2-1-2	8.00	a	7.50	abc	4.25	a-f	2.25	ghi	1.75	ghi
7-2-2F-2	8.00	a	8.00	a	4.50	a-e	2.25	ghi	2.00	f-i
7-2-3F-4	7.75	ab	7.25	a-d	3.25	d-g	2.00	hi	2.00	f-i
7-2-4F-2	7.75	ab	6.50	c-f	3.75	b-g	2.25	ghi	2.25	e-h
7-4-1-3	8.00	a	7.00	a-e	4.50	a-e	3.00	d-h	2.25	e-h
7-4-2F-2	7.75	ab	7.25	a-d	4.50	a-e	2.50	f-i	2.25	e-h
7-4-3F-4	7.75	ab	7.00	a-e	4.00	a-f	2.75	e-i	2.50	d-g
8-2-1-4	7.25	bcd	7.00	a-e	3.75	b-g	2.25	ghi	2.00	f-i
8-2-2F-1	7.75	ab	7.25	a-d	4.75	a-d	2.75	e-i	2.50	d-g
8-2-3F-3	7.50	abc	6.50	c-f	3.00	efg	2.00	hi	1.75	ghi
8-5-1-1	7.50	abc	7.25	a-d	3.25	d-g	2.25	ghi	2.00	f-i
8-5-2F-2	6.75	de	6.00	ef	3.25	d-g	2.25	ghi	2.25	e-h
8x11	8.00	a	6.75	b-f	4.50	a-e	2.75	e-i	2.50	d-g
8x16	8.00	a	7.25	a-d	5.00	abc	4.00	a-d	2.75	c-f
8x19	7.50	abc	6.00	ef	3.25	d-g	3.00	d-h	3.00	b-e
9x19	7.50	abc	7.00	a-e	5.00	abc	3.75	b-e	3.00	b-e
Celebration	7.25	bcd	6.75	b-f	5.25	ab	4.50	ab	3.75	ab
Premier	7.75	ab	6.50	c-f	3.75	b-g	2.25	ghi	2.25	e-h

† Turf visual quality was rated on a 1 to 9 scale where 1 = dead or dormant turf, 6 = acceptable turf visual quality and 9 = excellent turf.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 6. Post-drought stress mean turfgrass visual quality from 27 September – 15 October for sixty-nine bermudagrass entries during the recovery period in 2013.

	Turf Visual Quality†					
Bermudagrass Entry	2013					
	27-Sep	Group‡	8-Oct	Group	15-Oct	Group
11x12	2.75	d-g	3.50	e-j	4.00	e-j
11x15	3.50	b-e	4.25	b-g	5.00	a-f
11x18	2.25	fg	3.75	d-i	3.75	f-k
12x15	2.25	fg	2.50	ijk	2.50	klm
12x20	2.50	efg	3.00	g-k	3.75	f-k
12x21	4.25	ab	5.25	abc	5.50	a-d
12x6	3.50	b-e	4.50	a-f	4.50	c-h
12x7	2.50	efg	3.25	f-k	3.25	h-m
12x8	3.50	b-e	4.25	b-g	4.75	b-g
13x2	2.50	efg	2.75	h-k	2.75	j-m
13x8	2.25	fg	3.75	d-i	3.50	g-l
13x9	3.25	b-f	4.25	b-g	4.00	e-j
14x15	3.00	c-g	3.50	e-j	4.00	e-j
14x18	3.75	a-d	4.25	b-g	5.00	a-f
14x6	3.50	b-e	4.25	b-g	5.00	a-f
14x7	4.00	abc	4.25	b-g	5.00	a-f
15x2	2.50	efg	3.50	e-j	3.50	g-l
16x17	3.25	b-f	3.75	d-i	5.25	a-e
16x19	3.25	b-f	4.25	b-g	4.75	b-g
16x4	2.75	d-g	3.00	g-k	3.25	h-m
16x6	3.25	b-f	3.75	d-i	4.50	c-h
17x10	3.75	a-d	4.25	b-g	5.25	a-e
17x7	3.00	c-g	3.75	d-i	4.50	c-h
18x14	2.25	fg	2.50	ijk	2.50	klm
18x15	3.00	c-g	3.75	d-i	4.25	d-i
18x18	3.00	c-g	4.00	c-h	4.25	d-i
18x19	3.00	c-g	3.75	d-i	3.75	f-k
18x3	3.50	b-e	4.50	a-f	5.00	a-f
18x6	2.75	d-g	3.00	g-k	3.25	h-m
19x10	4.00	abc	5.00	a-d	5.50	a-d
19x16	4.00	abc	5.25	abc	6.00	ab
19x6	2.75	d-g	3.75	d-i	4.00	e-j
19x7	4.25	ab	5.50	ab	5.75	abc
1x9	4.75	a	5.75	a	6.25	a
20-2-1F-4	2.25	fg	3.00	g-k	3.75	f-k

20-2-2F-3	2.75	d-g	3.25	f-k	4.25	d-i
20-4-1F-1	2.00	g	2.50	ijk	2.25	lm
20-4-2F-2	2.00	g	2.25	jk	2.25	lm
20-4-3F-4	2.50	efg	2.50	ijk	2.25	lm
20x16	3.25	b-f	4.50	a-f	5.50	a-d
20x2	3.75	a-d	5.00	a-d	4.75	b-g
20x6	3.25	b-f	4.75	a-e	4.75	b-g
20x7	4.75	a	5.25	abc	5.50	a-d
2x10	3.00	c-g	3.75	d-i	3.75	f-k
2x14	2.00	g	2.00	k	2.00	m
2x7	3.00	c-g	3.25	f-k	3.25	h-m
4x20	2.50	efg	2.75	h-k	2.75	j-m
5x6	2.25	fg	3.00	g-k	2.75	j-m
6x1	2.25	fg	3.00	g-k	2.75	j-m
6x2	2.25	fg	3.00	g-k	3.25	h-m
7-1-1-4	2.75	d-g	3.25	f-k	3.50	g-l
7-2-1-2	2.25	fg	2.50	ijk	2.75	j-m
7-2-2F-2	2.50	efg	3.00	g-k	3.00	i-m
7-2-3F-4	2.00	g	2.25	jk	2.25	lm
7-2-4F-2	2.25	fg	2.75	h-k	3.25	h-m
7-4-1-3	2.75	d-g	3.25	f-k	3.50	g-l
7-4-2F-2	2.25	fg	2.75	h-k	3.50	g-l
7-4-3F-4	2.75	d-g	2.75	h-k	3.75	f-k
8-2-1-4	2.25	fg	2.50	ijk	2.75	j-m
8-2-2F-1	2.50	efg	3.00	g-k	3.50	g-l
8-2-3F-3	2.00	g	2.75	h-k	3.25	h-m
8-5-1-1	2.50	efg	3.00	g-k	3.00	i-m
8-5-2F-2	2.50	efg	3.00	g-k	2.75	j-m
8x11	3.00	c-g	3.75	d-i	4.00	e-j
8x16	4.00	abc	4.75	a-e	4.75	b-g
8x19	4.00	abc	4.25	b-g	4.75	b-g
9x19	3.50	b-e	3.75	d-i	4.00	e-j
Celebration	4.75	a	5.50	ab	5.25	a-e
Premier	3.00	c-g	3.50	e-j	4.00	e-j

† Turf visual quality was rated on a 1 to 9 scale where 1 = dead or dormant turf, 6 = acceptable turf visual quality and 9 = excellent turf.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 7. Mean normalized difference vegetative index (NDVI) from 31 July – 20 August for sixty-nine bermudagrass entries during the drought treatment period in 2012.

	NDVI†							
Bermudagrass Entry	2012							
	31-Jul	Group‡	7-Aug	Group	13-Aug	Group	20-Aug	Group
11x12	0.729	no	0.578	m-q	0.356	t-w	0.302	o-u
11x15	0.716	o	0.680	a-m	0.506	c-r	0.429	c-r
11x18	0.806	a-k	0.668	a-o	0.435	k-w	0.338	k-u
12x15	0.826	a-g	0.559	n-q	0.374	r-w	0.307	o-u
12x20	0.821	a-h	0.755	a-f	0.553	b-m	0.449	a-o
12x21	0.814	a-j	0.666	b-o	0.550	b-m	0.504	a-j
12x6	0.800	b-k	0.664	b-o	0.488	e-t	0.475	a-m
12x7	0.771	g-n	0.681	a-m	0.477	f-u	0.409	d-t
12x8	0.835	a-e	0.736	a-g	0.526	b-p	0.449	a-o
13x2	0.796	b-l	0.557	n-q	0.326	vw	0.274	r-u
13x8	0.810	a-j	0.739	a-g	0.508	c-r	0.395	g-u
13x9	0.837	a-d	0.727	a-h	0.548	b-m	0.442	b-p
14x15	0.789	c-m	0.729	a-h	0.491	d-s	0.465	a-n
14x18	0.801	b-k	0.664	c-o	0.463	g-u	0.404	f-u
14x6	0.800	b-k	0.649	d-o	0.467	g-u	0.403	f-u
14x7	0.801	b-k	0.701	a-l	0.582	a-h	0.561	a-e
15x2	0.782	d-n	0.583	l-q	0.424	m-w	0.357	i-u
16x17	0.827	a-f	0.785	a	0.696	a	0.602	a
16x19	0.825	a-g	0.779	abc	0.623	a-d	0.589	ab
16x4	0.769	h-o	0.632	g-p	0.523	b-p	0.477	a-m
16x6	0.769	h-o	0.671	a-n	0.472	g-u	0.418	c-s
17x10	0.824	a-g	0.726	a-h	0.573	a-j	0.469	a-n
17x7	0.765	i-o	0.671	a-n	0.525	b-p	0.493	a-k
18x14	0.807	a-k	0.640	f-o	0.384	q-w	0.262	tu
18x15	0.833	a-f	0.681	a-m	0.461	g-v	0.379	h-u
18x18	0.765	j-o	0.558	n-q	0.400	n-w	0.326	m-u
18x19	0.772	g-n	0.657	d-o	0.492	d-s	0.443	b-p
18x3	0.814	a-j	0.722	a-i	0.594	a-g	0.544	a-g
18x6	0.830	a-f	0.644	e-o	0.343	uvw	0.277	r-u
19x10	0.801	b-k	0.638	f-o	0.516	c-q	0.480	a-m
19x16	0.821	a-h	0.711	a-j	0.576	a-i	0.516	a-h
19x6	0.847	ab	0.763	a-d	0.568	a-k	0.485	a-l
19x7	0.798	b-k	0.684	a-m	0.505	c-r	0.424	c-r
1x9	0.791	c-m	0.742	a-g	0.628	abc	0.547	a-g
20-2-1F-4	0.816	a-j	0.669	a-o	0.448	h-w	0.356	i-u
20-2-2F-3	0.820	a-i	0.698	a-l	0.474	f-u	0.364	h-u

20-4-1F-1	0.814	a-j	0.587	k-q	0.379	r-w	0.265	stu
20-4-2F-2	0.742	l-o	0.495	q	0.358	s-w	0.340	k-u
20-4-3F-4	0.804	a-k	0.640	f-o	0.394	o-w	0.290	p-u
20x16	0.818	a-j	0.713	a-j	0.526	b-p	0.438	b-q
20x2	0.833	a-e	0.705	a-k	0.607	a-f	0.572	abc
20x6	0.818	a-j	0.705	a-k	0.517	c-q	0.406	e-u
20x7	0.791	c-m	0.762	a-e	0.618	a-e	0.591	ab
2x10	0.778	f-n	0.653	d-o	0.439	j-w	0.340	k-u
2x14	0.740	mno	0.499	q	0.324	w	0.253	u
2x7	0.766	i-o	0.605	i-q	0.405	n-w	0.286	q-u
4x20	0.811	a-j	0.518	pq	0.320	w	0.266	stu
5x6	0.798	b-k	0.583	l-q	0.398	o-w	0.361	i-u
6x1	0.803	a-k	0.613	h-q	0.393	p-w	0.346	k-u
6x2	0.823	a-h	0.605	i-q	0.453	h-w	0.367	h-u
7-1-1-4	0.784	d-n	0.551	opq	0.411	n-w	0.328	m-u
7-2-1-2	0.824	a-g	0.673	a-n	0.440	j-w	0.291	p-u
7-2-2F-2	0.797	b-k	0.635	g-p	0.430	l-w	0.318	n-u
7-2-3F-4	0.827	a-f	0.666	a-o	0.412	n-w	0.298	o-u
7-2-4F-2	0.753	k-o	0.690	a-m	0.421	m-w	0.309	o-u
7-4-1-3	0.847	ab	0.744	a-g	0.561	b-l	0.487	a-l
7-4-2F-2	0.834	a-e	0.743	a-g	0.533	b-n	0.444	b-p
7-4-3F-4	0.841	abc	0.702	a-k	0.443	i-w	0.336	l-u
8-2-1-4	0.764	j-o	0.661	c-o	0.465	g-u	0.437	b-q
8-2-2F-1	0.801	b-k	0.683	a-m	0.447	h-w	0.350	j-u
8-2-3F-3	0.789	c-m	0.602	j-q	0.370	s-w	0.263	stu
8-5-1-1	0.822	a-h	0.613	h-q	0.427	l-w	0.369	h-u
8-5-2F-2	0.788	c-m	0.611	h-q	0.445	i-w	0.381	h-u
8x11	0.829	a-f	0.718	a-j	0.567	a-k	0.488	a-l
8x16	0.814	a-j	0.783	ab	0.654	ab	0.563	a-d
8x19	0.799	b-k	0.671	a-n	0.522	b-p	0.478	a-m
9x19	0.790	c-m	0.713	a-j	0.588	a-g	0.552	a-f
Celebration	0.781	e-n	0.728	a-h	0.581	a-h	0.506	a-i
Premier	0.857	a	0.739	a-g	0.529	b-o	0.448	a-o

† NDVI (Normalized difference vegetative index) measured by a Trimble GreenSeeker sensor (N Tech Industries Inc., Ukiah, CA) on a scale of zero to one, a bigger number indicate a greener plot.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 8. Post-drought stress mean normalized difference vegetative index (NDVI) from 4 September – 1 October for sixty-nine bermudagrass entries during the recovery period in 2012.

Bermudagrass Entry	NDVI† 2012 4-Sep	Group‡	10-Sep	Group	17-Sep	Group	1-Oct	Group
11x12	0.615	m-s	0.745	c-m	0.762	c-m	0.789	a-g
11x15	0.742	a-l	0.809	a-h	0.810	a-h	0.808	a-e
11x18	0.764	a-j	0.834	a-d	0.838	abc	0.831	ab
12x15	0.664	g-q	0.804	a-h	0.821	a-g	0.837	ab
12x20	0.791	a-f	0.818	a-g	0.817	a-g	0.797	a-f
12x21	0.802	abc	0.779	a-k	0.784	a-l	0.717	i-l
12x6	0.789	a-f	0.831	a-d	0.831	a-f	0.814	a-d
12x7	0.667	g-p	0.800	a-h	0.807	a-i	0.797	a-f
12x8	0.657	i-q	0.637	o-r	0.571	pq	0.470	q
13x2	0.512	s-w	0.647	n-q	0.707	l-o	0.792	a-g
13x8	0.718	a-n	0.832	a-d	0.840	abc	0.813	a-d
13x9	0.750	a-k	0.817	a-g	0.825	a-g	0.813	a-d
14x15	0.797	a-d	0.833	a-d	0.833	a-e	0.807	a-e
14x18	0.662	h-q	0.743	d-n	0.728	h-n	0.713	j-m
14x6	0.690	c-o	0.780	a-k	0.793	a-k	0.795	a-g
14x7	0.752	a-k	0.773	a-k	0.775	b-l	0.758	c-j
15x2	0.557	p-v	0.688	j-o	0.724	i-o	0.770	b-j
16x17	0.766	a-j	0.774	a-k	0.754	d-m	0.675	k-n
16x19	0.822	ab	0.857	ab	0.850	ab	0.837	ab
16x4	0.733	a-m	0.805	a-h	0.809	a-h	0.797	a-f
16x6	0.776	a-i	0.816	a-g	0.810	a-h	0.790	a-g
17x10	0.717	a-n	0.746	c-l	0.714	k-o	0.646	mno
17x7	0.795	a-e	0.834	a-d	0.832	a-f	0.812	a-d
18x14	0.574	o-u	0.685	k-o	0.723	j-o	0.789	a-g
18x15	0.663	g-q	0.722	g-o	0.750	f-m	0.801	a-f
18x18	0.680	d-o	0.784	a-j	0.789	a-l	0.794	a-g
18x19	0.731	a-m	0.763	b-k	0.752	e-m	0.728	g-l
18x3	0.792	a-f	0.858	ab	0.848	ab	0.839	a
18x6	0.543	q-v	0.655	l-p	0.665	no	0.744	e-j
19x10	0.733	a-m	0.818	a-g	0.818	a-g	0.798	a-f
19x16	0.768	a-j	0.796	a-h	0.795	a-k	0.797	a-f
19x6	0.770	a-j	0.828	a-e	0.824	a-g	0.792	a-g
19x7	0.627	l-s	0.712	h-o	0.679	mno	0.618	nop
1x9	0.822	ab	0.842	abc	0.831	a-f	0.826	ab

20-2-1F-4	0.475	t-w	0.544	rst	0.506	qr	0.553	p
20-2-2F-3	0.577	o-t	0.663	l-p	0.642	op	0.644	no
20-4-1F-1	0.558	p-v	0.731	e-o	0.768	b-l	0.786	a-h
20-4-2F-2	0.659	i-q	0.795	a-i	0.811	a-h	0.809	a-e
20-4-3F-4	0.508	s-w	0.648	m-q	0.664	no	0.720	h-l
20x16	0.689	c-o	0.802	a-h	0.806	a-i	0.814	a-d
20x2	0.834	a	0.837	a-d	0.829	a-f	0.788	a-g
20x6	0.530	r-v	0.546	rst	0.507	qr	0.449	q
20x7	0.797	a-d	0.816	a-g	0.806	a-j	0.782	a-i
2x10	0.660	i-q	0.780	a-k	0.792	a-k	0.783	a-i
2x14	0.454	uvw	0.511	st	0.536	q	0.608	nop
2x7	0.601	n-s	0.761	b-k	0.770	b-l	0.792	a-g
4x20	0.453	vw	0.554	qrs	0.567	pq	0.607	op
5x6	0.784	a-g	0.832	a-d	0.836	a-d	0.826	abc
6x1	0.666	g-p	0.774	a-k	0.779	a-l	0.827	ab
6x2	0.709	b-n	0.813	a-g	0.828	a-g	0.826	abc
7-1-1-4	0.603	n-s	0.715	h-o	0.744	g-n	0.751	d-j
7-2-1-2	0.675	e-p	0.802	a-h	0.801	a-j	0.814	a-d
7-2-2F-2	0.635	k-r	0.813	a-g	0.823	a-g	0.844	a
7-2-3F-4	0.614	m-s	0.787	a-i	0.802	a-j	0.809	a-e
7-2-4F-2	0.716	a-n	0.820	a-f	0.833	a-e	0.819	abc
7-4-1-3	0.772	a-j	0.818	a-g	0.817	a-g	0.798	a-f
7-4-2F-2	0.705	b-n	0.795	a-i	0.790	a-l	0.809	a-e
7-4-3F-4	0.578	o-t	0.724	f-o	0.730	h-n	0.786	a-h
8-2-1-4	0.765	a-j	0.801	a-h	0.799	a-j	0.802	a-e
8-2-2F-1	0.527	r-v	0.580	p-s	0.568	pq	0.573	p
8-2-3F-3	0.406	w	0.455	t	0.428	r	0.451	q
8-5-1-1	0.716	a-n	0.805	a-h	0.805	a-j	0.812	a-d
8-5-2F-2	0.673	f-p	0.785	a-j	0.780	a-l	0.780	a-j
8x11	0.652	j-q	0.699	i-o	0.682	mno	0.662	l-o
8x16	0.809	abc	0.829	a-d	0.814	a-g	0.801	a-f
8x19	0.782	a-h	0.783	a-j	0.769	b-l	0.733	f-k
9x19	0.773	a-i	0.818	a-g	0.811	a-h	0.800	a-f
Celebration	0.777	a-i	0.831	a-d	0.839	abc	0.829	ab
Premier	0.805	abc	0.864	a	0.860	a	0.836	ab

† NDVI (Normalized difference vegetative index) measured by a Trimble GreenSeeker sensor (N Tech Industries Inc., Ukiah, CA) on a scale of zero to one, a bigger number indicate a greener plot.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 9. Mean normalized difference vegetative index (NDVI) from 15 August –12 September for sixty-nine bermudagrass entries during the drought treatment period in 2013.

Bermudagrass Entry	NDVI†									
	2013									
	15-Aug	GROUP‡	22-Aug	GROUP	29-Aug	GROUP	5-Sep	GROUP	12-Sep	GROUP
11x12	0.742	c-p	0.647	a-k	0.470	a-j	0.298	c-q	0.256	f-m
11x15	0.773	b-j	0.643	a-k	0.501	a-h	0.325	c-q	0.296	c-l
11x18	0.755	b-n	0.662	a-i	0.455	a-k	0.266	g-q	0.223	g-m
12x15	0.734	f-r	0.576	f-o	0.343	ijk	0.216	opq	0.184	klm
12x20	0.761	b-m	0.648	a-k	0.346	ijk	0.241	l-q	0.205	i-m
12x21	0.693	p-t	0.508	no	0.388	c-k	0.300	c-q	0.351	b-f
12x6	0.750	b-n	0.678	a-g	0.482	a-j	0.396	a-f	0.321	c-j
12x7	0.749	b-n	0.646	a-k	0.450	a-k	0.296	c-q	0.256	f-m
12x8	0.712	m-t	0.596	e-o	0.411	b-k	0.264	g-q	0.264	e-m
13x2	0.780	a-g	0.636	a-m	0.376	e-k	0.227	m-q	0.208	i-m
13x8	0.791	abc	0.620	b-n	0.337	jk	0.204	pq	0.163	m
13x9	0.773	b-j	0.725	abc	0.546	ab	0.396	a-f	0.304	c-k
14x15	0.736	e-q	0.640	a-k	0.467	a-j	0.300	c-q	0.264	e-m
14x18	0.729	h-r	0.662	a-i	0.435	a-k	0.375	a-j	0.336	b-g
14x6	0.773	b-j	0.641	a-k	0.466	a-j	0.357	a-l	0.291	d-l
14x7	0.684	rst	0.589	e-o	0.472	a-j	0.385	a-g	0.351	b-f
15x2	0.758	b-n	0.644	a-k	0.458	a-k	0.328	c-q	0.294	c-l
16x17	0.772	b-j	0.699	a-e	0.555	ab	0.404	a-e	0.415	abc
16x19	0.768	b-l	0.750	a	0.556	ab	0.420	abc	0.334	b-h
16x4	0.769	b-l	0.618	b-n	0.472	a-j	0.322	c-q	0.246	f-m
16x6	0.730	g-r	0.563	g-o	0.428	a-k	0.298	c-q	0.260	f-m
17x10	0.787	a-d	0.682	a-g	0.524	a-e	0.379	a-h	0.328	c-i
17x7	0.782	a-f	0.637	a-l	0.466	a-j	0.321	c-q	0.284	d-m
18x14	0.742	c-p	0.546	i-o	0.370	f-k	0.224	n-q	0.189	klm
18x15	0.779	a-h	0.648	a-k	0.456	a-k	0.311	c-q	0.283	d-m
18x18	0.726	i-s	0.604	d-o	0.458	a-k	0.260	g-q	0.223	g-m
18x19	0.728	i-r	0.517	mno	0.379	d-k	0.277	e-q	0.236	f-m
18x3	0.719	k-t	0.581	e-o	0.429	a-k	0.311	c-q	0.285	d-m
18x6	0.776	a-i	0.593	e-o	0.362	h-k	0.249	j-q	0.212	h-m
19x10	0.745	b-o	0.644	a-k	0.491	a-j	0.380	a-h	0.386	a-e
19x16	0.733	f-r	0.616	c-n	0.446	a-k	0.318	c-q	0.302	c-l
19x6	0.825	a	0.725	abc	0.531	a-d	0.317	c-q	0.265	e-m
19x7	0.789	a-d	0.699	a-e	0.571	a	0.422	abc	0.385	a-e
1x9	0.758	b-n	0.655	a-j	0.552	ab	0.463	a	0.454	ab
20-2-1F-4	0.760	b-m	0.615	c-o	0.452	a-k	0.265	g-q	0.214	g-m
20-2-2F-3	0.772	b-j	0.625	b-n	0.424	a-k	0.322	c-q	0.257	f-m
20-4-1F-1	0.732	f-r	0.614	c-o	0.386	c-k	0.216	opq	0.180	lm

20-4-2F-2	0.733	f-r	0.541	j-o	0.357	h-k	0.214	opq	0.190	klm
20-4-3F-4	0.720	k-t	0.551	i-o	0.356	h-k	0.225	n-q	0.195	klm
20x16	0.753	b-n	0.623	b-n	0.487	a-j	0.358	a-l	0.286	d-m
20x2	0.758	b-n	0.583	e-o	0.433	a-k	0.355	a-m	0.322	c-i
20x6	0.671	t	0.577	f-o	0.428	a-k	0.306	c-q	0.281	d-m
20x7	0.746	b-o	0.645	a-k	0.529	a-e	0.459	ab	0.487	a
2x10	0.741	c-p	0.662	a-i	0.480	a-j	0.267	f-q	0.233	f-m
2x14	0.719	l-t	0.496	o	0.309	k	0.202	q	0.179	lm
2x7	0.676	st	0.671	a-h	0.452	a-k	0.317	c-q	0.265	e-m
4x20	0.742	c-p	0.520	l-o	0.365	g-k	0.233	l-q	0.191	klm
5x6	0.698	o-t	0.570	g-o	0.421	a-k	0.265	g-q	0.199	j-m
6x1	0.769	b-l	0.718	a-d	0.523	a-f	0.319	c-q	0.239	f-m
6x2	0.720	k-t	0.591	e-o	0.417	b-k	0.253	h-q	0.234	f-m
7-1-1-4	0.693	p-t	0.586	e-o	0.428	a-k	0.264	g-q	0.236	f-m
7-2-1-2	0.785	a-e	0.682	a-g	0.486	a-j	0.261	g-q	0.187	klm
7-2-2F-2	0.739	d-p	0.680	a-g	0.462	a-k	0.280	d-q	0.233	f-m
7-2-3F-4	0.793	ab	0.652	a-j	0.420	a-k	0.228	m-q	0.206	i-m
7-2-4F-2	0.782	a-f	0.610	c-o	0.423	a-k	0.266	g-q	0.222	g-m
7-4-1-3	0.785	a-e	0.719	a-d	0.525	a-e	0.332	b-p	0.273	e-m
7-4-2F-2	0.727	i-r	0.683	a-g	0.533	abc	0.324	c-q	0.284	d-m
7-4-3F-4	0.766	b-l	0.678	a-g	0.461	a-k	0.310	c-q	0.252	f-m
8-2-1-4	0.779	a-h	0.650	a-k	0.470	a-j	0.280	d-q	0.225	g-m
8-2-2F-1	0.751	b-n	0.738	ab	0.531	a-d	0.320	c-q	0.285	d-m
8-2-3F-3	0.725	j-s	0.555	h-o	0.414	b-k	0.250	i-q	0.215	g-m
8-5-1-1	0.748	b-o	0.650	a-k	0.414	b-k	0.262	g-q	0.211	i-m
8-5-2F-2	0.708	n-t	0.542	i-o	0.390	c-k	0.244	k-q	0.227	g-m
8x11	0.719	k-t	0.605	d-o	0.517	a-g	0.371	a-k	0.301	c-l
8x16	0.755	b-n	0.648	a-k	0.506	a-h	0.350	a-n	0.281	d-m
8x19	0.685	q-t	0.531	k-o	0.404	b-k	0.302	c-q	0.262	f-m
9x19	0.760	b-m	0.616	c-n	0.492	a-i	0.378	a-i	0.300	c-l
Celebration	0.770	b-k	0.601	d-o	0.524	a-f	0.408	a-d	0.397	a-d
Premier	0.787	a-d	0.691	a-f	0.446	a-k	0.335	a-o	0.287	d-l

† NDVI (Normalized difference vegetative index) measured by a Trimble GreenSeeker sensor (N Tech Industries Inc., Ukiah, CA) on a scale of zero to one, a bigger number indicate a greener plot.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 10. Post-drought stress mean normalized difference vegetative index (NDVI) from 27 September – 15 October for sixty-nine bermudagrass entries during the recovery period in 2013.

	NDVI†					
Bermudagrass Entry	2013					
	27-Sep	Group‡	8-Oct	Group	15-Oct	Group
11x12	0.262	g-u	0.428	d-s	0.459	e-t
11x15	0.339	b-k	0.512	a-h	0.573	a-i
11x18	0.216	j-u	0.489	a-k	0.571	a-i
12x15	0.169	stu	0.262	v-z	0.317	t-x
12x20	0.233	h-u	0.354	i-z	0.454	f-u
12x21	0.408	a-e	0.554	a-e	0.627	a-d
12x6	0.344	b-j	0.467	b-n	0.516	c-o
12x7	0.229	j-u	0.365	h-z	0.424	j-w
12x8	0.259	g-u	0.418	d-u	0.449	g-u
13x2	0.204	n-u	0.280	s-z	0.345	r-x
13x8	0.204	n-u	0.344	j-z	0.435	h-v
13x9	0.313	c-p	0.423	d-u	0.547	b-l
14x15	0.295	d-s	0.431	d-s	0.469	e-s
14x18	0.400	a-f	0.471	b-m	0.600	a-e
14x6	0.331	c-n	0.455	b-p	0.578	a-h
14x7	0.398	a-f	0.544	a-f	0.586	a-g
15x2	0.305	c-r	0.427	d-t	0.459	e-t
16x17	0.357	b-i	0.476	b-l	0.562	a-j
16x19	0.313	c-p	0.411	d-v	0.538	b-m
16x4	0.214	k-u	0.324	m-z	0.432	i-w
16x6	0.319	c-p	0.450	b-p	0.530	c-n
17x10	0.368	b-g	0.562	a-d	0.634	abc
17x7	0.315	c-p	0.463	b-o	0.557	a-k
18x14	0.166	stu	0.263	v-z	0.329	s-x
18x15	0.273	f-u	0.459	b-p	0.569	a-i
18x18	0.280	e-u	0.460	b-p	0.527	c-o
18x19	0.243	g-u	0.397	f-w	0.458	e-t
18x3	0.310	c-q	0.448	b-q	0.594	a-f
18x6	0.228	j-u	0.364	h-z	0.418	k-x
19x10	0.414	a-d	0.494	a-j	0.583	a-g
19x16	0.333	c-m	0.533	a-g	0.592	a-g
19x6	0.254	g-u	0.407	e-w	0.505	c-p
19x7	0.433	abc	0.582	abc	0.627	a-d
1x9	0.462	ab	0.592	ab	0.677	ab

20-2-1F-4	0.229	j-u	0.317	n-z	0.409	l-x
20-2-2F-3	0.287	d-t	0.420	d-u	0.480	e-r
20-4-1F-1	0.152	u	0.224	yz	0.312	u-x
20-4-2F-2	0.179	r-u	0.275	u-z	0.351	r-x
20-4-3F-4	0.165	tu	0.237	xyz	0.301	vwx
20x16	0.312	c-q	0.498	a-i	0.567	a-j
20x2	0.362	b-h	0.447	b-q	0.581	a-g
20x6	0.299	d-r	0.500	a-i	0.556	a-k
20x7	0.516	a	0.636	a	0.693	a
2x10	0.240	g-u	0.380	h-x	0.488	d-r
2x14	0.162	tu	0.235	xyz	0.279	x
2x7	0.267	g-u	0.343	k-z	0.479	e-r
4x20	0.184	q-u	0.277	t-z	0.352	r-x
5x6	0.202	o-u	0.310	p-z	0.410	l-x
6x1	0.228	j-u	0.338	l-z	0.424	j-w
6x2	0.232	i-u	0.346	j-z	0.468	e-s
7-1-1-4	0.232	i-u	0.330	l-z	0.434	i-w
7-2-1-2	0.164	tu	0.218	z	0.290	wx
7-2-2F-2	0.209	l-u	0.315	o-z	0.389	n-x
7-2-3F-4	0.170	stu	0.236	xyz	0.312	u-x
7-2-4F-2	0.179	r-u	0.259	w-z	0.355	q-x
7-4-1-3	0.277	f-u	0.389	g-w	0.449	g-u
7-4-2F-2	0.238	h-u	0.370	h-y	0.452	f-u
7-4-3F-4	0.227	j-u	0.289	r-z	0.365	p-x
8-2-1-4	0.199	p-u	0.297	q-z	0.385	o-x
8-2-2F-1	0.229	i-u	0.331	l-z	0.414	k-x
8-2-3F-3	0.221	j-u	0.321	m-z	0.425	j-w
8-5-1-1	0.206	m-u	0.319	n-z	0.404	l-x
8-5-2F-2	0.215	k-u	0.336	l-z	0.397	m-x
8x11	0.315	c-p	0.425	d-u	0.496	c-q
8x16	0.316	c-p	0.478	b-l	0.527	c-o
8x19	0.330	c-o	0.490	a-k	0.537	b-m
9x19	0.337	b-l	0.420	d-u	0.451	f-u
Celebration	0.498	a	0.552	a-e	0.625	a-d
Premier	0.261	g-u	0.435	c-r	0.466	e-s

† NDVI (Normalized difference vegetative index) measured by a Trimble GreenSeeker sensor (N Tech Industries Inc., Ukiah, CA) on a scale of zero to one, a bigger number indicate a greener plot.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 11. Mean digital image analysis (DIA) from 31 July – 20 August for sixty-nine bermudagrass entries during the drought treatment period in 2012.

	DIA†							
Bermudagrass Entry	2012							
	31-Jul	Group‡	7-Aug	Group	13-Aug	Group	20-Aug	Group
11x12	1.517	b-n	1.217	m-p	0.963	n-t	0.918	k-w
11x15	1.521	a-m	1.425	a-i	1.245	a-k	1.151	a-k
11x18	1.526	a-i	1.429	a-h	1.136	c-q	1.015	f-v
12x15	1.525	a-j	1.280	j-n	0.972	l-t	0.910	k-w
12x20	1.516	c-o	1.429	a-h	1.238	a-k	1.124	a-m
12x21	1.527	a-i	1.356	a-l	1.316	a-e	1.316	a-d
12x6	1.523	a-l	1.428	a-h	1.178	a-o	1.157	a-k
12x7	1.528	a-i	1.399	a-k	1.169	a-p	1.039	d-u
12x8	1.544	ab	1.438	a-g	1.244	a-k	1.155	a-k
13x2	1.542	abc	1.293	i-n	0.937	p-t	0.824	p-w
13x8	1.535	a-g	1.483	ab	1.309	a-g	1.079	b-q
13x9	1.527	a-i	1.383	a-k	1.221	a-k	1.048	c-s
14x15	1.517	b-n	1.435	a-h	1.184	a-o	1.121	a-n
14x18	1.524	a-k	1.355	b-l	1.123	c-r	1.044	c-s
14x6	1.527	a-i	1.422	a-i	1.162	b-p	1.068	b-r
14x7	1.525	a-i	1.358	a-l	1.275	a-i	1.297	a-e
15x2	1.519	b-m	1.325	d-n	1.033	j-t	0.916	k-w
16x17	1.451	r	1.362	a-k	1.344	abc	1.321	abc
16x19	1.496	m-q	1.401	a-k	1.344	abc	1.255	a-g
16x4	1.497	l-q	1.327	c-n	1.174	a-o	1.153	a-k
16x6	1.528	a-i	1.389	a-k	1.170	a-p	1.138	a-l
17x10	1.529	a-i	1.382	a-k	1.249	a-j	1.282	a-f
17x7	1.539	a-e	1.409	a-j	1.282	a-h	1.231	a-h
18x14	1.531	a-i	1.330	c-n	0.966	m-t	0.760	uvw
18x15	1.498	k-q	1.378	a-k	1.119	c-r	0.933	i-w
18x18	1.532	a-h	1.316	e-n	1.123	c-r	1.061	b-r
18x19	1.539	a-f	1.408	a-j	1.219	a-k	1.082	b-q
18x3	1.527	a-i	1.450	a-e	1.332	a-d	1.224	a-h
18x6	1.533	a-h	1.339	c-m	0.954	o-t	0.808	p-w
19x10	1.520	a-m	1.383	a-k	1.262	a-j	1.172	a-k
19x16	1.495	m-q	1.429	a-h	1.316	a-f	1.246	a-g
19x6	1.535	a-g	1.441	a-f	1.284	a-h	1.205	a-i
19x7	1.517	b-n	1.400	a-k	1.191	a-n	1.114	a-o
1x9	1.532	a-h	1.439	a-g	1.348	abc	1.331	ab
20-2-1F-4	1.526	a-i	1.389	a-k	1.132	c-q	0.870	l-w
20-2-2F-3	1.529	a-i	1.403	a-j	1.129	c-q	0.798	r-w

20-4-1F-1	1.526	a-i	1.301	h-n	0.890	rst	0.780	s-w
20-4-2F-2	1.517	b-n	1.201	nop	0.938	p-t	1.178	a-k
20-4-3F-4	1.536	a-g	1.302	h-n	0.969	l-t	0.680	w
20x16	1.504	i-q	1.428	a-i	1.255	a-j	1.041	d-t
20x2	1.514	e-o	1.410	a-j	1.394	ab	1.366	a
20x6	1.498	k-q	1.460	abc	1.216	a-k	1.071	b-r
20x7	1.526	a-i	1.410	a-j	1.351	abc	1.264	a-f
2x10	1.527	a-i	1.382	a-k	1.122	c-r	0.921	j-w
2x14	1.514	d-o	1.122	p	0.875	st	0.755	vw
2x7	1.528	a-i	1.360	a-l	1.055	h-t	0.869	l-w
4x20	1.492	n-q	1.143	op	0.826	t	0.687	w
5x6	1.531	a-i	1.226	l-p	1.081	f-s	1.077	b-r
6x1	1.499	j-q	1.268	k-o	0.917	q-t	0.843	n-w
6x2	1.510	g-o	1.282	j-n	1.081	e-s	0.952	h-w
7-1-1-4	1.481	pq	1.208	m-p	1.035	j-t	0.902	k-w
7-2-1-2	1.536	a-g	1.484	ab	1.122	c-r	0.828	p-w
7-2-2F-2	1.517	c-n	1.355	b-l	1.029	j-t	0.835	o-w
7-2-3F-4	1.536	a-g	1.421	a-i	1.050	h-t	0.845	m-w
7-2-4F-2	1.534	a-g	1.389	a-k	1.072	h-s	0.804	q-w
7-4-1-3	1.521	a-m	1.453	a-d	1.237	a-k	1.126	a-l
7-4-2F-2	1.504	i-q	1.377	a-k	1.164	b-p	0.982	g-v
7-4-3F-4	1.513	f-o	1.411	a-j	1.074	g-s	0.762	t-w
8-2-1-4	1.515	d-o	1.390	a-k	1.141	c-q	1.085	b-p
8-2-2F-1	1.540	a-d	1.426	a-i	1.202	a-l	1.018	e-v
8-2-3F-3	1.529	a-i	1.336	c-n	1.012	k-t	0.831	p-w
8-5-1-1	1.527	a-i	1.307	f-n	1.041	i-t	0.899	k-w
8-5-2F-2	1.507	h-p	1.306	g-n	1.104	d-s	1.049	c-s
8x11	1.518	b-n	1.354	b-l	1.200	a-m	1.087	a-p
8x16	1.530	a-i	1.458	a-d	1.404	a	1.281	a-f
8x19	1.490	opq	1.373	a-k	1.252	a-j	1.201	a-j
9x19	1.519	b-m	1.398	a-k	1.271	a-i	1.275	a-f
Celebration	1.479	q	1.386	a-k	1.315	a-f	1.249	a-g
Premier	1.547	a	1.491	a	1.280	a-h	1.122	a-n

† DIA (digital image analysis) measures calculate percent living coverage via SigmaScan software.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 12. Post-drought stress mean digital image analysis (DIA) from 4 September – 1 October for sixty-nine bermudagrass entries during the recovery period in 2012.

	DIA†							
Bermudagrass Entry	2012							
	4-Sep	Group‡	10-Sep	Group	17-Sep	Group	1-Oct	Group
11x12	1.244	i-u	1.421	a-k	1.389	b-k	1.477	abc
11x15	1.337	a-k	1.437	a-i	1.415	a-j	1.426	b-k
11x18	1.337	a-l	1.453	a-e	1.458	a-d	1.450	a-j
12x15	1.229	k-u	1.391	a-n	1.399	a-k	1.415	b-l
12x20	1.375	a-d	1.450	a-f	1.446	a-e	1.448	a-j
12x21	1.392	abc	1.445	a-g	1.451	a-e	1.394	g-n
12x6	1.333	a-m	1.408	a-l	1.423	a-i	1.411	b-m
12x7	1.259	e-u	1.426	a-j	1.391	a-k	1.458	a-i
12x8	1.317	b-p	1.334	h-q	1.310	klm	1.111	r
13x2	1.205	p-v	1.372	b-o	1.395	a-k	1.486	ab
13x8	1.367	a-f	1.457	a-d	1.415	a-j	1.472	a-f
13x9	1.355	a-j	1.422	a-k	1.440	a-e	1.451	a-j
14x15	1.329	a-m	1.452	a-f	1.437	a-g	1.448	a-j
14x18	1.315	b-p	1.411	a-l	1.384	c-k	1.396	f-n
14x6	1.265	d-u	1.397	a-m	1.426	a-i	1.468	a-g
14x7	1.357	a-j	1.445	a-g	1.426	a-i	1.450	a-j
15x2	1.184	r-v	1.319	k-q	1.347	f-k	1.425	b-k
16x17	1.305	b-p	1.361	d-o	1.344	h-k	1.336	m-q
16x19	1.328	a-n	1.443	a-g	1.417	a-j	1.426	b-k
16x4	1.274	d-t	1.340	g-q	1.368	d-k	1.397	e-n
16x6	1.360	a-h	1.426	a-j	1.426	a-i	1.440	a-j
17x10	1.322	b-o	1.361	c-o	1.370	d-k	1.337	m-q
17x7	1.372	a-e	1.440	a-h	1.434	a-i	1.469	a-g
18x14	1.152	u-x	1.331	i-q	1.384	c-k	1.386	h-o
18x15	1.190	q-v	1.307	l-q	1.319	klm	1.407	c-m
18x18	1.298	c-r	1.443	a-g	1.397	a-k	1.472	a-f
18x19	1.323	a-o	1.421	a-k	1.444	a-e	1.385	i-o
18x3	1.318	b-p	1.482	a	1.469	abc	1.434	a-j
18x6	1.186	r-v	1.347	e-p	1.392	a-k	1.440	a-j
19x10	1.290	c-s	1.401	a-m	1.393	a-k	1.442	a-j
19x16	1.306	b-p	1.440	a-h	1.439	a-f	1.424	b-k
19x6	1.419	ab	1.479	ab	1.445	a-e	1.475	a-d
19x7	1.302	c-q	1.384	a-n	1.318	klm	1.323	n-q
1x9	1.327	a-n	1.438	a-i	1.448	a-e	1.426	a-k
20-2-1F-4	1.173	t-w	1.234	qrs	1.214	no	1.281	pq
20-2-2F-3	1.220	m-u	1.274	o-s	1.359	e-k	1.350	k-p

20-4-1F-1	1.277	d-t	1.404	a-l	1.401	a-k	1.456	a-i
20-4-2F-2	1.361	a-g	1.417	a-k	1.448	a-e	1.473	a-e
20-4-3F-4	1.177	s-w	1.310	l-q	1.381	c-k	1.409	b-m
20x16	1.263	d-u	1.428	a-j	1.370	d-k	1.377	j-o
20x2	1.355	a-j	1.420	a-k	1.457	a-d	1.449	a-j
20x6	1.213	n-v	1.248	p-s	1.122	op	1.099	r
20x7	1.313	b-p	1.404	a-l	1.434	a-i	1.450	a-j
2x10	1.258	e-u	1.391	a-n	1.376	d-k	1.399	d-n
2x14	1.063	wx	1.170	st	1.230	mn	1.311	opq
2x7	1.204	p-v	1.352	d-p	1.381	c-k	1.421	b-k
4x20	1.103	vwx	1.191	rst	1.236	lmn	1.298	pq
5x6	1.359	a-i	1.443	a-g	1.436	a-h	1.453	a-j
6x1	1.176	s-w	1.341	g-q	1.343	ijk	1.406	c-m
6x2	1.251	g-u	1.382	a-n	1.383	c-k	1.414	b-l
7-1-1-4	1.155	u-x	1.286	n-r	1.326	jkl	1.312	opq
7-2-1-2	1.342	a-k	1.468	abc	1.422	a-i	1.451	a-j
7-2-2F-2	1.243	j-u	1.398	a-m	1.430	a-i	1.457	a-i
7-2-3F-4	1.315	b-p	1.437	a-i	1.427	a-i	1.468	a-g
7-2-4F-2	1.344	a-j	1.439	a-h	1.429	a-i	1.442	a-j
7-4-1-3	1.334	a-m	1.458	a-d	1.451	a-e	1.462	a-h
7-4-2F-2	1.222	l-u	1.364	c-o	1.393	a-k	1.439	a-j
7-4-3F-4	1.210	o-v	1.323	j-q	1.377	c-k	1.427	a-k
8-2-1-4	1.265	d-u	1.392	a-n	1.391	b-k	1.447	a-j
8-2-2F-1	1.182	s-v	1.294	m-r	1.238	lmn	1.272	q
8-2-3F-3	1.043	x	1.103	t	1.092	p	1.077	r
8-5-1-1	1.286	c-t	1.385	a-n	1.436	a-h	1.428	a-j
8-5-2F-2	1.246	h-u	1.363	c-o	1.365	e-k	1.387	h-o
8x11	1.254	f-u	1.331	i-q	1.310	klm	1.295	pq
8x16	1.377	a-d	1.474	ab	1.477	ab	1.447	a-j
8x19	1.249	g-u	1.378	a-o	1.374	d-k	1.389	h-n
9x19	1.343	a-k	1.440	a-h	1.422	a-i	1.431	a-j
Celebration	1.254	f-u	1.346	f-p	1.346	g-k	1.343	l-q
Premier	1.437	a	1.482	a	1.483	a	1.503	a

† DIA (digital image analysis) measures calculate percent living coverage via SigmaScan software.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 13. Mean digital image analysis (DIA) from 15 August – 12 September for sixty-nine bermudagrass entries during the drought treatment period in 2013.

Bermudagrass Entry	DIA† 2013 15-Aug	Group‡	22-Aug	Group	29-Aug	Group	5-Sep	Group	12-Sep	Group
11x12	1.544	a-g	1.493	a-f	1.210	a-i	1.210	a-i	0.740	b-m
11x15	1.538	a-h	1.439	a-j	1.045	b-o	1.045	b-o	0.784	a-m
11x18	1.537	a-h	1.458	a-i	1.019	b-o	1.019	b-o	0.515	j-m
12x15	1.505	e-n	1.318	i-l	0.791	m-p	0.791	m-p	0.490	klm
12x20	1.536	a-h	1.448	a-j	0.873	i-p	0.873	i-p	0.589	g-m
12x21	1.432	r	1.367	d-l	1.190	a-j	1.190	a-j	1.058	abc
12x6	1.542	a-g	1.521	a-d	1.245	a-e	1.245	a-e	0.875	a-i
12x7	1.526	a-l	1.464	a-i	0.945	d-o	0.945	d-o	0.565	g-m
12x8	1.502	f-n	1.402	a-j	0.990	c-o	0.990	c-o	0.780	a-m
13x2	1.536	a-h	1.415	a-j	1.014	b-o	1.014	b-o	0.597	g-m
13x8	1.552	abc	1.478	a-h	1.153	a-l	1.153	a-l	0.566	g-m
13x9	1.538	a-h	1.508	a-e	1.169	a-l	1.169	a-l	0.754	a-m
14x15	1.499	g-n	1.454	a-i	0.988	c-o	0.988	c-o	0.663	e-m
14x18	1.530	a-j	1.466	a-i	1.159	a-l	1.159	a-l	0.791	a-l
14x6	1.544	a-f	1.513	a-d	1.204	a-i	1.204	a-i	0.771	a-m
14x7	1.453	o-r	1.429	a-j	1.231	a-g	1.231	a-g	1.002	a-e
15x2	1.527	a-j	1.484	a-h	1.013	b-o	1.013	b-o	0.891	a-g
16x17	1.513	b-n	1.500	a-e	1.325	abc	1.325	abc	0.839	a-j
16x19	1.518	a-n	1.525	abc	1.291	a-d	1.291	a-d	0.803	a-l
16x4	1.505	e-n	1.451	a-j	0.988	c-o	0.988	c-o	0.569	g-m
16x6	1.481	l-p	1.337	g-l	0.904	e-p	0.904	e-p	0.670	e-m
17x10	1.542	a-g	1.420	a-j	1.128	a-m	1.128	a-m	0.754	a-m
17x7	1.550	a-d	1.509	a-e	1.064	b-n	1.064	b-n	0.720	c-m
18x14	1.527	a-j	1.402	a-j	0.841	k-p	0.841	k-p	0.441	m
18x15	1.523	a-m	1.484	a-h	1.047	b-o	1.047	b-o	0.837	a-k
18x18	1.525	a-l	1.425	a-j	1.089	a-n	1.089	a-n	0.654	f-m
18x19	1.527	a-j	1.379	b-k	0.954	d-o	0.954	d-o	0.661	e-m
18x3	1.511	b-n	1.457	a-i	1.097	a-n	1.097	a-n	0.818	a-l
18x6	1.510	c-n	1.426	a-j	0.844	j-p	0.844	j-p	0.589	g-m
19x10	1.488	i-o	1.452	a-i	1.150	a-l	1.150	a-l	1.040	a-d
19x16	1.503	f-n	1.443	a-j	1.147	a-l	1.147	a-l	0.804	a-l
19x6	1.561	a	1.530	ab	1.204	a-i	1.204	a-i	0.629	g-m
19x7	1.513	b-n	1.485	a-g	1.237	a-f	1.237	a-f	1.095	a
1x9	1.526	a-k	1.539	a	1.425	a	1.425	a	1.073	ab
20-2-1F-4	1.541	a-g	1.414	a-j	1.146	a-l	1.146	a-l	0.569	g-m
20-2-2F-3	1.535	a-h	1.330	h-l	0.954	d-o	0.954	d-o	0.532	i-m
20-4-1F-1	1.486	j-o	1.394	a-j	0.928	e-p	0.928	e-p	0.496	j-m
20-4-2F-2	1.436	qr	1.344	f-l	0.880	h-p	0.880	h-p	0.568	g-m
20-4-3F-4	1.489	i-o	1.223	lm	0.761	nop	0.761	nop	0.484	lm

20x16	1.525	a-m	1.473	a-h	1.173	a-k	1.173	a-k	0.670	e-m
20x2	1.516	a-n	1.414	a-j	1.140	a-l	1.140	a-l	0.868	a-i
20x6	1.476	n-r	1.373	c-l	1.030	b-o	1.030	b-o	0.817	a-l
20x7	1.478	n-q	1.428	a-j	1.247	a-e	1.247	a-e	0.822	a-l
2x10	1.509	c-n	1.416	a-j	1.018	b-o	1.018	b-o	0.545	g-m
2x14	1.360	s	1.031	n	0.597	p	0.597	p	0.440	m
2x7	1.480	m-q	1.427	a-j	1.127	a-m	1.127	a-m	0.569	g-m
4x20	1.495	h-o	1.234	klm	0.702	op	0.702	op	0.641	g-m
5x6	1.488	i-o	1.410	a-j	1.003	b-o	1.003	b-o	0.704	d-m
6x1	1.528	a-j	1.491	a-g	0.948	d-o	0.948	d-o	0.585	g-m
6x2	1.508	c-n	1.388	a-j	0.990	c-o	0.990	c-o	0.483	lm
7-1-1-4	1.505	d-n	1.357	e-l	0.981	c-o	0.981	c-o	0.678	e-m
7-2-1-2	1.548	a-e	1.517	a-d	1.124	a-m	1.124	a-m	0.626	g-m
7-2-2F-2	1.545	a-f	1.519	a-d	1.077	b-n	1.077	b-n	0.540	h-m
7-2-3F-4	1.534	a-h	1.449	a-j	0.894	f-p	0.894	f-p	0.608	g-m
7-2-4F-2	1.531	a-i	1.445	a-j	0.994	b-o	0.994	b-o	0.540	h-m
7-4-1-3	1.544	a-f	1.488	a-g	1.138	a-m	1.138	a-m	0.774	a-m
7-4-2F-2	1.516	a-n	1.497	a-f	1.226	a-h	1.226	a-h	0.572	g-m
7-4-3F-4	1.509	c-n	1.458	a-i	0.971	d-o	0.971	d-o	0.589	g-m
8-2-1-4	1.509	c-n	1.431	a-j	1.100	a-n	1.100	a-n	0.721	c-m
8-2-2F-1	1.519	a-n	1.505	a-e	1.291	a-d	1.291	a-d	0.548	g-m
8-2-3F-3	1.526	a-k	1.378	b-k	0.884	g-p	0.884	g-p	0.534	i-m
8-5-1-1	1.531	a-i	1.463	a-i	0.826	l-p	0.826	l-p	0.566	g-m
8-5-2F-2	1.440	pqr	1.156	mn	0.866	i-p	0.866	i-p	0.610	g-m
8x11	1.513	b-n	1.359	e-l	0.988	c-o	0.988	c-o	0.573	g-m
8x16	1.527	a-j	1.463	a-i	1.209	a-i	1.209	a-i	0.638	g-m
8x19	1.482	k-p	1.297	j-m	0.877	i-p	0.877	i-p	0.794	a-l
9x19	1.537	a-h	1.452	a-i	1.213	a-i	1.213	a-i	0.884	a-h
Celebration	1.477	n-r	1.442	a-j	1.341	ab	1.341	ab	0.999	a-f
Premier	1.556	ab	1.502	a-e	1.109	a-n	1.109	a-n	0.534	i-m

† DIA (digital image analysis) measures calculate percent living coverage via SigmaScan software.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 14. Post-drought stress mean digital image analysis (DIA) from 27 September – 15 October for sixty-nine bermudagrass entries during the recovery period in 2013.

Bermudagrass Entry	DIA†					
	2013					
	27-Sep	Group‡	8-Oct	Group	15-Oct	Group
11x12	0.808	d-t	0.996	f-r	4.000	e-j
11x15	0.900	b-k	1.088	b-k	5.000	a-f
11x18	0.749	g-v	0.958	f-u	3.750	f-k
12x15	0.562	v	0.722	s-w	2.500	klm
12x20	0.763	f-v	0.882	h-v	3.750	f-k
12x21	1.042	abc	1.303	a-d	5.500	a-d
12x6	0.901	b-k	1.110	b-j	4.500	c-h
12x7	0.683	k-v	0.905	g-v	3.250	h-m
12x8	0.794	e-t	1.098	b-k	4.750	b-g
13x2	0.716	i-v	0.872	h-v	2.750	j-m
13x8	0.726	i-v	0.971	f-t	3.500	g-l
13x9	0.813	d-t	1.049	d-n	4.000	e-j
14x15	0.794	e-t	0.976	f-s	4.000	e-j
14x18	0.955	a-h	1.152	a-g	5.000	a-f
14x6	0.906	b-j	1.123	a-i	5.000	a-f
14x7	0.978	a-f	1.185	a-f	5.000	a-f
15x2	0.843	c-q	1.012	e-p	3.500	g-l
16x17	0.916	b-i	1.136	a-h	5.250	a-e
16x19	0.904	b-j	1.121	a-i	4.750	b-g
16x4	0.571	uv	0.817	l-w	3.250	h-m
16x6	0.857	b-p	1.053	c-m	4.500	c-h
17x10	0.887	b-l	1.160	a-g	5.250	a-e
17x7	0.829	c-r	1.137	a-h	4.500	c-h
18x14	0.620	r-v	0.710	s-w	2.500	klm
18x15	0.843	c-q	1.078	b-l	4.250	d-i
18x18	0.801	d-t	1.061	b-l	4.250	d-i
18x19	0.788	e-u	1.007	e-q	3.750	f-k
18x3	0.903	b-j	1.123	a-i	5.000	a-f
18x6	0.688	j-v	0.858	i-v	3.250	h-m
19x10	0.964	a-g	1.140	a-h	5.500	a-d
19x16	0.993	a-e	1.271	a-e	6.000	ab
19x6	0.711	i-v	1.035	d-o	4.000	e-j
19x7	1.019	a-d	1.328	ab	5.750	abc
1x9	1.143	a	1.385	a	6.250	a
20-2-1F-4	0.683	k-v	0.902	g-v	3.750	f-k

20-2-2F-3	0.698	i-v	0.938	f-u	4.250	d-i
20-4-1F-1	0.609	s-v	0.705	t-w	2.250	lm
20-4-2F-2	0.702	i-v	0.731	r-w	2.250	lm
20-4-3F-4	0.648	o-v	0.705	t-w	2.250	lm
20x16	0.881	b-m	1.152	a-g	5.500	a-d
20x2	0.826	c-s	1.163	a-g	4.750	b-g
20x6	0.878	b-m	1.137	a-h	4.750	b-g
20x7	1.076	ab	1.300	a-d	5.500	a-d
2x10	0.664	m-v	0.916	g-v	3.750	f-k
2x14	0.567	v	0.575	w	2.000	m
2x7	0.657	n-v	0.816	l-w	3.250	h-m
4x20	0.749	g-v	0.741	q-w	2.750	j-m
5x6	0.705	i-v	0.844	j-v	2.750	j-m
6x1	0.643	o-v	0.759	p-w	2.750	j-m
6x2	0.740	h-v	0.791	m-w	3.250	h-m
7-1-1-4	0.764	f-v	0.840	k-w	3.500	g-l
7-2-1-2	0.618	r-v	0.691	uvw	2.750	j-m
7-2-2F-2	0.632	q-v	0.778	o-w	3.000	i-m
7-2-3F-4	0.602	tuv	0.653	vw	2.250	lm
7-2-4F-2	0.676	l-v	0.698	uvw	3.250	h-m
7-4-1-3	0.750	g-v	0.958	f-u	3.500	g-l
7-4-2F-2	0.688	j-v	0.839	k-w	3.500	g-l
7-4-3F-4	0.668	l-v	0.779	o-w	3.750	f-k
8-2-1-4	0.629	q-v	0.719	s-w	2.750	j-m
8-2-2F-1	0.740	h-v	0.882	h-v	3.500	g-l
8-2-3F-3	0.672	l-v	0.784	n-w	3.250	h-m
8-5-1-1	0.640	p-v	0.790	m-w	3.000	i-m
8-5-2F-2	0.637	q-v	0.785	n-w	2.750	j-m
8x11	0.788	e-u	0.946	f-u	4.000	e-j
8x16	0.872	b-n	1.110	b-j	4.750	b-g
8x19	0.967	a-g	1.048	d-n	4.750	b-g
9x19	0.878	b-m	1.017	e-p	4.000	e-j
Celebration	1.016	a-d	1.320	abc	5.250	a-e
Premier	0.861	b-o	0.951	f-u	4.000	e-j

† DIA (digital image analysis) measures calculate percent living coverage via SigmaScan software.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 15. Mean leaf firing from 7 August – 20 August for sixty-nine bermudagrass entries during the drought treatment period in 2012.

	Leaf firing †					
Bermudagrass Entry	2012					
	7-Aug	Group‡	13-Aug	Group	20-Aug	Group
11x12	6.00	e-k	3.75	h-m	3.50	h-n
11x15	7.75	a-f	5.50	a-i	4.75	c-k
11x18	6.00	e-k	4.25	f-l	4.00	f-n
12x15	5.00	ijk	3.25	j-m	3.25	i-n
12x20	8.25	a-d	5.50	a-i	5.00	c-j
12x21	8.25	a-d	6.00	a-g	5.75	a-g
12x6	6.00	e-k	4.75	d-l	4.25	e-m
12x7	8.00	a-e	4.75	d-l	4.50	d-l
12x8	7.75	a-f	4.25	f-l	4.25	e-m
13x2	4.00	kl	3.00	klm	2.50	lmn
13x8	8.50	abc	5.75	a-h	5.25	b-i
13x9	7.25	a-h	5.50	a-i	5.25	b-i
14x15	8.25	a-d	5.75	a-h	5.75	a-g
14x18	7.50	a-g	5.75	a-h	5.00	c-j
14x6	6.50	c-j	4.75	d-l	4.50	d-l
14x7	7.25	a-h	6.75	a-d	6.50	a-d
15x2	5.75	f-k	3.75	h-m	3.50	h-n
16x17	9.00	a	7.50	a	7.50	a
16x19	8.25	a-d	6.50	a-e	6.00	a-f
16x4	6.75	b-i	5.50	a-i	5.00	c-j
16x6	7.50	a-g	5.00	c-k	5.00	c-j
17x10	8.50	abc	6.00	a-g	5.75	a-g
17x7	7.25	a-h	5.25	b-j	5.25	b-i
18x14	5.50	g-k	3.50	i-m	3.00	j-n
18x15	6.75	b-i	4.50	e-l	4.25	e-m
18x18	5.50	g-k	4.50	e-l	4.00	f-n
18x19	7.50	a-g	5.25	b-j	5.25	b-i
18x3	7.00	a-i	5.25	b-j	5.25	b-i
18x6	6.25	d-j	3.50	i-m	3.00	j-n
19x10	8.25	a-d	5.25	b-j	5.25	b-i
19x16	8.50	abc	7.00	abc	6.50	a-d
19x6	8.50	abc	6.00	a-g	6.00	a-f
19x7	7.75	a-f	5.00	c-k	5.00	c-j
1x9	7.75	a-f	7.00	abc	6.75	abc
20-2-1F-4	7.00	a-i	5.25	b-j	5.00	c-j

20-2-2F-3	8.00	a-e	4.25	f-l	4.00	f-n
20-4-1F-1	4.50	jk	2.75	lm	2.25	mn
20-4-2F-2	4.00	kl	3.75	h-m	3.75	g-n
20-4-3F-4	7.00	a-i	4.00	g-m	3.25	i-n
20x16	8.75	ab	5.75	a-h	5.00	c-j
20x2	8.25	a-d	7.00	abc	6.75	abc
20x6	8.00	a-e	4.75	d-l	4.50	d-l
20x7	8.75	ab	7.25	ab	7.25	ab
2x10	6.75	b-i	4.25	f-l	3.75	g-n
2x14	2.25	l	2.00	m	2.00	n
2x7	5.25	h-k	4.00	g-m	3.50	h-n
4x20	5.75	f-k	3.00	klm	3.00	j-n
5x6	4.50	jk	3.25	j-m	3.25	i-n
6x1	4.50	jk	3.25	j-m	3.25	i-n
6x2	6.00	e-k	4.50	e-l	3.75	g-n
7-1-1-4	5.25	h-k	3.50	i-m	3.50	h-n
7-2-1-2	8.25	a-d	4.25	f-l	3.25	i-n
7-2-2F-2	7.00	a-i	4.50	e-l	4.00	f-n
7-2-3F-4	6.75	b-i	3.25	j-m	3.00	j-n
7-2-4F-2	7.25	a-h	4.00	g-m	3.50	h-n
7-4-1-3	7.50	a-g	5.75	a-h	5.50	a-h
7-4-2F-2	6.75	b-i	5.25	b-j	4.75	c-k
7-4-3F-4	7.50	a-g	4.00	g-m	4.00	f-n
8-2-1-4	6.50	c-j	4.75	d-l	4.75	c-k
8-2-2F-1	6.75	b-i	4.50	e-l	3.50	h-n
8-2-3F-3	6.00	e-k	3.25	j-m	2.75	k-n
8-5-1-1	6.50	c-j	4.25	f-l	4.00	f-n
8-5-2F-2	6.50	c-j	4.75	d-l	4.25	e-m
8x11	7.25	a-h	5.25	b-j	5.25	b-i
8x16	8.75	ab	7.00	abc	6.75	abc
8x19	7.50	a-g	6.25	a-f	6.25	a-e
9x19	6.75	b-i	6.00	a-g	5.75	a-g
Celebration	9.00	a	5.25	b-j	5.25	b-i
Premier	8.00	a-e	4.50	e-l	4.50	d-l

† Leaf firing was rated on a 1 to 9 scale where 1 = total leaf firing and 9 =no leaf firing.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 16. Mean leaf firing from 22 August – 12 September for sixty-nine bermudagrass entries during the drought treatment period in 2013.

Bermudagrass Entry	Leaf firing†							
	2013							
	22-Aug	Group‡	29-Aug	Group	5-Sep	Group	12-Sep	Group
11x12	8.25	a-d	4.75	a-h	3.50	b-g	2.75	e-j
11x15	8.50	abc	4.75	a-h	3.50	b-g	3.25	c-h
11x18	8.75	ab	4.50	b-i	2.75	e-h	2.25	g-j
12x15	7.75	b-e	3.00	hij	2.25	fgh	2.00	hij
12x20	8.50	abc	3.75	e-j	2.25	fgh	2.25	g-j
12x21	8.00	a-e	4.75	a-h	5.00	ab	4.50	abc
12x6	8.75	ab	5.00	a-g	4.25	b-e	3.25	c-h
12x7	8.50	abc	4.50	b-i	3.25	c-h	2.25	g-j
12x8	8.00	a-e	3.75	e-j	3.50	b-g	2.75	e-j
13x2	7.50	cde	3.25	g-j	2.50	fgh	2.00	hij
13x8	8.25	a-d	4.00	d-j	1.75	h	1.75	ij
13x9	9.00	a	5.25	a-f	3.25	c-h	2.50	f-j
14x15	8.50	abc	4.75	a-h	2.75	e-h	2.50	f-j
14x18	8.75	ab	4.25	c-j	3.75	b-f	3.50	c-g
14x6	8.75	ab	4.75	a-h	3.25	c-h	3.00	d-i
14x7	8.00	a-e	5.25	a-f	4.75	abc	4.00	a-e
15x2	8.25	a-d	4.00	d-j	3.25	c-h	2.75	e-j
16x17	8.75	ab	5.75	a-d	4.75	abc	4.00	a-e
16x19	8.75	ab	6.25	ab	4.50	a-d	3.75	b-f
16x4	8.50	abc	4.50	b-i	2.75	e-h	2.25	g-j
16x6	8.00	a-e	4.25	c-j	3.25	c-h	2.50	f-j
17x10	8.25	a-d	4.50	b-i	3.50	b-g	3.00	d-i
17x7	8.75	ab	4.50	b-i	2.75	e-h	2.75	e-j
18x14	8.00	a-e	2.75	ij	2.00	gh	2.00	hij
18x15	8.50	abc	4.75	a-h	3.25	c-h	3.00	d-i
18x18	7.50	cde	4.25	c-j	2.25	fgh	2.25	g-j
18x19	8.25	a-d	3.50	f-j	3.00	d-h	2.25	g-j
18x3	7.75	b-e	4.75	a-h	3.50	b-g	3.25	c-h
18x6	8.50	abc	3.25	g-j	2.00	gh	2.00	hij
19x10	8.50	abc	5.00	a-g	4.50	a-d	4.25	a-d
19x16	8.25	a-d	3.75	e-j	3.75	b-f	3.00	d-i
19x6	8.25	a-d	4.25	c-j	2.75	e-h	2.25	g-j
19x7	8.50	abc	5.50	a-e	4.50	a-d	4.00	a-e
1x9	8.75	ab	6.50	a	6.00	a	5.25	a
20-2-1F-4	8.50	abc	4.75	a-h	2.25	fgh	2.00	hij
20-2-2F-3	7.75	b-e	3.50	f-j	2.75	e-h	2.50	f-j

20-4-1F-1	7.25	de	3.75	e-j	3.00	d-h	1.75	ij
20-4-2F-2	7.75	b-e	3.50	f-j	2.25	fgh	2.00	hij
20-4-3F-4	7.50	cde	3.50	f-j	1.75	h	1.50	j
20x16	8.75	ab	5.25	a-f	3.50	b-g	3.00	d-i
20x2	8.25	a-d	4.00	d-j	3.50	b-g	3.25	c-h
20x6	7.25	de	3.75	e-j	3.25	c-h	3.25	c-h
20x7	9.00	a	5.75	a-d	4.75	abc	4.50	abc
2x10	8.25	a-d	5.50	a-e	2.50	fgh	2.25	g-j
2x14	5.50	f	2.50	j	2.00	gh	1.50	j
2x7	8.75	ab	5.75	a-d	2.75	e-h	2.00	hij
4x20	7.00	e	3.25	g-j	2.00	gh	1.75	ij
5x6	8.25	a-d	4.50	b-i	2.75	e-h	2.00	hij
6x1	8.50	abc	5.00	a-g	2.25	fgh	2.00	hij
6x2	8.25	a-d	4.75	a-h	2.25	fgh	2.25	g-j
7-1-1-4	8.50	abc	4.25	c-j	2.50	fgh	2.25	g-j
7-2-1-2	8.50	abc	5.00	a-g	2.25	fgh	1.75	ij
7-2-2F-2	9.00	a	5.25	a-f	2.25	fgh	2.00	hij
7-2-3F-4	8.00	a-e	3.50	f-j	2.00	gh	2.00	hij
7-2-4F-2	8.00	a-e	5.00	a-g	2.25	fgh	2.00	hij
7-4-1-3	8.50	abc	5.00	a-g	3.25	c-h	2.50	f-j
7-4-2F-2	8.25	a-d	5.25	a-f	2.75	e-h	2.25	g-j
7-4-3F-4	8.75	ab	5.00	a-g	3.25	c-h	2.50	f-j
8-2-1-4	8.50	abc	4.25	c-j	2.50	fgh	2.00	hij
8-2-2F-1	8.50	abc	5.50	a-e	3.00	d-h	2.50	f-j
8-2-3F-3	8.25	a-d	3.00	hij	2.00	gh	1.75	ij
8-5-1-1	8.75	ab	4.00	d-j	2.50	fgh	2.00	hij
8-5-2F-2	7.50	cde	3.25	g-j	2.50	fgh	2.25	g-j
8x11	8.25	a-d	4.50	b-i	3.00	d-h	2.75	e-j
8x16	8.25	a-d	5.75	a-d	4.50	a-d	3.25	c-h
8x19	7.50	cde	3.75	e-j	3.75	b-f	3.50	c-g
9x19	8.50	abc	5.75	a-d	4.50	a-d	3.00	d-i
Celebration	8.00	a-e	6.00	abc	5.00	ab	5.00	ab
Premier	8.00	a-e	4.50	b-i	2.25	fgh	2.25	g-j

† Leaf firing was rated on a 1 to 9 scale where 1 = total leaf firing and 9 =no leaf firing.

‡ Genotype means with the same letter in the same column are not significantly different at the p=0.05 level.

Table 17. Rank of performance of sixty-nine bermudagrass entries.

Bermudagrass Entries	Times in Top Statistical Group†	Notes
1x9	47	OSU Experimental
20x7	46	OSU Experimental
12x21	38	OSU Experimental
Celebration	38	Good drought performance standard
14x7	37	OSU Experimental
19x10	37	OSU Experimental
8x16	37	OSU Experimental
16x17	35	OSU Experimental
16x19	34	OSU Experimental
19x16	32	OSU Experimental
20x2	32	OSU Experimental
11x15	29	OSU Experimental
19x7	29	OSU Experimental
9x19	29	OSU Experimental
19x6	28	OSU Experimental
14x15	27	OSU Experimental
17x7	26	OSU Experimental
12x6	25	OSU Experimental
17x10	25	OSU Experimental
18x3	25	OSU Experimental
7-4-1-3	24	OSU Experimental
20x16	23	OSU Experimental
Premier	23	Poor drought performance standard
12x20	22	OSU Experimental
13x9	22	OSU Experimental
7-2-1-2	21	OSU Experimental
8x19	21	OSU Experimental
13x8	20	OSU Experimental
11x18	19	OSU Experimental
14x6	19	OSU Experimental
16x6	17	OSU Experimental
7-2-4F-2	17	OSU Experimental
14x18	16	OSU Experimental
12x7	15	OSU Experimental
16x4	15	OSU Experimental
7-2-2F-2	15	OSU Experimental
7-2-3F-4	14	OSU Experimental

7-4-2F-2	14	OSU Experimental
8-2-1-4	13	OSU Experimental
2x10	12	OSU Experimental
5x6	12	OSU Experimental
8-5-1-1	12	OSU Experimental
6x1	11	OSU Experimental
6x2	11	OSU Experimental
8x11	11	OSU Experimental
11x12	10	OSU Experimental
18x15	10	OSU Experimental
18x19	10	OSU Experimental
20x6	10	OSU Experimental
8-2-2F-1	10	OSU Experimental
20-2-1F-4	9	OSU Experimental
20-4-2F-2	9	OSU Experimental
2x7	9	OSU Experimental
7-4-3F-4	9	OSU Experimental
12x8	8	OSU Experimental
18x18	8	OSU Experimental
12x15	6	OSU Experimental
15x2	5	OSU Experimental
20-2-2F-3	5	OSU Experimental
20-4-1F-1	5	OSU Experimental
13x2	4	OSU Experimental
8-5-2F-2	4	OSU Experimental
18x14	3	OSU Experimental
18x6	3	OSU Experimental
7-1-1-4	2	OSU Experimental
20-4-3F-4	1	OSU Experimental
8-2-3F-3	1	OSU Experimental
2x14	0	OSU Experimental
4x20	0	OSU Experimental

†Number of times that the entry's mean appeared in the A statistical ranking group at the p=0.05 level. There were 49 total groups of data from 2012 to 2013.

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