IDENTIFICATION OF IMPROVED TRAFFIC TOLERANCE IN EXPERIMENTAL AND COMMERCIALLY AVAILABLE BERMUDAGRASS VARIETIES

By

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Title of Study: IDENTIFICATION OF IMPROVED TRAFFIC TOLERANCE IN EXPERIMENTAL AND COMMERCIALLY AVAILABLE BERMUDAGRASS VARIETIES

Major Field: HORTICULTURE

Abstract: Injury from foot traffic is one of the most challenging problems athletic field managers face in regards to the playing surface. The purpose of this research was to identify experimental as well as commercially available bermudagrasses with improved traffic tolerance for use on athletic fields. A Cady-type traffic simulator (CTS), constructed from a walk-behind core aerator, was used in providing traffic injury to bermudagrasses. In 2012 the CTS was used on each grass plot once a week, operating in a two forward pass mode, representing one game per week. Traffic applications in 2012 were administered from May through October. In 2013, a one game per week and a two game per week treatment, operating in a two and four forward pass mode, respectively, was evaluated on all cultivars. A total of 24 commercially available and 16 experimental bermudagrass entries were evaluated for traffic tolerance during the two years of this research. Spring green-up [SG] (1-9 scale, 9=best, 6=satisfactory) was assessed in 2013. In 2012 and 2013, turfgrass quality [TQ], and traffic tolerance [TT] was assessed using a 1 - 9 visual ratings scale (9=best, 6=satisfactory performance) as well as visual live percent cover [PLC] and digital image analysis [DIA] for percent living cover on a weekly basis immediately prior to the next traffic event. Significant entry x date effects were found in both years for TQ, TT, PLC and DIA. Entry x date x game effects were never significant but a highly significant entry x game effect was found for TT and PLC. Cultivars having the best overall traffic tolerance included ‘Riviera’, ‘NorthBridge’, ‘Latitude 36’, and ‘SWI 1057’. Varieties having lower traffic tolerance included ‘Midlawn’, ‘NuMex-Sahara’, and ‘SWI-1117’. Results of this work should aid sports field managers in the south central Great Plains region in selecting bermudagrass cultivars that have improved traffic tolerance.

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CHAPTER I

Literature Review

Bermudagrasses (*Cynodon* species) are used widely as turfgrasses in the southern United States, Australia, Africa, India, China, and South America. These grasses are adapted to the sub-tropical and tropical regions in the world. In the 1700s, common bermudagrass (*C. dactylon*) was introduced to the warmer regions of the United States from India and Africa (Deputy et al., 1998). Bermudagrasses are extensively used on home lawns, athletic fields, and golf courses. This grass is also used extensively along roadways, waterways, and other potential erosion sites in order to protect the soil. Bermudagrass can furthermore be used as forage for livestock and as a means of hay production.

Bermudagrass is a warm season, perennial grass genus which spreads vegetatively by stolons, rhizomes, and shoots. It has a narrow and continuous collar with hairs, a ligule with a fringe of hairs about one to three mm long and auricles are absent. The vernation of turf-type bermudagrasses is folded, with the leaf blade being 1.5 to 4 mm wide. Standard bermudagrass cultivars may vary in a number of characteristics. This grass grows best at moderate to high temperatures around 80 to 95 degrees F (Bell, 2011).

Bermudagrass has the dynamic ability to withstand heat, drought, and traffic and has few damaging insect or disease problems when compared with other warm-season or cool-season grasses (Han, 2009). However, bermudagrass does not grow well in shade. As light decreases, bermudagrass develops narrow, elongated leaves; thin upright stems; elongated internodes, and weak rhizomes (Bell, 2011). Spring dead spot and winter injury are two very common issues which affect bermudagrass in the transition zone (portions of USDA cold hardiness zones 5b, through 7a where grasses experience colder winters than the Southern United States (USDA cold-hardiness zones 8-10) (Taliaferro et al., 2004). Two fungi, *Ophiosphaerella herpotricha* and *Ophiosphaerella korrae* are the principal causal agents of spring dead spot in Oklahoma (Walker, 2013). Infection of vulnerable grasses begins in late September and will persist as long as soil temperatures are above 50° F in Oklahoma.

Sports turf and golf course applications have vastly different needs and resources to manage the grasses and uphold higher standards of turf excellence than what is expected of most home lawns, parks, and commercial grounds (Han, 2009). Bermudagrass used for athletic purposes is normally more intensively managed than any other type of situation. Turfgrass on athletic sites is expected to have high density, deep green color, and grow quickly (Martin et al., 2007). On sports fields and golf course grounds, turfgrass cover may be damaged or otherwise disturbed by the various sporting activities that take place on the turf. If a golf club removes a divot out of a fairway or a cleat takes a chunk out of a field and the bermudagrass is slow to recuperate, then other plants (weeds) have the opportunity to invade the playing surface.

Traffic Tolerance

Traffic can be defined as injury to a turfgrass stand from pressure, tearing, and scuffing directly on the tissues (Robinson, 2005). Field wear is a function of several factors such as size of athletes, intensity of use, turf density, turf regrowth and soil moisture at the time of events (Powell, 2006). The outcome of increasing the intensity of traffic and wear is to cause increasing damage to the soil through soil compaction and physical damage to the overall turf stand. In the first phases of compaction there may be little damage to soil structure but increasing amounts of traffic leads to compaction which is from deformation and destruction of the soil aggregates (Canaway, 1976). Soil compaction occurs mostly in the more violent sports such as football, where the application of large horizontal forces to the turf causes the surface of the soil to be smeared out as happens in a case of the sliding tackle in soccer (Henderson et al., 2005). It is the damage to the grass component of turf which is perhaps most immediately apparent to the user and is likely to cause more concern than soil compaction which may, however, be more troublesome in the long run, and increase the susceptibility of the grass to further wear (Canaway, 1976). Abrasion and tearing of leaf tissue causes damage to the protective cuticle which provides pathogens a manner of entry and dropping plant water use efficiency.

The grass and the soil are affected in different ways. The mechanisms are so interdependent that an effect on one produces an indirect effect on the other. Turf exposed to heavy amounts of traffic eventually develops bare soil spots. The bare spots are the result of compressed soils and chronic plant injury. Bare spots allow more light penetration and less moisture competition to weed seeds, ultimately increasing the

susceptibility to weed infestations (Trenholm et al., 2000). Soil compaction is the most well studied cause of soil structure damage associated with wear.

Anatomical and morphological features may determine the degree of wear tolerance among different species and cultivars; physiological factors may also be important but experimental evidence is lacking. Studies have shown that turfgrass species that have both rhizomes and stolons, along with dense above ground growth, are better adapted to withstand greater amounts of traffic (Beard, 1973). It is thought that the amount and distribution of sclerenchyma, which is a supportive or protective tissue, composed of thickened, dry, and hardened cells (Shearman and Beard, 1975), and other strengthening tissues are factors influencing turfgrass wear tolerance. Little is known about the physiology of wear tolerance. A study of leaf percentage moisture and percentage relative turgidity showed no correlation with the observed wear tolerance of the seven species studied (Canaway, 1976). Environmental factors may also decrease wear tolerance. Those that reduce recovery are specifically targeted. For instance, low light intensity caused by shading is known to reduce wear tolerance (Canaway, 1976).

Recovery from wear is the highest during the summer when bermudagrass growth rates are at their highest. Winter sports, particularly football, impose far greater wear pressure on playing surfaces at a time of year when bermudagrass growth is slowest. When the climate is cooler, bermudagrass growth may be halted for several months. Resistance to wear is one of the most important components to consider when establishing a sports field (Roche et al., 2009). The first bermudagrass trial for wear tolerance was conducted by Beard et al. (1981). Effects were quantified by analyzing the amount of verdure remaining after traffic had been induced upon the turfgrass.

Numerous traffic simulation devices and techniques have been developed to mimic real world athletic field traffic (Younger, 1961; Shildrick, 1971; Sherman et al., 1974; Canaway, 1976; Bourgoin and Mansat, 1981; Cockerham and Brinkmann, 1989; Carrow et al., 2001; Shearman et al., 2001; Kowalewski et al., 2013). Traffic simulators developed in previous years have proven to induce consistent and reproducible traffic, but the traffic they create is not similar to the normal wear that takes place on an athletic field (Henderson et al., 2005). Previous simulators have used a rolling drum type apparatus to apply traffic. The rolling style application is more oriented for dual vector versus the three vector forces needed to correctly portray athletic field traffic. For the purpose of this review only the most used previous traffic devices will be discussed.

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The brinkman traffic simulator (BTS) is a drawn-type traffic simulator that is used widely in the U.S. as an athletic field traffic simulator (Cockerham and Brinkman 1989). This machine utilizes differentially connected studded drums to create traffic stress over large plot areas very quickly, but it must be pulled over the plots. The BTS is normally pulled with a tractor or some type of utility vehicle which causes extra soil compaction and traffic damage. This extra compaction and traffic damage is one of the negative aspects of the BTS. Previous research with the BTS determined it produces 300 cleat marks m^{-2} $pass^{-1}$ (Cockerham and Brinkman, 1989; Henderson et al., 2005).

Differential-Slip Traffic Simulator & GA-SCW

Canaway (1976) used a differential slip drive to cause more realistic tearing of the turfgrass canopy and soil surface by modifying a rotary tiller into a traffic simulation device using studded rollers mounted on two axels (Hoiberg, 2012). Carrow et al. (2001)

developed a device at the University of Georgia (GA), which accomplishes both soil compaction (SC) and wear (W) (Hoiberg, 2012). The GA-SCW provides compaction from the weight of the machine and wear from the differential slip action of the middle cleated drum (Carrow et al., 2001). The GA-SCW is a self-propelled unit and can be operated in both forward and reverse to speed application of simulated traffic over large areas.

Baldtree Traffic Simulator

The Baldtree traffic simulator is an adapted Ryan GA 30, riding aerification unit prepared with fabricated, spring loaded steel plate feet studded with screw in cleats (Kowalewski et al., 2013). The Baldtree traffic simulator is a durable yet versatile tool capable of being operated at various ground speeds and directions to produce simulated athletic field traffic. Recent research on the Baldtree Traffic Simulator shows increased force activity and an increase in the number of cleat marks per pass with the modified aerator. Since the Baldtree traffic simulator produces considerably more cleat marks per pass and ground reaction force than the BTS and Cady Traffic Simulator (CTS), the device is useful for researchers looking to simulate heavy athletic field traffic in a limited number of passes (Kowalewski et al., 2013). It should be noted that the Baldtree traffic device wasn't in production until after this research trial had been initiated.

Athletic Field Traffic Evaluation

The traffic tolerance of commercially available seeded and vegetative hybrid bermudagrasses has been evaluated previously. Goddard et al. (2008) reported that 'Tifway' (*C. dactylon* X *C. transvaalensis*) and 'Riviera' (*C. dactylon*) exhibited better traffic tolerance than 'Quickstand', using the CTS at the University of Tennessee-

Knoxville. Trappe et al. (2009) at the University of AR at Fayetteville reported that Riviera, 'TifGrand', and Tifway exhibited the best traffic tolerance in a study of 42 bermudagrasses using the CTS. Traffic tolerance work at the University of Florida at the Plant and Soil Science Research Station in Citra, FL suggested that Celebration and TifGrand maintained the highest density under traffic simulation using the CTS, while Celebration was found to have the overall best wear tolerance when evaluated by digital image analysis (DIA) using a light box (Williams et al., 2010).

A traffic tolerance study was conducted at the University of Kentucky at Lexington from May 2007 to November 2008. Bermudagrass varieties evaluated included Quickstand, 'Yukon', Riviera, and Tifway. The object of that study was to compare the traffic tolerance of overseeded bermudagrass with non-overseeded bermudagrass (Deaton and Williams, 2010). Traffic applications were applied using the BTS. An analysis of results, using only visual percent live cover, revealed that regardless of overseeding, Riviera and Tifway performed significantly better overall than Quickstand or Yukon.

In the summer and fall of 2007 and 2008, a traffic tolerance study was conducted at the University of Arkansas at Fayetteville on the 2002 NTEP Bermudagrass Trial. Traffic was applied once per week for four or five consecutive weeks with the CTS using four forward directional passes (Trappe et al., 2011). Commercially available cultivars Celebration, 'Midlawn', 'Premier', 'Princess 77', 'Patriot', Riviera, 'Sunsport', TifGrand, 'TifSport', Tifway, 'Veracruz' and Yukon were in the top statistical category for turfgrass digital image coverage in the summer of both 2007 and 2008 based on the turf performance index (Trappe et al., 2011). The experimental genotype 'OKC 70-18' was

also included in the top statistical category. Fall traffic tolerance response was difficult to assess due to freeze injury to the grass canopy and cessation of growth due to winter dormancy. Fall results were not as vast as the summer results with only Celebration and Premier being included in the top statistical group. Only cultivars included in the 2007 NTEP Bermudagrass Trial were discussed in this review of literature since the focus of this thesis research was conducted on entries in the 2007 NTEP bermudagrass trial.

Traffic trials at North Carolina State University at Raleigh evaluated wear tolerance on seven rating dates during August and September. 'Latitude 36' was at the top for wear tolerance ratings on six of the seven rating dates, with each rating finishing within the top statistical group. Other entries to finish in the top statistical group for each rating date were 'NorthBridge', Premier and Tifway (Morris, 2011). Ratings are based on visual traffic tolerance and quality ratings from 1-9 (9=best, 6=minimum satisfactory quality) that follow the NTEP measurement guidelines.

The objectives of this thesis research were to evaluate 31 official cultivar entries from the 2007 NTEP bermudagrass trial plus nine local entries for visual quality, visually assessed traffic tolerance, visually assessed percent living cover and digitally assessed percent living cover following traffic with the Cady traffic simulator at Stillwater, OK. Work by Goddard et al. (2008), Deaton and Williams (2010), Williams et al. (2010), Morris (2011), and Trappe et al. (2011), suggested that Tifway, Latitude 36, Riviera, NorthBridge, Celebration, Premier and TifGrand were ideal candidates for use as commercial standards when evaluating the traffic tolerance of experimental bermudagrasses. Those varieties were present in this research. By evaluating numerous

bermudagrass cultivars for traffic tolerance we will be able to more effectively make suggestions for athletic field managers to ensure an improved playing surface.

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CHAPTER II

Evaluation of 40 Bermudagrass Entries for Traffic Tolerance

Literature Review

Bermudagrasses (*Cynodon* species) are a principal species used as turfgrasses in the southern United States, Australia, Africa, India, China, and South America. These grasses are adapted to the sub-tropical and tropical regions in the world. In the 1700s, common bermudagrass (*C. dactylon*) was introduced to the warmer regions of the United States from India and Africa (Deputy et al., 1998). Bermudagrasses are extensively used on home lawns, athletic fields, and golf courses. This grass is also used extensively along roadways, waterways, and other potential erosion sites in order to protect the soil. Bermudagrass can furthermore be used as forage for livestock and as a means of hay production.

The National Turfgrass Evaluation Program (NTEP), headquartered at Beltsville, MD, is an example of a private not-for-profit organization that connects cultivar breeders and researchers with the commercial and end user component of the turfgrass industry. The NTEP facilitates the coordination of cultivar research trials which are conducted at select sites across the United States. These trials have established and regulated guidelines to protect the consistency and reliability of the research and turfgrass

maintenance methods. The following information is taken from other traffic studies in different areas of the United States. Trials, of all kinds, should be conducted in different climatic regions in order to test bermudagrass response to different conditions. Data from different climatic regions will insure the selection of an appropriate cultivar for any situation.

Numerous traffic simulation devices and techniques have been developed to mimic real world athletic field traffic (Younger, 1961; Shildrick, 1971; Sherman et al., 1974; Canaway, 1976; Bourgoin and Mansat, 1981; Cockerham and Brinkmann, 1989; Carrow et al., 2001; Shearman et al., 2001; Kowalewski et al., 2013). Traffic simulators developed in previous years have proven to induce consistent and reproducible traffic, but the traffic they create is not similar to the normal wear that takes place on an athletic field (Henderson et al., 2005). Previous simulators have used a rolling drum type apparatus to apply traffic. The rolling style application is more oriented for dual vector versus the three vector forces needed to correctly portray athletic field traffic. For the purpose of this review only the most used previous traffic devices will be discussed.

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negative aspects of the BTS. Previous research with the BTS determined it produces 300 cleat marks m^{-2} $pass^{-1}$ (Cockerham and Brinkman, 1989; Henderson et al., 2005).

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The traffic tolerance of commercially available seeded and vegetative hybrid bermudagrasses has been evaluated previously. Goddard et al. (2008) reported that 'Tifway' (*C. dactylon* X *C. transvaalensis*) and 'Riviera' (*C. dactylon*) exhibited better traffic tolerance than 'Quickstand', using the CTS at the University of Tennessee-Knoxville. Trappe et al. (2009) at the University of AR at Fayetteville reported that Riviera, 'TifGrand', and Tifway exhibited the best traffic tolerance in a study of 42 bermudagrasses using the CTS. Traffic tolerance work at the University of Florida at the Plant and Soil Science Research Station in Citra, FL suggested that Celebration and TifGrand maintained the highest density under traffic simulation using the CTS, while 'Celebration' was found to have the overall best wear tolerance when evaluated by digital image analysis (DIA) using a light box (Williams et al., 2010).

A traffic tolerance study was conducted at the University of Kentucky at Lexington from May 2007 to November 2008. Bermudagrass varieties evaluated included Quickstand, 'Yukon', Riviera, and Tifway. The object of this study was to compare the traffic tolerance of overseeded bermudagrass with non-overseeded bermudagrass (Deaton and Williams, 2010). Traffic applications were applied using the BTS. An analysis of results, using only visual percent live cover, revealed that regardless of overseeding, Riviera and Tifway performed significantly better overall than Quickstand or Yukon.

In the summer and fall of 2007 and 2008, a traffic tolerance study was conducted at the University of Arkansas at Fayetteville on the 2002 NTEP Bermudagrass Trial. Traffic was applied once per week for four or five consecutive weeks with the CTS using four forward directional passes (Trappe et al., 2011). Commercially available cultivars Celebration, 'Midlawn', 'Premier', 'Princess 77', 'Patriot', Riviera, 'Sunsport', TifGrand, 'TifSport', Tifway, 'Veracruz' and Yukon were in the top statistical category for turfgrass digital image coverage in the summer of both 2007 and 2008 based on the turf performance index (Trappe et al., 2011). The experimental genotype 'OKC 70-18' was also included in the top statistical category. Fall traffic tolerance response was difficult to assess due to freeze injury to the grass canopy and cessation of growth due to winter dormancy. Fall results were not as vast as the summer results with only Celebration and Premier being included in the top statistical group. Only cultivars included in the 2007 NTEP Bermudagrass Trial were discussed in this review of literature since the focus of this thesis research was conducted on entries in the 2007 NTEP bermudagrass trial.

Traffic trials at North Carolina State University at Raleigh evaluated wear tolerance on seven rating dates during August and September. 'Latitude 36' was at the top for wear tolerance ratings on six of the seven rating dates, with each rating finishing within the top statistical group. Other entries to finish in the top statistical group for each rating date were 'NorthBridge', Premier and Tifway (Morris, 2011). Ratings are based on visual traffic tolerance and quality ratings from 1-9 (9=best, 6=minimum satisfactory quality) that follow the NTEP measurement guidelines.

The objectives of this thesis research were to evaluate 31 official cultivar entries from the 2007 NTEP bermudagrass trial plus nine local entries for visual quality, visually

assessed traffic tolerance, visually assessed percent living cover and digitally assessed percent living cover following traffic with the Cady traffic simulator at Stillwater, OK. Work by Goddard et al. (2008), Deaton and Williams (2010), Williams et al. (2010), Morris (2011), and Trappe et al. (2011), suggested that Tifway, Latitude 36, Riviera, NorthBridge, Celebration, Premier and TifGrand were ideal candidates for use as commercial standards when evaluating the traffic tolerance of experimental bermudagrasses. Those varieties were present in this research. By evaluating numerous bermudagrass cultivars for traffic tolerance we will be able to more effectively make suggestions for athletic field managers to ensure an improved playing surface.

Materials and Methods

Description of Research Site and Entries

Research was conducted on test Block F-7 (Latitude 36° 7'27.12"N, Longitude 97° 6'6.25"W) which was the 2007 – 2012 NTEP Bermudagrass Trial, at the Oklahoma State University Turfgrass Research Center on the grounds of the Oklahoma Botanic Garden, 1.6 km west of Stillwater, OK. The soil types present within the block consisted of an Easpur loam (Fine-loamy, mixed, superactive, thermic Flueventic Haplustoll) and Pulaski fine sandy loam (coarse-loamy, mixed, superactive, nonacidic, thermic Udic Ustifluvents) (USDA-NRCS, 2013).

Seeded and vegetative entries in the trial were originally planted by seed and plugs, respectively, in August of 2007. In 2008 – 2011 the trial was fertilized with a total of 195 kg N ha^{-1} yr^{-1} (4.0 lbs. of N 1,000 $ft.^2$ yr^{-1}), mowed at 1.3 cm (0.5 inches) approximately three times wk^{-1} and irrigated as needed to avoid drought stress.

During 2007-2011 an unsuccessful attempt was made to effectively establish populations of the fungus *Ophiosphaerella korrae,* one of the three casual agents of spring dead spot disease (Walker, 2013), so as to screen the entries for resistance/tolerance to the disease. In that prior trial on the test site, all entries were inoculated in September 2007 with a blend of three virulent isolates of *O. korrae*... Three inoculation sites per plot were conducted in a diagonal. Inoculation sites were marked with a number 13 AWG wire bent in a shape of the number 9 and buried at the inoculation site. The rounded portion was flattened to be perpendicular to the stem of the nine, and then the wire was inserted in the middle of each inoculation core. This method

of marking allowed for later use of a metal detector to locate the original inoculation site. Symptoms of the disease from this specific organism failed to materialize at the test site.

There were 40 total entries in this research trial conducted for traffic tolerance. Thirty-one of these were official entries in the 2007 NTEP bermudagrass trial and nine were local entries specific to this trial but not the 2007 NTEP bermudagrass trial. By the end of this trial in fall 2013, 19 entries were commercially available and 21 remained experimental. Commercially available official 2007 NTEP bermudagrass trial entries included Riviera, Princess 77, 'Nu-Mex Sahara', Midlawn, Tifway, 'Gold Glove', Sunsport, Patriot, Latitude 36, NorthBridge, 'Pyramid 2', 'Hollywood', Yukon, Veracruz, and 'Royal Bengal'. Local entries that were not officially entered in the 2007 NTEP bermudagrass trial but were available commercially in Oklahoma or the U.S. and present in this traffic tolerance trial were U-3 from the Tulsa Grass and Sod Farm located at Tulsa, OK ('U-3 TGS'), U-3 from the former Northcutt Sod Farm at Lexington, OK ('U-3 NC'), U-3 from the Southern Illinois University at Carbondale ('U-3 SIU'), TifGrand, Celebration, Quickstand, and 'Astro'. Official 2007 NTEP bermudagrass entries that were not commercially available by the end of the trial were Premier, 'SWI-1070', 'SWI-1081', 'SWI-1083', 'SWI-1113', 'SWI-1117', 'SWI-1122', 'SWI-1057', 'BAR 7 CD5', 'RAD-CD1', 'OKS 2004-2', 'PSG 91215', 'PSG 94524', 'IS-01-201', 'PSG PROK', 'PSG 9Y2OK', and OKC 70-18. Local entry 'OKS 2004-3' remained non-commercialized by the end of the trial.

Cultural Management

The nitrogen fertilizer regime used in this trial was 244 kg ha^{-1} (5 lbs. N 1,000 ft^{-2}) per growing season, which lasted from April-September in 2012 and 2013.

Phosphorus and potassium were optimized by fertilizations determined after soil testing. The target optimum phosphorus and potassium test indices using the Melich III test were 72 kg ha^{-1} (65 lbs. P $acre^{-1}$) and 280 kg ha^{-1} (250 lbs. K $acre^{-1}$) respectively or slightly above.

Plots were mowed three times a week with a reel mower at 2.54 cm (1 in). This mowing height was chosen due to the common use of it on intensively managed athletic fields. Plots were irrigated each week as necessary to replace evapotranspiration and to prevent wilting. As a weed control regime, a split application of oxadiazon (Ronstar 2G, Bayer, NC) at 96.8 kg ha^{-1} + 96.8kg ha^{-1} (2 lbs. ai $acre^{-1}$) was be applied since severe traffic damage was expected (Table 2). Oxadiazon does not inhibit adventitious root formation on stolons growing over the damaged area. In order to control disease, a preventative split application of fungicides was also applied (approximately September and October) to control the fungi that are responsible for causing spring dead spot disease (Table 2).

Construction of the Cady Traffic Simulator

The Cady traffic simulator (CTS) was used to apply the traffic factor in this research trial. The first CTS was developed at Michigan State University by Jason Henderson. Our version of the CTS was created by modifying a Jacobsen T-1224 walk behind aerator in this research study (Fig. 1a). The aerating tines were removed and replaced with a “foot” like apparatus that was used to create the amount of traffic necessary (Fig. 1b). The “foot” of the CTS was held together by two steel plates that are 13.9 x 10.6 x 0.95 cm, these plates were attached to a looped tire section.

To create the traffic, a set of five bolts were used on the bottom of each piece of steel. These 0.95 cm grade 8 hardened steel bolts were used to create traffic using a 1.95 cm protruding end which penetrated the ground during administration of the traffic factor. The feet alternately strike the ground as the machine moved over the turf surface producing dynamic forces in three directions (Henderson et al., 2005).

Tires were cut into pieces of 45.97 x 13.9 cm using a reciprocating saw and a metal band saw. The tires acted as a flex device which simulates a more realistic foot impact of an athlete. The first sets of "feet" were made with a steel belted tire. After approximately four weeks of Cady traffic simulator usage, the tires fractured near the outer edge of the top steel plate. The second set of "feet" were made with the same tire to use the resources that had already been purchased for the project and to insure uniform administration of the traffic factor over all replications of entries during the traffic administration event during which the foot fracture occurred. Since it was assumed that the tires would again break in another three to four weeks, a 750/16 nylon belted, 10 ply tire was purchased to replace the steel belted tire. The tires used for the remainder of this research trial were Kumho 225 brand, 8 ply, load range D (Kuhmo Tire U.S.A). The CTS is able to operate in two directions; forward and reverse. However, it was only operated in the forward direction in this research trial due to border conditions between individual plots in this research trial. The CTS has shown excellent promise of becoming a tool for athletic field researchers due to suitable administration of simulated foot traffic and injury as can be seen in Figure 1c. The aggressiveness of the CTS increases wear beyond that of traditional traffic simulators, which is its primary advantage to its use. The design of the self-propelled unit also makes it maneuverable, enabling its use in restricted

areas. However, there is still room for enhancement. The CTS has a slow operating speed and narrow effective swath making traffic applications to large areas (greater than 740 m^2) impractical. The CTS also has more moving parts than traditional simulators making potential down time (breakdowns) a greater possibility (Henderson et al., 2005). Two passes with the CTS creates the same number of cleat marks per square meter that one National Football League (NFL) game is estimated to produce between the hash marks at the 40-yard line (Henderson et al., 2005).

Traffic Application

Traffic was applied as a strip application at one level in 2012 and at two levels in 2013. A portion of each plot was left un-trafficked in 2012 and 2013 to leave as a relative control for comparison. However, the untreated portion of the plot was not evaluated, only used as a practical reference for maintenance of the plots. Each traffic application used only the forward direction by the CTS. The forward direction of the CTS was used due to speculation that the reverse direction would damage the CTS due to border conditions in plot areas. In 2012, traffic applications were made weekly, as allowed, from May to October at a one game per week level which consisted of two forward direction passes by the CTS (Henderson et al., 2005). The two forward directional passes created a significant amount of traffic but we did not feel enough separation of cultivar response to traffic stress occurred at the one game per week level in 2012 so an additional traffic level treatment factor was added in 2013. In 2013, traffic applications were made weekly, as allowed, from May to October at the one game per week level and at a two game per week level. A two game level application consisted of four forward directional passes by the CTS. Two passes with the CTS creates the same

number of cleat marks per square meter that one National Football League (NFL) game would produce between the hash marks at the 40-yard line (Henderson et al., 2005).

In 2013, plots were not trafficked for the weeks of 5 and 19 August due to environmental conditions and two mechanical breakdowns. Traffic was resumed on 12 and 26 August, but the absence of traffic for these weeks could have had an effect on weekly results. To make up for the absence of traffic during August, consecutive traffic applications were made to account for those missed events due to complications. The addition of the four pass treatment allowed for a significant amount of separation between grass varieties. This additional treatment was necessary in order to create a more extreme amount of damage on the plots to aggressively measure the bermudagrass' traffic tolerance.

Visual Evaluation Parameters

The NTEP cooperators use a visual rating system to estimate different parameters for measurement (Morris and Shearman, 2000). For this bermudagrass cultivar evaluation study, a rating system based upon the guidelines prepared by NTEP was selected.

Four types of visual measurements were conducted during this study. In order to keep them consistent, all of the visual measurements were taken by one evaluator. Below is a description of how each measurement was made and the frequency of assessment.

Spring Green-up (SG)

Green-up is a measure of the transition from winter dormancy to active spring growth. It is based on plot color not genetic color. The visual rating of spring green-up is based on a 1 to 9 rating scale with 1 being straw brown and 9 being dark green. Spring green-up was measured until most grass plots were a 6 or higher or until administration

of the traffic factor commenced. Spring green-up data is only presented in 2013 and was taken for five weeks.

Turfgrass Quality (TQ)

Turfgrass Quality is based on 9 being outstanding or ideal turf and 1 being poorest or dead. A rating of 6 or above is generally considered minimally acceptable. A quality rating value of 9 is reserved for a perfect or ideal grass, but it also can reflect a completely exceptional treatment plot. The NTEP requires quality ratings on a monthly basis. Quality ratings take into account the aesthetic and practical aspects of the turf. Quality ratings are not based on color alone, but on a combination of color, density, uniformity, texture, and disease or environmental stress (Morris and Shearman, 2000). Visual measurements were made every two-three weeks in this category.

Traffic Tolerance (TT)

Traffic tolerance is the combination of wear and compaction stress that occurs whenever a turf is exposed to foot or vehicular traffic. Wear injury occurs immediately upon trafficking a turf. Wear injury symptoms are often expressed within hours and definitely within days. Compaction stress injury is more chronic, it is expressed over time. The NTEP reports traffic tolerance as visual estimate of turfgrass tolerance using a 1 to 9 rating scale with 1 being no tolerance or 100% injury, and 9 being complete tolerance or no injury (Morris and Shearman, 2000). This research trial is only concerned with the immediate wear injury symptoms caused by traffic application. This visual evaluation parameter is valuable because it allows the evaluator to see the immediate effect of the traffic application on the overall plot, not just the amount of live green cover. Traffic injury is not always able to be seen in a photograph, a percent live green cover

rating, or a quality rating. Traffic tolerance ratings are important because of these aforementioned factors. Visual traffic tolerance measurements were taken every two-three weeks in this category.

Visual Percent Live Green Coverage (PLC)

Visually evaluated percentage living ground cover is based on surface area covered by the originally planted species [0 to 100%]. It is generally used to express damage caused by disease, insects, weed encroachment, or environmental stress. In this research trial it was used to express damage caused by traffic applications from the CTS. The visual live green cover is often rated in the spring, summer, and fall. This timing allows one to track the turfgrass response to various stresses during the growing season (Morris and Shearman, 2000). Digital image analysis was used in order to determine living ground cover as well; visual measurements were taken as a rough check upon the accuracy of the digital analysis and relevance to those of the digital analysis. Visual measurements were made every two-three weeks in this category.

Digital Evaluation (DIA)

Digital image analysis provides an objective method of measuring percent live green turfgrass coverage and comparing turfgrass response to injury and its relative recovery rate. The goal of digital image analysis was to remove human subjectivity with injury ratings or trafficked turfgrass to a predetermined end point. Prior to the first applied traffic, digital images were taken of each plot to record live green cover for later analysis. Digital image capture for live green cover determination was performed before each simulated traffic event. The software used to analyze the digital images was SigmaScan Pro 5.0 (Systat Software, Chicago, IL). A turf analysis macro was developed

for the program by Dr. Mike Richardson and Dr. Doug Karcher from Arkansas (Richardson et al., 2001). This macro allows the live green cover to be correctly determined by the SigmaScan software.

Photos were taken in a natural light setting between the hours of 09:00-12:00 and 14:00-17:00 Central time zone depending on sun position to ensure no shadows were present. Since photos were taken at different times of the day throughout this research trial Sigma Scan settings were altered when necessary to assure the most truthful scan was delivered. Hue settings used to analyze photos were between 35-100 and 40-100 depending on the daylight situation during the day that digital images were taken.

Statistical Analysis

Cultivars within field trials were planted in a randomized complete block design (RCB) with 3 replications. The RCB was the best experimental design for this situation. The field or orchard is divided into units to account for organized sources of variation in the field not due to experimental treatment. Treatments are then assigned at random to the experimental units in the blocks-once in each block. In 2012, the study was set up in a split plot in time design. The main plots were the cultivar of bermudagrass and subplots were rating dates within cultivars. In 2013, the study was set up in a split block, split in time with traffic regimes as main plots, cultivars as subplots and rating dates within traffic by cultivar plots as sub-sub plots due to adding an extra traffic application. Statistical analysis was conducted to assess the effects of the independent variables cultivar, block, and evaluation date, as well as their interactions with respect to the dependent variables SG, TQ, TT, PLC, DIA using Statistical Analysis Systems Software version 9.3 (SAS, Cary, NC, 27513) for the personal computer. An Analysis of Variance

(ANOVA) procedure was performed using SAS 9.3 software General Linear Models Procedure Proc GLM. This analysis also used Fisher's Protected LSD test to compare cultivar means within dates within seasons when the F-test deemed appropriate (at $P \leq 0.05$). Protection means that you only use the mean separation procedure when the appropriate ANOVA F-test of the specified independent variable resulted in a P value less than or equal to 0.05. If the P value for the ANOVA F-test was greater than 0.05, which was used in this study as the significant value, it was concluded that the data are consistent with the null hypothesis that all population means are identical.

Turf Performance Index

A Turf Performance Index (TPI) has been used by multiple researchers, including Trappe et al. (2011), as a method to identify top performing cultivars with respect to a performance parameter. The TPI was determined for each entry with respect to each evaluation parameter in cases where statistical significance for that parameter was found. For the purpose of this study, a ranking in the highest statistical category refers to the number of times varieties appeared in the "a" statistical group.

Results and Discussion

Results of this research are grouped and presented by data type. Yearly data are discussed sequentially in regard to each evaluation parameter.

2012 Results

In 2012, the 2007 NTEP Bermudagrass Trial received a one game per week treatment with the CTS from May - October. A summary concerning the results of ANOVA testing performed upon the dependent parameters evaluated is shown in Table 3. Analysis of turfgrass quality revealed that there were highly significant date and entry by date effects (Table 3). Concerning traffic tolerance, there were highly significant entry, date, and entry by date effects. In regard to visual percent live cover; there were highly significant entry, date, and entry by date effects. Concerning digital image analysis, there were highly significant entry, date, and entry by date effects.

Turfgrass Quality

Significant differences amongst varieties were present on three out of nine rating dates (Table 4). Hollywood, Quickstand, and U-3-NC rated higher than standards Tifway, Premier, Patriot, TifGrand, and Celebration on two out of three significant rating dates. Turfgrass quality was very similar among all entries with only small significant differences between top and bottom performing varieties. An accepted quality rating is a 6 on a 1-9 rating scale. Latitude 36 had the most rating dates below an acceptable quality rating than all other entries in this trial at four dates below a 6. However, Patriot, Midlawn, and Pyramid 2 were the only cultivars to have a quality rating below 5 throughout all rating dates, including no significant dates.

Traffic Tolerance

Significant differences amongst varieties were present on six out of nine rating dates (Table 5). Riviera and SWI-1057 rated higher than NorthBridge and OKC 70-18 on one out of six rating dates. Riviera, SWI-1057, NorthBridge, and OKC 70-18 rated higher than Patriot, Latitude 36, and Celebration on two out of six rating dates. Nu-Mex Sahara, Tifway, Premier, Midlawn, Yukon, TifGrand, U-3-SIU, SWI-1117, BAR 7CD5, PST-R6FLT RAD-CD1, and U-3-TGS rated the lowest amongst varieties being significantly worse than Riviera and SWI-1057 on at least five out of six rating dates. Varieties Tifway, Premier, RAD-CD1, and U-3 TGS were the lowest overall rated varieties rating lower than top performing varieties on six out of six dates; at least two out of nine traffic tolerance ratings were below acceptable for every variety mentioned. Varieties such as NuMex-Sahara and Tifway had five unacceptable traffic tolerance ratings. Similar to findings at NC State, Riviera and NorthBridge performed high in visual traffic tolerance ratings reported by Morris (2011). However, in contrast to the findings at NC State, reported by Morris (2011), Tifway and Premier did not perform as well as Riviera and NorthBridge in this research trial.

Visual Percent Live Cover

Significant differences amongst varieties for PLC were present on seven out of nine rating dates (Table 6). Riviera, NorthBridge, and SWI-1057 rated significantly better than Princess 77, Celebration, OKC 70-18, Hollywood, SWI-1083, SWI-1113 and OKS 2004-3 on one out of seven rating dates. These 10 top performing varieties rated higher than Tifway and Patriot on at least three rating dates and higher than Latitude 36 on four out of seven dates. Consistent with findings at the University of Kentucky (Deaton and

Williams, 2010), Riviera was one of the top performers for visual PLC ratings. However, in contrast to the findings of Deaton and Williams (2010) at the University of Kentucky, Tifway did not perform as well as Riviera in this research trial. Midlawn and SWI-1117 were the poorest performing varieties overall concerning visual percent live cover ratings.

Digital Image Analysis

Significant differences amongst varieties were present on 12 out of 19 rating dates (Table 7). The DIA data identified many top performing varieties for digital PLC including Riviera, Princess 77, Royal Bengal, Celebration, Quickstand, and Pyramid 2 rated higher than NorthBridge, Hollywood, and Astro on one out of 12 rating dates. These nine top performing varieties rated higher than Tifway and TifGrand on three out of 12 dates and higher than Latitude 36 and Patriot on four out of 12 dates. Midlawn and SWI-1117 rated significantly lower than all other cultivars on four out of 12 rating dates. SWI-1117 and NuMex-Sahara were the poorest performing varieties overall, rating lower than top performing varieties on nine and eight dates out of 12, respectively.

Turfgrass Performance Index (TPI)

A summary of the performance among cultivars based on the number of times each appeared in the top statistical group ("a" group) for a given parameter appears in Table 8. An analysis of turfgrass quality revealed Hollywood, Quickstand, and U-3-NC appeared in the top statistical group more often than any other cultivar in this trial at three out of nine times compared to other cultivars that were in the top statistical group one and two times out of three (Table 8). Concerning visual traffic tolerance, Riviera and SWI-1057 appeared in the top statistical group more often than all other cultivars in this trial at six out of six times followed by SWI-1083, NorthBridge, and OKC 70-18 at five out of

six times (Table 8). Nu-Mex Sahara, Tifway, Premier, RAD-CD1, and U-3-NC appeared the least amount of times in the top statistical group at 0 out of six times. An analysis of visual live cover revealed Riviera, SWI-1057, and NorthBridge appeared in the top statistical group more often than all other cultivars in this trial at seven out of seven times. Concerning digital image analysis, many top performing varieties were found based on the TPI. Similar to results found at the University of Arkansas (Trappe et al., 2010), commercially available varieties Celebration, Princess 77, Patriot, and Riviera were in the top statistical category 12 out of 12 times, as many times or more than all other varieties. Varieties also found 12 times in the top statistical category, not included in University of Arkansas data, were SWI-1070, SWI-1081, SWI-1083, Pyramid 2, Royal Bengal, PSG 9Y2OK, Quickstand, U-3-SIU, U-3-NC, U-3-TGS, and OKS2004-3. In contrast to the findings at the University of Arkansas, Midlawn, Tifway, and TifGrand were not considered top performing varieties based on the TPI. Midlawn, Tifway, and TifGrand appeared in the TPI seven and nine times out of 12, respectively. Poorest performing varieties in the TPI were SWI-1117 and NuMex-Sahara which appeared in the TPI three and four times out of 12, respectively.

2013

In 2013, in order to further separate cultivar response to traffic stress, the 2007 NTEP Bermudagrass Trial received a one game per week and a two game per week treatment with the CTS. The overall size of the plots in the research block allowed for the addition of the two game per week treatment. The addition of the two game per treatment allowed for a significant amount of separation between grass varieties. This additional treatment was necessary in order to create a greater amount of damage in order to more effectively measure the bermudagrass' traffic tolerance under more stressful circumstances. A summary concerning the results of ANOVA testing performed for multiple variables evaluated is shown in Table 9. In regard to spring green-up, there were highly significant entry, rep, and date effects but no entry by date effect so results are presented as an overall entry effect (Table 9). An analysis of visual quality ratings revealed there were highly significant game, entry, date, date by game, and entry by date effects. In regard to visual traffic tolerance, there were highly significant rep, game, entry, date, entry by game, date by game, and entry by date effects. Concerning visual percent live cover, there were highly significant rep, game, entry, date, entry by game, date by game, and entry by date effects. In regard to digital percent live cover, there were highly significant rep, game, entry, date by game, and entry by date effects.

Visual Spring Green-up

Premier, NorthBridge, OKS 2004-2, OKS 2004-3, and OKC 70-18 appeared in the top statistical group meaning that they were the earliest varieties to green-up (Table 10). Visual ratings revealed that Celebration, Princess 77, Veracruz, and SWI-1057 were

the latest entries to green-up. Late green-up by Celebration and Princess 77 could be explained by high winter kill ratings (Morris, 2010).

Turfgrass Quality

Concerning turfgrass quality, bermudagrass receiving traffic at two games per week had significantly lower visual quality than that receiving just one game per week on four out of nine rating dates (Table 11). Entry response to traffic was pooled over one and two game treatments because entry x game interaction was not significant. However, significant differences amongst varieties were present on five out of nine rating dates (Table 12). Riviera was rated higher than Latitude 36 and NorthBridge on one out of six rating dates but was higher than Tifway on five out of six dates. Concerning visual mean quality amongst varieties, Midlawn, NuMex-Sahara, Tifway, Premier, Golden Glove, and OKC 70-18 rated the lowest compared to all other varieties. Premier rated unacceptable on six ratings dates while Midlawn, Tifway, and OKC 70-18 rated unacceptable on five rating dates, regardless of significance. NuMex-Sahara, and Golden Glove rated unacceptable on two dates.

Traffic Tolerance

A two game per week regime produced significantly lower visual traffic tolerance on six of six significant rating dates (Table 13). Concerning entry by date effects, significant differences amongst varieties were present on four out of nine rating dates (Table 14). NorthBridge and Latitude 36 rated significantly higher than other commercial standards Riviera, Tifway, TifGrand, Celebration and Patriot on at least three out of four rating dates. NorthBridge and Latitude 36 rated higher than Tifway and

TifGrand on all four visual rating dates. Similar results have been shown at North Carolina State University in Raleigh using a visual traffic tolerance rating regarding top performing varieties Latitude 36 and NorthBridge (Morris, 2011). Premier and Tifway were also reported to have similar traffic tolerance ratings to NorthBridge and Latitude 36 at NC State, however in Stillwater, OK NorthBridge and Latitude 36 performed significantly better than Premier and Tifway on three and four rating dates, respectively. Mean separation of entries based on game one and game two applications are shown in Table 15. Entries performed differently under a one game application compared to a two game application. Under a one game application, every entry performed satisfactory except SWI-1081 and it rated at a 5.9 scale which is very close to acceptable. Under a two game application, only seven out of 40 entries performed in an acceptable manner concerning traffic tolerance. Entries Princess 77, Latitude 36, NorthBridge, RAD-CD1, PSG 9Y2OK, OKC 70-18, and OKS 2004-3 all performed above the 6.0 acceptable rating while all other entries fell below the acceptable scale under the two game regime.

Visual Percent Live Cover

Overall, a two game per week regime produced significantly lower visual percent live cover on five out of six significant rating dates and was not significantly different than a one game per week treatment on one out of six rating dates (Table 13). The inability to find differences in performance under a one or two game traffic treatment on the 18 September rating date could be explained by two mechanical breakdowns during the month of August in which traffic events were unable to be performed until mechanical actions were taken. Mean separation of entries based on a one game and two game applications are shown in Table 15. Entries performed differently under a one game

application compared to a two game application in regard to visual percent live cover. Every entry rated lower under a two game per week application except SWI-1081, RAD-CD1, U-3-NC, and U-3-TGS which rated equal or a small amount higher under a two game per week application. A two game per week application should cause more extreme damage causing entries to perform significantly worse, but that is not always the case. Significant differences amongst varieties were present on six out of nine rating dates concerning mean visual percent live cover (Table 16). NorthBridge and U-3-SIU rated significantly higher than Riviera, Latitude 36, Tifway, and Celebration on just one out of nine rating dates. NorthBridge, U-3- SIU, Latitude 36, Tifway, and Celebration rated significantly higher than Patriot on at least five rating dates and higher than Premier on three rating dates. Similar to visual percent live cover data reported at the University of Kentucky (Deaton and Williams, 2010); Riviera and Tifway demonstrated better traffic tolerance than Quickstand and Yukon in that trial as well. Poor performing varieties included NuMex-Sahara, Golden Glove, SWI-1081, and SWI-1117 which rated significantly lower than top performing varieties on at least five out of nine rating dates.

Digital Image Analysis

Overall, digital live cover was lower under a two game per week traffic regime than a one game per week regime. Digital percent live cover was significantly lower under a two game per week regime than a one game regime on nine of 10 significant rating dates (Table 17). An analysis of entries on different dates produced a significant effect and significant differences were present amongst entries on eight out of 15 rating dates (Table 18). A number of commercially available and experimental varieties performed well on seven out of eight rating dates. Tifway, Latitude 36, NorthBridge,

TifGrand, Celebration, Astro, SWI-1113, U-3 SIU, and OKS 2004-3 performed better than Riviera on two out of eight dates and better than Patriot on five out of eight rating dates. Poorest performing varieties include NuMex-Sahara, Golden Glove, and PSG 91215 which were rated lower than top performing varieties on seven out of eight rating dates.

Turfgrass Performance Index

Using the TPI as a means of summary of performance, with respect to TQ, Riviera appeared in the TPI six out of six times (Table 19). Standard varieties Latitude 36 and NorthBridge appeared in the TPI five out of six times compared to standard variety Tifway which appeared only one out of six times. Midlawn was the poorest performing variety in the TPI, appearing zero out of six times. Concerning mean TT, the TPI revealed Latitude 36 and NorthBridge were in the top statistical group more often than other varieties. An analysis of TT revealed 10 varieties that never appeared in the top statistical group. Varieties include SWI-1081, SWI-1122, BAR 7 CD5, NuMex-Sahara, Midlawn, Tifway, U-3-TGS, Celebration, Quickstand, U-3-SIU, and TifGrand. NorthBridge and U-3 SIU appeared in the top statistical group a total of nine out of nine times concerning visual percent live cover. Concerning visual percent live cover, Riviera, Tifway, Latitude 36, Royal Bengal, TifGrand, Celebration, Astro, PSG 9Y20K, and OKS 2004-3 appeared in the top statistical group eight out of nine times. SWI-1081 appeared in the top statistical group zero out of nine times in response to visual live cover assessment. Concerning digital image analysis, entries SWI-1113, U-3 SIU, OKS 2004-3, Tifway, Latitude 36, NorthBridge, TifGrand, Celebration, and Astro appeared in the top statistical group more often than other entries on seven out of 15 rating dates (Table

18). Digital image analysis at the University of Arkansas also showed varieties Tifway, TifGrand and Celebration performing in the top statistical group in regards to TPI (Trappe et al, 2010). Entries NuMex-Sahara, Golden Glove, and PSG 91215 never appeared in the top statistical group compared to the top performing entries that appeared seven out of 15 times.

Discussion

In 2012, visual ratings were taken every two to four weeks. In early 2012, visual ratings were only being taken every month. In June of 2012, it was decided that visual evaluations should be taken every two to three weeks. Concerning top performing varieties, Riviera was the cultivar that appeared the most times in the top statistical group, doing so in three out of four evaluation parameters. There were numerous top performing entries in 2012, both commercial and experimental, in the 2007 NTEP Bermudagrass trial (Table 8). Concerning digitally assessed live cover there were 12 varieties that placed in the top statistical group versus two varieties in the top statistical group when visual live cover was considered. This difference in overall performance concerning the two evaluation parameters could be explained by differences in conducting evaluations. Digital photographs store data in a two dimensional aspect which may not allow the current digital image analysis approach to discern actual differences that a visual evaluation conducted from a three dimensional aspect can discern. Visual percent live cover ratings were taken in the same portion of the plot as the digital images. It is possible that real differences in performance were unable to be discerned by the digital image analysis approach when a natural light source is used versus using a light box. "The light box will ensure a quality image (assuming camera settings are correct), which

will maximize accuracy. Also, the light box will standardize lighting conditions so that it possible to compare DIA results across dates or locations, which is not advisable with natural light" (D.E. Karcher, personal communication, 2013). Further research should be done to discern possible differences between a natural light source and a light box image.

In 2013, visual ratings were taken every two weeks except for the months of July and September. Only one visual rating was taken in each month due to a heavy rain fall event and a machine breakdown hindering traffic application for those weeks. To make up for the lost traffic event, a back to back traffic event was performed on consecutive days. In regards to digital images, photographs were not taken every week due to the previous mentioned environmental and mechanical issues during the months of July, August, and September. In 2013, there were numerous top performing varieties in the 2007 NTEP Bermudagrass Trial (Table 19). Concerning date by game effects, overall mean results of games were pooled among dates. In every evaluation category, two games per week resulted in significantly lower turfgrass performance than a one game per week regime, which was expected on several rating dates. The addition of the extra game did make a difference in reference to date, but not in reference to an entry by date by game effect. This effect came very close to being significantly different ($P = 0.16$), but the failure could be explained by the superiority of the varieties present in this trial. Concerning entry by date effects, results were shown through an overall pooled effect among entries in regard to games since there was no overall entry by date by game effect. Poor performance in spring green-up ratings could be explained by entries such as Celebration and Princess 77 having high winter kill ratings in the past (Morris, 2010). NorthBridge appeared in the top statistical group most often in regards to evaluation

parameters (Table 19). Latitude 36 and U-3 SIU did not differ in regards to their TPI in two out of the three evaluation categories and was only one rating date behind top performing cultivars NorthBridge and U-3 SIU in regards to visual live cover.

Conclusion

In 2012 and 2013, there were numerous top performing varieties in regard to each evaluation parameter. This can be explained by this trial containing some of the best bermudagrasses concerning many characteristics including traffic tolerance. Latitude 36, Riviera, NorthBridge, and some experimental varieties performed similar to Tifway in some evaluation parameters but significantly better in regards to others. Varieties such as Celebration and Princess 77, while usually providing good wear tolerance, should most likely be avoided in a climatic region such as Stillwater, OK due to high winter kill ratings (Morris, 2010). There were many varieties included in the 2007 NTEP Bermudagrass Trial that are also included in the 2013 NTEP Bermudagrass Trial. Entries such as Riviera and Latitude 36, top performing varieties, are serving as standard entries in the 2013 NTEP Trial. Unfortunately, top performing variety NorthBridge was not included in the 2013 – 2018 NTEP Bermudagrass Trial as a standard. However, based on its performance in this research trial it is a top choice in regards to traffic tolerance in the Stillwater, OK climatic zone.

In the past, Tifway was the standard grass of choice, especially in the southern United States, and was installed on a majority of athletic fields and golf courses, but with the new cultivars available today, sports field managers have additional options (Williams, 2010). Whether it is building a field or renovating an old one, there are more varieties to consider than just going with the standards of the past.

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Table 1: Annual Fertilizer Schedule in 2012 and 2013.

Year	Date	Fertilizer†
2012	9-April	46-0-0
	7-May	46-0-0
	21-May	46-0-0
	5-June	46-0-0
	21-June	46-0-0
	5-July	46-0-0
	17-July	46-0-0
	1-August	46-0-0
	16-August	46-0-0
	13- September	46-0-0
	27-September	46-0-0
2013	3-May	46-0-0
	20- May	17-17-17
	10- June	46-0-0
	29- June	46-0-0
	10- July	46-0-0
	1-August	17-17-17
	20- August	46-0-0
	9- September	46-0-0

†All fertilizer was quick release and granular form.

Table 2: Pesticide Applications for 2012 and 2013.

Year	Date	Pesticide Trade Name	Purpose
2012	22-February	Trimec and Glyphosate	Winter Weeds
	10-May	Ronstar Flo	Pre-emergent
	9-August	Dylox	Grubs
	16-October	Banner Maxx II	Spring Dead Spot
2013	11-February	Ronstar Flo	Pre-emergent
	15- May	Ronstar G	Pre-emergent
	3- July	Merit	Grubs
	1October	Pendulum	Pre-emergent

Table 3. Block F7 2012 F-tests for entry, rep, date, and their interactions on visual turfgrass quality [TQ], visual traffic tolerance [TT], visual percent live cover [PLC], and digital image analysis [DIA].

Source	**TQ**		**TT**		**PLC**		**DIA**	
	df	sign	df	sign	df	sign	df	Sign
Entry (E)	39	NS†	39	***	39	***	39	**
Rep (R)	2	NS	2	NS	2	NS	2	NS
E*R[Error A]	78	--	78	--	78	--	78	--
Date (D)	8	***	8	***	7	***	18	***
D*E	312	***	312	***	273	***	702	***
D*R[Error B]	640	--	640	--	560	--	1440	--

*, **, *** significant at $P = 0.05$, 0.01, and 0.001 respectively.
†NS, not significant at the 0.05 level.

Table 4. Mean visual quality of 40 entries under a one game per week treatment in the Block F7 2007 NTEP Bermudagrass Trial during 2012.

Entry	21-May	4-Jun	27-Jun	17-Jul	31-Jul	14-Aug	13-Sep	1-Oct	10-Oct
Riviera	6.0b-d	6.7	7.3	7.0ab	6.3	6.3	6.0	6.0	6.0a
Princess 77	5.3d	5.3	7.3	6.3b-d	6.3	6.0	5.7	6.0	6.0a
NuMex-Sahara	5.3d	5.7	7.0	6.7a-c	6.7	6.3	6.0	6.0	6.0a
SWI-1070	5.3d	6.7	7.0	6.3b-d	6.0	6.7	6.3	6.0	6.0a
SWI-1081	6.0b-d	6.3	7.3	6.3b-d	6.0	5.7	6.0	6.0	6.0a
SWI-1083	6.0b-d	6.3	7.0	7.0ab	6.0	6.3	6.0	6.3	6.0a
SWI-1113	6.0b-d	6.3	7.3	6.7a-c	6.0	6.0	5.7	6.3	6.0a
SWI-1117	6.0b-d	6.0	6.7	6.7a-c	6.3	6.3	6.0	6.0	6.0a
SWI-1122	6.0b-d	6.0	6.7	7.3a	6.0	5.7	5.7	6.3	6.0a
Midlawn	5.7cd	7.0	7.3	6.7a-c	5.3	4.3	6.0	6.0	5.0c
Tifway	6.0b-d	6.0	7.0	6.0cd	6.0	6.0	5.7	6.0	5.7ab
Premier	6.0b-d	6.7	7.0	6.0cd	6.3	6.3	5.7	6.3	6.0a
SWI-1057	5.3d	6.3	8.0	6.7a-c	6.3	6.0	6.0	6.0	6.0a
BAR 7 CD5	6.3d	6.0	6.7	6.3b-d	6.7	6.3	6.0	6.0	5.3ab
Gold Glove	6.0a-c	6.0	6.3	5.7d	5.3	5.7	6.0	6.0	6.0a
Sunsport	5.7b-d	6.0	7.0	6.0cd	5.7	5.7	6.3	6.0	6.0a
Patriot	6.7cd	7.0	7.0	6.0cd	6.0	4.7	6.0	6.0	5.7ab
Latitude 36	5.7ab	7.3	7.0	6.0cd	5.3	5.7	5.7	6.0	6.0a
NorthBridge	6.0b-d	6.3	7.7	6.7a-c	6.0	5.7	5.7	6.3	6.0a
RAD-CD1	6.0b-d	5.7	7.0	6.3b-d	6.0	5.7	5.7	6.0	6.0a
OKS 2004-2	6.3a-c	6.3	6.3	6.0cd	6.3	6.0	6.3	6.0	6.0a
PSG 91215	6.0b-d	6.0	7.0	6.7a-c	6.3	5.3	5.7	6.0	6.0a
PSG 94524	6.3a-c	5.7	7.3	6.0cd	6.0	6.0	6.0	6.0	6.0a
IS-01-201	6.0b-d	5.7	7.3	5.7d	6.3	6.3	6.3	6.0	6.0a
Pyramid 2	6.0a-c	6.7	7.7	6.3b-d	5.7	4.7	6.0	6.0	6.0a
Hollywood	6.3a-c	6.7	7.0	6.7a-c	6.0	6.0	6.3	6.7	6.0a
Yukon	6.3cd	6.3	7.0	7.0ab	6.3	6.3	6.0	6.3	6.0a
Veracruz	5.7a-c	6.0	7.0	6.0d	6.0	5.7	6.0	6.7	6.0a
Royal Bengal	6.3b-d	6.3	7.0	6.3b-d	6.0	6.0	5.3	6.0	6.0a
PSG PROK	6.0a-c	6.7	7.3	6.3b-d	6.0	6.0	6.3	6.0	6.0a
PSG 9Y2OK	6.3ab	6.0	7.3	6.3b-d	5.7	5.3	6.0	6.3	6.0a
TifGrand	6.7b-d	6.0	7.0	6.0cd	5.7	5.7	5.7	6.0	5.3ab
OKC70-18	6.0b-d	7.3	7.3	7.3a	6.3	6.0	5.7	6.3	6.0a
Celebration	6.0ab-d	6.3	7.3	6.3b-d	6.3	6.0	6.0	6.0	5.3ab
Quickstand	7.0a	7.3	7.0	7.3a	6.3	6.0	6.0	6.0	6.0a
U-3-SIU	6.7ab	6.0	7.0	5.7d	6.3	6.0	6.0	5.7	5.7ab
U-3-NC	7.0a	7.0	7.7	7.0ab	6.3	5.7	5.3	6.0	6.0a
U-3-TGS	6.7ab	6.3	7.0	6.3b-d	6.3	6.3	6.0	6.3	5.7ab
Astro	5.7cd	7.0	7.0	6.3b-d	6.0	6.0	6.0	6.0	6.0a
OKS2004-3	6.0b-d	6.7	7.3	6.3b-d	5.7	5.7	6.3	6.3	6.0a
LSD(0.05)†	**0.92**	**NS**	**NS**	**0.86**	**NS**	**NS**	**NS**	**NS**	**0.39**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 5. Mean visual traffic tolerance of 40 entries under a one game per week treatment in the Block F7 2007 NTEP Bermudagrass Trial during 2012.

Entry	21-May	4-Jun	27-Jun	17-Jul	31-Jul	14-Aug	13-Sep	1-Oct	10-Oct
Riviera	6.7a-c	7.0a-d	7.3	7.0a-c	6.3a-c	7.0	6.3	6.3ab	6.7a
Princess 77	5.7d-f	6.7b-e	7.3	7.3ab	7.0a	7.0	6.7	6.0a-c	5.7b-d
NuMex-Sahara	5.0f	5.3fg	6.7	6.3b-e	6.0bc	6.7	5.7	5.7b-d	4.7e
SWI-1070	6.3b-d	6.0d-g	7.0	6.3b-e	6.7ab	7.0	5.7	6.3ab	5.7b-d
SWI-1081	6.3b-d	6.3c-f	6.7	6.7a-d	6.7ab	6.7	6.3	6.0a-c	5.7b-d
SWI-1083	6.7a-c	6.3c-f	7.7	7.0a-c	6.3a-c	6.7	6.7	6.7a	6.0a-c
SWI-1113	6.3b-d	6.0d-g	7.3	7.3ab	6.7ab	7.0	6.0	6.0a-c	5.7b-d
SWI-1117	5.0f	5.0g	6.0	6.0d-e	6.3a-c	6.7	5.3	5.3cd	4.7e
SWI-1122	6.3b-d	6.0d-g	7.0	6.7a-d	6.7ab	7.0	6.0	5.7b-d	5.3c-e
Midlawn	5.7d-f	6.3c-f	6.7	6.7a-d	6.0bc	6.0	5.0	3.3e	3.3f
Tifway	5.3ef	5.3fg	6.0	6.0d-e	5.7c	6.7	6.0	5.0d	5.3c-e
Premier	6.3b-d	6.0d-g	6.7	6.3b-e	6.0bc	6.0	6.0	5.7b-d	5.3c-e
SWI-1057	6.7a-c	7.0a-d	8.0	6.7a-d	6.7ab	6.7	6.3	6.0a-c	6.3ab
BAR 7 CD5	5.7d-f	5.7e-g	6.3	5.7de	6.3a-c	6.3	6.0	5.3cd	4.7e
Gold Glove	5.7d-f	6.0d-g	6.7	5.7de	5.7c	6.3	6.0	6.0a-c	5.7b-d
Sunsport	5.7d-f	5.3fg	7.3	6.7a-d	6.3a-c	6.7	6.0	5.7b-d	5.3c-e
Patriot	6.3b-d	7.0a-d	7.0	7.0a-c	6.3a-c	6.0	6.0	5.3cd	5.0de
Latitude 36	6.0c-e	7.0a-d	6.7	7.7a	6.3a-c	6.3	6.0	5.7b-d	5.3c-e
NorthBridge	7.3a	7.3a-c	8.0	7.3ab	6.7ab	6.3	6.3	5.7b-d	6.0a-c
RAD-CD1	6.0c-e	5.3fg	6.3	5.7de	5.7c	6.3	5.7	5.7b-d	5.7b-d
OKS 2004-2	7.0ab	6.0d-g	6.0	6.0d-e	5.7c	6.3	6.3	5.3cd	5.7b-d
PSG 91215	6.0c-e	6.0d-g	6.7	7.0a-c	6.7ab	6.0	6.3	5.3cd	5.3c-e
PSG 94524	6.0c-e	5.3fg	6.7	6.0d-e	6.3a-c	7.0	6.0	5.7b-d	6.0a-c
IS-01-201	6.0c-e	5.7e-g	7.0	7.0a-c	6.0bc	6.3	6.0	5.7b-d	5.7b-d
Pyramid 2	7.0ab	6.7b-e	8.0	7.0a-c	6.3a-c	6.3	6.0	5.7b-d	5.3c-e
Hollywood	6.7a-c	6.7b-e	6.3	6.3b-e	6.3a-c	6.7	6.3	6.7a	6.0a-c
Yukon	6.3b-d	6.0d-g	7.0	6.0b-e	6.3a-c	6.0	6.3	5.7b-d	5.0de
Veracruz	5.7d-f	5.3fg	7.3	6.7a-d	6.7ab	6.7	6.3	6.0a-c	6.3ab
Royal Bengal	6.7a-c	6.7b-e	7.0	6.3b-e	6.7ab	6.7	6.3	6.0a-c	5.3c-e
PSG PROK	6.3b-d	6.0d-g	7.3	6.7a-d	6.7ab	7.0	6.7	6.0a-c	5.3c-e
PSG 9Y2OK	6.7a-c	5.7e-g	7.0	6.3b-e	6.0bc	6.3	6.0	5.7b-d	5.3c-e
TifGrand	6.0c-e	5.3fg	6.3	5.3e	5.7c	6.3	6.3	5.7b-d	6.0a-c
OKC70-18	7.3a	8.0a	7.7	7.7a	7.0a	6.7	6.7	6.0a-c	5.3c-e
Celebration	6.3b-d	7.7ab	7.0	7.3ab	6.3a-c	6.3	6.3	6.0a-c	6.0a-c
Quickstand	6.0c-e	7.0a-d	7.0	6.7a-d	6.0bc	6.0	6.0	5.3cd	5.3c-e
U-3-SIU	6.3b-d	6.7b-e	6.7	6.0d-e	6.3a-c	7.0	7.0	5.7b-d	5.7b-d
U-3-NC	6.7a-c	7.3a-c	7.7	7.0a-c	6.7ab	6.0	6.0	5.3cd	5.0de
U-3-TGS	6.3b-d	5.7e-g	7.3	6.0d-e	6.0bc	6.0	6.0	5.7b-d	4.7e
Astro	6.0c-e	6.7b-e	7.0	6.7a-d	6.3a-c	6.3	7.0	6.0a-c	5.3c-e
OKS2004-3	6.3b-d	6.3c-f	7.0	7.0a-c	7.0a	6.7	6.0	5.7b-d	5.3c-e
LSD(0.05)†	**0.97**	**1.1**	**NS**	**1.3**	**0.86**	**NS**	**NS**	**0.81**	**0.95**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 6. Mean visual percent living cover of 40 entries under a one game per week treatment in the Block F7 2007 NTEP Bermudagrass Trial during 2012.

Entry	4-Jun	27-Jun	17-Jul	31-Jul	14-Aug	13-Sep	1-Oct	10-Oct
Riviera	95.7a-f	98.0a-d	98.0ab	96.7	97.0ab	96.0ab	94.7a-d	95.3a
Princess 77	96.0a-e	97.7b-e	98.3a	97.0	96.3ab	95.7a-c	94.0a-e	94.0a-c
NuMex-Sahara	90.3i-n	96.7e	96.3cd	95.7	96.7ab	92.7d	94.0a-e	87.7gh
SWI-1070	92.0e-n	97.0de	96.7b-d	97.0	97.3a	94.3a-d	95.7ab	92.7a-e
SWI-1081	92.7c-l	97.7b-e	97.7a-c	96.3	95.7a-c	96.0ab	95.3a-c	92.7a-e
SWI-1083	93.7b-j	98.0a-d	97.7a-c	96.3	96.3ab	97.0a	96.0ab	94.0a-c
SWI-1113	91.3g-n	98.0a-d	98.3a	98.0	96.7ab	94.7a-d	94.3a-d	93.3a-d
SWI-1117	90.0i-m	96.7e	96.0d	95.7	97.0ab	93.0cd	90.7f	87.0h
SWI-1122	89.7j-m	97.7b-e	97.3a-d	97.0	95.7a-c	94.7a-d	93.3b-f	90.7b-h
Midlawn	94.0b-i	97.3c-e	97.0a-d	93.7	90.7d	88.7e	84.3g	79.0i
Tifway	88.0n	97.7b-e	97.3a-d	96.0	95.7a-c	96.0ab	90.7f	89.7d-g
Premier	92.3d-m	97.3c-e	97.3a-d	96.0	94.3a-c	94.3a-d	94.3a-d	91.0b-h
SWI-1057	95.7a-f	98.3a-c	98.0ab	97.0	96.3ab	95.7a-c	94.3a-d	93.7a-c
BAR 7 CD5	88.3nm	96.7e	96.3cd	96.0	96.7ab	95.0a-d	91.3ef	88.3f-h
Gold Glove	93.3b-k	97.0de	96.3cd	95.7	95.3a-c	95.7a-c	94.7a-d	92.0a-f
Sunsport	89.0l-m	97.3c-e	97.3a-d	95.7	95.0a-c	94.7a-d	93.3b-f	91.0b-h
Patriot	97.3ab	97.3c-e	98.0ab	95.3	92.3cd	94.7a-d	92.7c-f	89.3e-h
Latitude 36	94.0b-i	97.7b-e	98.0ab	95.3	94.7a-c	93.7b-d	92.3d-f	91.3b-g
NorthBridge	97.0ab	99.0a	98.0ab	96.3	95.3a-c	95.7a-c	95.0a-d	94.3ab
RAD-CD1	89.7j-m	97.3c-e	96.7b-d	97.0	95.0a-c	94.3a-d	94.3a-d	90.3c-h
OKS 2004-2	92.7c-l	96.7e	97.0a-d	96.7	94.3a-c	96.0ab	92.7c-f	92.3a-e
PSG 91215	91.7f-n	97.3c-e	98.3a	96.3	94.7a-c	94.0b-d	92.7c-f	90.3c-h
PSG 94524	89.3k-n	97.7b-e	97.0a-d	97.0	97.7a	95.3a-d	93.7a-e	93.7a-c
IS-01-201	91.7f-n	98.3a-c	98.0ab	95.7	96.3ab	95.7a-c	93.7a-e	93.0a-e
Pyramid 2	95.0a-g	98.7ab	97.7a-c	95.3	90.3d	95.3a-d	94.3a-d	91.3b-g
Hollywood	94.7a-h	97.3c-e	97.3a-d	97.3	96.7ab	96.3ab	96.3a	93.3a-d
Yukon	94.0b-i	97.7b-e	96.0d	95.7	96.0ab	96.0ab	95.0a-d	89.3e-h
Veracruz	88.0n	97.7b-e	97.3a-d	96.3	95.3a-c	95.7a-c	95.0a-d	94.0a-c
Royal Bengal	95.7a-f	97.7b-e	97.0a-d	97.0	96.3ab	94.7a-d	93.7a-e	91.3b-g
PSG PROK	91.7f-n	98.3a-c	98.0ab	97.0	96.7ab	96.0ab	94.7a-d	90.3c-h
PSG 9Y2OK	91.7f-n	98.3a-c	97.3a-d	96.3	95.0a-c	95.0a-d	94.7a-d	91.3b-g
TifGrand	90.7h-n	96.7e	96.0d	95.7	93.7b-d	95.0a-d	92.7c-f	92.7a-e
OKC70-18	98.3a	98.0a-d	98.3a	97.0	95.0a-c	95.7a-c	95.0a-d	91.0b-h
Celebration	96.3a-d	97.3c-e	98.3a	96.7	96.0ab	94.7a-d	94.0a-e	92.3a-e
Quickstand	96.7a-c	97.0de	97.3a-d	96.7	95.7a-c	95.3a-d	92.7c-f	90.7b-h
U-3-SIU	95.7a-f	97.0de	96.7b-d	96.7	97.0ab	97.0a	92.3d-f	93.0a-e
U-3-NC	95.7a-f	98.3a-c	98.0ab	96.7	96.0ab	93.7b-d	92.7c-f	91.0b-h
U-3-TGS	91.7e-f	97.3c-e	96.7b-d	96.3	96.3ab	95.3a-d	93.7a-e	88.0gh
Astro	92.0f-n	97.3c-e	97.3a-d	97.3	96.0ab	97.0a	94.3a-d	92.0a-f
OKS2004-3	94.0b-i	98.0a-d	98.0ab	97.7	96.7ab	95.7a-c	94.3a-d	92.3a-e
LSD(0.05)†	**4.2**	**1.2**	**1.6**	**NS**	**3.6**	**2.7**	**2.8**	**3.9**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 7. Mean digital percent living cover of 40 entries under a one game per week treatment in the Block F7 2007 NTEP Bermudagrass Trial during 2012.

Entry	7-May	15-May	22-May	29-May	5-Jun	11-Jun	18-Jun	26-Jun	7-Jul	11-Jul
Riviera	99.8a-c	92.1a-e	97.2a-g	96.5a-d	98.1a-g	98.0a-g	99.0a	99.0a-c	99.6	99.9
Princess 77	99.8a-c	96.0a-e	99.1a-c	95.9a-f	98.0a-g	98.9a-d	99.5a	99.4ab	99.7	99.6
NuMex-Sahara	99.0de	86.7ef	96.9b-h	93.1d-i	94.7j	93.9hi	95.1c	95.7fg	98.8	99.7
SWI-1070	99.7a-d	91.3a-e	98.1a-g	96.0a-e	97.6a-h	98.1a-g	98.8a	98.7a-e	99.5	99.5
SWI-1081	99.7a-d	92.8a-e	99.0a-c	95.4a-h	97.5a-h	96.7a-h	97.6ab	97.8a-f	99.2	99.6
SWI-1083	99.9a	97.5a-d	99.6ab	97.5a-c	99.1ab	98.1a-g	99.2a	99.0a-c	99.7	99.7
SWI-1113	99.8a-c	90.4a-e	95.4f-h	91.4h-k	96.6e-j	98.0a-g	99.2a	98.8a-d	99.7	99.7
SWI-1117	97.4f	79.3fg	96.0d-h	92.1e-j	95.5ij	93.4i	95.1c	94.2g	99.1	99.6
SWI-1122	99.4a-d	90.2a-e	97.9a-g	93.6b-i	97.5a-h	97.5a-g	98.7ab	98.6a-e	99.6	99.8
Midlawn	99.5a-d	90.9a-e	98.7a-c	97.3a-c	97.4b-i	98.2a-g	98.7ab	99.1a-c	99.5	99.8
Tifway	99.9a	66.4h	95.7e-h	89.0jk	97.6a-h	98.0a-g	99.5a	98.8a-c	99.5	99.9
Premier	99.7a-d	87.7d-f	95.4gh	91.5g-k	97.6a-h	97.7a-g	98.7ab	98.8a-d	99.4	96.2
SWI-1057	99.8a-d	95.2a-e	98.4b-e	95.4a-h	98.6a-d	98.8a-d	99.4a	99.3a-c	99.6	99.8
BAR 7 CD5	99.6a-d	79.7fg	94.5h	87.9k	95.8h-j	95.20-i	96.4bc	96.3e-g	98.3	99.4
Gold Glove	98.4e	89.2a-f	98.0a-g	92.3e-j	96.9d-i	95.2f-i	97.4a-c	97.0b-f	99.0	99.0
Sunsport	99.3a-d	90.87-e	97.9a-g	94.8a-h	96.5f-j	95.9d-i	98.6ab	98.2a-e	99.3	99.8
Patriot	99.8a	89.6a-f	99.3a-c	97.7a	98.4a-g	98.8a-d	99.3a	99.2a-c	99.3	98.3
Latitude 36	99.9a	91.8a-d	99.3a-c	98.5a	98.7a-d	99.5a	99.7a	99.7a	99.9	99.5
NorthBridge	100.0a	90.a-e	88.5i	97.9a	98.6a-d	99.4a-c	99.7a	99.6a	99.8	99.9
RAD-CD1	99.2a-d	88.4c-f	98.0a-g	91.9f-j	97.8a-g	95.7e-i	98.2ab	97.0b-f	98.7	99.1
OKS 2004-2	99.5a-d	75.3gh	96.7c-h	92.3e-j	96.8d-i	95.3f-i	97.9ab	98.0a-f	99.2	99.5
PSG 91215	99.7a-c	91.7a-e	98.7a-d	95.2a-h	97.9a-g	96.3c-i	97.9ab	98.0a-f	98.8	99.6
PSG 94524	99.2cd	86.8ef	99.0a-c	93.6c-i	97.2b-i	95.2g-i	97.5a-c	96.9c-f	98.9	99.6
IS-01-201	99.4a-d	93.1a-e	99.0a-c	95.5a-f	98.2a-g	96.4b-i	97.9ab	98.2a-e	99.2	99.7
Pyramid 2	99.9ab	93.1a-e	98.6a-d	95.5a-g	98.5a-e	98.5a-e	99.1a	99.0a-c	99.6	99.7
Hollywood	99.7a-c	90.3a-e	98.1a-f	96.5a-d	97.5a-h	96.5a-h	97.9ab	97.9a-f	99.5	99.6
Yukon	99.7a-d	92.0a-e	99.3a-c	96.8a-d	98.1a-g	98.4a-e	96.4bc	96.4d-g	99.7	99.8
Veracruz	99.5a-d	91.5a-e	96.7c-h	90.7i-k	96.4g-j	97.9a-g	99.2a	98.9a-c	99.5	99.8
Royal Bengal	99.9a	96.9a-e	99.6ab	98.1a	98.5a-e	99.3a-c	99.4a	99.5a	99.7	99.9
PSG PROK	99.9a	88.7b-f	98.7a-c	95.7a-f	97.8a-g	98.6a-e	99.2a	99.3a-c	99.7	99.9
PSG 9Y2OK	99.6a-d	91.6a-e	98.8a-c	95.1a-h	97.9a-g	97.5a-g	98.7ab	98.4a-e	99.3	99.8
TifGrand	99.8a-c	90.8a-e	97.1b-h	92.3e-j	96.9c-i	97.2a-g	98.8a	98.3a-c	99.3	99.9
OKC70-18	99.9a	99.4a	99.9a	98.5a	99.4a	99.4ab	99.7a	99.6a	99.7	99.6
Celebration	99.9a	98.3a-c	99.4ab	97.3a-c	98.9a-c	99.5a	99.6a	99.6a	99.8	99.8
Quickstand	99.9ab	97.9a-d	99.6ab	97.5a-c	98.4a-f	99.3a-c	99.0a	99.4ab	99.8	99.8
U-3-SIU	99.9a	93.3a-e	97.8a-g	94.8a-h	98.4a-f	97.4a-g	98.9a	98.4a-e	99.2	99.3
U-3-NC	99.9ab	98.9ab	99.60ab	97.6ab	98.5a-e	99.1a-c	99.4a	99.6a	99.8	99.8
U-3-TGS	99.5a-d	96.2a-e	98.8a-c	95.7a-f	98.3a-f	98.3a-f	98.9a	98.9a-c	99.7	99.7
Astro	99.8a-c	94.7a-e	98.2a-e	93.5c-i	97.9a-g	98.5a-e	98.0ab	98.6a-e	99.6	99.9
OKS2004-3	99.8a-c	94.0a-e	98.5a-d	97.1a-d	98.2a-g	98.9a-d	99.4a	99.4ab	99.6	99.8
LSD(0.05)†	**0.69**	**10.4**	**2.7**	**4.0**	**1.9**	**3.0**	**2.5**	**2.4**	**NS**	**NS**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 7. (Continued)

Entry	16-Jul	25-Jul	31-Jul	7-Aug	13-Aug	21-Aug	28-Aug	10-Sep	9-Oct
Riviera	99.4	95.5ab	99.8	99.9	98.4a	99.2a	98.7	99.1	98.0ab
Princess 77	99.1	94.8ab	99.2	99.5	96.8ab	99.1a	97.2	96.7	97.1a-c
NuMex-Sahara	97.3	95.0ab	95.2	99.3	95.0a-d	97.3ab	97.2	99.0	97.1a-c
SWI-1070	98.4	95.7ab	99.1	99.7	95.3a-c	99.1a	97.4	99.7	96.6a-c
SWI-1081	98.1	96.3ab	96.9	99.2	94.8a-d	98.5a	97.2	98.7	96.5a-c
SWI-1083	98.0	98.6a	98.3	99.3	97.0ab	99.4a	97.9	99.6	97.4ab
SWI-1113	99.2	97.0ab	98.9	99.8	97.6ab	99.4a	99.0	99.4	97.4ab
SWI-1117	97.3	95.6ab	94.8	97.6	92.6a-d	97.9ab	97.8	98.4	92.8de
SWI-1122	98.1	95.6ab	96.2	98.4	93.5a-d	98.5a	95.9	99.0	96.7a-c
Midlawn	97.3	84.2c-e	88.0	99.3	75.2ef	93.8bc	94.4	97.7	91.6ef
Tifway	99.3	96.6ab	98.1	99.6	96.2a-c	99.5a	97.6	99.1	96.3a-c
Premier	93.3	94.5a-c	84.0	91.1	78.5de	96.3a-c	97.4	98.8	97.9ab
SWI-1057	99.4	90.4a-d	97.3	98.6	93.8a-d	97.8ab	97.8	99.7	98.4ab
BAR 7 CD5	97.5	95.7ab	98.4	99.6	97.5ab	98.6a	98.6	99.6	96.0a-c
Gold Glove	94.6	87.4b-d	91.8	95.6	83.6a-e	95.8a-c	94.3	98.5	96.9a-c
Sunsport	98.6	95.0ab	97.5	99.3	94.3a-d	99.0a	96.8	99.6	97.8ab
Patriot	94.8	70.6f	89.6	94.1	61.4f	89.2c	91.1	95.3	92.0e
Latitude 36	98.6	73.9ef	86.2	98.8	81.4b-e	92.6c	92.8	95.7	95.7b-d
NorthBridge	98.7	94.0a-c	96.7	99.0	92.0a-d	98.2a	96.6	99.7	98.8a
RAD-CD1	94.7	90.8a-d	90.9	95.3	79.9c-e	97.3ab	95.6	98.7	98.2ab
OKS 2004-2	95.9	90.3a-d	79.8	85.0	74.5ef	96.2a-c	97.5	99.0	97.2a-c
PSG 91215	97.2	92.8a-c	90.1	98.3	83.6a-e	95.3a-c	94.0	98.4	96.6a-c
PSG 94524	97.8	95.1ab	97.4	99.0	94.4a-d	98.7a	97.5	97.8	97.5ab
IS-01-201	98.5	95.8ab	97.8	99.7	93.7a-d	99.1a	96.9	98.9	95.8b-d
Pyramid 2	98.3	93.7a-c	95.3	99.3	90.8a-e	97.2ab	98.0	99.3	97.4ab
Hollywood	97.9	94.0a-c	96.5	99.5	96.4a-c	98.0ab	96.4	99.0	94.3c-e
Yukon	98.7	95.1ab	99.1	99.2	97.8ab	99.3a	97.6	99.7	95.7b-d
Veracruz	99.1	94.3a-c	98.2	99.6	97.3ab	98.8a	98.2	99.8	98.1ab
Royal Bengal	99.0	94.3a-c	97.8	99.8	97.5ab	98.7a	96.8	99.7	97.2a-c
PSG PROK	99.3	98.4a	98.9	99.0	98.5a	99.5a	98.5	99.7	96.6a-c
PSG 9Y2OK	98.7	92.2a-d	98.4	99.8	95.3a-c	97.9b	97.0	98.3	97.8ab
TifGrand	98.8	88.4a-d	95.1	97.6	83.8a-e	97.2ab	96.3	99.8	97.8ab
OKC70-18	93.3	82.1de	95.7	99.0	86.8a-e	96.2a-c	95.2	98.9	89.1f
Celebration	99.4	97.1ab	99.3	99.5	97.8ab	99.4a	97.7	99.7	98.3ab
Quickstand	98.9	97.8ab	98.4	99.7	97.4ab	99.3a	97.6	99.9	97.1a-c
U-3-SIU	95.9	94.9ab	99.5	99.7	97.9ab	99.0a	96.1	98.8	97.2a-c
U-3-NC	99.4	93.7a-c	96.5	99.2	95.0a-d	98.7a	97.6	99.8	96.3a-c
U-3-TGS	97.1	90.9a-d	94.0	99.7	88.3a-e	97.0a-c	95.2	97.3	96.4ab
Astro	98.4	92.6a-d	97.9	99.8	96.8ab	98.5a	97.3	99.1	98.0ab
OKS2004-3	99.1	96.1ab	98.2	99.0	96.4a-c	99.1a	97.8	99.6	98.4ab
LSD(0.05)†	**NS**	**10.5**	**NS**	**NS**	**16.7**	**4.4**	**NS**	**NS**	**3.0**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 8. Turfgrass Performance Index of 40 cultivars in the Block F7 2007 NTEP bermudagrass trial by evaluation parameters turfgrass quality [TQ], traffic tolerance [TT], percent live cover [PLC], and digital image analysis [DIA] during 2012.

Entry	TQ	TT	PLC	DIA
Riviera	2†	6	7	12
Princess 77	1	3	6	12
NuMex-Sahara	2	0	2	4
SWI-1070	1	2	4	12
SWI-1081	1	3	5	12
SWI-1083	2	5	6	12
SWI-1113	2	3	6	9
SWI-1117	2	1	1	3
SWI-1122	2	2	3	11
Midlawn	1	1	1	7
Tifway	1	0	3	9
Premier	1	0	4	8
SWI-1057	2	6	7	11
BAR 7 CD5	1	1	2	5
Golden Glove	2	1	4	6
Sunsport	1	2	3	10
Patriot	1	3	3	8
Latitude 36	2	3	2	8
NorthBridge	2	5	7	11
RAD-CD1	1	0	3	7
OKS 2004-2	2	1	4	6
PSG 91215	2	2	2	11
PSG 94524	2	2	5	6
IS-01-201	1	1	6	10
Pyramid 2	2	3	5	12
Hollywood	3	4	6	11
Yukon	2	1	3	9
Veracruz	2	4	5	9
Royal Bengal	1	3	5	12
PSG PROK	2	3	5	11
PSG 9Y2OK	2	1	5	12
TifGrand	1	1	2	9
OKC70-18	2	5	6	10
Celebration	1	3	6	12
Quickstand	3	2	4	12
U-3-SIU	2	1	4	12
U-3-NC	3	4	4	12
U-3-TGS	2	0	3	12
Astro	1	3	5	11
OKS2004-3	1	2	6	12

† Number of times cultivar appeared in statistical group “a” where mean separation had been performed using the Protected Fisher’s Least Significant Difference Test at p=0.05.

Table 9. Block F7 2013 F-tests for entry, rep, games, date, and their interactions on visual spring green-up [SG], visual turfgrass quality [TQ], visual traffic tolerance [TT], visual live cover [PLC], and digital image analysis [DIA].

Source	SG		TQ		TT		PLC		DIA	
	df	sign	df	Sign	df	sign	df	sign	df	Sign
Rep (R)	2	***	2	NS†	2	*	2	*	2	*
Games (G)	--	--	1	**	1	**	1	**	1	**
R*G[Error a]	--	--	2	--	2	--	2	--	2	--
Entry(E)	39	***	39	***	39	***	39	***	39	***
R*E[Error b]	78	--	78	--	78	--	78	--	78	--
E*G	--	--	39	NS	39	**	39	**	39	NS
R*E*G[Error c]	--	--	78	--	78	--	78	--	78	--
D	4	***	8	***	8	***	8	***	14	***
D*G	--	--	8	***	8	***	8	***	14	***
E*D	156	NS†	312	***	312	***	312	***	546	***
E*D*G	---	---	312	NS	312	NS	312	NS	546	NS
R*D(E*G)[Error d]	---	---	1280	--	1280	--	1280	--	2240	--

*, **, *** significant (sign) at $P = 0.05$, 0.01, and 0.001 respectively.

†NS, not significant at the 0.05 level.

Table 10. Mean visual spring green-up of 40 entries under a one game per week treatment in the Block F7 2007 NTEP Bermudagrass Trial during 2013.

Entry	Overall Mean
Riviera	4.8c-i
Princess 77	3.8lm
NuMex-Sahara	4.6d-k
SWI-1070	4.5e-l
SWI-1081	4.4e-l
SWI-1083	4.5e-l
SWI-1113	4.5e-l
SWI-1117	4.4e-l
SWI-1122	4.6d-j
Midlawn	4.1i-m
Tifway	4.2h-m
Premier	5.4a-c
SWI-1057	3.9k-m
BAR 7 CD5	4.0j-m
Golden Glove	4.3f-l
Sunsport	4.4e-l
Patriot	4.2g-m
Latitude 36	5.0b-e
NorthBridge	5.6ab
RAD-CD1	4.8c-i
OKS 2004-2	5.2a-d
PSG 91215	4.6d-j
PSG 94524	4.4e-l
IS-01-201	4.2g-m
Pyramid 2	4.9b-g
Hollywood	4.9b-g
Yukon	4.8c-h
Veracruz	3.8lm
Royal Bengal	4.3f-k
PSG PROK	4.4e-l
PSG 9Y2OK	5.0b-f
TifGrand	3.9k-m
OKC70-18	5.8a
Celebration	3.6m
Quickstand	4.1i-m
U-3-SIU	4.0j-m
U-3-NC	4.5e-l
U-3-TGS	4.2h-m
Astro	5.0b-e
OKS2004-3	5.4a-c
LSD(0.05)†	**0.69**

†Means within columns followed by the same letters are not statistically different at *P* =0.05 based on Fisher's LSD test.

Table 11. Comparison of overall bermudagrass quality on nine rating dates in the 2007 NTEP bermudagrass trial under two traffic applications in 2013.

Date	1 Game Week^{-1}	2 Games Week^{-1}	LSD†
29-May	7.2	6.8	NS
11-Jun	6.3	5.9	NS
25-Jun	6.2	6.1	NS
16-Jul	6.2	6.2	NS
8-Aug	6.3a	5.7b	0.18
26-Aug	6.2a	5.8b	0.31
18-Sep	5.6a	5.0b	0.47
7-Oct	5.5	5.3	NS
28-Oct	4.7a	4.0b	0.18

†Means within rows followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 12. Mean visual quality of 40 entries pooled over one game and two game per week treatments in the Block F7 2007 NTEP Bermudagrass Trial in 2013.

Entry	29-May	11-Jun	25-Jun	16-Jul	8-Aug	26-Aug	18-Sep	7-Oct	28-Oct
Riviera	7.3a-c	6.0	6.1	6.6a-c	6.1a-c	6.0a-d	5.6	5.6a-c	4.6a-c
Princess 77	7.3a-c	6.0	6.6	6.3b-e	5.6de	5.6cd	5.1	5.5a-d	4.5a-d
NuMex-Sahara	6.8c-f	6.1	6.0	6.0d-f	6.0b-d	6.0a-d	5.3	5.1c-e	4.1c-e
SWI-1070	7.1a-d	5.8	6.3	6.6a-c	5.6ed	5.8b-d	5.1	5.6a-c	4.6a-c
SWI-1081	7.0b-e	6.1	6.0	6.0d-f	6.0b-d	6.0a-d	5.3	5.5a-d	4.1c-e
SWI-1083	7.0b-e	6.1	6.1	6.1c-f	6.0b-d	6.0a-d	5.6	5.3b-e	4.5a-d
SWI-1113	7.5ab	6.0	6.1	6.8ab	6.3ab	6.1a-c	5.3	5.6a-c	4.6a-c
SWI-1117	6.5ef	6.1	6.0	6.1c-f	6.3ab	6.0a-d	5.3	5.1c-e	3.5fg
SWI-1122	7.1a-d	6.1	6.3	6.8ab	6.3ab	6.5a	5.1	5.3b-e	4.1c-e
Midlawn	7.0b-e	6.1	6.0	6.1c-f	5.6ed	5.6cd	5.1	4.8ef	3.3g
Tifway	6.8c-f	6.1	6.1	5.8ef	6.0b-d	5.5d	4.6	4.3f	4.5a-d
Premier	6.8c-f	6.1	6.0	5.8ef	5.8c-e	5.6cd	5.3	5.3b-e	4.5a-d
SWI-1057	7.0b-d	6.3	6.1	6.3b-e	6.1a-c	6.0a-d	5.5	5.6a-c	5.0a
BAR 7 CD5	6.6d-f	6.1	6.1	6.3b-e	6.3ab	6.1a-c	5.1	5.0de	3.6e-g
Gold Glove	6.6d-f	5.6	6.0	5.6f	6.1a-c	5.8b-d	5.5	5.1c-e	4.3b-d
Sunsport	6.5ef	5.8	6.0	6.0d-f	6.0b-d	6.1a-c	5.5	5.8ab	4.5a-d
Patriot	6.5ef	6.3	6.1	6.5a-d	6.0b-d	6.0a-d	4.8	5.0de	4.0d-f
Latitude 36	7.6a	6.3	7.0	7.0a	6.3ab	5.8b-d	5.6	5.8ab	4.8ab
NorthBridge	7.5ab	6.3	6.3	6.1c-f	6.5a	6.1a-c	5.6	6.0a	4.8ab
RAD-CD1	7.3a-c	6.1	6.3	6.5a-d	6.5a	6.5a	5.1	5.8ab	4.1c-e
OKS 2004-2	7.0b-d	6.3	6.0	6.1c-f	6.1a-c	6.0a-d	6.0	6.0a	4.1c-e
PSG 91215	7.1a-d	6.0	6.1	6.0d-f	6.0b-d	6.0a-d	5.3	5.3b-e	4.1c-e
PSG 94524	6.3f	5.6	6.0	6.1c-f	6.3ab	6.1a-c	5.5	5.1c-e	4.0d-f
IS-01-201	6.3f	6.1	6.0	6.1c-f	6.0b-d	6.1a-c	5.5	5.5a-d	4.1c-e
Pyramid 2	7.3a-c	6.3	6.3	6.3b-e	6.0b-d	5.8b-d	5.6	5.5a-d	4.5a-d
Hollywood	7.1a-d	6.1	6.3	6.1c-f	5.8c-e	6.0a-d	5.3	5.0de	4.1c-e
Yukon	7.5ab	6.1	6.1	6.1c-f	6.5a	6.3ab	5.1	5.3b-e	4.6a-c
Veracruz	6.8c-f	6.3	6.3	6.3b-e	6.1a-c	6.3ab	5.6	5.6a-c	4.6a-c
Royal Bengal	7.0b-e	6.0	6.3	6.1c-f	6.1a-c	6.1a-c	5.5	5.6a-c	4.3b-d
PSG PROK	6.8c-f	6.3	6.0	6.3b-e	6.1a-c	6.3ab	5.3	5.5a-d	4.5a-d
PSG 9Y2OK	7.0b-e	6.3	6.3	6.5a-d	6.1a-c	6.3ab	5.5	5.8ab	4.1c-e
TifGrand	7.1a-d	6.1	6.1	6.5a-d	6.0b-d	5.5d	5.0	5.0de	5.0a
OKC70-18	7.5ab	6.1	6.5	6.1c-f	5.5e	5.5d	5.0	5.0de	4.0d-f
Celebration	6.8c-f	6.1	6.1	6.1c-f	5.8c-e	6.0a-d	5.3	5.3b-e	4.6a-c
Quickstand	6.6d-f	6.3	6.3	6.5a-d	5.8c-e	6.1a-c	5.3	5.8ab	4.1c-e
U-3-SIU	7.1a-d	6.1	6.0	6.0d-f	6.0b-d	6.0a-d	5.5	5.5a-d	4.5a-d
U-3-NC	7.1a-d	6.0	6.0	6.8ab	6.0b-d	6.0a-d	5.1	5.3b-e	4.3b-d
U-3-TGS	7.0b-d	6.0	6.0	6.6a-c	6.5a	5.8b-d	5.3	5.1c-e	4.1c-e
Astro	7.1a-d	6.3	6.3	6.0d-f	6.0b-d	5.5d	5.6	5.1c-e	4.5a-d
OKS2004-3	7.3a-c	6.0	6.1	6.0d-f	6.0b-d	6.0a-d	5.6	5.6a-c	4.6a-c
LSD(0.05)†	**0.61**	**NS**	**NS**	**0.58**	**0.45**	**0.57**	**NS**	**0.59**	**0.60**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 13. Bermudagrass traffic tolerance (TT) and percent live cover (PLC) on nine rating dates in the 2007 NTEP bermudagrass trial under two traffic applications in 2013.

	TT			PLC		
Date	Game 1	Game 2	LSD†	Game 1	Game 2	LSD
29-May	7.4	7.2	NS	97.2	96.7	NS
11-Jun	6.6a	5.9b	0.49	94.3a	90.3b	3.1
25-Jun	6.3a	5.9b	0.38	95.3a	93.2b	0.87
16-Jul	6.3	3	NS	95.0a	93.3b	0.79
8-Aug	6.4	6.2	NS	96.8a	94.8b	0.79
26-Aug	6.3a	5.6b	0.09	96.2a	93.5b	0.36
18-Sep	6a	5.4b	0.28	90.8a	89.3a	1.6
7-Oct	5.9a	5.4b	0.32	89.1	87.8	NS
28-Oct	5.2a	4.1b	0.37	78.1	75.4	NS

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 14. Mean visual traffic tolerance of 40 entries pooled over one game and two game per week treatments in the Block F7 2007 NTEP Bermudagrass Trial in 2013.

Entry	29-May	11-Jun	25-Jun	16-Jul	8-Aug	26-Aug	18-Sep	7-Oct	28-Oct
Riviera	7.6	6.8	6.3b-e	6.6	6.1c-e	6.0	6.1	5.6bc	5.0a-d
Princess 77	7.6	6.3	6.6a-c	6.3	6.1c-e	6.0	6.0	5.6bc	5.0a-d
NuMex-Sahara	7.0	6.1	5.5gh	5.8	6.1c-e	5.8	5.5	5.5bc	4.5d-g
SWI-1070	7.5	6.0	6.5a-d	6.3	6.1c-e	5.8	6.0	5.6bc	5.1a-c
SWI-1081	7.1	6.1	6.0d-g	5.8	6.0de	5.5	5.5	5.5bc	4.5d-g
SWI-1083	7.3	5.5	5.6f-h	5.8	6.3b-e	6.0	5.6	5.5bc	5.1a-c
SWI-1113	7.5	6.1	6.0d-g	6.3	6.3b-e	6.1	6.0	5.8a-c	5.0a-d
SWI-1117	6.6	6.0	5.6f-h	6.0	6.5a-d	6.3	5.6	5.3bc	4.0g
SWI-1122	7.3	6.3	6.0d-g	6.3	6.3b-e	6.1	6.0	5.5bc	4.5d-g
Midlawn	7.3	6.5	6.1d-f	6.0	6.1c-e	5.6	4.8	4.5d	3.0h
Tifway	7.1	6.1	6.0d-g	5.6	6.3b-e	5.5	4.6	4.5d	4.5d-g
Premier	7.1	6.3	6.0d-g	6.0	6.3b-e	5.6	5.5	5.3bc	5.3ab
SWI-1057	7.3	6.8	6.3b-e	6.6	6.1c-e	5.8	6.0	5.8a-c	5.1a-c
BAR 7 CD5	6.6	6.1	5.6f-h	5.8	6.3b-e	5.8	5.5	5.1cd	3.3h
Gold Glove	7.0	6.0	6.0d-g	5.8	6.5a-d	5.8	5.8	5.5bc	4.5d-g
Sunsport	7.0	6.3	5.6f-h	6.0	6.0de	6.0	5.6	6.0ab	4.5d-g
Patriot	7.0	6.8	6.1d-f	6.3	6.0de	6.0	5.6	5.8a-c	4.5d-g
Latitude 36	7.8	6.6	7.0a	6.8	6.6a-c	6.3	6.5	6.5a	5.5a
NorthBridge	7.6	6.8	6.6a-c	6.1	7.0a	6.5	6.3	6.0ab	5.3ab
RAD-CD1	7.8	6.0	6.3b-e	6.5	6.6a-c	6.1	5.8	5.8a-c	4.3e-g
OKS 2004-2	7.3	6.5	6.0d-g	6.0	6.6a-c	6.1	6.0	5.6bc	4.6d-f
PSG 91215	7.0	6.5	6.1d-f	5.6	6.1c-e	5.8	5.8	5.8a-c	4.3e-g
PSG 94524	6.5	5.6	5.5gh	5.8	6.6a-c	5.8	5.3	5.5bc	4.3e-g
IS-01-201	7.0	6.3	5.3h	6.0	6.1c-e	5.5	5.6	5.8a-c	4.8b-e
Pyramid 2	7.1	6.1	6.1d-f	6.3	6.0de	6.0	6.0	6.0ab	4.8b-e
Hollywood	7.5	6.5	6.6a-c	6.3	5.8e	6.0	5.6	5.6bc	4.5d-g
Yukon	7.5	6.5	6.3b-e	6.1	6.5a-d	6.1	5.5	5.8a-c	4.5d-g
Veracruz	7.1	6.5	6.3b-e	6.6	6.6a-c	6.1	6.0	6.0ab	5.1a-c
Royal Bengal	7.3	6.1	6.0d-g	6.0	6.1c-e	6.3	6.0	5.8a-c	4.6d-f
PSG PROK	7.1	6.3	5.8e-g	6.0	6.5a-d	6.0	5.6	5.6bc	4.5d-g
PSG 9Y2OK	7.6	6.1	6.1d-f	6.3	6.8ab	6.6	6.0	6.0ab	4.5d-g
TifGrand	7.6	6.3	6.1d-f	6.6	6.1c-e	5.8	5.5	5.1cd	4.8b-e
OKC70-18	7.8	6.3	6.8ab	6.5	6.1c-e	6.0	5.8	5.8a-c	4.5d-g
Celebration	7.1	6.3	5.6f-h	6.0	6.1c-e	6.1	5.5	5.6bc	4.5d-g
Quickstand	7.1	6.3	5.6f-h	6.0	6.1c-e	5.8	5.5	5.6bc	4.1fg
U-3-SIU	7.5	6.1	6.3b-e	5.8	6.0de	5.6	5.6	5.3bc	4.8b-e
U-3-NC	7.3	5.8	6.1d-f	6.6	6.3b-e	5.6	5.8	5.8a-c	4.1fg
U-3-TGS	7.3	5.8	5.8e-g	6.3	6.3b-e	5.6	5.5	5.3bc	4.3e-g
Astro	7.3	6.1	6.1d-f	6.0	6.5a-d	5.5	5.6	5.1cd	5.0a-d
OKS2004-3	7.5	6.3	6.1d-f	6.1	6.1c-e	5.8	6.0	6.0ab	5.5a
LSD(0.05)†	**NS**	**NS**	**0.62**	**NS**	**0.5**	**NS**	**NS**	**0.73**	**0.54**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 15. Bermudagrass traffic tolerance (TT) and percent live cover (PLC) as affected by number of games per week in 2013.

Entry	**TT**		**PLC**	
	Game 1	Game 2	Game 1	Game 2
Riviera	6.5a-d	5.9b-g	94.6a-d	91.5a-e
Princess 77	6.3b-g	6.0b-e	93.5a-g	92.2a-d
NuMex-Sahara	6.1f-j	5.4j-m	90.3h-m	86.8g-j
SWI-1070	6.4b-f	5.8d-i	92.6b-i	90.7b-f
SWI-1081	5.9j	5.6e-l	89.4k-m	90.5b-f
SWI-1083	6.1f-i	5.6e-l	91.4f-l	90.5b-f
SWI-1113	6.3b-g	5.9c-h	94.0a-f	91.6a-e
SWI-1117	6.1f-i	5.4i-l	89.2lm	86.9g-j
SWI-1122	6.3c-h	5.7c-j	92.4c-j	91.5a-e
Midlawn	6.1f-j	5.0m	91.2g-l	85.5ij
Tifway	6.0ji	5.2lm	93.5a-g	92.5a-c
Premier	6.0g-j	5.8c-i	92.3c-j	91.9a-e
SWI-1057	6.5a-e	5.9b-g	94.5a-e	93.7ab
BAR 7 CD5	6.1f-j	5.0m	91.7f-l	84.6j
Gold Glove	6.3b-g	5.4j-m	90.2i-m	87.7f-j
Sunsport	6.1f-j	5.6e-l	91.9e-j	89.1c-g
Patriot	6.2f-h	5.8c-j	87.8m	86.3h-j
Latitude 36	6.8a	6.4a	94.5a-e	92.3a-c
NorthBridge	6.6a-c	6.3ab	95.6a	94.3a
RAD-CD1	6.2e-j	6.1a-c	91.4f-l	91.9a-e
OKS 2004-2	6.3b-g	5.8c-i	92.3c-j	91.7a-e
PSG 91215	6.2f-j	5.5f-l	90.1i-m	88.9d-i
PSG 94524	6.0h-j	5.3k-m	90.3h-m	88.7e-i
IS-01-201	6.1f-j	5.5h-l	90.4h-m	90.3b-f
Pyramid 2	6.2e-j	5.9c-h	92.2c-j	91.0a-f
Hollywood	6.2e-j	5.8c-i	91.2g-l	90.0b-g
Yukon	6.2e-j	5.9b-g	93.3a-g	91.4a-e
Veracruz	6.7ab	5.9c-h	95.1ab	91.1a-e
Royal Bengal	6.2e-j	5.8c-i	93.3a-g	91.7a-e
PSG PROK	6.2d-i	5.6f-l	92.9b-h	90.7b-f
PSG 9Y2OK	6.4b-f	6.1a-c	93.6a-g	92.2a-d
TifGrand	6.2e-j	5.8c-j	93.7a-g	92.4a-c
OKC70-18	6.4c-f	6.0b-f	92.1e-j	90.8b-f
Celebration	6.1f-i	5.6d-k	94.6a-d	93.0ab
Quickstand	6.0g-j	5.5f-l	92.4c-j	90.6b-f
U-3-SIU	6.2e-j	5.6e-l	93.6a-g	92.9ab
U-3-NC	6.1f-j	5.8c-j	91.2g-l	91.4a-e
U-3-TGS	6.0g-f	5.5f-l	89.8j-m	90.0b-g
Astro	6.3c-h	5.5g-l	94.8a-c	91.2a-e
OKS2004-3	6.2d-i	6.0a-d	93.8a-g	92.8ab
LSD(0.05)†	0.29	0.41	2.6	3.3

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 16. Mean visual percent live cover of 40 entries pooled over one game and two game per week treatments in the Block F7 2007 NTEP Bermudagrass Trial in 2013.

Entry	29-May	11-Jun	25-Jun	16-Jul	8-Aug	26-Aug	18-Sep	7-Oct	28-Oct
Riviera	97.8ab	96.0a	96.0a-c	96.1a	96.1a-c	95.0a-e	92.8a-e	89.8a-h	78.3d-i
Princess 77	97.6a-c	93.1a-f	96.8ab	95.1a-c	95.6a-e	94.1ef	89.8b-i	89.8a-h	83.8a-g
NuMex-Sahara	96.5b-f	92.6a-g	90.3h-j	93.8a-e	94.8c-f	94.1ef	87.0g-j	82.6l-o	65.6j-m
SWI-1070	97.3a-c	90.1e-i	96.1a-c	94.6a-d	94.5d-f	94.6b-f	85.3j	88.1d-j	84.5a-g
SWI-1081	96.5b-f	91.3b-h	93.6b-h	92.6c-g	95.0b-f	94.3d-f	88.5e-j	87.5f-k	70.1h-k
SWI-1083	96.6a-e	87.3hi	92.1d-j	93.0b-g	96.1a-c	95.1a-d	90.0b-i	88.6c-i	79.8a-h
SWI-1113	97.6a-c	91.1b-h	94.5a-f	95.6ab	95.3a-e	94.3d-f	92.0a-f	91.3a-f	83.6a-g
SWI-1117	95.6d-f	88.5g-i	90.6g-j	93.0b-g	96.1a-c	95.5ab	88.3f-j	85.3i-m	59.5lm
SWI-1122	97.0a-d	91.6a-h	95.3a-d	95.5a-c	96.1a-c	95.6a	88.8d-j	90.5a-f	77.0d-i
Midlawn	97.0a-d	94.0a-e	94.3b-f	94.5a-d	94.5d-f	94.0f	89.8b-i	79.5o	58.0m
Tifway	96.8a-e	91.5a-h	94.5a-f	93.6a-f	95.8a-e	94.3d-f	92.3a-f	90.1a-h	88.3a-c
Premier	96.3b-f	94.1a-e	94.1b-f	91.0e-g	94.3ef	94.8a-f	91.1a-g	90.3a-g	82.8a-g
SWI-1057	97.1a-d	95.1a-c	95.8a-c	95.5a-c	95.5a-e	94.5c-f	90.8a-h	93.0ab	88.3a-c
BAR 7 CD5	95.3ef	92.1a-g	89.1j	93.5a-g	96.3a-c	95.0a-e	89.0c-j	81.3m-o	61.8k-m
Gold Glove	96.1c-f	88.6f-i	93.8b-g	90.6g	96.0a-d	94.6b-f	89.0c-j	86.1g-l	66.0j-m
Sunsport	96.6a-e	92.8a-g	91.3e-j	92.1d-g	95.5a-e	95.1a-d	90.5a-i	89.1b-i	71.8h-j
Patriot	96.5b-f	94.8a-d	94.5a-f	95.0a-d	95.1b-f	94.6b-f	74.0k	80.8no	58.1m
Latitude 36	98.1a	94.1a-e	97.8a	96.1a	95.1b-f	95.3a-c	90.5a-i	90.3a-g	83.5a-g
NorthBridge	98.1a	95.5ab	96.3a-c	94.5a-d	96.8a	95.6a	94.8a	93.6a	89.5a
RAD-CD1	97.5a-c	91.3b-h	95.6a-c	93.6a-f	96.5ab	95.1a-d	90.1b-i	90.5a-f	74.8g-j
OKS 2004-2	97.3a-c	93.8a-e	94.6a-e	92.6c-g	96.5ab	94.6b-f	93.3a-c	90.1a-h	75.0g-j
PSG 91215	96.3b-f	93.0a-g	94.0b-g	90.8fg	95.5a-e	95.0a-e	86.1ij	86.0h-l	69.0i-l
PSG 94524	95.0f	86.0i	90.0ij	93.3a-g	96.3a-c	94.6b-f	90.5a-i	88.3d-i	71.6h-k
IS-01-201	96.1c-f	93.1a-f	91.1f-j	93.6a-f	96.0a-d	94.6b-f	90.1b-i	87.6e-j	70.6h-k
Pyramid 2	96.8a-e	92.6a-g	96.0a-c	95.3a-c	95.6a-e	94.6b-f	90.5a-i	88.3d-i	74.8g-j
Hollywood	97.5a-c	93.3a-e	96.6ab	94.3a-d	95.6a-e	94.6b-f	89.5b-j	83.3k-o	70.8h-k
Yukon	97.1a-d	93.6a-e	95.1a-d	94.8a-d	96.8a	95.1a-d	92.1a-f	87.6e-j	78.6b-i
Veracruz	96.5b-f	93.1a-f	94.5a-f	95.5a-c	96.5ab	95.1a-d	90.1b-i	91.0a-f	86.0a-f
Royal Bengal	97.1a-d	92.0a-g	95.1a-d	94.8a-d	96.3a-c	95.5ab	93.3a-c	92.1a-d	76.6f-i
PSG PROK	96.8a-e	92.5a-f	91.5e-j	94.1a-d	96.3a-c	95.1a-d	93.0a-d	89.8a-h	77.1d-i
PSG 9Y2OK	97.3a-c	93.3a-e	95.1a-d	95.5a-c	96.8a	95.3a-c	92.8a-e	91.3a-f	79.0b-h
TifGrand	97.5a-c	92.8a-g	95.6a-c	93.3a-g	95.8a-e	94.5c-f	90.5a-i	91.0a-f	86.6a-e
OKC70-18	98.1a	92.8a-g	96.3a-c	94.6a-d	93.6f	94.5c-f	89.0c-j	86.0h-l	78.5c-i
Celebration	97.0a-d	94.0a-e	93.5b-h	94.6a-d	96.1a-c	95.5ab	92.6a-f	92.6a-c	88.5ab
Quickstand	96.6a-e	91.5a-h	93.0c-i	95.1a-c	95.8a-e	94.5c-f	90.5a-i	89.8a-h	76.8e-i
U-3-SIU	97.6a-c	91.5a-h	95.8a-c	94.1a-d	96.1a-c	94.8a-f	93.6ab	91.6a-f	84.1a-g
U-3-NC	97.0a-d	90.6c-h	94.1b-f	95.5a-c	96.0a-d	95.0a-e	88.6d-j	88.6c-i	76.5f-i
U-3-TGS	97.1a-d	90.3d-i	94.5a-f	95.0a-d	96.3a-c	94.0f	86.6h-j	84.0j-m	71.6h-k
Astro	96.8a-e	92.1a-g	95.8a-c	94.3a-d	95.6a-e	94.8a-f	92.3a-f	88.6c-i	86.8a-d
OKS2004-3	97.3a-c	93.1a-f	95.8a-c	94.6a-d	96.0a-d	94.3d-f	92.1a-f	91.8a-e	84.6a-g
LSD(0.05)†	**1.5**	**4.6**	**3.5**	**2.9**	**1.6**	**.99**	**4.4**	**4.3**	**9.8**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 17. Comparison of overall bermudagrass digitally assessed live cover on 15 rating dates in the 2007 NTEP bermudagrass trial under two traffic applications in 2013.

Date	1 Game Week^{-1}	2 Games Week^{-1}	LSD†
13-May	96.6	95.7	NS
22-May	99.6a	96.1b	1.5
29-May	99.9a	99.5b	0.32
4-Jun	99.9a	99.4b	0.32
11-Jun	99.3a	96.6b	2.7
19-Jun	99.9a	95.9b	2.3
25-Jun	98.3	98.0	NS
9-Jul	98.5a	95.9b	0.65
16-Jul	99.9a	97.9b	0.37
8-Aug	98.5	98.5	NS
26-Aug	99.8a	99.4b	0.15
18-Sep	96.0a	92.4b	2.2
7-Oct	92.9	92.2	NS
22-Oct	91.7a	81.0b	5.2
28-Oct	79.0	78.5	NS

†Means within rows followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 18. Mean digital live cover of 40 entries pooled over one game and two game per week treatments in the Block F7 2007 NTEP Bermudagrass Trial in 2013.

Entry	13-May	2-May	29-May	4-Jun	11-Jun	19-Jun	25-Jun
Riviera	98.3a-e	97.4	99.9	99.9	98.9	98.6	98.4a-f
Princess 77	94.5f-k	95.3	99.9	99.9	99.1	99.3	99.2a-c
NuMex-Sahara	94.0g-l	94.4	99.1	98.8	97.8	95.0	96.0i-k
SWI-1070	97.5a-g	95.5	99.8	99.8	96.1	96.8	98.9a-d
SWI-1081	95.8b-i	97.8	99.8	99.7	97.1	97.2	96.9e-i
SWI-1083	94.8e-j	97.9	99.8	99.7	94.7	96.7	97.9b-g
SWI-1113	97.8a-f	99.0	99.9	99.8	96.4	98.9	98.5a-e
SWI-1117	92.8i-m	94.8	99.4	99.3	96.3	95.8	96.4h-j
SWI-1122	98.1a-e	99.3	99.9	99.8	97.8	98.4	97.8c-g
Midlawn	95.1d-j	98.6	99.8	99.8	98.9	95.8	98.0a-g
Tifway	99.0a-c	99.3	99.9	99.9	98.2	98.7	99.2a-c
Premier	99.1ab	98.3	99.9	99.9	98.8	98.5	98.9a-d
SWI-1057	95.6c-i	98.8	99.9	99.9	98.9	99.1	99.5ab
BAR 7 CD5	91.2k-m	94.8	97.7	97.5	97.6	95.4	96.7f-j
Gold Glove	91.7j-m	95.4	99.4	99.3	95.4	95.1	94.4k
Sunsport	93.6h-l	98.4	99.5	99.4	97.7	96.0	95.2jk
Patriot	91.7j-m	98.5	99.6	99.5	98.4	99.2	98.1a-f
Latitude 36	99.4a	99.2	99.9	99.9	98.7	99.5	99.5ab
NorthBridge	99.7a	99.6	99.9	99.9	98.1	99.3	98.9a-d
RAD-CD1	97.2a-g	99.0	99.9	99.9	98.3	99.2	99.0a-d
OKS 2004-2	98.4a-d	98.6	99.9	99.8	98.1	98.1	98.9a-d
PSG 91215	94.0g-l	98.7	99.4	99.3	97.7	96.5	96.7g-j
PSG 94524	97.5a-g	97.2	99.5	99.4	96.6	96.9	96.9e-i
IS-01-201	90.7lm	97.8	99.2	99.0	97.7	95.6	96.7g-j
Pyramid 2	98.1a-e	97.5	99.7	99.7	97.9	98.4	98.6a-e
Hollywood	97.5a-g	97.0	99.9	99.9	98.5	99.0	98.6a-e
Yukon	97.4a-g	97.0	99.8	99.8	98.5	98.9	98.9a-d
Veracruz	89.9m	95.8	99.8	99.8	98.9	98.1	99.0a-d
Royal Bengal	98.3a-e	99.5	99.8	99.8	98.6	98.0	98.6a-d
PSG PROK	95.5c-i	96.1	99.6	99.5	97.3	96.6	97.9b-h
PSG 9Y2OK	97.7a-f	99.5	99.9	99.9	98.5	99.3	99.3a-c
TifGrand	98.3a-e	99.5	99.9	99.9	98.6	99.6	99.6a
OKC70-18	99.1ab	98.6	99.9	99.9	98.3	99.1	99.0a-d
Celebration	96.2a-i	98.8	99.9	99.9	98.1	99.3	98.5a-e
Quickstand	91.9j-m	97.7	99.5	99.4	98.0	97.6	97.5d-i
U-3-SIU	96.5a-h	98.4	99.9	99.9	98.8	99.1	99.0a-d
U-3-NC	96.4a-h	98.8	99.7	99.6	97.6	97.0	97.8c-h
U-3-TGS	95.2d-j	97.6	99.7	99.6	98.1	97.8	98.2a-g
Astro	99.2ab	98.5	99.9	99.9	98.4	98.4	98.7a-d
OKS2004-3	99.4a	99.4	99.9	99.9	98.8	99.1	98.8a-d
LSD(0.05)†	**3.5**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.7**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 18. (Continued).

Entry	9-Jul	16-Jul	8-Aug	26-Aug	18-Sep	7-Oct	22-Oct	28-Oct
Riviera	98.3a	99.4	98.9q	99.7	97.4ab	94.2a-g	85.9b-i	81.5b-i
Princess 77	97.2a-d	99.5	98.0b	99.4	94.3a-f	94.5a-g	90.8a-g	86.7a-e
NuMex-Sahara	95.6b-e	98.1	97.1h	99.2	90.3d-f	85.7k-m	76.3kl	65.6l-o
SWI-1070	97.6a-d	98.9	96.4l	99.6	89.1f	91.6c-j	90.0a-g	88.9a-d
SWI-1081	96.7a-d	98.4	97.8d	99.5	92.4b-f	91.8c-j	86.8a-i	72.9g-m
SWI-1083	96.2a-e	98.7	98.7u	99.6	94.2a-f	92.6b-i	88.6a-h	82.6a-g
SWI-1113	97.9ab	99.4	97.8c	99.7	96.5a-c	96.0a-d	90.8a-g	86.6a-e
SWI-1117	96.2a-e	98.3	98.6v	99.4	90.9c-f	88.2i-l	76.7j-l	59.5n-p
SWI-1122	98.2a	99.5	99.1o	99.7	92.7b-f	94.7a-g	87.7a-i	79.8c-j
Midlawn	97.1a-d	98.6	96.9i	99.1	94.4a-f	81.7m	72.5lm	57.4op
Tifway	97.8ab	98.7	98.8s	99.5	96.8ab	94.6a-g	92.2a-e	91.7ab
Premier	93.9ef	97.9	96.7k	99.6	95.4a-e	95.0a-f	90.9a-g	85.8a-f
SWI-1057	97.8ab	99.5	97.6f	99.8	95.2a-e	97.4ab	93.1a-d	91.6ab
BAR 7 CD5	96.3a-e	97.4	99.4h	99.4	94.4a-f	85.3lm	67.0m	63.0m-p
Gold Glove	92.2f	95.7	98.9r	99.5	93.4b-f	90.6e-k	80.9h-l	67.6k-m
Sunsport	95.2c-e	97.9	98.4y	99.4	95.0a-e	93.8a-g	83.7e-k	72.7g-m
Patriot	97.6a-c	99.2	97.6g	99.4	73.5g	81.9m	79.4i-l	52.6p
Latitude 36	98.5a	99.6	96.8j	99.6	93.8a-f	94.7a-g	88.7a-g	87.0a-e
NorthBridge	98.7a	99.5	99.5g	99.8	99.3a	98.3a	95.3a	92.8a
RAD-CD1	98.5a	99.8	99.8a	99.8	94.3a-f	95.0a-f	86.4b-i	75.9f-l
OKS 2004-2	96.3a-e	99.3	99.7b	99.7	97.8ab	94.4a-g	87.0a-i	74.5g-l
PSG 91215	95.1de	97.3	97.6e	99.5	90.2ef	90.3f-l	82.3g-k	69.3j-n
PSG 94524	98.1a	99.2	98.7t	99.7	94.2a-f	91.6d-j	82.7g-k	71.3i-m
IS-01-201	96.3a-e	98.4	99.3n	99.4	94.5a-f	92.0c-j	83.5f-k	71.0h-m
Pyramid 2	97.0a-d	99.0	98.5x	99.7	94.6a-f	92.8b-i	85.2c-j	77.3f-k
Hollywood	96.9a-d	98.9	98.5w	99.6	94.0a-f	87.4j-l	83.4f-k	72.9g-m
Yukon	97.9a	99.3	99.6d	99.6	95.9a-e	92.0c-j	87.0a-i	81.6b-h
Veracruz	97.5a-d	99.3	99.3m	99.7	94.6a-f	95.5a-e	91.8a-f	89.0a-d
Royal Bengal	97.7a-c	99.1	99.1p	99.8	97.6ab	96.7a-c	88.1a-g	79.4d-j
PSG PROK	97.5a-d	98.5	99.5e	99.8	97.3ab	94.1a-g	89.1a-g	79.9c-i
PSG 9Y2OK	98.7a	99.5	99.7c	99.8	97.4ab	95.5a-e	90.2a-g	81.3b-i
TifGrand	98.2a	99.2	98.1a	99.5	94.9a-f	95.4a-e	93.7a-c	90.5ab
OKC70-18	97.0a-d	99.2	94.8m	99.3	92.9b-f	89.8g-l	86.7a-i	81.4b-i
Celebration	98.2a	99.2	99.4j	99.7	97.2ab	97.3ab	94.4ab	91.6ab
Quickstand	98.2a	99.2	99.5f	99.7	95.3a-e	93.9a-g	85.4c-i	79.9c-i
U-3-SIU	96.9a-d	99.1	99.3l	99.6	98.1ab	95.8a-d	92.4a-d	87.5a-e
U-3-NC	98.5a	99.3	99.3k	99.8	92.4b-f	92.4b-i	84.6d-k	79.4d-j
U-3-TGS	97.9ab	98.9	99.4i	99.6	90.6d-f	88.6h-l	80.9h-l	72.7g-m
Astro	98.0ab	99.0	98.3z	99.5	97.2ab	93.4a-g	89.5a-h	90.2a-c
OKS2004-3	98.4a	99.6	99.5e	99.5	96.1a-d	96.3a-d	92.3a-e	87.9a-d
LSD(0.05)†	**2.5**	**NS**	**29.0**	**NS**	**5.8**	**5.1**	**8.6**	**10.5**

†Means within columns followed by the same letters are not statistically different at $P = 0.05$ based on Fisher's LSD test.

Table 19. Turfgrass Performance Index of 40 cultivars in Block F7 2007 NTEP bermudagrass trial by evaluation parameters visual quality [TQ], visual traffic tolerance [TT], visual live cover [PLC], and digital live cover [DIA] during 2013.

Entry	TQ	TT	PLC	DIA
Riviera	6	1	8	5
Princess 77	3	2	7	6
NuMex-Sahara	1	0	2	0
SWI-1070	4	2	4	5
SWI-1081	2	0	0	2
SWI-1083	2	1	4	4
SWI-1113	6	2	7	7
SWI-1117	2	1	2	1
SWI-1122	4	0	7	4
Midlawn	0	0	3	3
Tifway	1	0	8	7
Premier	1	1	5	6
SWI-1057	4	2	8	6
BAR 7 CD5	2	0	4	2
Golden Glove	1	1	1	0
Sunsport	3	1	5	2
Patriot	2	1	3	2
Latitude 36	5	4	8	7
NorthBridge	5	4	9	7
RAD-CD1	5	2	6	5
OKS 2004-2	3	1	6	6
PSG 91215	2	1	3	0
PSG 94524	2	1	3	3
IS-01-201	2	1	3	2
Pyramid 2	3	1	6	4
Hollywood	2	1	5	4
Yukon	4	2	7	5
Veracruz	4	3	7	6
Royal Bengal	3	1	8	6
PSG PROK	4	1	7	4
PSG 9Y2OK	4	2	8	6
TifGrand	3	0	8	7
OKC70-18	1	2	4	4
Celebration	2	0	8	7
Quickstand	3	0	6	3
U-3-SIU	4	0	9	7
U-3-NC	3	1	4	2
U-3-TGS	2	0	4	2
Astro	2	2	8	7
OKS2004-3	4	2	8	7

† Number of times cultivar appeared in statistical group “a” where mean separation had been performed using the Protected Fisher’s Least Significant Difference Test at p=0.05.

Figure 1a. Jacobsen T-1224 converted to Cady Traffic Simulator.

Figure 1b. Feet of the Cady Traffic Simulator.

Figure 1c. Front view of feet of Cady Traffic Simulator.

CHAPTER IV

Summary

In 2012 and 2013, there were numerous top performing varieties in regard to each evaluation parameter. This can be explained by this trial containing some of the overall best bermudagrasses in regards to many characteristics including traffic tolerance. There were many varieties included in the 2007 NTEP Bermudagrass Trial that are also included in the 2013 NTEP Bermudagrass Trial. Entries such as Riviera and Latitude 36, top performing varieties in this trial, will act as standard entries in the 2013 NTEP Trial. Unfortunately, top performing variety NorthBridge was not be included in the 2013 NTEP Trial but is still suggested, based on this research trial, to be a top choice in regards to traffic tolerance in the Stillwater, OK climatic zone.

Research Limitations

Through the findings of this research and working with the CTS weekly, we feel the CTS and methods used to create the CTS should be more standardized in order to more accurately compare research trials at differing sites around the nation using the CTS. One of the biggest points of uncertainty lies in choosing a tire material for the foot construction. After talking with many other researchers doing the same type of work

with the CTS, it was learned that almost every individual was using a different type of tire for the feet of the CTS. In order to accurately compare traffic tolerance research trials results there should be a standard tire used in the construction of the CTS. Any chosen tire will need to be extremely durable as we found that a steel belted tire lacked the durability for the intense usage necessary in conducting multiple trials at our test site. Another limitation to this research was that we had to switch tire materials after the first month of traffic application due to the steel belted tire severing in half. We believe that switching from a steel belted tire to a nylon belted tire could have an effect on early results. Further force measurements should be done on all types of machines being used to aid in cross comparison of results amongst published trials. Force research among differing tire materials would be expected to significantly different due to the possibility of a different force being exerted by a steel belted tire versus a nylon belted tire. This further research would allow the standardization of the CTS and more accurate comparison among trials. Future research should also be done on traffic tolerances of bermudagrass with various numbers of passes made by the Cady traffic simulator. Based on this research trial, we do not believe two forward passes with the CTS creates enough damage to separate cultivar performance in a significant manner. Four forward passes by the CTS should be the minimum amount used to separate performance differences in visual quality, traffic tolerance, and live cover amongst cultivars of bermudagrass.

One limitation to this research is concerning digital image analysis as an evaluation tool. For the purpose of this study, a natural light source was chosen to take photographs to assess traffic injury. The decision to use a natural light source was made due to the large number of photographs being taken on a given day. Time was taken into

account and it was decided to use a natural light source because of the previous mentioned reasons. Previous research trials have used a natural light source (Henderson et al., 2005) or a light box (Trappe et al., 2011). Using a consistent light source will allow different photos to be compared more accurately on different days. Analyzing photographs taken under different lighting conditions was one of the biggest hardships during this research trial. While we believe our data is accurate and follows previous research, we believe a consistent light source could have made analysis of photos easier. A comparison study of a natural light source versus a light box would be beneficial to a situation such as this. This type of comparison would have given valuable information to which method was more appropriate for this research trial.

The turfgrass performance index (TPI) as previously utilized by Trappe et al. (2011) proved to be a useful method of identification of those varieties that provided the greatest frequency of elite performance in our research. Trappe et al. (2011) stated "Traffic tolerance as expressed by TPI rankings is difficult to compare to previous published reports of traffic or wear tolerance of bermudagrass cultivars, as there is no statistical analysis included with TPI rankings other than a determination that there is variability among cultivars. However, a cumulative TPI provides more information regarding traffic tolerance of cultivars, especially when there are few statistical differences in coverage of cultivars across dates." TPI rankings summarize statistical findings within a trial but TPI units are generally not themselves analyzed for statistical significance, although they could be statistically analyzed.

Outcomes and Impacts

Based on the findings of this research, we were able to rank experimental and commercially available bermudagrasses on their traffic tolerance at the test site. This data, combined with other findings, will potentially aid in decision making concerning commercialization of experimental cultivars and further use of fertile breeding lines. It is possible that selection of specific clones from within the plots of Oklahoma State University seeded and vegetative cultivars can be performed upon completion of the trial for further testing. In theory, these selections should have improved traffic tolerance over that of the original broad parent population. Using the research-based findings, cultivar use suggestions can be made for this region of the United States. These findings should prove useful in directing athletic field managers towards selecting a cultivar that they can use to the fullest ability on their fields. Ultimately, this may allow for more efficient use of resources by minimizing the amount of time and money required to maintain a high-quality facility (Williams et al., 2010). Additionally, findings from work conducted upon the 2007 NTEP Bermudagrass trial can be compared with traffic tolerance findings from other NTEP test sites in an attempt to compare overall trends for the various cultivars tested at each test site.

Although traffic creates soil compaction and decreases rooting (Canaway, 1976), this study only measured the direct response of bermudagrass cultivars to simulated athletic field traffic. These results show that several bermudagrass cultivars possess higher traffic tolerance, while some have poor traffic tolerance. Selecting improved, traffic-tolerant bermudagrasses will help reduce maintenance costs and increase

sustainability of golf courses and athletic fields while also producing a higher quality and safer surface for sports and athletes (Trappe et al., 2011).

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