Published December 1, 2014
JOURNAL OF PLANT REGISTRATIONS
CULTIVAR

Registration of 'DALSA 0605' St. Augustinegrass

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ABSTRACT

'DALSA 0605' (Reg. No. CV-274, PI 671959) is an embryo rescue-derived interploid hybrid of St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] resulting from a cross between TAES 5382 (African triploid PI 291594) and 'Palmetto' (diploid). DALSA 0605 was evaluated under the designation TAES 5471-18 and TXSA 19 and was approved for release as a new cultivar by Texas A&M AgriLife in 2014. DALSA 0605 is a vegetatively propagated, genetically stable, and uniform cultivar. It is distinguished from other cultivars of St. Augustinegrass for traits and characteristics that include (i) tolerance to gray leaf spot disease (caused by *Magnaporthe grisea* Couch), (ii) significantly reduced levels of fecundity and juvenile development of southern chinch bugs (*Blissus insularis* Barber) as compared to 'Raleigh' and 'Texas Common', and (iii) superior drought resistance conferred through a combination of tolerance to drying soil, deep rooting potential, and rapid recovery following drought. In addition, DALSA 0605 exhibited percentage rates of establishment and turfgrass quality ratings (normal and drought-stress conditions) comparable to commercial checks in multilocation (seven) and multiyear (two) field evaluations. DALSA 0605 is well suited for use on residential and commercial lawns, as well as other recreational sites, throughout the southern and southeastern United States.

Journal of Plant Registrations
doi:10.3198/jpr2014.05.0036crc
Received 21 May 2014. Registration by CSSA.
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St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] is a popular warm-season turfgrass species widely used as a lawn grass in subtemperate and humid environments in tropical and subtropical regions (Sauer, 1972). It is a perennial, highly stoloniferous, C_4 turfgrass species propagated vegetatively through stolons, plugs, and sod resulting in its clonal cultivation in monoculture. The scientific literature indicates that the genus *Stenotaphrum* Trin. (Family: Panicoideae) contains approximately seven species (Sauer, 1972); however, only *S. secundatum*, St. Augustinegrass, is currently of commercial significance to the turf industry. The origin of St. Augustinegrass is unknown, but speculation is that it originated in Old World tropics (coastlines and islands of the Indian Ocean) and from southern China to the South Pacific (Busey, 2003; Sauer, 1972). It was brought to the New World either through European migration or before the European colonization through an earlier transoceanic dispersal (Sauer, 1972). Nonetheless, St. Augustinegrass has been reported to occur on all continents of the world except Antarctica (Busey, 1995) and has become part of the natural flora of both North and South America since the 1700s.

Genetic variability exists among genotypes of St. Augustinegrass for traits such as morphology and adaptability as well as biotic and abiotic stress tolerance. Such genetic variation is believed to be partitioned between different ploidy

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Abbreviations: RCB, randomized complete block; SCRI, Specialty Crops Research Initiative; SPN, Spaced Plant Nursery; TPI, Turfgrass Performance Index.

levels (Busey and Zaenker, 1992; Busey et al., 1993). Diploids ($x = 9$; $2n = 2x = 18$) such as 'Raleigh' (unpatented; Bateman, 1980), 'Delmar' (Wayne et al., 1988) and 'Captiva' (Nagata and Busey, 2010) have finer, thinner, darker green leaf blades compared with polyploids ($2n = \sim 27–32$) such as 'Floratam' (unpatented; Horn et al., 1973) and 'FX-10' (Busey, 1992), which exhibit better insect and disease resistance, as well as drought tolerance (Busey, 2003). Floratam has been shown to avoid wilting better than diploid genotypes such as Seville and Florida Common during brief intervals of water deficit (Busey, 1996). Floratam also outperformed other St. Augustinegrass cultivars for resistance to leaf firing as well as time required to recover following a 60-d rainout period in Texas (Steinke et al., 2010). Until recently, the polyploid gene pool has not been readily available as a breeding resource due to sterility barriers resulting from differences in ploidy levels. Genovesi et al. (2009) described a protocol whereby in vitro embryo rescue methods allowed for the recovery of viable hybrids (interploids) when polyploid females were crossed with diploid males. 'DALSA 0605' (Reg. No. CV-274, PI 671959) is the first reported embryo rescue-derived interploid hybrid cultivar of St. Augustinegrass proposed for commercial release.

St. Augustinegrass is a popular turfgrass because of its ability to tolerate shade better than other warm-season turfgrass species (Beard, 1973). The primary concerns with the use of St. Augustinegrass have been its perceived reduced water use efficiency and its susceptibility to southern chinch bugs (*Blissus insularis* Barber) and to diseases such as large patch disease caused by *Rhizoctonia solani* Kühn and gray leaf spot disease caused by *Magnaporthe grisea* Couch. DALSA 0605 represents a genetic improvement over the current commercially available cultivars of St. Augustinegrass on the basis of its superior drought tolerance characteristics, tolerance to gray leaf spot disease, reduced rate of reproduction of southern chinch bug, higher percentage mortality of tropical sod webworm (*Herpetogramma phaeopteralis* Guenée), and adaptability to a wide range of environmental conditions encountered across the southern and southeastern United States.

Materials and Methods

Embryo Rescue

In vitro embryo rescue technique was utilized in the development of DALSA 0605 in 2004. Following pollination by 'Palmetto' (Kirkland and Wagner, 1995; 'Palmetto' is a registered trademark of Sod Solutions, Inc.) (diploid pollen parent), enlarged ovules from TAES 5382 (African polyploidy, PI 291594) were dissected to recover developing embryos 14 to 21 d postpollination. Hybrid embryos with vestigial endosperm attached were transferred to the half-strength Murashige and Skoog basal medium (Murashige and Skoog, 1962) containing 5% sucrose as a carbon source and osmoticum, and incubated at 25°C with an 18-h photoperiod for 5 to 7 wk (Genovesi et al., 2009) before the DALSA 0605 plantlet was transplanted to the greenhouse. To determine the 2C DNA content of DALSA 0605 in comparison to its parental lines, young leaf tissue samples of DALSA 0605, TAES 5382 and Palmetto were sent to the Flow Cytometry and Imaging Core laboratory (Dr. K. Arumuganathan, Seattle, WA).

Morphology

Morphological data were obtained in June 2013 from three replicate 18.9-L pots each of DALSA 0605, Floratam, Raleigh, and Palmetto maintained under field conditions (Table 1). Leaf blade length was determined for the three tallest leaves in each of the three replicate pots for all four entries by measuring the distance between the base and the tip of the leaf. Leaf blade width was recorded for the same three tallest leaves at the widest point of the leaf blade. Internode length and diameter between the fifth and sixth node, and node diameter of the fourth node, were measured for the three longest stolons in each pot.

Field Performance

DALSA 0605 and 22 other experimental lines and a commercial check, Raleigh, were evaluated in a strip trial from 2007 to 2010 in Dallas, TX. Twenty-four entries were planted in a randomized complete block (RCB) experimental design with three replications. A total of 90 7.6- cm^2 by 7.6-cm^2 plugs were planted in a 3-m^2 by 9-m^2 plot, and plots were provided 9.76 to 19.5 g m^{-2} yr^{-1} of nitrogen (N) and mowed at 7.6 to 10.2 cm in height with rotary mowers. Irrigation was provided to prevent drought stress during the study. For the purpose of this publication, only the data for DALSA 0605 are included for comparison to the commercial check, Raleigh (Table 2). On the basis of its superior performance in the strip trial, DALSA 0605 was advanced and evaluated in replicated field trial no. 1 from 2009 to 2011 in Dallas. Seventy experimental lines and two commercial checks, Raleigh and Captiva, were planted in a RCB with three replications. Six 7.6-cm^2 by 7.6-cm^2 plugs of each entry were planted in 1.8-m^2 by 1.8-m^2 plots, which

Table 1. Morphological characteristics of DALSA 0605 and three commercial cultivars of St. Augustinegrass.

Cultivar	Leaf blade length†	Leaf blade width‡	Internode length§	Internode diameter§	Node diameter§
	mm				
DALSA 0605	321.3a¶	7.5a	65.3a	2.8a	4.2a
Floratam	225.7b	8.2a	53.0b	2.7a	4.8a
Palmetto	195.7bc	6.7a	46.7b	2.0b	2.8b
Raleigh	189.0c	8.3a	46.0b	2.3ab	3.2b

† Leaf blade length was determined by measuring the distance between the base and the tip of the three tallest leaves in each of the three replicate pots. Mean of nine measurements.

‡ Leaf blade width was recorded at the widest point for the three tallest leaves in each of the three replicate pots. Mean of nine measurements.

§ Internode length and diameter were measured between the fifth and sixth node for the three longest stolons in each of the three replicate pots. Node diameter was measured for the fourth node. Mean of nine measurements.

¶ Means in a column followed by the same letter(s) are not significantly different by Fisher's Protected LSD Test ($P = 0.05$).

were maintained as described above. In this publication, only the data for DALSA 0605 in comparison to the commercial checks, Raleigh and Captiva are presented (Table 3). Due to its promising performance in the strip trial and replicated field trial no. 1 in Dallas, DALSA 0605 was advanced to the multilocation progeny evaluation trail referred to as 2011 Specialty Crops Research Initiative (SCRI) Shared Spaced Plant Nursery (SSPN).

DALSA 0605 (coded as TXSA 19) was established in 2011 SCRI SSPN at seven locations (Dallas and College Station, TX; Stillwater, OK; Raleigh, NC; Tifton and Griffin, GA; and Gainesville, FL) and evaluated for a 2-yr period (2011 and 2012). The 2011 SSPN was composed of 160 experimental lines and three commercial checks (Floratam, Raleigh, and Palmetto) that were planted in May to June 2011 in a RCB experimental design with two replications. A single 7.6-cm^2 by 7.6-cm^2 plug was planted in the center of a 1.5-m^2 by 1.5-m^2 plots maintained as described above. Irrigation was provided to promote plot establishment in 2011. In 2012, irrigation was withheld during the growing months to induce drought stress. The locations that experienced drought stress in 2012 were Dallas and College Station, TX; Stillwater OK; Gainesville, FL; and Raleigh, NC. Only data for DALSA 0605 compared with the three commercial checks Floratam, Raleigh, and Palmetto are presented here (Tables 4–6).

Drought-Stress Response

To evaluate the response of DALSA 0605 through a soil dry-down period and recovery following drought-stress conditions, two separate experiments (Fig. 1) were conducted following White et al. (1993) in the greenhouse at Dallas, maintained at 30/24°C (day/night) for Experiment 1 (September–December 2012) and 27/21°C (day/night) for Experiment 2 (January–May, 2013). Experiments 1 and 2 each consisted of four replications of DALSA 0605, DALSA 0406, Floratam, and Raleigh established in 9-cm^2 by 9-cm^2 pots containing potting mix (Sunshine Mix VP, Sun Gro Horticulture). After 4 wk of growth in period, all four replicate pots of four genotypes were arranged in a RCB design in a large tub (62-L volume, 27 cm deep) filled with fritted clay (Absorb-N-Dry, Balcones Co.). During the acclimation period of 5 wk for Experiment 1 and 2 wk for Experiment 2, tubs with fritted clay were watered three times per week. After acclimation, the plants were subjected to a prolonged dry-down period by completely withholding watering. The induced drought persisted for 67 d before rewetting in Experiment 1, allowing for a potential for recovery; the induced drought lasted for 103 d before rewetting in Experiment 2, where mortality was desired. The induced drought-stress period was followed by a 28-d recovery period in both experiments. Turfgrass quality was assessed visually on a 1-to-9 scale (1 = brown/fired, 5 = minimally acceptable, and 9 = excellent) at weekly intervals during the course of the dry-down,

Table 2. Turfgrass performance characteristics recorded from 2007 to 2010 in the strip trial in Dallas, TX.

Entry	Mean turfgrass quality†				Mean density‡			Genetic color§			Fall color¶			Spring green-up#			TPI††	Rank
	2007	2008	2009	2010	2008	2009	2010	2008	2009	2010	2007	2008	2010	2008	2009	2010		
DALSA 0605	6.5a‡‡	6.1a	6.1a	5.3a	7.7a	7.7a	5.1a	5.7a	7.0a	5.0a	8.0a	6.3a	7.3a	1.7a	5.3a	6.7a	16	1
Raleigh	6.4a	5.2	4.8	4.5	6.4	5.1	5.2a	5.3a	6.3a	4.7a	4.3	4.7	7.3a	1.3	3.0	6.0a	7	2

† Turf quality rated on a scale of 1 to 9 where 1 = undesirable quality, 9 = the ideal highest quality of turf and 5 = the minimum acceptable turf quality.

‡ Density rated on scale of 1 to 9 where 1 = bare ground and 9 = the highest number of plants per unit area.

§ Genetic color rated on scale of 1 to 9 where 1 = being light green and 9 = dark green.

¶ Fall color rated on a scale of 1 to 9 where 1 = being straw brown and 9 = dark green.

Spring green-up rated on a scale of 1 to 9 where 1 = being straw brown and 9 = dark green.

†† TPI, Turf Performance Index, represents the total number of times an entry appeared in the top statistical group as indicated by the letter "a" in the data columns to the left.

‡‡ Means were separated using Fisher's Least Significant Difference Test ($P = 0.05$).

Table 3. Turfgrass performance characteristics recorded from 2009 to 2011 in the replicated field trial no. 1 in Dallas, TX.

Entry	Mean turfgrass quality†			Mean density‡			Genetic color§			Disease resistance¶	Spread #	Leaf firing††	TPI‡‡	Rank
	2009	2010	2011	2009	2010	2011	2009	2010	2011					
	1–9			1–9			1–9			1–9	1–9	1–9		
DALSA 0605	5.2a§§	5.7a	5.6a	6.1a	6.1a	7.3a	8.0a	6.0a	7.0a	8.0a	8.0a	8.3a	12	1
Captiva	4.2	4.5	3.8	5.4a	5.9a	4.6	8.0a	5.7a	6.7a	7.0a	5.0	5.2	6	2
Raleigh	4.1	4.5	3.2	4.9a	5.4a	4.4	7.0a	5.0a	5.7	6.3	6.3	6.0a	5	3

† Turf quality rated on a scale of 1 to 9, where 1 = undesirable quality, 9 = the ideal highest quality of turf and 5 = the minimum acceptable turf quality.

‡ Density rated on scale of 1 to 9, where 1 = bare ground and 9 = the highest number of plants per unit area.

§ Genetic color rated on scale of 1 to 9, where 1 = being light green and 9 = dark green.

¶ Disease resistance (Gray leaf spot) was rated on a scale of 1 to 9, where 1 = susceptible and 9 = no damage.·

Spread was rated on a scale of 1 to 9, where 1 = original plug size and 9 = Full plot coverage.

†† Drought tolerance assessed as leaf firing on a 1 to 9 visual rating scale, with 1 = 100% leaf firing and 9 = no leaf firing.

‡‡ TPI, Turf Performance Index, represents the total number of times an entry appeared in the top statistical group as indicated by the letter "a" in the data columns to the left.

§§ Means were separated using Fisher's Least Significance Difference Test ($P = 0.05$).

as well as 28 d after watering was resumed for evaluation of recovery potential.

Evaluations comparing the rooting potential of DALSA 0605 and Floratam were performed in a greenhouse at College Station, TX (Fig. 2). Repeated 35-d studies were conducted during spring (April–May) and summer (June–July) 2013. Greenhouse temperatures during the studies were maintained at 30/21°C (day/night). To initiate experiments, sod plugs (10 cm diam. by 5 cm deep) were placed atop clear plastic columns (10 cm diam. by 92 cm deep) filled with potting soil (Metro-Mix, Sun Gro Horticulture). Sod plugs were fertilized using a complete fertilizer and were maintained under well-watered conditions by irrigating daily with 0.6 cm of water during the 35-d experiment. At the conclusion of the 35-d study, soil and roots were separated into upper (1–46 cm) and lower (46–92 cm) column depths. Roots were washed clean of soil before determining total root length using root scanning software WinRHIZO (Regents Instruments). Following root length determination, roots were oven dried for 72 h at 65°C before weighing.

Disease and Insect Pest Tolerance

To evaluate the disease resistance and/or susceptibility of DALSA 0605 to the gray leaf spot fungal disease, several experiments were conducted (Metz et al., 2012): whole plant, detached stolon and detached leaf assays under growth chamber conditions, and whole plant screening under field conditions. Eight commercial and nine advanced breeding lines of St. Augustinegrass, including DALSA 0605, were included in the test. Details on inoculum preparation and evaluation technique were described in Metz et al. (2012).

Susceptibility to the southern chinch bug was evaluated in vented (Lumite screen) plastic shoe box cages. DALSA 0605, eight other advanced breeding lines, Floratam, Raleigh, and Texas Common were compared for their acceptability as hosts. Only the data for DALSA 0605 in comparison to the commercial

Table 4. Mean percentage coverage of DALSA 0605 compared with the commercial checks from seven locations during 2011 and 2012.

Entry	Mean percentage coverage†													Grand mean	TPI‡
	College Station, TX		Dallas, TX		Gainesville, FL		Griffin, GA		Tifton, GA		Jackson Spring, NC	Stillwater, OK			
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2011	2012		
DALSA 0605	52.5a§	97.5a	9.3a	75.0a	24.2	67.5a	55.6a	72.5a	62.3a	73.3a	55.0a	56.7a	94.1a	61.2	12
Palmetto	45.8a	100.0a	13.2a	93.8a	43.0a	77.5a	61.3a	58.8a	52.7a	57.5	46.7a	43.8a	81.7a	59.7	12
Floratam	75.8a	100.0a	17.4a	96.3a	24.3	67.5a	55.0a	75.0a	58.5a	59.5	83.3a	47.9a	81.7a	64.8	11
Raleigh	70.8a	100.0a	1.4	43.8	35.8a	72.5a	45.0a	56.3a	35.5	57.1	48.3a	32.1	74.5	51.8	7

† Percentage coverage was estimated on a percentage basis; 1% = original plug size and 100% = full plot coverage.

‡ TPI, Turf Performance Index, represents the total number of times an entry appeared in the top statistical group as indicated by the letter "a" in the data columns to the left.

§ Means were separated using Fisher's Least Significance Difference Test ($P = 0.05$).

Table 5. Mean turfgrass quality of DALSA 0605 compared with the commercial checks during normal (2011 and 2012) and dry-down conditions (2012) across the southern and southeastern United States.

Entry	Mean turfgrass quality†									Dry-down mean turfgrass quality† in 2012						
	College Station, TX	Dallas, TX	FL‡	Griffin, GA	Tifton, GA	NC‡	OK‡	Grand mean	TPI§	College Station, TX	Dallas, TX	FL‡	NC‡	OK‡	Grand mean	TPI§
	1–9									1–9						
DALSA 0605	5.4a	4.7a	5.6a	7.0a	6.1a	5.6a	5.8a	5.8	7	5.0a	6.5a	3.6a	5.0a	4.8a	5.0	5
Palmetto	5.2a	4.4a	4.3a	6.0a	6.0a	5.9a	5.1a	5.3	7	4.3a	5.3a	2.9a	6.8a	5.0a	4.9	5
Raleigh	5.4a	2.8a	3.9a	5.7a	4.8a	5.7a	5.2a	4.8	7	5.0a	4.0	3.9a	6.8a	5.0a	4.9	4
Floratam	5.5a	4.5a	4.6a	6.8a	6.3a	4.7a	6.3a	5.6	7	5.8a	5.3a	3.9a	4.0	4.5a	4.7	4

† Turf quality rated on a scale of 1 to 9 where 1 = undesirable quality, 9 = the ideal highest quality of turf and 5 = the minimum acceptable turf quality.

‡ FL = Gainesville, FL; NC = Jackson Spring, NC; OK = Stillwater, OK.

§ TPI, Turf Performance Index, represents the total number of times an entry appeared in the top statistical group as indicated by the letter "a" in the data columns to the left.

Table 6. Cumulative turfgrass performance indices of DALSA 0605 compared with the commercial checks.

Entry	Mean turf quality†	Mean turf quality dry-down‡	Mean percentage cover§	Total TPI¶	Rank
DALSA 0605	7	5	12	24	1.5
Palmetto	7	5	12	24	1.5
Floratam	7	4	11	22	3
Raleigh	7	4	7	18	4

† TPI, Turf Performance Index, for the mean turf quality obtained from Table 5.

‡ TPI for the mean turf quality under dry-down conditions obtained from Table 5.

§ TPI for the mean percentage cover obtained from Table 4.

¶ Cumulative TPI calculated by adding TPI values of all three traits.

checks, Floratam, Captiva, TX Common and Raleigh are presented here (Table 7). Four replicates of each genotype were cultivated in the greenhouse and grown in plastic pots (15.24 cm. top diam., 12.7 cm bottom diam., 17.7-cm-tall). One attached stolon (~200–250 cm. long) from each plant was inserted through a slit in the side of each cage, and the slit was filled with a stretched cotton ball and sealed with silicon. Ten adult chinch bugs (five females and five males) were introduced into each cage and allowed to reproduce to develop as a population through one generation. At the end of the experiment, all nymphs and adults were collected from the cages to determine susceptibility for each genotype.

DALSA 0605, nine other advanced breeding lines, and Raleigh were evaluated for resistance to the tropical sod webworm. Only the data for DALSA 0605 is included here for comparison to the commercial check Raleigh (Table 8). Plants of each genotype maintained in the greenhouse and clippings were harvested from each grass and evaluated in no-choice tests in the laboratory to evaluate resistance. For each test, neonate (newly hatched) larvae were introduced into 9-cm-diam. by 20-mm plastic Petri dishes (Reinert et al., 2009). Each dish was provided with two water-saturated filter paper discs, and water was added to the filter paper as needed to keep it saturated to maintain the grass clippings. Each dish was provided with a small amount of fresh leaf tissue (~3 g) of the respective grass. Grass was added or replaced daily or every other day throughout the experiment so that turgid fresh grass was always available to the developing larvae in the dishes. Larvae for the study were obtained from a laboratory-reared colony of tropical sod webworms. Mortality was recorded throughout the experiment when the larvae were fed. Larvae were weighed after 15 d of feeding, which was just a few days before the larvae began to pupate. Pupas were weighed within 1 d after pupation, and the days to pupation and adult emergence were recorded.

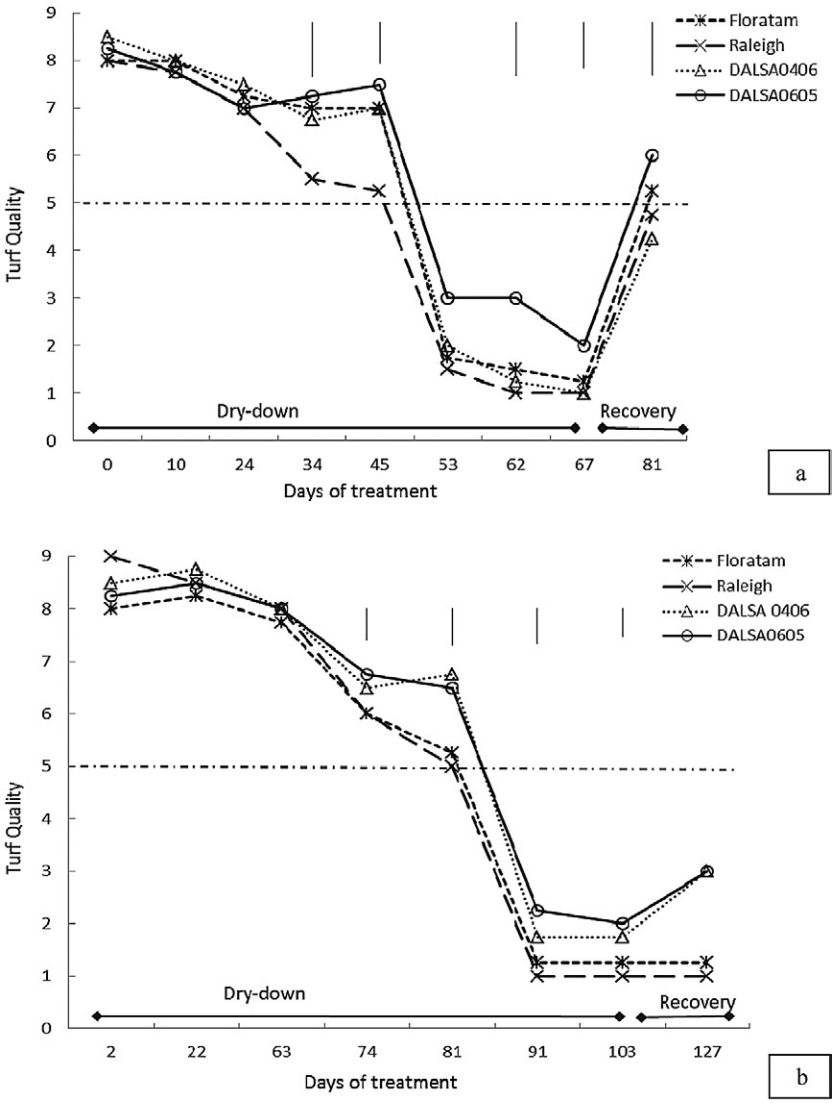

Fig. 1. Response and recovery of DALSA 0605 following prolonged drought stress in two separate greenhouse experiments—(a) Experiment 1, (b) Experiment 2—conducted in Dallas, TX. Vertical bars indicated LSD values where significant differences were detected ($P = 0.05$) for comparison between genotypes at a given day of treatment. The horizontal dotted line indicates minimum acceptable turf quality.

Characteristics

Origin

DALSA 0605 is an interploid hybrid resulting from a cross made between TAES 5382 (Africa polyploid) and Palmetto (diploid) in 2004. TAES 5382 is the program designation given to PI 291594, a germplasm introduction from Zimbabwe, Africa obtained from the USDA–ARS Plant Genetic Resources Conservation Unit, Griffin, GA. PI 291594 was reported by Milla-Lewis et al. (2013) to be triploid, $2n = 27$, which is sterile and incapable of setting fertile seed when crossed with a diploid cultivar. Results of the flow cytometry show that DALSA 0605 has intermediate 2C DNA content (1.24 pg/2C) compared with TAES 5382 (1.78 pg/2C) and Palmetto (1.03 pg/2C).

Morphology

Morphological measurements show that DALSA 0605 has longer internode and leaf blade lengths compared with all tested commercial checks (Table 1). Because of its faster leaf growth (elongation), DALSA 0605 may require more frequent mowing, similar to Floratam, than cultivars with compact growth habits such as Raleigh. The internode diameter of DALSA 0605 is in the same statistical group as Floratam and Raleigh, and the node diameter is in the same statistical group as Floratam. There were no significant differences in the leaf blade width of DALSA 0605 compared with all tested commercial checks.

Field Performance

DALSA 0605 was tested in a spaced plant nursery (SPN) along with 384 progeny planted in 2005 in Cleveland, TX (in cooperation with Ralph Sanders Turf Farms). After 2 yr of evaluation in Cleveland, DALSA 0605 was one of 10 progeny selected in 2006 for testing in a strip trial in Dallas that was

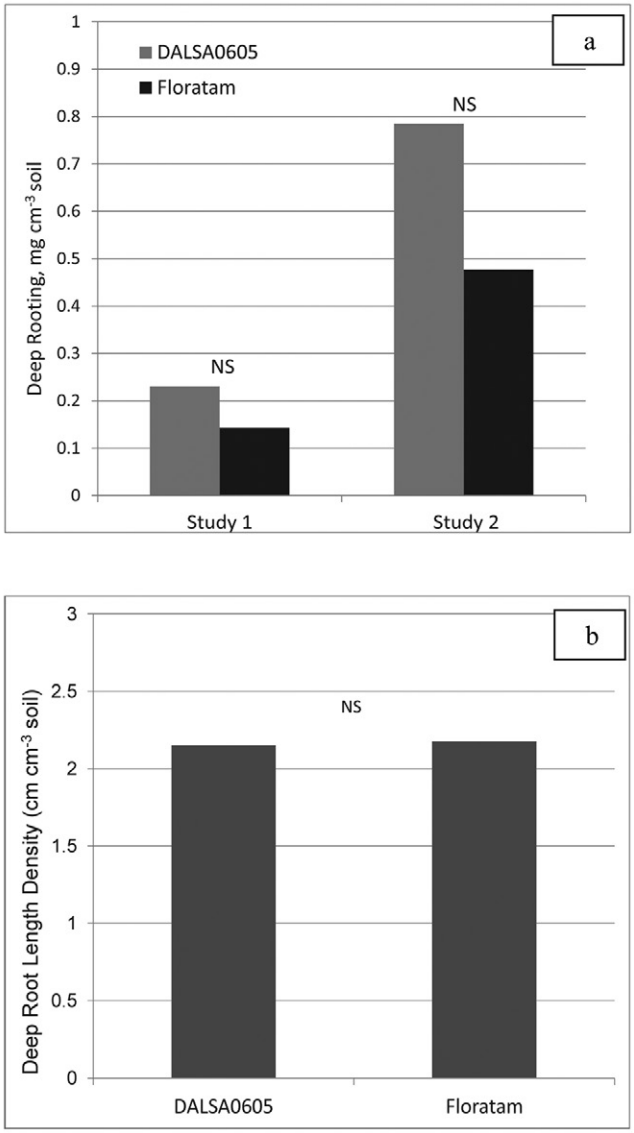

Fig. 2. Deep rooting potential of DALSA 0605 compared with Floratam St. Augustinegrass from greenhouse rooting column studies in College Station, TX. Upper figure (a) is total deep (46–92 cm depth) root length density for spring (Study 1) and summer (Study 2) studies. Lower figure (b) is total root length density of deep roots as determined through root scanning. Evaluations were made 35 d following sod establishment. Means were not significantly (NS) different based on Fishers LSD ($\alpha = 0.05$).

initially planted with 24 entries in 2005. Ten of the poorest-performing entries were discarded and replaced with 10 new entries (DALSA 06xx series) including DALSA 0605 in 2006. Data from the strip trial (2007–2010) for DALSA 0605 along with Raleigh are presented in Table 2. On the basis of mean turfgrass quality, mean density, genetic color, fall color, and spring green-up, DALSA 0605 ranked number one in the trial, with a total Turfgrass Performance Index (TPI; number of times it appeared in the top statistical group) (Wherley et al., 2011) of 16 as compared to Raleigh, with a total TPI of 7 (Table 2). Based on its superior performance in the strip trial, DALSA 0605 was advanced to the replicated field trial no. 1 in Dallas. Data collected for mean turfgrass quality, spread, mean shoot density, genetic color, disease resistance (gray leaf spot), and leaf firing, showed that DALSA 0605 was ranked number one,

Table 7. Development of southern chinch bugs through one generation on St. Augustinegrass in a no-choice cage greenhouse test in Dallas, TX.

Genotype	Mean population per cage		
	Total nymphs	Total adults	Total bugs
DALSA 0605	0.0d†	9.8b	9.8e
Floratam	0.8d	9.5b	10.3e
Captiva	20.3bcd	9.0b	29.3cde
Texas Common	54.0ab	9.8b	63.8bc
Raleigh	103.0a	15.5ab	118.5a

† Means in a column followed by the same letter are not significantly different by Fisher's Protected LSD Test ($P = 0.05$).

with a total TPI of 12 (Table 3), compared with Captiva with a TPI of 6 and Raleigh with a TPI of 5. Due to its continued superior performance at the Dallas location, DALSA 0605 was advanced to the 2011 SCRI SSPN. Data taken for percentage establishment in 2011 and 2012 at seven locations showed DALSA 0605 and Palmetto to be tied for highest TPI of 12 (Table 4). For mean turfgrass quality ratings taken under an optimal irrigation regime across seven locations, DALSA 0605 performed similarly to Palmetto, Raleigh, and Floratam, with a total TPI of 7 (Table 5). When drought stress was imposed at five of seven locations in 2012, DALSA 0605 and Palmetto exhibited a TPI of 5, followed by Raleigh and Floratam each with a TPI of 4 (Table 5). Overall, DALSA 0605 tied with Palmetto for a ranking of 1.5 in this study based on percentage establishment and turfgrass quality across seven locations during 2011 and 2012 (Table 6).

Drought-Stress Response

Competitive dry-down studies between DALSA 0605 and other commercial entries were conducted in Dallas to screen for tolerance to drying soil and recovery following drought. The experiments took place in the confines of a restricted 27-cm-deep root zone under uniformly drying soils and thus tested the comparative drought tolerance between entries. The turfgrass quality of all entries declined during the course of the dry-down period (no watering) in both experiments (Fig. 1a and 1b), primarily due to leaf tissue firing. In Experiment 1, the trend was toward higher turfgrass quality ratings for DALSA 0605 when compared to Floratam, Raleigh, and DALSA 0406 during dry-down period (Fig. 1a). At 34 and 45 d of no watering, turfgrass quality of DALSA 0605, DALSA 0406, and Floratam was significantly higher than Raleigh. At 62 and 67 d of no watering, DALSA 0605 and Floratam exhibited significantly higher turfgrass quality than DALSA 0406 and Raleigh. Turfgrass quality recovered gradually after rewatering, which was initiated following 67 d of dry-down. Within 13 d of rewatering, DALSA 0605 and Floratam were the only entries to recover to an acceptable turfgrass quality (≥5).

In Experiment 2, a longer dry-down was provided. Throughout much of the dry-down, the turfgrass quality of DALSA 0605 and DALSA 0406 was significantly better than Raleigh and Floratam. After 91 d of dry-down, turfgrass quality for DALSA 0605 was significantly higher than that for DALSA 0406, Raleigh, and Floratam. After 103 d, Raleigh and Floratam were completely dead and did not recover following rewatering, in contrast to DALSA 0605 and DALSA 0406 (Fig.

Table 8. Resistance to tropical sod webworm among cultivars of St. Augustinegrass in laboratory no-choice tests in Dallas, TX.

Genotype	15-day-old larvae		Pupa			Adult	
	% mort†,‡	Wt.§	% mort†,‡	Wt.¶	d to pupa#	% mort†,‡	d to adult#
	%	mg	%	mg	d	%	d
Raleigh	0.0b††	34.7b	8.0ab	40.3cd	22.7ab	12.0bcd	31.8ab
DALSA0605	4.0ab	44.5cd	20.0a	41.8bcd	20.8e	36.0a	30.2cde

† Mean % of larvae mortality (mort) at 15 days after egg hatch, % mortality at pupation and % mortality at adult emergence.

‡ Data were transformed to arcsine for analysis; untransformed means presented here.

§ Mean weight of surviving larvae after feeding on each genotype for 15 d.

¶ Mean weight for only those individuals that pupated (weight taken within 1 d of pupation).

Mean number of days from egg hatch to pupation and adult emergence for larvae fed on each genotype.

†† Means in a column followed by the same letter are not significantly different by Fisher's Protected LSD Test (P=0.05).

1b). By maintaining superior quality under increasing drought stress, DALSA 0605 demonstrates superior drought tolerance relative to other commercial St. Augustinegrass cultivars. This combined with an ability to rapidly recover from drought once irrigation is resumed suggests it would be well adapted for use in landscapes where irrigation frequency or amount is restricted during water conservation periods.

General observational data from multiple locations and years have indicated that DALSA 0605 possesses excellent drought quality, maintaining excellent color and delayed leaf wilt/firing during periods of limited water availability compared with other St. Augustinegrass germplasm. To examine the drought avoidance aspects of DALSA 0605 in more detail, rooting evaluations were conducted in College Station during 2013. A trend toward greater deep (46–92 cm depth) root development in DALSA 0605 relative to Floratam was observed in both experiments (Fig. 2a), but differences were not significant in either study. When pooled across studies, DALSA 0605 exhibited greater deep rooting development compared with Floratam; however, differences were not significant. Total root length (cm) of roots within the 46–92 cm depth of soil volume was also nearly identical between DALSA 0605 and Floratam (Fig. 2b). Deep rooting has been considered a primary aspect of drought avoidance in turfgrasses. These rooting data emphasize that DALSA 0605 possesses comparable deep rooting potential to Floratam, which is currently the industry standard for drought avoidance.

Disease and Insect Pest Tolerance

Gray leaf spot disease is most prevalent during periods of warm temperatures and prolonged rainfall and/or irrigation, combined with excessive levels of N fertilizer (Atilano and Busey, 1983; Harmon et al., 2005). Symptoms of the disease first appear on leaf blades as small brown specks to spots that rapidly enlarge to form oval to elongated necrotic areas about 0.2 to 0.7 cm in length. However, spots may reach 2 cm in length with as many as 30 or more lesions per leaf blade (Smiley et al., 1996). Based on lesion size and severity ratings, Metz et al. (2012) showed that TAES 5382 (polyploidy maternal parent) and DALSA 0605 were consistently classified as highly resistant or resistant using the rank-sum method analysis. Palmetto (diploid pollen parent) was classified as susceptible. This finding concurs with other researchers who have attributed resistance to biotic stress in St. Augustinegrass to ploidy level (Reinert et al., 1986; Busey, 2003) and is consistent with previously reported observations (Busey, 2003; Harmon et al., 2005; Jo et al., 2007), which indicated that the introduced African polyploid FX-10 exhibits resistance to *M. grisea*. Figure 3 shows DALSA 0605 expressing high levels of tolerance to the gray leaf spot disease relative to 'Mercedes' and Raleigh in a study conducted in 2009 in Dallas under field conditions (Metz et al., 2012).

The population development for southern chinch bugs was assayed after one generation (approximately 6 wk) for each genotype. No nymphs and less than 10 adults were recovered from DALSA 0605. Population development on DALSA 0605 was significantly lower than Raleigh and Texas Common

Fig. 3. Image of DALSA 0605 (right) expressing high levels of tolerance to the gray leaf spot disease relative to Mercedes and Raleigh (left and center, respectively) in a study conducted in 2009 in Dallas, TX, under field conditions.

(Table 7) but not significantly different from Floratam, which had originally been identified as resistant to southern chinch bug (Reinert and Dudeck, 1974; Reinert et al., 1980). Floratam resistance was originally documented to causing a high level of antibiosis (80–100% mortality of confined chinch bugs within 7 d) (Reinert and Dudeck, 1974). In preliminary tests in the 2000s (J. A. Reinert, unpublished data), neither DALSA 0605 nor Floratam produced significant mortality of confined southern chinch bugs; however, as shown in Table 7 and in another study (Reinert et al., 2011), DALSA 0605 and Floratam exhibit a totally different form of resistance, that is, a failure of chinch bug populations to develop and reproduce (antixenosis). This new form of resistance in conjunction with other management strategies (particularly reduced rates of N) should help provide better management for this most important pest of St. Augustinegrass.

DALSA 0605 did not cause significant mortality or reduced larval weight of tropical sod webworm after 15 d in a no-choice feeding study. DALSA 0605 did provide a significant 20% mortality at pupation and a significant 36% mortality at adult emergence (Table 8). Other parameters measured did not show a significant effect for DALSA 0605.

Summary

DALSA 0605 is the first embryo rescue-derived interploid variety of St. Augustinegrass proposed for release. It exhibits traits and characteristics including drought resistance, comparable to Floratam, conferred through a combination of tolerance to drying soil, deep rooting potential, and rapid recovery following drought; tolerance to gray leaf spot disease superior than Raleigh, Floratam, and Palmetto; reduced fecundity of southern chinch bugs similar to Floratam; and wide adaptation across the southern and southeastern United States. DALSA 0605 is a sterile interploid hybrid with no viable seed formation, resulting in little chance of off-type contamination in the sod production fields.

Availability

Texas A&M AgriLife Research–Dallas, TX, will maintain breeder stock of DALSA 0605. Only foundation, registered, and certified classes of sod are recognized for DALSA 0605. All certified production must be directly from registered, foundation, or breeder stock. Vegetative propagules of DALSA 0605 are available from the corresponding author for research purposes. Stock of DALSA 0605 has been deposited in the USDA–ARS National Center for Genetic Resources Preservation, where it will be available for distribution 20 years after the plant patent filing date.

References

Atilano, R.A., and P. Busey. 1983. Susceptibility of St. Augustinegrass germplasm to *Pyricularia grisea*. Plant Dis. 67:782–783. doi:10.1094/PD-67-782

Bateman, D.R. 1980. Notice to sod producers and growers relative to the naming and release of the new St. Augustine cultivar 'Raleigh'. North Carolina Agric. Res. Serv, Raleigh, NC.

Beard, J.B. 1973. Turfgrass: Science and culture. Prentice Hall, Englewood Cliffs, NJ.

Busey, P. 1992. `FX-10`, a variety of St. Augustinegrass. U.S. Plant Patent 7852. Date issued: 7 April.

Busey, P. 1995. Genetic diversity and vulnerability of St. Augustinegrass. Crop Sci. 35:322–327. doi:10.2135/cropsci1995.0011183X003500020005x

Busey, P. 1996. Wilt avoidance in St. Augustinegrass germplasm. HortScience 31:1135–1138.

Busey, P. 2003. St. Augustinegrass, *Stenotaphrum secundatum* (Walt.) Kuntze. In: M.D. Casler and R.R. Duncan, editors, Turfgrass biology, genetics, and breeding. John Wiley & Sons, Hoboken, NJ. p. 309–330.

Busey, P., R.M. Giblin-Davis, and B.J. Center. 1993. Resistance in *Stenotaphrum* to the sting nematode. Crop Sci. 33:1066–1070. doi:10.2135/cropsci1993.0011183X003300050038x

Busey, P., and E.I. Zaenker. 1992. Resistance bioassay from southern chinch bug (Heteroptera: Lygaeidae) excreta. J. Econ. Entomol. 85:2032–2038.

Genovesi, A.D., R.W. Jessup, M.C. Engelke, and B.L. Burson. 2009. Interploid St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Knutze] hybrids recovered by embryo rescue. In Vitro Cell. Dev. Biol. Plant 45:659–666. doi:10.1007/s11627-009-9230-x

Harmon, P., L. Datnoff, R. Nagata, M. Brecht, and C. Stiles. 2005. Gray leaf spot of St. Augustinegrass: Cultural and chemical options. EDIS, University of Florida IFAS Extension. http://edis.ifas.ufl.edu/pp126.

Horn, G.C., A.E. Dudeck, and R.W. Toler. 1973. 'Floratam' St. Augustinegrass: A fast growing new variety for ornamental turf resistant to St. Augustine decline and chinch bugs. Florida Agric. Exp. Stn. Circ. S-224.

Jo, Y.K, G.L. Wang, and M.J. Boehm. 2007. Expression analysis of rice defense-related genes in turfgrass in response to *Magnaporthe grisea*. Phytopathology 97:170–178. doi:10.1094/PHYTO-97-2-0170

Kirkland, E.R., and T.A. Wagner. 1995. St. Augustine grass `SS-100'. U.S. Plant Patent 9395. Date issued: 5 December.

Metz, S.P., A. Chandra, A.D. Genovesi, and C.F. Campos. 2012. Comparison of screening methods to evaluate the response of St. Augustine grass to *Magnaporthe oryzae*. Plant Pathol. 61:255–261. doi:10.1111/j.1365-3059.2011.02521.x

Milla-Lewis, S.R., M.C. Zuleta, G.A. Van Esbroeck, K.H. Quesenberry, and K.E. Kenworthy. 2013. Cytological and molecular characterization of genetic diversity in *Stenotaphrum*. Crop Sci. 53:296–308. doi:10.2135/cropsci2012.04.0234

Murashige, T., and F. Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue. Physiol. Plant. 15:473–497. doi:10.1111/j.1399-3054.1962.tb08052.x

Nagata, R.T., and P. Busey. 2010. St. Augustine grass plant named `NUF-76'. U.S. Plant Patent 21,280. Date issued: 7 September

Reinert, J.A., B.D. Bruton, and R.W. Toler. 1980. Resistance of St. Augustinegrass to southern chinch bug and St. Augustine decline strain of Panicum mosaic virus. J. Econ. Entomol. 73:602–604.

Reinert, J.A., P. Busey, and F.G. Bilz. 1986. Old World St. Augustinegrass resistant to the southern chinch bug (Heteroptera: Lygaeidae). J. Econ. Entomol. 79:1073–1075.

Reinert, J.A., A. Chandra, and M.C. Engelke. 2011. Susceptibility of cultivars and genera of turfgrass to the southern chinch bug *Blissus insularis* (Hemiptera: Lygaeidae). Fla. Entomol. 94:158–163. doi:10.1653/024.094.0206

Reinert, J.A., and A.E. Dudeck. 1974. Southern chinch bug resistance in St. Augustinegrass. J. Econ. Entomol. 67:275–277.

Reinert, J.A., M.C. Engelke, A.D. Genovesi, A. Chandra, and J.E. McCoy. 2009. Resistance to tropical sod webworm (*Herpetogramma phaeopteralis*) in St. Augustinegrass and zoysiagrass. Int. Turfgrass Soc. Res. J. 11:663–673.

Sauer, J. 1972. Revision of *Stenotaphrum* (Gramineae: Paniceae) with attention to its historical geography. Brittonia 24:202–222. doi:10.2307/2805871

Smiley, R.W., P.H. Dernoden, and B.B. Clarke. 1996. Compendium of turfgrass diseases. American Phytopathological Society, St. Paul, MN.

Steinke, K., D. Chalmers, J. Thomas, R. White, and G. Fipps. 2010. Drought response and recovery characteristics of St. Augustinegrass cultivars. Crop Sci. 50:2076–2083. doi:10.2135/cropsci2009.10.0635

Wayne C.M., T.P. Riordan, and V.D. Meier. 1988. St. Augustine grass. U.S. Plant Patent 6372. Date issued: 1 November.

Wherley, B.G., P. Skulkaew, A. Chandra, A.D. Genovesi, and M.C. Engelke. 2011. Low-input performance of zoysiagrass (*Zoysia* spp.) cultivars maintained under dense tree shade. HortScience 46:1033–1037.

White, R.H., M.C. Engelke, S.J. Morton, and D. Ruezinsky. 1993. Irrigation water requirements of zoysiagrass. In: R.N. Carrow, editor, Int. Turfgrass Soc. Res. J. Intertec Publishing Corp., Overland Park, KS. p. 587–593.