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Gamma-ray Irradiation Induces Useful Morphological Variation in Bermudagrass

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Abstract

Bermudagrass, *Cynodon dactylon* (L.) Pers. is a widely used warm-season turfgrass species in warmer regions of the world. Gamma (ɣ) irradiation has been used to generate useful variations in turfgrass breeding for various morphological traits. The objective of the present study was to measure and determine variations in morphology and turfgrass characteristics of a native drought resistant bermudagrass germplasm irradiated with 70, 90 or 110 Gy using a ^{60}Co source. The stolons containing a single node were irradiated and immediately planted for regeneration in a greenhouse at the Akdeniz University, Antalya, Turkey. Selected mutants regenerated from the irradiated stolons were clonally propagated and transplanted into plastic pots for further observations of turfgrass characteristics. Survival rates of stolons exposed to 70, 90 and 110 Gy were 76%, 43% and 17% respectively, 6 weeks after treatment. Dosages of 85 and 57 Gy were determined as LD_{50} and LD_{20} for the cuttings, respectively. The linear reduction of survival rate with increasing gamma-rays was highly correlated (r^2=0.99). A total of four mutant lines (0.3 % of the irradiated plants) showed a distinct dwarfed growth habit. Three of these lines were originated from 70 Gy and one from 110 Gy. These mutant lines exhibited more dwarf growth habit, higher shoot density, finer leaf texture than parental genotype. Mutant lines developed in this study can be used for the development of improved bermudagrass cultivars for landscaping and sports turf.

Keywords: breeding, dwarf mutants, ^{60}Co, mutation, turfgrass

Introduction

Bermudagrass [*Cynodon dactylon* (L.) Pers.] is a warm-season grass widely used for pasture, forage, turfgrass, soil stabilization, and remediation (Burton, 1947; Taliaferro, 2003). *Cynodon* genotypes with all known ploidy levels exist in the eastern Mediterranean of Turkey (Gulsen *et al*., 2009). The tetraploid *C. dactylon* genotypes have been the sole genetic pool for development of seeded-type bermudagrass cultivars. Some of the native tetraploid C. *dactylon* genotypes collected from coastal Mediterranean region of Turkey possessed superior drought tolerance and darker green color than commercial bermudagrass cultivars (ex. 'Princess 77', 'Riviera') under Mediterranean conditions (Sever Mutlu *et al*., 2014).These wild germplasm of bermudagrass is well adapted to the region's biotic and abiotic factors. However, their rapid vertical growth, coarse-leaf texture and long internodes are undesirable and limit their use as turfgrass. Rapid, upright shoot growth requires frequent mowing and irrigation, increasing energy cost during active growing season (Chen *et al*., 2009). Dwarf bermudagrass mutants induced by gamma radiation exhibited enhanced drought resistance compared to their wild-type parents (Lu *et al*., 2008). Therefore, there is an increasing demand for slow-growing dwarf type turf cultivars with high drought resistance. Irradiation mutagenesis has been used to create genetic diversity in major crops. Ahloowalia and Maluszynski (2001) reported that more than1800 released cultivars developed either as direct mutants or derived from their crosses worldwide. Mutation breeding has successfully been used in turfgrasses (Busey, 1980; Dickens *et al*., 1981; Burton, 1985; van Harten, 1998; Hanna and Elsner, 1999). Gamma-rays irradiation has also been successfully used to generate new breed lines of bermudagrass from the wild germplasm (Lu *et al*., 2009). Each of these mutant turf cultivars possessed finer texture and superior turgrass quality than their parental genotypes (Li *et al*., 2010). The most frequent mutant character from the irradiated plants is dwarfism (Powell *et al*., 1974). Many dwarf-type bermudagrass cultivars (ex. 'Tifway II',

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'TifEagle') were developed by gamma irradiation (Burton 1985; Hanna *et al.*, 1997b; Hanna and Elsner 1999). The aim of this research was to induce dwarf mutants from native drought resistant bermudagrass genotypes to generate new breed lines/cultivars of bermudagrass. The mutant progenies with dwarf type growth habit, and superior turfgrass characteristics can be used in seeded-type (4x) bermudagrass breeding. The morphological traits and other turf characteristics of dwarf mutants induced by gamma irradiation in comparison to their parents were evaluated.

Materials and Methods

Plant material and mutation treatment

A local tetraploid bermudagrass genotype 'B-165'collected from Erzin-Hatay city Turkey, was used as the plant material (Gulsen *et al.*, 2009). The 'B-165' exhibits dark green color and was determined to be highly drought resistant after a multi-year/environment evaluation under Mediterranean conditions (Sever Mutlu, unpublished data). However, it exhibited an undesirable rapid upright growth habit with coarser leaf texture compared to commercial bermudagrass cultivars. Stolons of 'B-165' were collected from the mature field plot at Akdeniz University, Antalya, Turkey and attached soil was washed off with tap water. The stolons were cut into single node cuttings, placed in plastic petri dishes and irradiated with 0, 70, 90 or 110 Gy doses of γ-radiation from ^{60}Co with a dose rate of approximately 35 Gy/h at 100 cm source-to-sample distance. Each treatment consisted of 450 cuttings.

The control cuttings were not irradiated, but placed in petri dishes and kept in 5°C to maintain moisture until planting. After irradiation, the cuttings were immediately planted in the mixture of peat, vermiculite and perlite (3:1:1, v/v/v) for regeneration in a greenhouse under natural light conditions on Feb 15, 2011. The 30 plants regenerated from the irradiated stolons with visible morphological changes compared to their respective wild-type plants were selected and transplanted into the plastic pots for further observation of growth and turf characteristics in Apr 2011. Among them, four mutant lines exhibiting dwarf characteristics with finer leaf texture, shorter canopy height than 'B-165' parental plants were chosen, and clonally propagated for detailed evaluation in Jun 2011.

Experimental design was a randomized complete block with 4 replications for each line. Plants were allowed to grow for 3 months in a greenhouse under natural light and at temperature of 25-35°C. During the establishment period, plants were fertilized with 2.5 g N m^{-2} with 15N-6.6P-12.5K, a complex fertilizer, biweekly and irrigated daily to prevent visual wilt symptoms and mowed at 5 cm weekly. The plants were maintained outside the greenhouse under full sun conditions from Oct 2011 to Feb 2012 to detect variations in color retention, dormancy and relative chlorophyll content in comparison to their parental germplasm in the fall.

Data collection and statistical analyses

Irradiation dosage effect on single node cuttings

Survival of the cuttings was scored 6 weeks after irradiation treatment. Survival rate was calculated as a percentage of cuttings with re-growth divided by the total number. The data-points obtained in this way were fitted to the probit function: $probit(p) = a + b\sqrt{2}erf^{-1}(2p-1)$ where a is the y-intercept, b is slope and p is the normalized survival probability. The fit was performed by using the ROOT package (Brun, 1997). In addition an inverse fit was performed as a consistency check and for easy display of data. In all cases the probit-fit and the inverse fit agreed perfectly. The probit function can be easily used to determine any lethality dose (LD).

Morphological characterization of mutant plant lines

Canopy heights with and without seedhead measurements were made on five random plants for each pot. Longest leaf at third node below apical meristem on main upright tiller was used for the measurement of leaf length and leaf width. Seed head density was determined quantitatively by counting seed heads per pot. Five mature inflorescences were collected from each pot to determine the number of racemes per inflorescence, raceme length, seed head exertion from the base of the inflorescence to the flag leaf, and peduncle length. The measurements in each pot were made on five randomly selected stolons for internode length and diameter between 3rd and 4th fully extended nodes from apical meristem, stolon length from apical meristem to the 5th node; and for total stolon number by counting stolons per pot. Visual assessment of leaf texture was an estimate of leaf width.

The visual ratings of texture, shoot density, fall color retention and fall/winter dormancy were collected as described by the National Turfgrass Evaluation Program (NTEP) (Morris, 2004). Five measurements were taken within each pot for relative chlorophyll content using a chlorophyll meter (Field Scout CM 1000; Spectrum Technologies, Inc., Plainfield, IL).

Treatment differences were tested using analysis of variance procedures with PROC GLM (SAS release 8.0; SAS Institute, Cary, NC). Means were separated using Fisher's protected least significant difference ($P<0.05$) procedure.

Results

Probit analysis indicated that LD_{50} and LD_{20} dosages were 85±7and 57±14 Gy, respectively (Fig. 1). Survival rates of cuttings irradiated at 70, 90 and 110 Gy were 76%, 43% and 17%, respectively. The linear reduction of survival rate with increasing γ-rays was highly negatively correlated (r^2=0.99). Irradiation of 1350 single-node cuttings resulted in four morphological mutants (0.3 % of the total irradiated cuttings) with dwarf/semi dwarf growth habit. Three of these, 165-70-1, 165-70-5, and 165-70-6, were obtained from cuttings treated at 70 Gy, and one mutant line, 165-110-1, at 110 Gy. The mutant lines exhibited finer plant texture, a more dwarf habit and slower vertical growth than the wild type 'B-165' (Table 1). The mutant lines with and without seed heads, respectively, were 26% to 38%, and 30% to 51% shorter than wild-type control.

The mutant lines exhibited significant morphological differences compared to wild type (Table 1). The leaf blade length reduced by 34%-46%, and 28% in the lines generated by 70 Gy and 110 Gy, respectively. The leaf blade width also narrowed by 25% to 31%. The mutant lines had significantly finer leaf texture (6.0 to 7.5 rating scale) compared to coarse textured parental genotype (4.0). The stolon number was both increased by 42% (165-70-6) and decreased by 30% (165-110-1). Stolon length was reduced by 27% to 42%, and by 52% in mutant lines originated from 70 Gy and 110 Gy, respectively. Stolon internodes were thinner and up to 31% and 54% shorter in mutant lines originated from 70 Gy and 110 Gy.

Table 1. Morphological characteristics of the dwarf mutant bermudagrass (*C. dactylon*) lines generated via γ-radiation

Traits[1]	Control	Mutant bermuda lines				% Difference from control					
	'B-165'	'165-70-1'	'165-70-5'	'165-70-6'	'165-110-1'	'165-70-1'	'165-70-5'	'165-70-6'	'165-110-1'	Lsd (p≤0.05)	Sig[2]
CH (cm)	15.4 a[3]	8.8 c	7.7 c	7.5 c	10.9 b	-43	-50	-51	-29	1.48	***
CHWS (cm)	24.0 a	15.0 c	17.5 b	17.0 b	17.7 b	-38	-27	-29	-26	1.80	***
LW (mm)	3.0 a	2.2 b	2.3 b	2.1 b	2.3 b	-28	-25	-31	-25	0.06	*
LL (cm)	10.2 a	5.5 c	6.7 b	5.6 c	7.3 b	-46	-34	-44	-28	0.86	***
SN	3.3 b	3.0 b	3.0 b	4.7 a	2.3 c	-9	-9	41	-30	0.90	**
SL (cm)	15.8 a	9.2 b	11.5 b	11.0 b	7.6 bc	-42	-27	-30	-52	2.60	**
ID (mm)	1.32 a	1.09 b	1.23 ab	1.17 ab	1.07 b	-17	-7	-11	-19	0.20	*
IL (cm)	3.5 a	2.9 ab	2.4 b	2.8 b	1.6 c	-16	-31	-19	-54	0.54	**
SHD (no/pot)	65 c	28 d	129 b	71 c	206 a	-57	98	9	217	17.90	***
RN	4.4 b	4.9 a	4.7 ab	4.3 b	5.0 a	10	6	-2	13	0.38	*
RL (cm)	4.2 a	3.4 c	3.6 bc	3.9 ab	4.1 a	-19	-14	-7	-2	0.36	*
SHE (mm)	41.2 a	22 d	30.6 bc	35.1 b	28.5 c	-47	-26	-15	-31	4.90	**
PL (cm)	10.0 a	7.0 d	7.9 c	8.9 b	8.1 c	-30	-22	-12	-19	0.40	***
CHL1	250.9 c	260.7 b	264.4 b	274.0 a	240.7 d	4	5	9	-4	9.00	**
CHL2	115.0 b	131.7 a	119.5 b	136.8 a	118.5 b	15	4	19	3	8.50	**
SD	4.8 c	7.5 a	6.3 b	6.0 b	6.5 b	58	33	26	37	0.78	**
T	4.0 d	6.8 a	6.5 b	6.5 b	6.0 c	-70	-63	-63	-50	0.42	***
FD (%)	60 a	40 c	50 b	35 c	55 ab	-33	-17	-42	-8	9.50	*
FCR	4.5 d	7 a	6.0 b	6.5 ab	5.8 bc	56	33	44	28	0.59	**

[1] CH-canopy height without seed head; CHWS-canopy height with seed head; LW-leaf blade width at third node below apical meristem; LL-leaf blade length at third node below apical meristem; SN-stolon number per pot; SL-stolon length; ID and IL-internode diameter and internode length measured from between 3rd and 4th fully extended nodes from apical meristem ; SHD-seed head density–seed head number per pot; RN-number of racemes per inflorescence; RL-raceme length; SHE-seed head exertion from the base of the inflorescence to the flag leaf; PL-peduncle length as the measurement of internode from base of whorl to first node; CHL1 and CHL2-relative chloropyll content on 19 Oct 2011 and 4 Dec 2011, respectively; SD-shoot density rated on a 1 to 9 scale with 9 equaling maximum density; T-leaf texture rated on a 1 to 9 rating scale with 1 equaling coarse and 9 equaling fine texture; FD-fall/winter dormancy rated on 0-100 % scale with 100 equaling complete dormancy, with straw brown colour of entire leaves on 4 Dec 2011 ; FCR-Fall colour retention, rated on a 1 to 9 visual rating scale with 1 equaling straw brown or no colour retention, and 9 equaling dark green on 20 Nov 2011.

[2] *, **, ***: significant at probability of 0.05, 0.01 and 0.001, respectively.

[3] Values followed by the same letter within a trait were not significantly different from each other according to the LSD (P=0.05).

Table 2. Correlation coefficients among morphological traits of mutant bermudagrass (*C. dactylon*) lines generated via γ-radiation

Traits[1]	ID	SL	SN	RN	RL	SHD	SHE	PL	LL	LW	CH	CHWS	CHL 1	CHL2	SD	T	FD	FCR
IL	0,51*[2]	0,65**	ns[3]	-0,56**	ns	-0,78**	ns	ns	ns	0,48*	ns	ns	ns	ns	-0,50*	ns	ns	ns
ID	__	0,49*	ns	ns	ns	ns	0,46*	ns	ns	ns	ns	0,52*	ns	ns	-0,53*	-0,48*	ns	-0,49*
SL		__	ns	-0,71**	ns	ns	0,69**	0,71**	0,67**	0,63*	0,57*	0,74**	ns	ns	-0,68**	-0,67**	ns	-0,72**
SN			__	-0,49*	ns	ns	ns	ns	ns	ns	ns	ns	0,62*	0,61*	ns	ns	ns	ns
RN				__	ns	ns	-0,57*	-0,57*	ns	ns	ns	ns	-0,55*	ns	0,50*	ns	ns	ns
RL					__	ns	0,69**	0,77**	0,64*	ns	0,63*	0,68**	ns	ns	-0,58*	-0,71**	0,45*	-0,64*
SHD						__	ns	ns	ns	ns	ns	ns	-0,53*	ns	ns	ns	ns	ns
SHE							__	0,96**	0,66**	ns	0,52*	0,81**	ns	ns	-0,83**	-0,73**	ns	-0,71**
PL								__	0,75**	0,55*	0,65**	0,86**	ns	ns	-0,84**	-0,83**	0,44*	-0,79**
LL									__	0,79**	0,92**	0,93**	-0,57*	-0,63*	-0,75**	-0,92**	0,82**	-0,92**
LW										__	0,71**	0,71**	ns	-0,47*	-0,68**	-0,73**	0,55*	-0,64**
CH											__	0,84**	-0,65**	-0,50*	-0,59*	-0,94**	0,69**	-0,81**
CHWS												__	ns	-0,54*	-0,81**	-0,93**	0,69**	-0,94**
CHL 1													__	0,59*	ns	0,49*	-0,71**	0,45*
CHL2														__	0,45*	0,50*	-0,72**	0,67**
SD															__	0,77**	-0,49*	0,78**
T																__	-0,60*	0,88**
FD																	__	-0,77**

[1] IL and ID-internode length and internode diameter measured from between 3rd and 4th fully extended nodes from apical meristem ; SL-stolon length; SN-stolon number per pot; RN-number of racemes per inflorescence; RL-raceme length; SHD-seed head density, number of seed head per pot; SHE-seed head exertion from the base of the inflorescence to the flag leaf; PL-peduncle length as the measurement of internode from base of whorl to first node; LL and LW-leaf blade length and leaf blade width at third node below apical meristem; CH-canopy height without seed head; CHWS-canopy height with seed head; CHL1 and CHL2-relative chlorophyll content on 19 Oct 2011 and 4 Dec 2011, respectively; SD-shoot density rated on a 1 to 9 scale with 9 equaling maximum density; T-leaf texture rated on a 1 to 9 rating scale with 1 equaling coarse and 9 equaling fine texture; FD-fall/winter dormancy rated on 0-100 % scale with 100 equaling complete dormancy, with straw brown colour of entire leaves on 4 Dec 2011 ; FCR-fall colour retention, rated on a 1 to 9 visual rating scale with 1 equaling straw brown or no colour retention, and 9 equaling dark green on 20 Nov 2011.

[2] *, **: significant at probability of 0.05 and 0.01, respectively.

[3] ns: non-significant at probability of 0.05.

Significant changes in inflorescence characteristics were also observed in mutant lines (Table 1). Compared to wild-type, seed head density both reduced by 57% and increased threefold in mutant lines. The number of racemes per inflorescence increased up to 13%, and raceme length shortened up to 19%. In addition, the peduncle length and seed head exertion from the base of the inflorescence to the flag leaf were reduced in all mutant lines. Highest reduction in peduncle length (% 30) and seed head exertion (% 47) was identified in mutant line '165-70-1'.

The mutant lines showed up to 58% higher shoot density. There was significant variation between mutant lines and control plants in terms of dormancy, relative chlorophyll content and color retention in late fall/winter period. Mutant lines retained their green color 28% to 56% better and developed up to 55% less dormancy in fall. Relative chlorophyll contents of mutant lines were up to 19% higher. Improvement in fall/winter performances as demonstrated by lower dormancy, higher chlorophyll content and darker green color in late fall was especially evident in mutant

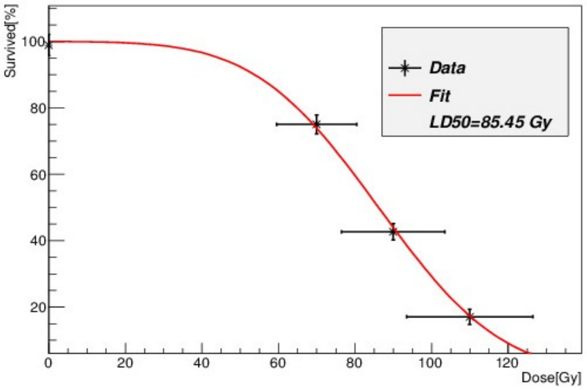

Fig. 1. Gamma ray dosage effects on survival of single-node bermudagrass cuttings ('B-165')

lines 165-70-1 and 165-70-6 (Table 1).

Correlation coefficients among morphological traits are presented in Table 2. The relatively high correlations between shoot density and fall color retention (*r*= 0.78), and shoot density and texture (*r*= 0.77) reflected opportunity for spontaneous selection for the traits. Shoot density was also negatively correlated with internode length (*r*= -0.50), diameter (*r*= -0.53), stolon length (*r*=- 0.68), peduncle length (*r*=- 0.84), leaf length (r=- 0.75), leaf width (*r*=- 0.68), seed head density (r=- 0.83), and canopy height (r=- 0.59). Therefore, selection for plants with shorter lengths of internode, stolon, leaf blade, raceme, and peduncle, and shorter canopy height and thinner internode diameter and narrower leaf blade should increase shoot density and concurrently improve leaf texture. The canopy height was positively correlated with stolon length (r= 0.57), leaf length (r= 0.92), leaf width (r= 0.71), peduncle length (r= 0.65), and raceme length (r= 0.63); and negatively with leaf texture (r=- 0.94), shoot density (r=- 0.59), fall color retention (r=- 0.81), and chlorophyll content (r=- 0.65). Results indicate that plants with shorter stolon, leaf blade, raceme and peduncle, and narrower leaf blade exhibit more dwarf growth habit which in turn exhibits denser, finer textured turf with higher chlorophyll content and better fall color retention.

Discussion

Increasing γ-ray dosage significantly reduced survival rates (r^2=0.99) in bermudagrass. Similar results were reported with other species of *Poaceae* family (Busey, 1980; Krishna *et al.*, 1984; Hase *et al.*, 1999; Zaka *et al.*, 2002). Results showed that gamma irradiation doses of 70 to 113 Gy were successful in creating bermudagrass mutants, concurring with earlier reports (Powel *et al.*, 1974; Burton, 1985; Hanna *et al.*, 1997b; Caetano-Anolles, 1999; Hanna and Elsner, 1999; Lu *et al.*, 2009). Four dwarf mutant bermudagrass lines (0.3%) were obtained, comparable to 0.4% dwarf bermudagrass and St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] mutants reported by Lu *et al.*, (2009) and (Li *et al.*, 2010), respectively. Dwarfisms have been associated with defection in biosynthesis or reception of gibberellins (Ross *et al.* 1997), brassinosteroids (Noguchi *et al.* 1999), and regulation of cell elongation (Takahashi *et al.* 1995) or with abnormal cell walls (Reiter *et al.*, 1993).

The LD50 dose was determined to be 85 Gy. Bermudagrass exerted a higher tolerance to gamma irradiation compared to St. Augustinegrass (30- 48.5 Gy) (Busey, 1979; Li *et al.*, 2010). The most dwarf mutant line was 51% shorter, similar to 55% reduction in bermudagrass (Lu *et al.*, 2009), and to 31-84% reduction in other species of grass family (Cheema and Atta, 2003; Al-Salhi *et al.*, 2004; Borzouei *et al.*, 2010; Nasab *et al.*, 2010; Kim *et al.*, 2015). Reduction in canopy height and slow-growing trait in dwarf lines may further improve drought resistance over parental genotype. Reports by Lu *et al.* (2008) and Chen et al. (2009) demonstrated enhanced drought resistance of dwarf mutants compared to their wild type parents, probably due to reduced leaf area. Studies with bentgrasses (*Agrostis sp.*) also indicated that slow-growing turfgrass may be able to survive drought stress for prolonged periods of time (DaCosta and Huang, 2006, 2007).

Useful morphological variations were created by γ-radiation. The bermudagrass mutants had higher shoot density and finer plant texture with significantly smaller leaves and shortened internodes and stolons. As a result of gamma radiation, shorter internodes and smaller leaves were reported in bermudagrass (Hanna, 1990; Chen *et al.*, 2009; Tiwari *et al.*, 2014), centipedegrass [*Eremochloa ophiuroides* (Munro) Hack.] (Pedersen and Dickens, 1985; van Harten, 1998) and St.Augustinegrass (Powell and Toler, 1980; Reynolds *et al.*, 2009; Li *et al.*, 2010); and enhanced shoot/tiller density in wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) (Breslavets, 1946), and purple false brome *(Brachypodium distachyon*) (Kim *et al.*, 2015). The turfgrass quality is associated with compact growth pattern and finer leaves (Reynolds *et al.*, 2009). Superior turfgrass quality of dwarf lines was also reported with other studies using gamma radiation in the development of dwarf cultivars of bermudagrass (Burton, 1985; Hanna et al., 1997b; Hanna and Elsner, 1999; Tiwari *et al.*, 2014), St.Augustinegrass (Busey, 1980; Reynolds *et al.*, 2009) and centipedegrass (Dickens *et al.*, 1981).

High variations in inflorescence characteristics were found between mutant lines and wild type parent. Among the dwarf mutants, 165-110-1, generated from 110 Gy is particularly interesting since it produced threefold more inflorescences with 13% increase in raceme number per inflorescences. Enhanced panicle length and number in rice (*Oryza sativa* L.) (Maity *et al.*, 2005), and nearly eightfold more inflorescences in St. Augustinegrass were reported (Li *et al.*, 2010) among the mutants. Wu *et al.* (2006) reported that inflorescence prolificacy had 51% positive correlation on seed yield, indicating that selection for increased inflorescence prolificacy would be one of the best indirect selection traits for improvement of seed yield in bermudagrass. Mutant line '165-110-1'would enlarge the germplasm pool of bermudagrass and serve as a good breeding material to enhance seed yield.

The mutant lines exhibited better fall performance in comparison to the wild-type control, as manifested by better green color retention in conjunction with higher relative chlorophyll content and lower dormancy. Chlorophyll content is one of the important parameter reflecting the ability of plants to withstand stress. Dwarf mutant lines developed through gamma radiation with enhanced chlorophyll content, chilling and drought tolerance have been reported in *Stylosanthes guianensis* (Tan *et al.*, 2009).

New genetic variations generated by mutation breeding are particularly advantageous in improving an already outstanding genotype (Busey, 1977;Ahloowalia and Maluszynski, 2001) such as'Tifsport', a fine-textured mutant bermudagrass, developed from a coarse-textured cold hardy cultivar 'Midiron' (Hanna *et al.*, 1997b). Moreover, 'Tifsport' has been reported to have significantly higher turfgrass quality than 'Midiron' with sufficient cold tolerance (Taliaferro, 2003). The genotype 'B-165' used as parent in the present study has excellent drought resistance but its coarse texture and rapid upright growth habit were undesirable. Similarly, the dwarf mutant lines generated from 'B-165' exhibited finer plant texture with slower vertical growth. Otherwise, transferring the high drought resistance of 'B-165' into commercially acceptable dwarf type background would have required lengthy phenotypic recurrent selections. Because the mutant lines derived from the drought resistant line 'B-165', they potentially bear a comparable drought resistance. Thus, evaluation of the mutants for drought resistance would be a necessary step to see whether or not they retained this important trait.

Conclusions

The results showed that dwarf mutants of bermudagrass generated through gamma irradiation induced mutation had higher shoot density, finer plant texture and exhibited better fall performance compared to the wild-type control. The lines can be used for the development of improved bermudagrass cultivars for landscaping and sports turf.

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