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Genetic divergence analysis in turf grasses based on morphological traits

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ABSTRACT

Despite of enhancing interest on turfs in India, all the available varieties of turf grasses in the country are being imported and are often poorly adapted to the prevailing climatic conditions. This prompted to begin a collection activity of turfgrass species, with the ultimate goal of identifying promising materials for further development of lawns suitable for various conditions. The present investigation conducted on eight species and four varieties of turf grasses depicted significant differences in all the growth related traits studied. All turf grasses under study exhibited fine leaf texture except *Eragrostis curvula* (Schrad.) Nees having medium coarse texture, *Paspalum notatum* Flugge and *Argentine bahia* having coarse texture and *Poa pratensis* L. which exhibited medium fine leaf texture. The *Agrostis palustris* L. exhibited maximum mean performance for shoot density/25 cm^2 (277.33), whereas minimum was exhibited by *Cynodon dactylon* L. var Panama (57.67). The coefficient of variation was minimum for relative water content (GCV = 13.77, PCV = 14.60) and maximum for root length (GCV = 64.70, PCV = 66.46). Heritability estimates for all the traits were generally moderate to high. High heritability was observed for shoot density per 25 cm^2 (98.00), whereas moderate heritability was observed for dry root/shoot ratio (64.12). High heritability along with high genetic advance was observed for shoot density per 25cm^2 (h^2 = 98.00, GA = 142.02) and germination percentage (h^2 = 96.50, GA = 48.16).

Key words: Genetic advance, Heritability, Qualitative and quantitative traits, Turf grass and Variability

Turf grasses are considered an integral part of landscape ecological systems worldwide which provide aesthetic value (Roberts *et al.* 1992). These are narrow-leaved grass species that form a uniform, long-lived ground cover that can tolerate traffic and low mowing heights (Rongda *et al.* 2008). Turf grasses are widely used in enhancing and maintaining the function and beauty of lawns, aesthetic fields, etc. all over the world (Fender 2006, King and Balogh 2006). Rapid urbanization, expanding buildings, growing interest on the need to beautify rural and urban areas, emphasis on outdoor living and recreation have lead to evaluation of different types of turf grasses for various uses. The main turf species of interest belongs to family Poaceae. Turf grasses consist of a remarkably diverse group of species which are selectively used on the basis of applications and/or climatic conditions. Turf grasses may be divided into two groups based on their origins and geographical distributions which include cool-season grasses such as *Festuca arundinacea*, *Poa pratensis* L., *Lolium perene* L., *Agrostis palaustris*, *Festuca rubra*, etc. and warm-season grasses like *Cynodon dactylon* L., *Stenotaphrum secundatum, Eremochloa ophiuroides*, *Zoysia japonica*, *Buchloe dactyloides*, *Paspalum notatum* Flugge, etc (Huang 2006). Turf grass is certainly one of the most popular groundcovers and useful for pathways and play surfaces.

Quantitative genetic information regarding the source populations are needed to devise an effective selection programme. It is necessary to obtain information on the extent and nature of genetic variation, heritability, genotype and environment interactions and prediction of genetic advance by selection (Dudley and Moll 1969). By estimating the variance components of these turf characteristics of the species, the reliability of the phenotypic value, heritability and genetic gain from selection can be predicted. Coefficients of variation allows a meaningful comparison of the variation of several traits of plants belonging to the same population, as well as a comparison of the variation of the same trait as expressed by different populations (of the same or different crops). Heritability tells us about the additive genetic variance and phenotypic variance (Nyquist 1991) and is useful in designing an effective breeding programme. Most of the work on turf grasses has been done in foreign countries, viz. USA, Australia, Japan, Singapore, etc. but these grass species and varieties have not proved suitable for Indian agro-climatic conditions because a variety bred under a specific climatic zone, may not necessarily perform well under other climatic zones. No work has been carried out on the aspect of turf grass breeding in India. In order to contribute towards improvement in turf grasses, the present

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investigation was undertaken to analyse diversity the growth related traits in turf grass species and varieties. The objective of this study was to evaluate the turf grass species for various growth related qualitative and quantitative traits.

MATERIALS AND METHODS

The material utilized for the present study consisted of seven species and four varieties of turf grasses named as *Agrostis palustris* L., *Eragrostis curvula* (Schrad.) Nees, *Paspalum notatum* Flugge, *Argentine bahia, Poa pratensis* L., *Cynodon dactylon* L. var bargusto, *C. dactylon* var Palma, *C. Dactylon* var Panam, *C. dactylon* var Panama, C. *dactylon* var Selection 1, *Lolium perene* L. The seeds of turf grass species were procured from NBPGR, New Delhi.

The present investigation was carried out at Research Farm of Division of Floriculture and Landscaping, Indian Agricultural Research Institute, New Delhi after rainy seasons 2011-12 in a randomized block design with three replications. The above farm is situated at 77°12'E longitude 28°40'N latitude and at an altitude of 228.16 m above the mean sea level. Seeds of all the species were sown in the beds to raise turfs. All the grass species were given uniform management practices for healthy growth and development. Recommended dose of N, P and K were applied at the time of field preparation before planting. Weeding was done as and when required. The visual observations recorded on various turf grass qualitative traits, viz. leaf blade colour, leaf texture, growth habit, weed intensity, shoot density and growth rate and quantitative traits, viz. germination percentage (%), shoot length (cm), root length (cm), fresh weight of shoots (g), fresh weight of roots (g), dry weight of shoots (g), dry weight of roots (g), shoot density per 25 cm^2, root density per 25 cm^2, dry root/shoot ratio, relative water content in percentage (RWC).

Germination was measured according to International rules for seed testing, 2008. The shoot length was measured from the base to tip of five randomly selected shoots. The average was calculated and expressed in centimetre (cm). Root length was measured for the longest extending roots and was expressed in cm. For dry weight of shoots and roots, the turf grasses were removed from soil and shoots and roots were separated using grass clipper. These were dried in a hot air oven at 60°C for 24 hr and then weighed and calculated. The shoot is a basic unit to describe turf grass abundance. Hence, shoot density is a key parameter to assess the turf health. Shoot and root density measurements were taken at the end of experiment by removing three soil cores with a 25 cm^2 soil probe from three random locations of each plot. Shoot and root density was calculated by counting total number of shoots and roots per 25 cm^2 area. Leaf samples from the youngest fully expanded leaves were taken for recording the relative water content. RWC was estimated by Barr and Weatherly (1950) method and expressed in percentage.

The mean performance of turf grass species for morphological traits was calculated by Microsoft office excel worksheet, 2007 version. The analysis of variance for each variable was done as per the procedure described by Panse and Sukhatme (1967). The genotypic and phenotypic coefficient of variation was calculated according to formula given by Burton and De Vane (1953). Heritability (broad sense) in per cent was estimated as per the formula given by Burton and De Vane (1953), Johnson *et al*. (1955) and Hanson *et al*. (1956). Genetic advance and genetic gain were calculated as per the formula suggested by Lush (1949) and Johnson *et al*. (1955). The mean and standard error (SE) were worked out as per standard methods (Panse and Sukhatme 1967) and coefficient of variation was calculated using the following formula: CV= S/X*100 where S is the standard deviation and X is the mean.

RESULTS AND DISCUSSION

Analysis of variances revealed highly significant differences among species for all the growth related traits under study (Table 1).This concluded the existence of wide range of variability for different traits which revealed that considerable improvement can be made in turf grasses.

Performance per se of turf grasses for qualitative traits

The various qualitative traits of turf grass are given in Table 2. The turf grass species, viz. *Agrostis palustris*, *Argentine bahia* exhibited green colour. The light green colour was observed in *Eragrostis curvula* and *Paspalum notatum.* Species such as *Cynodon dactylon* var Bargusto, *Cynodon dactylon* var Palma, *Cynodon dactylon* var Panam, *Cynodon dactylon* var Selection 1 exhibited medium green colour, whereas dark green colour was observed in *Poa pratensis*, *Cynodon dactylon* var Panama and *Lolium perene*. Therefore, these different species having different colours may be used for creating various shades of colour in a lawn or turf. All turf grasses under study exhibited fine leaf texture except *Eragrostis curvula* having medium coarse

Table 1 Analysis of variance (ANOVA) for morphological traits of turf grasses

Source of variance	df	Mean sum of square (MSS): Germination percentage (%)	Shoot length (cm)	Root length (cm)	Fresh weight of shoots (g)	Fresh weight of roots (g)	Dry weight of shoots (g)	Dry weight of roots (g)	Dry root/ shoot ratio	Relative water content	Shoot density /25 cm^2	Root density /25 cm^2
Replication	2	59.62**	2.70	0.12	0.0059	0.0016	0.0047	0.0030	0.011	1.906	17.375**	5.11**
Genotypes	11	1719.94**	59.30**	21.58**	0.0106**	0.015**	0.0039	0.0023	0.050**	308.75**	14658.99**	48.21**
Error	22	20.69	1.09	0.387	0.0091	0.0059	0.0072	0.0022	0.0079	12.137	101.450	0.97

Table 2 Performance of turf grass species and varieties for qualitative traits

Species and varieties	Leaf blade colour	Leaf texture	Growth habit	Weed intensity	Growth rate
Agrostis palustris	Green	Fine	Spreading	1.7	8.6
Eragrostis curvula	Light green	Medium coarse	Upright	7.6	7.7
Paspalum notatum	Light green	Coarse	Spreading	4.7	5.3
Argentine bahia	green	Coarse	Spreading	8.3	2.7
Poa pratensis	Dark green	Medium fine	Spreading	1.3	5.0
Cynodon dactylon var Bargusto	Medium green	Fine	Spreading	4.3	8.1
C. dactylon var Palma	Medium green	Fine	Spreading	4.6	7.6
C. Dactylon var Panam	Medium green	Fine	Spreading	4.5	8.2
C. dactylon var Panama	Dark green	Fine	Spreading	5.3	7.9
C. dactylon var Selection 1	Medium green	Fine	Spreading	5.7	5.0
Lolium perene	Dark green	Fine	Upright	2.6	7.6

*Scores: 1: Low weed intensity, 9: High weed intensity; ** Scores: 1: Slow growth rate, 9: Fast growth rate

texture, *Paspalum notatum* and *Argentine bahia* having coarse texture and *Poa pratensis* which exhibited medium fine leaf texture. Most of the turf grasses exhibited spreading growth habit except *Eragrostis curvula* and *Lolium perene* having upright growth habit. The high weed intensity score was recorded in turf grass species, viz. *Eragrostis curvula* (score 8.3) followed by *Argentine bahia* (score 7.6), whereas low intensity score was observed in *Agrostis palustris* (score 1.3) followed by *Poa pratensis* (score 1.7) and *Lolium perene* (score 2.6). Fast growth rate based on visual observations was recorded in *Agrostis palustris* (score 8.6), *C.d.* var. Panam (score 8.2) and *C.d.* var. Bargusto, (score 8.1) However, slow growth rate was observed in *Argentine bahia.*

Performance per se of turf grasses for growth related traits

Mean performance of the different species revealed that no single specie was superior for all traits (Table 3). The data presented in Table 3 and 4 revealed a high range in germination percentage (22.13-93.43), shoot length (2.06-15.4 cm), root length (1.20-8.67 cm), relative water content (54.35-86.41), shoot density/25cm^2 (57.67-277.33) and root density/25 cm^2 (2.83-15.80).

The maximum germination was observed in *Agrostis palustris* L. (93.43 %) followed by *Lolium perene* (85.28 %). However, minimum germination was recorded in *Argentine bahia* (22.13 %). These findings are in accordance with the findings of Peacock and Dudeck (1989) in turfgrass germinations. The longest shoot was recorded in *Eragrostis curvula* (15.4 cm) followed by *Lolium perene* (13.66 cm) and *Cynodon dactylon* var Bargusto (12.4 cm), whereas *Argentine bahia* exhibited shortest shoots (3.1 cm). This might be various environmental and genetic factors which influence the shoot growth rate, one of them being ethylene

Table 3 Mean performance of turf grass species and varieties for morphological traits

Turf grass species	Germination percentage (%)	Shoot length (cm)	Root length (cm)	Fresh weight of shoots (g)	Fresh weight of roots (g)	Dry weight of shoots (g)	Dry weight of roots (g)	Dry root/ shoot ratio	Relative water content	Shoot density /25 cm^2	Root density /25 cm^2
Agrostis palustris	93.43	7.73	3.13	0.04	0.023	0.012	0.004	0.312	56.69	277.33	3.63
Eragrostis curvula	36.31	15.4	8.67	0.11	0.028	0.031	0.007	0.232	77.02	108.00	2.83
Paspalum notatum	31.28	2.06	1.3	0.09	0.017	0.022	0.002	0.125	65.2	128.00	8.73
Argentine bahia	22.13	3.1	1.43	0.08	0.018	0.015	0.004	0.289	84.14	114.00	11.33
Poa pratensis	76.45	7.1	4.6	0.066	0.024	0.013	0.006	0.552	70.35	127.33	7.13
Cynodon dactylon var Bargusto	45.63	12.4	6.6	0.15	0.113	0.036	0.006	0.164	77.73	102.67	9.97
C. dactylon var Palma	56.53	5.3	1.4	0.13	0.082	0.035	0.005	0.154	68.49	215.00	11.60
C. dactylon var Panam	67.83	10.7	5.63	0.08	0.031	0.024	0.009	0.405	71.07	71.00	14.87
C. dactylon var Panama	53.52	11.6	8	0.1	0.039	0.03	0.012	0.383	72.24	57.67	15.80
C. dactylon var Selection 1	48.52	5.7	1.2	0.05	0.016	0.012	0.003	0.233	54.35	110.33	5.90
Lolium perene	85.28	13.66	4.73	0.16	0.035	0.04	0.009	0.229	86.41	207.67	9.47
Mean	56.08	8.61	4.24	0.10	0.038	0.025	0.006	0.279	71.24	138.09	9.20
SEm±	3.71	0.85	0.51	0.0078	0.0019	0.0022	0.0012	0.073	2.84	8.22	0.80
CD(P=0.05)	7.34	1.68	1.01	0.015	0.0037	0.0043	0.0023	0.144	5.62	16.27	1.58
CD(P=0.01)	9.72	2.23	1.34	0.020	0.0049	0.0057	0.0031	0.191	7.44	21.54	2.10

Table 4 Estimates of genetic parameters for morphological traits in turf grasses

Traits	Range	Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)	Heritability (h^2)	Genetic advance (GA)
Germination percentage (%)	22.13-93.43	40.29	41.02	96.50	48.16
Shoot length (cm)	2.06-15.4	53.70	55.20	94.60	8.83
Root length (cm)	1.20-8.67	64.70	66.46	94.80	5.33
Fresh weight of shoots (g)	0.04-0.25	53.12	53.81	97.50	0.12
Fresh weight of roots (g)	0.013-0.082	28.73	30.37	89.50	0.01
Dry weight of shoots (g)	0.012-0.044	43.13	44.31	94.8	0.04
Dry weight of roots (g)	0.002-0.009	42.41	48.77	75.61	0.02
Dry root/shoot ratio	0.119-0.552	44.62	55.80	64.12	0.20
Relative water content	54.35-86.41	13.77	14.60	89.10	19.33
Shoot density/25 cm^2	57.67-277.33	47.61	48.11	98.00	142.02
Root density/25 cm^2	2.83-15.80	43.85	45.18	94.20	7.93

production which has been reported to influence the shoot growth in Turf grasses under varied stress conditions (Verslues *et al.* 1998)

Root length and root: shoot ratios are considered to be important survival factors of turf grass growing in areas of limited water (Simanton and Jordan 1986). Therefore, during the experiment, observations on root length and dry root: shoot ratios were also recorded. *Eragrostis curvula* showed maximum root length (8.67 cm) followed by *Cynodon dactylon* var Bargusto (6.6 cm). However, minimum root length was observed in *C. dactylon* var Selection 1 (1.2 cm) which was at par with *Paspalum notatum* (1.3 cm), *C. dactylon* var palna (1.4 cm) and *Argentine bahia* (1.43 cm). Rooting characteristics of turf grasses have a profound influence on their response to abiotic stresses and this has been supported by many earlier reports. The turf grasses having more root length, require less water, i.e. more tolerant to drought. Carrow (1996) reported that rooting depth is more important than total root production in selecting for drought avoidance. White *et al.* (1993) observed that based on root length characteristics, drought resistance vary from one turf grass species to other.

Higher dry root: shoot ratio indicates balanced shoot and root growth due to proper allocation of resources. In this study, highest dry root: shoot ratio was observed in *Poa pratensis* (0.552) followed by *Cynodon dactylon* var. Panam (0.405) and *Cynodon dactylon* var Panama (0.383). However, lowest was recorded in *Paspalum notatum* (0.125). Fresh and dry weight of shoots (g) was found maximum in *Lolium perene* (0.16 g and 0.04 g), whereas minimum was observed in *Agrostis palustris* (0.04 g and 0.012 g). Shoot dry weight indicates the biomass production under stress conditions. Chaves *et al.* (1991) reported the level of biomass production reflects the tolerance behaviour of the grasses as well as their photosynthetic efficiency. The relative water content was found maximum in *Lolium perene* (86.41) which was at par with *Argentine bahia* (84.14). High relative water content promotes photosynthetic competency in many grasses under various climatic conditions (Baker 1993).

Since shoot density is a key trait to assess the turf quality, therefore shoot density was measured during evaluation of various turf grasses. The highest shoot density/ 25 cm^2 was exhibited by *Agrostis palustris* (277.33), whereas lowest was found in *C. dactylon* var Panama (57.67) which was at par with *C. dactylon* var Panam. Maximum root density/25 cm^2 was observed in *C. dactylon* var Panama (15.80) followed by *C. dactylon* var Panam (14.87) which were at par to each other. However, minimum was exhibited by *Eragrostis curvula* (2.83) which was at par with *Agrostis palustris* (3.63).

Genetic parameters

The phenotypic coefficient of variation was observed to be higher than genotypic coefficient of variation which indicates greater genotype-environment interaction. However, high genotypic and phenotypic coefficient of variation were recorded for root length (GCV = 64.70, PCV = 66.46) followed by shoot length (GCV = 53.70, PCV = 55.20) and fresh weight of shoots (GCV = 53.12, PCV = 53.81) (Table 4). It is reported that if the value of phenotypic coefficient of variation is greater than genotypic coefficient of variation, the apparent variation is not only due to genotypes, but also due to influence of environment. High and moderate estimates of heritability (Broad sense) were obtained for all the growth related traits of turf grasses. This suggested the scope of improvement of these traits through direct selection. Similar findings of high heritability for various turf-type characteristics were also recorded by Browning and Riordan (1994) in Buffalo grass.

Heritability along with genetic advance is useful in prediction in the selection of individual (Johnson *et al.* 1955). High heritability along with genetic advance was found for shoot density/25 cm^2 (h^2 = 98.00, GA =142.02) (Table 4). These findings revealed that genotypic variation studied for said traits was probably due to high additive gene effects (Panse 1957). Selection for these traits would, therefore, be effective when based on phenotypic performance.

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