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Evaluation of Turfgrasses for Qualitative and Quantitative Traits in Varanasi Region of India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present experiment was conducted at Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. This study was carried out to evaluate performance of eleven turfgrass genotypes for qualitative traits, quantitative traits and their genetic variability under same climatic condition. The experimental design was a Randomized Block Design (RBD) with three replications. Eleven genotypes consist of Bermuda grass, Centipede grass, Panama grass, Bargusto grass, Tiftdwarf 419 grass, Local grass, Palma grass, Bahia grass, Manila grass, Crow Foot grass and Tanu Variant grass. These were assessed for their suitability to

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be used as turfgrass under Varanasi region. All the grasses exhibited semi prostrate growth habit except local grass having upright growth habit. Panama and Local grass showed fine leaf texture whereas, Manila grass exhibited coarse texture. Dark green colour was observed in Local, Crow Foot and Panama grass whereas, Centipede grass showed light green colour. Local grass exhibited maximum canopy height, leaf length, leaf width, chlorophyll content, stolen internode diameter, culm length, shoot length and shoot diameter. The maximum genotypic (187.22) and phenotypic variance (197.80) was observed for parameters like fresh weight. Canopy height showed maximum phenotypic coefficient of variation (47.04) and genotypic coefficient of variation (46.16) over all the parameters. Genetic advance maximum (27.49) for parameter fresh weight and genetic advance as a percentage of mean was maximum also for fresh weight (93.30). The maximum heritability at broad sense was observed for the parameter dry weight (98.25).

Keywords: Turfgrass; genotypes; qualitative parameters; quantitative parameters; genetic variability.

1. INTRODUCTION

Turfgrasses are the members of family Gramineae or Poaceae, which is the most biologically rich family in India. Poaceae family have 261 genera and more than 1334 species [1]. Turfgrasses are the key component of landscaping which beautifying the all over world [2]. Turfgrasses are plants that form regular ground covering like carpet and they also resist continuous mowing and heavy foot traffic [3]. There has been a close relationship between people and grass for millions of years. The Oligocene epoch, where the earliest well-defined grass fossils were discovered, is 25 million years old, demonstrating the long-standing association between humans and the grass family (Thomasson, 1987). There are three key advantages of turfgrass for people's lives i.e., ornamental, functional and recreational (Beard [4], Christians [5], Wiecko 2006, Turgeon 2008, Bell [6], Jankairam et al*.* 2015). Bermuda grass (*Cynodon dactylon* L.) is frequently used species and it can be grown easily in salt and drought condition [7]. In order to maintain nutrients and improve the level of chlorophyll of turfgrass, optimum irrigation need should be considered [8]. In the modern parts of the world, turfgrass is a common and frequent element of urban landscape. Turfgrasses are mainly used for enhancing the beauty of residential areas, lawn and all over the world [9]. Turf quality of the grasses is significantly reduced by the heat and drought [10]. The excellence of a sports field surface and its level of playability depend on the types of turfgrass and their respective cultivars. The different turfgrass species and varieties determine the quality of playground and athletic fields. Different environmental factors like temperature, humidity and sun light affects the growth and various qualitative and quantitative parameters of turfgrasses. Therefore, growth and quality of turfgrass vary from season to season and also vary with places [9]. The majority of research on turf grasses has taken place in other countries, including the USA, Australia, Japan, Singapore and others. However, these grass species and varieties have not proven suitable for Indian agro-climatic conditions because a variety that has been bred for one climate zone may not necessarily thrive in another [11].

To alleviate this issue, the research study conducted in Varanasi evaluated 11 types of turfgrasses to understand their qualitative and quantitative characteristics to prove their climatic suitability in Indian region.

2. MATERIALS AND METHODS

The materials used for the research study consisted of eleven genotypes of turfgrasses namely Bermuda grass, Centipede grass, Panama grass, Bargusto grass, Tiftdwarf 419 grass, Local grass, Palma grass, Bahia grass, Manila grass, Crow Foot grass and Tanu Variant grass. All the genotypes were collected from Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, K.N.K. College of Horticulture, Mandsaur, Madhya Pradesh. The current research was carried out at Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.), India during 2022 – 2023 in a Randomized Block Design (RBD) with three replications. The Varanasi is situated in the west part of Uttar Pradesh at an elevation of 80.71 m and a latitude of 25°31' north and a longitude of 82°97' east. Planting was done on 12th February 2022 by dibbling method on beds of size 3m × 2m. Mixed well rotten farmyard manure (FYM) at the rate 5 kg/ha and recommended dose of NPK before planting. Irrigation and weeding were done manually as and when required. The observation recorded on various grass traits *viz*. leaf colour, leaf texture, growth habit, canopy height (cm), leaf length (cm), leaf width (mm), shoot length (cm), shoot width (mm), root depth (cm), shoot density (25 cm^2), leaf chlorophyll content (SPAD value), Stolon internodal length (cm), stolon internodal diameter (mm), culm length (cm), Fresh weight (kg), dry weight (kg). The leaf texture and colour was assessed by visual multiple rating system from 1-9, where 9 denoted highest quality. Growth habit was assessed based on the orientation of its tillers (<30° = prostrate, 30°-59° = semi-prostrate and >60° = upright). Canopy height was measured by putting the straight geometric scale at lowest point (ground level) to highest point of grass. Leaf length, shoot length and root length were assessed by using geometric scale from base to the tip portion of five random selected grass plants. Then, those values were averaged to get accurate value and represents in centimeter (cm). Leaf width, shoot width and stolon internode diameter was measured by using the digital vernier caliper. Leaf chlorophyll content was assessed by using the SPAD meter (PLUS 502) to measure the SPAD value. The shoot density was calculated by placing a randomly positioned quadrant measuring 5cm × 5cm in the designated area of 25cm^2 at five positions within the plot. The fresh weight was estimated by collecting the sample of 20cm × 20cm area from each plot. For estimating the dry weight these samples were dried in hot air over for 48 hours. Stolon internode length was the distance between two mature nodes of the stolon from the third internode from the top. Culm length was measured the distance from the tip of the shoot to the first internode of a mature shoot. The analysis of variance for each parameter were analyzed by the procedure outlined by Panse and Sukhatme (1967). The genotypic and phenotypic co-efficient variances were calculated using the formula given by Burton [12]. The heritability was calculated using the formula given by Lush [13]. The genetic advance was calculated using the formula proposed by Johnson et al. [14].

3. RESULTS AND DISCUSSION

3.1 Qualitative Traits

The various qualitative traits are depicted from Table 1. Various turfgrass species have their unique texture and colour and is the most desirable characteristic from a landscaping standpoint [11]. The colour intensity, texture and habit of growing depends on the different agroclimatic zones. In a specific location one species show better colour hue but at another location it will be worse. Turgeon [3] reported that the quality of various warm season turfgrasses are affect by variation in season. The functional quality of a turfgrass is exclusively defined by its vegetative plant part and its growth and development, and functional qualities are actually the foundation of aesthetic qualities [15]. The turfgrass genotypes like Bermuda grass, Bahia grass, Bargusto grass, Tifdwarf 419 grass, Crow Foot grass, Panama grass, Centipede grass, Palma grass, Manila grass and Tanu Variant grass all showed semi prostrate growth habit. Whereas, genotype Local grass displayed an upright growth habit. Janakiram and Namita [16] also observed similar findings i.e., spreading habit of similar grass species. The turfgrass species, *viz*. Crow Foot grass, Panama grass and Local grass showed dark green colour. However, Bermuda grass and Manila grass exhibited medium green colour. The green colour was observed in Bahia grass, Bargusto grass, Tifdwarf 419 grass, Palma grass and Tanu Variant grass, whereas, Centipede grass showed poor light green colour. These many species, which come in a variety of hues, can be utilized to create varied shades of green on a lawn for enhancing the beautification. The turfgrass Panama grass and Local grass exhibited fine texture, whereas, most of the other grasses showed medium fine texture except Bermuda grass, Bahia grass and Centipede grass having medium coarse texture. While, Manila grass have coarse texture. Janakiram and Namita [16] also observed fine texture in Panama grass. The quality characteristics like leaf texture, leaf colour and growth habit of various grass species changes during the seasons (Malik et al., 2014).

3.2 Quantitative Traits

The genotypes were analyzed, and significant variations were recorded in their mean performance due to agroclimatic factors. The maximum average canopy height (11.25 cm) was observed in genotype Local grass followed by Tanu variant grass (9.91 cm). Whereas, minimum average canopy height was recorded in genotype Centipede grass (4.13 cm) followed by Palma grass (4.61 cm). Agnihotri et al. [9] confirmed that the growth habits of several genotypes can be utilized to clarify the variation in canopy height. Harivandi et al. [17] discovered that grasses from the same genus can display slight variations in same traits. The leaf length was found to be significantly maximum in Local grass (2.98 cm) followed by Tanu variant grass (2.21 cm) and minimum in Tifdwarf 419 grass (1.39 cm) followed by Centipede grass (1.44 cm). The length of the leaves depended on the frequency of mowing or cuttings that maximized vegetative yield [18,19].

The Palma grass (12.70 cm) was significantly recorded maximum root depth followed by Centipede grass (12.05 cm) whereas, Bargusto grass (9.22 cm) was significantly observed minimum root depth followed by Tifdwarf 419 grass (10.03 cm). Agnihotri et al. [9] was also observed similar root depth values in Palma grass. The response of lawn grasses to abiotic stresses is significantly influenced by their rooting characteristics and it was supported by previous observation of Wadekar et al. [11]. Bonos et al. [20] and Crush et al. [21] studied how tall fescue and perennial ryegrass differ in the distribution of their inherited root depth.

The highest shoot density was observed in Bargusto grass (29.28) followed by Tifdwarf 419 grass (28.33) whereas, minimum was recorded in Local grass (15.00) followed by Tanu Variant grass (21.72). Both genetic and environmental factors contribute to the variance in shoot density between genotypes. These findings are also confirmed by Janakiram and Namita [16] and Agnihotri et al. [9]. The leaf width was found to be significantly maximum in Local grass (2.14 mm) followed by Centipede grass (1.76 mm) and minimum in Bargusto grass (1.40 mm). These results are consistent with the findings of Kumar [22]. Agnihotri et al. [9] reported that the range of leaf widths observed among various turfgrass species is significantly affected by genetic variables.

A combination of genetic traits and environmental stress factors affect the chlorophyll content of various grass species (Leto et al. 2008). Here, in present study Local grass (14.34) was recorded with maximum chlorophyll content followed by Tanu Variant grass (9.05) whereas, Bargusto grass (4.07) was significantly observed minimum chlorophyll content followed by Palma grass (5.44). The green colour associated with chlorophyll denotes its concentration and shows the condition of the grass [9]. The maximum stolon internodal length was exhibited in Tanu Variant grass (2.56 cm) and minimum was observed in Bargusto grass (1.46 cm). A shorter stolon internodal length is preferred because it encourages the growth of denser turf, which enhances visual quality [9]. Similar findings were also observed by Kumar [22]. The maximum stolon internodal diameter was observed in Local grass diameter (0.91 mm) followed by Bargusto grass (0.87 mm) and minimum stolon internodal diameter was showed in Bermuda grass and Tanu Variant grass (0.79 mm) each. Similar results were also noted by Agnihotri et al. [9]. The Local grass (14.14 cm) was significantly noted maximum culm length followed by Tanu Variant grass (11.29 cm), and Centipede grass (5.04 cm) was showed minimum culm length followed by Bargusto grass (5.68 cm). Specific development habits of genotypes can be explained by the increase in culm length that has been seen among these genotypes.

The maximum fresh weight was observed in genotype Tanu Variant grass (86.50 kg) followed by Palma grass (81.45 kg) and minimum fresh weight was exhibited in Panama grass (45.90 kg). The similar findings were also noted by Kumar [22], Jankiram and Namita (2014). The Tanu Variant grass (34.42 kg) was significantly noted maximum dry weight and Bargusto grass (14.85 kg) exhibited minimum dry weight. Kumar (2021); Jankiram and Namita [16] also found the same result in their research. Shoot length is one of the key variables used to evaluate changes in environmental quality. It offers useful details about the way plants respond to diverse environmental factors. (Mahmood et al. [23], Ling et al. [24], Gvozdenac et al. [25]. In present study the shoot length was found to be significantly maximum in Local grass (14.70 cm) whereas, minimum shoot length was observed in Centipede grass (5.83 cm). Similarly shoot diameter is an important character of grass which showed the level of quality of turf. Present investigation reported maximum shoot diameter exhibited by Local grass (1.41 mm) and minimum in Bargusto grass (1.02 mm).

3.3 Genetic Variability

The genotypic variance was found to be lower than the phenotypic variance for all the characters under study. Pandey and Anurag [26] also found the same result in their research. Sahu et al. (2017) recorded that higher values for GV (genotypic variance) and PV (phenotypic variance) suggest that these qualities are limited influenced by the environment. The parameters fresh weight, dry weight and growth habit showed high variance. Whereas, canopy height and shoot density displayed moderate variance. On the other hand, parameters such as leaf length, root length, leaf width, leaf chlorophyll content, stolen internode length, stolen internode diameter and culm length exhibited low variance. Particularly, shoot length exhibited low genetic variance but moderate phenotypic variance. The analysis of the data revealed that all traits had higher phenotypic variance than genotypic variance, indicating the significant impact of the environment on these traits [27].

Phenotypic coefficient of variation (PCV) values were consistently higher than genotypic coefficient of variation (GCV) for all the quantitative traits assessed. The PCV for the traits showed a similar tendency to the GCV, but it had a greater value, demonstrating that environmental influences had a considerable impact on the expression of the trait. It means that selection based only on genotypic characteristics may be misleading and that environmental variables may have an impact on genotypic expression [28]. Namita et al. [29] and Singh and Singh [30] also reported similar findings in marigold. Low phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were recorded for stolen internode diameter and shoot diameter. Moderate values were exhibited for leaf width, shoot density and stolen internode length. However, canopy height, leaf length, leaf chlorophyll content, culm length, fresh weight, dry weight, shoot length and growth habit showed high PCV and GCV. In addition, root depth showed low GCV, it showed moderate PCV. Janakiram and Namita [16] reported that higher value of PCV compared to GCV suggesting that significant genotype-environment interaction on the traits.

The parameters such as canopy height, leaf length, leaf chlorophyll content, culm length, fresh weight, dry weight, shoot length, growth habit, shoot density, leaf width, stolen internode length, stolen internode diameter and shoot diameter showed high heritability. However, moderate heritability was observed for root depth. A high heritability suggests that the traits are less influenced by the environment [31]. Browning et al. [32] also reported high heritability for different turf-type characteristics in Buffalo grass. Janakiram and Namita [29] also reported high heritability for various turf-type characteristics across different turf grasses. Low genetic advance was observed in canopy height, leaf length, root depth, leaf chlorophyll content, culm length, shoot length, shoot density, leaf width, stolen internode length, stolen internode diameter, and shoot diameter. Whereas, it was moderate for growth habit and dry weight. However, fresh weight was showed high genetic advance. Janakiram and Namita [16] also reported similar genetic advance for character root depth. Heritability and genetic advance provide valuable insights for predicting individual selection [14]. The genetic advance as a percentage of mean was high for canopy height, leaf length, leaf chlorophyll content, culm length, shoot length, shoot density, leaf width, growth habit, stolen internode length, fresh weight and dry weight. Whereas, it was low for stolen internode diameter and medium for shoot diameter and root depth. Heritability alone does not provide a clear indication of the expected genetic improvement resulting from individual genotype selection in a population. However, high genetic advance as a percentage of mean suggests a predominance of additive gene action. Therefore, combining knowledge of genetic advance as a percentage of mean along with heritability is more valuable in formulating selection procedures [31]. The traits which showed high PCV, heritability, and genetic advance as a percentage of mean, suggesting a significant role of additive gene effects in trait inheritance [33-35].

Table 1. Performance of various turfgrasses for qualitative attributes

Genotype	Texture	Colour	Growth habit
G_1 (Bermuda grass)	Medium coarse	Medium green	Semi prostrate
G_2 (Bahia grass)	Medium coarse	Green	Semi prostrate
G_3 (Bargusto grass)	Medium fine	Green	Semi prostrate
G_4 (Tifdwarf 419 grass)	Medium fine	Green	Semi prostrate
G_5 (Crow Foot grass)	Medium fine	Dark green	Semi prostrate
G_6 (Panama grass)	Fine	Dark green	Semi prostrate
G_7 (Centipede grass)	Medium coarse	Light green	Semi prostrate
G_8 (Palma grass)	Medium fine	Green	Semi prostrate
G_9 (Manila grass)	Coarse	Medium green	Semi prostrate
G_{10} (Tanu Variant grass)	Medium fine	Green	Semi prostrate
G_{11} (Local grass)	Fine	Dark green	Upright

Table 2. Performance of various turfgrasses for canopy height, leaf length, root depth, shoot density, leaf width and leaf chlorophyll content

Genotype	Canopy Height (cm)	Leaf Length (cm)	Root Depth (cm)	Shoot Density	Leaf Width (mm)	Leaf Chlorophyll Content
G_1 (Bermuda grass)	5.34	1.50	10.73	23.94	1.66	7.06
G_2 (Bahia grass)	8.07	2.08	10.86	26.17	1.58	6.36
G_3 (Bargusto grass)	5.53	1.64	9.22	29.28	1.40	4.07
G_4 (Tifdwarf 419 grass)	4.66	1.39	10.03	28.33	1.65	6.23
G_5 (Crow Foot grass)	7.44	2.10	11.43	23.56	1.74	7.42
G_6 (Panama grass)	5.27	1.50	11.90	24.61	1.69	7.09
G_7 (Centipede grass)	4.13	1.44	12.05	26.17	1.76	6.13
G_8 (Palma grass)	4.52	1.57	12.70	26.17	1.71	5.44
G_9 (Manila grass)	5.35	1.70	10.68	25.72	1.55	5.67
G_{10} (Tanu Variant grass)	9.91	2.21	10.22	21.72	1.72	9.05
G_{11} (Local grass)	11.02	2.98	11.50	15.00	2.14	14.34
Mean	**6.51**	**1.83**	**11.03**	**24.61**	**1.69**	**6.45**
SE(m) (±)	**0.33**	**0.05**	**0.57**	**0.58**	**0.02**	**1.02**
CD (1%)	**1.34**	**0.19**	**NS**	**2.34**	**0.10**	**4.09**
CD (5%)	**0.99**	**0.14**	**1.69**	**1.72**	**0.07**	**3.02**

Table 3. Performance of various turfgrasses for stolon internodal length, stolon internodal width, culm length, fresh weight, dry weight, shoot length and shoot diameter

Genotype	Stolon Internodal Length (cm)	Stolen Internode Width (mm)	Culm Length (cm)	Fresh Weight (kg)	Dry Weight (kg)	Shoot Length (cm)	Shoot Diameter (mm)
G_1 (Bermuda grass)	1.88	0.79	5.86	49.50	15.07	6.75	1.29
G_2 (Bahia grass)	1.91	0.84	8.60	70.65	29.47	9.52	1.19
G_3 (Bargusto grass)	1.46	0.87	5.68	48.15	14.85	6.83	1.02
G_4 (Tifdwarf 419 grass)	1.77	0.82	5.82	65.02	19.57	6.89	1.29
G_5 (Crow Foot grass)	1.83	0.80	9.72	51.75	20.70	9.30	1.12
G_6 (Panama grass)	1.83	0.81	5.80	45.90	16.67	6.66	1.14
G_7 (Centipede grass)	1.75	0.84	5.04	72.00	20.25	5.83	1.26
G_8 (Palma grass)	1.61	0.83	5.89	81.45	30.82	6.93	1.19
G_9 (Manila grass)	1.96	0.80	9.62	58.50	20.70	10.68	1.31
G_{10} (Tanu Variant grass)	2.18	0.79	11.29	86.50	34.42	12.35	1.23

Genotype	Stolon Internodal Length (cm)	Stolen Internode Width (mm)	Culm Length (cm)	Fresh Weight (kg)	Dry Weight (kg)	Shoot Length (cm)	Shoot Diameter (mm)
G_{11} (Local grass)	2.17	0.91	14.14	57.60	22.50	14.70	1.41
Mean	1.82	0.82	7.33	62.94	22.25	8.17	1.21
SE(m) (±)	0.08	0.02	0.50	1.79	0.46	0.49	0.03
CD (1%)	0.31	0.06	1.99	7.19	2.02	1.96	0.12
CD (5%)	0.23	0.05	1.47	5.31	1.37	1.45	0.09

Table 4. Performance of various turfgrass genotypes for variability, heritability and genetic advance

Parameters	GV	PV	GCV	PCV	GA 5%	GAM 5%	h^2(b)
Canopy height (cm)	11.08	11.51	46.16	47.04	6.73	93.30	96.29
Leaf length (cm)	0.26	0.27	28.11	28.53	1.04	56.85	97.07
Root depth (cm)	0.81	1.82	8.17	12.28	1.23	11.20	44.28
Shoot density (25 cm^2)	14.29	15.26	15.37	15.88	7.54	30.64	93.66
Leaf width (mm)	0.03	0.04	10.76	11.24	0.36	21.26	91.59
Leaf chlorophyll content	4.76	7.65	30.72	38.95	3.54	49.91	62.18
Stolon internode length (cm)	0.08	0.10	14.68	16.48	0.51	26.94	79.38
Stolon internode diameter (mm)	0.002	0.003	4.92	6.22	0.07	8.40	62.50
Culm length (cm)	8.77	9.51	37.16	38.69	5.86	73.49	92.25
Fresh weight (kg)	187.22	197.80	21.91	22.46	27.49	44.02	95.13
Dry weight (kg)	42.47	43.23	29.26	29.52	13.31	59.74	98.25
Shoot length (cm)	9.70	10.51	34.87	36.31	6.16	69.00	92.25
Shoot diameter (mm)	0.01	0.01	8.06	9.23	0.18	14.58	76.32
Growth habit	88.89	93.96	22.12	22.74	18.89	44.32	94.60

4. CONCLUSIONS

For any sports field the choicest turfgrass must be a fine textured cool grass that spreads by rhizomes, a character that gives the ability to form dense sod, crowd out weeds, to withstand traffic (wear and tear) and stress (drought and heat tolerant). A grass that fills the void space, repair the ground by itself whereas, a desirable turfgrass for hotels, public gardens, recreational places must have dark green colour (high chlorophyll content), withstand heavy traffic, that lower down the glare of bright sunlight and gives an aesthetic view to the surroundings. In present research work, Local grass was found to hold all these characters. Hence, Local grass can be exploited to enhance the beauty of various places as compared to other species of turfgrasses like Tanu Variant grass, Centipede grass and Manila grass.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Karthikeyan S. Common tropical and subtropical sedges and grasses: Illustrated account: review. Rheedea. 2005;15(2):141 –142.
2. Roberts EC, Huffine WW, Grau FV, Murray JJ. Turfgrass Science – Historical Overview. *In*: Waddington, D.V., Carrow, R.N., and Shearman, R.C. (eds). 1997. Turfgrass. The American Society of Agronomy and Academic Press, Madison, Wisconsin USA. 1992;775.
3. Turgeon AJ. Turf grass Management. Reston Publishing Company, Virginia. 1980;26-29.
4. Beard JB. Turfgrass: Science and Culture, 1st Edn. Prentice Hall, Inc., Englewood Cliffs, NJ, London. 1973;658.
5. Christians NC. Fundamental of turfgrass management, 4th edn. Ann Arbor Press, Chelsea, MI. 2004;368.
6. Bell GE. Turfgrass physiology and ecology: Advanced Management Principles, 1st edn. Wallingford, Oxfordshire, UK. 2011;211.
7. Etemadi N, Khalighi A, Razmjoo KH, Lessani H, Zamani Z. Drought resistance of selected Bermuda grass {*Cynodon dactylon* (L.) Pers.} accessions. International Journal of Agriculture and Biology. 2005;7(4):612-615.
8. Mathowa T, Chinachit W, Yangyuen P, Ayutthaya SIN. Changes in turfgrass leaf chlorophyll content and some soil characteristics as influenced by irrigation treatments. International Journal of Environmental and Rural Development. 2012;3(2):181-187.
9. Agnihotri R, Chawla S, Patil S. Evaluation of warm season turfgrasses for various qualitative and quantitative traits under Gujarat agro-climatic conditions. Indian Journal of Agricultural Sciences. 2017;87(7):83-91.
   DOI: 10.56093/ijas.v87i7.71878
10. Jiang Y, Huang B. Drought and heat stress injury to two cool-season turfgrasses in relation to antioxidant metabolism and lipid peroxidation. Crop Science. 2001;41:436-442.
    DOI: 10.2135/cropsci2001.412436x
11. Wadekar VD, Patil PV, Kadam GB, Gawade NV, Bhosale PB. Evaluation of lawn grasses based on the qualitative and morphological traits. International Journal of Chemical Studies. 2018;6(4):1175-1179.
12. Burton GW. Quantitative inheritance in grass. *In*: 6th International Grassland Congress. 1952;1: 277–283.
13. Lush JL. Intro-site correlation and regression of off-spring on corn as a method of estimating heritability of characters. American Society of Animal Production. 1940;33:293-301.
14. Johnson HW, Robinson HF, Comstock RE. Estimate of genetic and environmental variability in soybean. Agronomy Journal. 1955;46:314 -318.
15. Gobilik J, Jerome V, David D. Preliminary selection of some ecotypes of *Cynodon dactylon* (L.) Pers. in Sabah, Malaysia for turfgrass use. Journal of Tropical Biolological Conservation. 2013;10:51–66.
    DOI: https://doi.org/10.51200/jtbc.v10i0.

16. Janakiram T, Namita N. Genetic divergence analysis in turf grasses based on morphological traits. Indian Journal of Agricultural Sciences. 2014;84(9):1035-1039.
DOI: 10.56093/ijas.v84i9.43415
17. Harivandi MA, Davis W, Gibeault VA, Henry M, Van Dam J, Wu L. Selecting the best turfgrass. *California turfgrass Culture. 1984;*34:17–18.
18. Hazard L, Ghesquiere M. Productivity under contrasting cutting regimes of perennial ryegrass selected for short and long leaves. Euphytica. 1997;95:295–299.
19. Hazard L, Ghesquiere M, Betin M. Breeding for management adaptation in perennial ryegrass (*Lolium perenne* L). I. Assessment of yield under contrasting cutting frequencies and relationships with leaf morphogenesis components. *Agronomie*. 1994;14(4):259-266.
20. Bonos SA, Rush D, Hignight K, Meyer WA. Selection for deep root production in tall fescue and perennial Ryegrass. Crop Science. 2004;44:1770–1775.
21. Crush JR, Easton HS, Waller JE, Hume DE, Faville MJ. Genotypic variation in patterns of root distribution, nitrate interception and response to moisture stress of a perennial ryegrass (*Lolium perenne* L.) mapping population. Grass and Forage Science. 2007;62:265–273.
DOI:https://doi.org/10.1111/j.1365-2494. 2007.00583.x
22. Kumar T. Evaluation of turf grasses for various qualitative and quantitative traits under Malwa Plateau of Madhya Pradesh. M.Sc. Thesis, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior. 2021;114.
23. Mahmood S, Hussain A, Saeed Z, Athar Z. Germination and seedling growth of corn (*Zea mays* L.) under varying levels of copper and zinc. International Journal of Environment Science and Technology. 2005;2(3):269-274.
DOI: 10.1007/BF03325886
24. Ling T, Fangke Y, Jun R. Effect of mercury to seed germination, coleoptile growth and root elongation of four vegetables. Research Journal of Phytochemistry. 2010;4(4):225-233.
DOI: 10.3923/rjphyto.2010.225.233.
25. Gvozdenac S, Indic D, Slavica V, Grahovac M, Vrhovac M, Boskovic Z, Marinkovic N. Germination root and shoot length as indicators of water quality. *Acta agriculturae*. 2013;16: 33.
26. Pandey P, Anurag PJ. Estimation of genetic parameters in indigenous rice. *Advances* in Agriculture and Botanics - International Journal of the Bioflux Society. 2010;2(1):79-84.
27. Anis G, Sabagh A E, Ghareb A, Rewainy IEL. Evaluation of promising lines in rice (*Oryza sativa* L.) to agronomic and genetic performance under Egyptian conditions. International Journal of Agronomy and Agricultural Research. 2016;8(3): 52-57.
DOI: 10.2135/cropsci2004.1770
28. Panwar S, Singh KP, Janakiram T. Genetic variability, heritability and genetic advance in African marigold (*Tagetes erecta* L.) genotypes. Progressive Horticulture. 2013; 45(1):135-140.
29. Namita, Singh KP, Raju DVS, Prasad KV, Bharadwaj C. Studies on genetic variability, heritability and genetic advance in French marigold (*Tagetes patula*) genotypes. Journal of Ornamental Horticulture. 2008;12:30-34.
30. Singh AK, Singh D. Genetic variability, heritability and genetic advance in marigold. Indian Journal of Horticulture. 2010;67:132-136.
31. Khinchi P, Jaiswal HK, Sharma A. Analysis of genetic variability, heritability and genetic advance for yield and yield associated traits in wheat. The Pharma Innovation Journal. 2022;11(5):1105-1109.
32. Browning SJ, Riordan TP, Johnson RK, Johnson-Cicalese J. Heritability estimates of turf-type characteristics in buffalo grass. Hort Science. 1994;29(3): 204 -205.
Available:https://doi.org/10.21273/HORTSCI.29.3.204
33. Dhakal R, Paudel D, Deosarkar D. Studies on genetic divergence and reaction to iron chlorosis in aerobic rice (*Oryza sativa* L.) on vertisols in Maharastra. Journal of Plant Stress Physiology. 1970;3:12-21.
DOI:https://doi.org/10.25081/jpsp.2017.v3.3387

34. Panse VG, Sukhatme PV. Statistical methods for Agricultural Workers. 4th Edn. ICAR, New Delhi. 1985;145-156.

35. Weicko G. Fundamentals of Tropical Turf Management, 1st edn. CABI, London, UK. 2006;205.

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