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Short Communication

Morphological variability and stability for seed and forage yield of marvel grass (*Dichanthium annulatum* (Forssk.) Stapf) under north western arid rangeland of Gujarat - India

Bhagirath Ram[1]*, Devi Dayal, S. L. Meena[2], Shamsudheen M, Arvind Kumar, Deepesh Machiwal and S. C. Vyas

Central Arid Zone Research Institute, Regional Research Station, Kukma, Bhuj-Kachchh, Gujarat 370 105; [2]Indian Grassland and Fodder Research Institute, Regional Research Station, Avikanagar, Tonk, Rajasthan

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Abstract

A study was conducted during *kharif* season of 2006, 2007 and 2008 to estimate stability and genetic variability of seed and forage yield of improved genotypes of marvel grass (*Dichanthium annulatum* (Forssk.) Stapf). GxE interaction was significant for all the characters *viz*., plant height, number of tillers/plant, green fodder yield, dry fodder yield and seed yield (kg/ha). G x E (linear) was also significant for all these five characters, indicating substantial amount of predictable G x E interaction. All seven genotypes were tested for three stability parameters, namely, mean, bi and S^2di. It is concluded that the direct selection for plant height along with simultaneous selection for tillers per plant will be responsive for improvement of dry fodder yield and seed yield per plant. The results provide useful information to aid the choice of marvel grass genotypes for the north western arid area of Gujarat. CAZRI-BH-DA-2 should be included in breeding programme intended to develop high yielding stable genotype.

Key words: *Dichanthium annulatum,* genotype x environment interaction, variability, selection, stability

Marvel grass (*Dichanthium annulatum* (Forssk.) Stapf) is a highly preferred forage grass in India. Being indigenous to the Indian and African gene centres, it shows maximum genetic diversity in India and South Africa [1]. Out of the 20 species of the genus *Dichanthium* reported from the tropics and subtropics, India has 8 species distributed in various agro-ecological zones [2]. Only two species, *viz*., *D. Annulatum* (Forssk.) Stapf and *D. caricosum* (L.) A Camus, are widely used for large scale forage production. Marvel grass commonly distributed throughout the plain and hills of India up to 1500 m altitude [3]. It has a wide range of adaptations from low rainfall areas in Rajasthan and Gujarat states to heavy rainfall areas of western and southern India [4]. It forms the dominant species of *Dichanthium- Cenchrus-Lasiurus* grass cover and known for its drought tolerance [5]. *Dichanthium-Cenchrus-Lasiurus* type grass cover are spread over an area of about 436,000 km², including northern parts of Delhi, Aravalli ranges, parts of Punjab, almost whole of Rajasthan, Gujarat and southern Uttar Pradesh [6]. Kachchh, the largest and the western most district of Gujarat state has a very difficult terrain, recurring drought, periodic seismicity, vast areas under salt marshes (ranns), undulating rocky terrain, shallow soil, high exploitation of potable ground water and depleting biodiversity pose serious threats to sustainable use of the land in the district [7]. Farmers in Kachch maintain a large herd of animals for their subsistance, which adds to the pressure on land and fodder resources. The major challenge for a breeder in region is to develop stable genotype that gives maximum

*Corresponding author's e-mail: bhagirathram_icar@yahoo.com
[1]Present address: Directorate of Rapeseed- Mustard Research, Sewar, Bharatpur 321303
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forage yield/unit area and consistent performance for productivity across the environments. To increase and stabilize the production and productivity, identification of suitable genotypes with high forage yield potential is of paramount importance. Stability analysis helps in understanding the genotypic adaptation under variable environmental changes.

The present experiment was carried out at the research farm of Central Arid Zone Research Institute, Regional Research Station, Kukma, Bhuj (22^o 41'11'' to 24^o 41' 47'' N latitude and 68^o 9' 46'' to 71^o 54'47'' E longitude) during *kharif* 2006, 2007 and 2008. The rainfall received during May to October for these years were 689.4, 701.60 and 315 mm, respectively. The soil of the experimental site was gravelly sand to loamy sand in texture with shallow depth (21 cm), low in organic C (0.38%), available N (214 kg/ha), P (7.0 kg/ha) and medium in available K (138.3 kg/ha) with alkaline pH (8.7). The range grass crop was raised under rainfed conditions with basal dose of 45 kg N and 20 kg P_2O_5/ha. The germplasm CAZRI-BH-*DA*-1, CAZRI-BH-*DA*-2, CAZRI-BH-*DA*-3, CAZRI-BH-*DA*-4, CAZRI-BH-*DA*-5 and CAZRI-BH-*DA*-6 were collected from Naliya, Rapar, Khavda, Bhirandiyara, Sumrasar and Dhurvana of Kachchh region and established in nursery during *kharif* 2005, respectively. Seven germplasm lines including one check GMG 1 were evaluated in a randomized block design with three replications. Each genotype was grown in 4 rows of 5 m length/replication with row-to-row distance of 75 cm and plants spaced at 50 cm apart. The observations were recorded on 5 random plants from each plot for morphological characters, *viz*., plant height (cm), number of tillers per plant, green fodder yield (kg/ha), dry fodder yield (kg/ha) and seed yield (kg/ha). The mean values were used for statistical analysis. Analysis of variance [8], estimation of phenotypic and genotypic coefficient of variation and heritability in broad sense [9] and genetic advance as percentage of mean [10] were computed as per standard procedures. Genotype x environment interaction were found to be significant in respect of all the characters studied, hence the data were subjected to stability analysis [11].

The analysis of variance for all the traits showed highly significant difference among the genotypes indicating sufficient amount of variability in the material. The highest genotypic and phenotypic coefficient of variation was observed for green fodder yield followed by number of tillers per plant in all the environments (Table 1). High genotypic and phenotypic coefficients of variation for green fodder yield and number of tillers per plant were also reported by Bhagirath *et al*. [12] in birdwood grass. High heritability (in broad sense) estimates were focused for green fodder yield (95.13 % E_1), plant height (93.56 % E_1), green fodder yield (91.11 % E_3), dry fodder yield (90.79 % E_1) and number of tillers per plant (86.82% E_3) indicating that these characters were less influenced by the environmental factor and direct selection for these characters would be effective for further improvement. The heritability (in broad sense) of tillers per plant (85.13 % E_2) with maximum genetic advance (44.53 % E_2) was observed which might be due to heritability with additive gene impact therefore selection may be effective (Table 1).

For each environment analysis of variance was carried out individually as well as pooled over the years on all the selected characters. Analysis of variance revealed significant differences amongst genotypes for all the observed characters in each of the three environments. Pooled analysis of variance over the three environments was also carried out in order to verify presence of G x E interactions (Table 1). G x E interactions variance was significant for all the observed characters. Variance due to genotype was also significant for all the observed characters. Variance due to environment was also significant for all the observed characters. These results indicated presence of substantial amount of genotype x environment interaction.

Stability analysis was carried out as per Eberhart and Russell [11] model for all the observed characters in order to verify the presence of variance due to component of G x E interaction (Table 2). Samuel *et al*. [13] and Paroda and Hays [14] emphasized that linear regression (b_i) could simply be regarded as a measure of response of a particular genotype, where the deviation around regression line (S^2_{di}) is the most appropriate measure of stability. Genotype with b_i =1 and lowest deviation around regression line could be termed most stable and *vice-versa*. Accordingly, it was possible to judge the stability of genotypes, with due consideration to their mean performance and linear response.

The genotype x environment interaction was present and it was highly significant for all the characters studied, as has been previously [15, 16]. As the environments selected in the present study were diverse (three consecutive year), the presence of significant G x E for observed characters indicates the relevance of the stability analysis. Genotype CAZRI -BH-DA-2, CAZRI-BH-DA-3 and CAZRI-BH-DA-4 having found to possess relative stable and high performance for plant

Table 1. Range, critical difference, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (b.s) and genetic advance in marvel grass in 3 environments

Genetic variability parameter	Plant height (cm)			Number of tillers/plant			Green fodder yield (kg/ha)			Dry fodder yield (kg/ha)			Seed yield (kg/ha)		
	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
Range	65.90-100.06	92.33-139.21	92.50-142.20	11.83-46.83	18.32-55.23	19.61-58.71	1674.10-6452.74	2450.04-8565.40	2540.11-9015.52	1174.65-343938	1478.65-3734.90	1568.81-3098.10	125.28-180. 97	138.77-180.29	140.42-198.52
CD (P=0.05)	3.57	21.17	22.55	6.54	16.12	18.21	671.91	1278.43	1055.12	385.91	804.44	801.73	11.43	13.22	15.55
CD (P=0.01)	6.47	29.69	32.97	9.17	22.60	23.98	914.97	1792.27	1712.55	541.01	1127.77	1191.06	16.03	18.53	20.41
GCV	14.10	14.92	16.25	28.86	44.46	48.12	53.09	52.11	54.81	32.71	26.59	27.12	9.06	8.65	9.01
PCV	15.07	18.36	20.58	31.13	48.18	50.11	54.43	55.00	55.98	34.38	26.59	28.18	10.01	9.75	10.5
h2 (b.s.)	93.56	66.02	68.33	85.82	85.13	86.82	95.13	89.59	91.11	90.79	66.61	70.12	82.04	78.21	80.56
GA as % of mean	26.12	34.05	36.02	18.47	44.53	45.41	42.21	41.87	41.52	19.02	17.86	43.72	28.10	28.84	31.85

E_1: Year 2006, E_2: Year 2007, and E_3: Year 2008

height (cm), number of tillers per plant, green fodder yield (kg/ha) over its respective population mean. Similarly, range was wider amongst all the genotypes tested. The result indicated that genotype CAZRI-BH-DA-2, CAZRI-BH-DA-3, and CAZRI-BH-DA-4 were expressed relatively wider range for character plant height, green fodder yield and dry fodder yield. Analysis of variance for stability indicated significant difference among the genotype for all five characters observed, indicating the diversity in the selected genotypes. Significant differences were observed among the environments too, indicating significant effect of environment in the expression of the traits. Genotype x environment interaction was significant for plant height, number of tillers per plant, green fodder yield, dry fodder yield and seed yield indicating that genotypes are varying over the environment due to G x E. The significant G x E interaction has been earlier [17-19]. The genotype CAZRI-BH-DA-2 attained more plant height along with regression coefficient equilant to unity and S^2di near to zero considered as stable. While the genotype CAZRI-BH-DA-3 had attained maximum plant height along with regression coefficient near to unity, exhibit average stability. The stability parameters for number of tillers per plant revealed that genotype CAZRI-BH- DA-4 had higher mean number of tillers per plant to general mean along with regression coefficient near to unity considered as average stable and desirable genotype. The genotype CAZRI-BH-DA-3 recorded maximum mean green fodder yield along with regression co-efficient near to unity, exhibiting average stability. Whereas genotype CAZRI-BH-DA-2 had high green fodder yield to general mean along with regression co-efficient near to unity considered as average stable and desirable. The stability parameters for dry fodder yield revealed that genotype CAZRI- BH-DA-3 had higher mean dry fodder yield to general mean along with non-significant regression coefficient and deviation from regression coefficient that shows average response and stability. The genotype CAZRI-BH-DA-2 recorded high mean seed yield to general mean along with regression coefficient near to unity and S^2di near to zero exhibiting the stability, therefore their performance was stable and desirable. While genotype CAZRI-BH-DA-3 had maximum seed yield along with non- significant regression coefficient and deviation from regression showing average response and stability. Bakheit *et al.* [19] reported that the Giza 15 variety out yielded (1.10 t ha^{-1}) other tested varieties followed by Giza 6 (1.07 t ha^{-1}) and Assiut population (0.99 t ha^{-1}) over both seasons. The estimates of phenotypic stability parameters (bi and S^2di) for seed yield showed that the

Table 2. Stability parameters of different genotypes for forage yield and yield attributing characters in *Dichanthium annulatum*

Genotype	Plant height (cm)			No. of tillers per plant			Green fodder yield (kg/ha)			Dry fodder yield (kg/ha)			Seed yield (kg/ha)		
	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}	Mean	b_i	S^2_{di}
CAZRI- BH - *DA*- 1	98.37	-0.10	205.58*	60.89	2.33*	1553.27**	3677.26	-0.19	7896.00**	2547.61	-1.35*	4763.40**	160.68	-1.10*	541.98**
CAZRI- BH -*DA* – 2	113.43	0.79*	4.72	40.16	0.52*	8.18	4043.61	1.12*	2759.73**	3072.09	1.72*	1624.35**	167.81	1.70*	-2.15
CAZRI- BH - *DA* - 3	125.94	1.13*	107.84*	48.69	0.05	46.58*	6508.56	-0.79*	3640.00**	3467.11	-0.34*	1413.29**	183.70	-0.10	52.03*
CAZRI- BH – *DA*- 4	113.49	1.57*	315.65*	45.29	0.89*	52.55*	5427.55	4.86*	25076.00**	2757.92	2.46*	1325.50**	171.68	2.79*	337.49*
CAZRI- BH - *DA* - 5	94.95	1.60*	75.90*	25.47	1.23*	247.04*	2685.62	1.47*	4013.40**	1944.56	2.44*	0716.44**	154.70	1.56*	5.21
CAZRI- BH - *DA* - 6	107.58	0.48*	230.16*	33.04	-0.17	98.20*	2637.33	0.85*	5782.70**	1691.35	1.12*	96.17*	155.40	0.32*	-22.97*
GMG 1 (C)	99.65	1.53*	384.00**	56.92	2.15*	2568.17**	2503.70	0.92*	146.99*	1712.43	0.61*	866.03**	143.16	1.83*	-8.73
Population mean	107.63			44.35			3926.23			2456.15			162.45		

* and ** Significant at 5 and 1 per cent level of significance, respectively

highest seed yielding varieties Giza 15 and Giza 6 exhibited less instability in seed yield while the Assiut population was more stable.

The results presented in this paper highlight the relative stability of selected marvel grass genotypes in three different growing seasons. The range of climatic conditions was sufficiently broad to provide for a substantial test of the genotypes. In fact, the effect of year was much more important than the effects, at least, for number of tillers per plant and seed yield. There were clear differences for these traits between the marvel grass genotypes across growing seasons. On the contrary, the effect of genotype on plant height is clearly most important, while the environment and genotype x environment interaction effects were of little importance. This suggests that the plant height is the stable traits in the tested marvel grass potential to respond better in favourable growing conditions.

The present results provide useful information to aid the choice of marvel grass genotypes in north western arid area of Gujarat. CAZRI-BH-DA-2 could be included in any breeding programme where objective is to develop high yielding stable genotype over the environment. It can be concluded that the direct selection for plant height along with simultaneous selection for tillers per plant will be responsive for improvement of dry fodder yield and seed yield per plant.

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