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HERITABLE VARIATIONS AND CHARACTER ASSOCIATION IN ANJAN GRASS (*CENCHRUS CILIARIS* L.)

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SUMMERY

The study involving twenty-eight genotypes of Anjan grass with two checks were evaluated in a Randomized Block Design with two replications at Grass Breeding Scheme, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra. Treatment differences were found to be significant for all the characters studied. High estimates of GCV and PCV were observed for traits *viz*., number of tillers/plant, leaf breadth, spike length and number of spikes per plant. High estimates of heritability (b.s.%) accompanied by high estimates of genetic advance as percentage of mean were observed for the characters namely number of tillers/plant, number of leaves/tiller, leaf length, leaf breadth, spike length, number of spikes/plant, spikelets per spike and green fodder yield. The characters like plant height, number of tillers per plant, leaf length, leaf breadth, spike length, spike breadth, spikelets per spike and dry matter percent showed significant positive genotypic and phenotypic correlations with green fodder yield. Leaf length exhibited high positive direct effect and significant positive genotypic correlation with green forage yield followed by leaf breadth, plant height, number of tillers per plant and spike breadth. The characters spike length, spikelets per spike and dry matter also exhibited high negative direct effects on green fodder yield, however its association with green fodder yield observed to be strong and positive. Thus indicating that emphasis should be given on these characters for green forage improvement in Anjan grass.

Key words : *Cenchrus ciliaris*, anjan grass, genetic variability, correlation, path coefficients, forage yield

Anjan grass is an inhabitant to arid and semi-arid subtropics of dry sandy areas in Africa, India, USA and Australia. It is an African native species that is drought-tolerant, resistant to heavy grazing and has fast growth, features that make this species valuable as a forage plant Tinoco-Ojanguren *et al.,* (2016). India is a thickly populated country of world; therefore, to satisfy their appetite, cultivation of food and fodder crops is must. But, in our country livestock population is also very huge and we are unable to produce sufficient green fodder for them, due to lack of resources Preeti *et al*., (2016). Therefore, it is an instant need to utilize the marginal lands and forest areas to cultivate the perennial grasses. *Cenchrus ciliaris* is a perennial grass and best suited for dessert environmental conditions. Anjan grass is highly nutritious considered excellent for pasture in hot, dry areas and is valued for its production of palatable forage and intermittent grazing during doughty periods in the tropics Kalamani *et al*., (2011). *C. ciliaris* has also been used as folk remedies for kidney pain, tumors, sores and wounds. It can be used as an anodyne (pain reliever), lactogogue (increased milk flow) and diuretic and as an emollient. It is an important medicinal, fodder as well as crop plant and traditionally used as famine food during drought. In extreme conditions when food is in scare seeds of this grass are consumed by tribals Arora and Kumar (2018).

In India it's natural species largely found in Rajasthan, Haryana, Punjab, Gujarat and parts of western U.P. and Tamilnadu. Among the twenty species, *C. ciliaris* and *C. setigerus* are most commonly used for forage production Pandey and Roy, (2011). In India, it is mainly grown in traditional pastureland farming system Adlin *et al.,* (2018). It encompasses a wide range of variation, and is generally apomictic. In order to have a choice for forage yield enhancement, the knowledge of nature and magnitude of variability existing in available germplasm, the association of the component characters with yield and their exact contribution through direct and indirect effects are very important. In view of this, present

investigation was undertaken to determine the relationship between genetic parameters.

MATERIALS AND METHODS

The experimental material consists of 30 diverse genotypes of Anjan grass was sown in randomized block design (RBD) with two replications during *kharif* season of 2019 at Grass Breeding Scheme, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra. It is situated in semi-arid sub-tropical region at 19° 47' to 19° 57' North latitude and 74° 32' to 74° 19' East longitude with elevation of 657 m above mean sea level. The weather conditions and rainfall received during the period of experimentation from meteorological week No. 25 to 40 of *Kharif* season 2019 depicted in figure 1. Each genotype was grown in 4 meter length of 2 rows with spacing 50 × 30 cm. The list of genotypes along with their source is presented in Table 1. Observations were recorded for 13 characters *viz*., days to 50% flowering, plant height (cm), number of tillers per plant, number of leaves per tiller, leaf length (cm), leaf breadth (cm), spike length (cm), spike breadth (cm), number of spikes per plant, spikelets per spike, dry matter percent, crude protein percent and green fodder yield (kg/tussock). Statistical analysis was performed by methods proposed by Panse and Sukhatme (1985). The variability parameters were estimated as suggested by Burton (1952), Johnson *et al*., (1955) and Allard (1960). The correlation coefficients were estimated as per the procedure outlined by Singh and Chaudhari (1977), while path coefficients analysis was performed by methods of Dewey and Lu (1959).

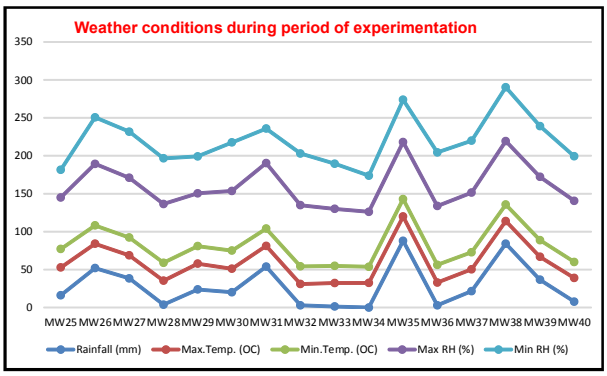

Fig. 1. Weather conditions during period of experimentation (Meteorological Week 25 to 40).

RESULTS AND DISCUSSION

Estimates of Variability

Variability parameters such as range, mean, genotypic variance, phenotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance and genetic advance as % of mean are presented in Table 2. The analysis of variance revealed significant genotypic differences in the material studied for all the characters indicating the presence of high genetic variability. The overall mean and range for yield and its components revealed that there was substantial genetic variability for most of the characters except leaf breadth, spike breadth, dry matter percent, crude protein percent and days to 50% flowering among all the genotypes under study.

The estimates of GCV and PCV for all the characters studied showed difference, PCV being

TABLE 1
List of *Cenchrus ciliaris* genotypes with their sources

S. No.	Genotype	Source	S. No.	Genotype	Source
1.	RHRGS-CC-1	Bikaner	16.	RHRGS-CC-18	Jhansi
2.	RHRGS-CC-3	Jodhpur	17.	RHRGS-CC-21	Jhansi
3.	RHRGS-CC-4	Jodhpur	18.	RHRGS-CC-22	Jodhpur
4.	RHRGS-CC-5	Bikaner	19.	RHRGS-CC-23	Jodhpur
5.	RHRGS-CC-6	Bikaner	20.	RHRGS-CC-24	Jodhpur
6.	RHRGS-CC-7	Avikanagar	21.	RHRGS-CC-30	Jodhpur
7.	RHRGS-CC-8	Jodhpur	22.	RHRGS-CC-31	Jhansi
8.	RHRGS-CC-9	Jodhpur	23.	RHRGS-CC-32	Jodhpur
9.	RHRGS-CC-10	Jhansi	24.	RHRGS-CC-33	Jodhpur
10.	RHRGS-CC-12	Jodhpur	25.	RHRGS-CC-37	Jhansi
11.	RHRGS-CC-13	Jodhpur	26.	RHRGS-CC-38	Jhansi
12.	RHRGS-CC-14	Jhansi	27.	RHRGS-CC-39	Jodhpur
13.	RHRGS-CC-15	Jhansi	28.	RHRGS-CC-40	Rahuri
14.	RHRGS-CC-16	Jodhpur	29.	CAZRI- 75	Jodhpur
15.	RHRGS-CC-17	Jhansi	30.	Phule Madras Anjan-1	Rahuri

TABLE 2
Estimates of variability parameters for green forage yield and yield contributing characters in Anjan grass

S. No.	Characters	Range	General mean	Genotypic variance (σ^2g)	Phenotypic variance (σ^2p)	Env. variance (σ^2e)	GCV (%)	PCV (%)	ECV (%)	Heritability (b. S) (%)	GA	G. A. as % of mean
1.	Days to 50 % flowering	41-49	44.10	3.92	7.23	3.31	4.49	6.09	4.12	54.2	3.00	6.81
2.	Plant height (cm)	73.30-104.10	88.77	47.07	59.67	12.61	7.73	8.70	4.00	78.9	12.55	14.14
3.	Tillers per plant (Nos.)	21-49.65	33.32	59.83	69.09	9.26	23.21	24.95	9.13	86.6	14.83	44.50
4.	Number of leaves/tiller	4.95-11	7.05	1.76	2.27	0.51	18.84	21.38	10.11	77.6	2.41	34.19
5.	Leaf length (cm)	26.09-46.30	36.68	23.19	30.32	7.13	13.13	15.01	7.28	76.5	8.67	23.65
6.	Leaf breadth (cm)	0.57-1.79	1.07	0.07	0.09	0.02	24.75	27.83	12.71	79.1	0.48	45.36
7.	Spike length (cm)	6.27-14.41	10.03	4.07	4.58	0.51	20.10	21.34	7.15	88.8	3.91	39.01
8.	Spike breadth (cm)	1.39-3.20	2.10	0.12	0.24	0.13	16.17	23.46	16.99	47.5	0.48	22.97
9.	No. of spikes/plant	2.22-13.70	6.84	12.46	13.33	0.86	51.63	53.39	13.60	93.5	7.03	102.85
10.	Spikelets/spike	72.75-162.87	112.27	433.96	514.46	80.50	18.55	20.20	7.99	84.4	39.41	35.10
11.	Dry matter (%)	26.31-32.76	28.76	2.63	3.76	1.13	5.64	6.74	3.69	69.9	2.79	9.71
12.	Crude protein (%)	7.88-11.70	9.46	0.66	0.66	0.01	8.57	8.61	0.79	99.2	1.66	17.58
13.	Green fodder yield (kg/tuss.)	0.335-0.686	0.479	0.008	0.009	0.001	18.15	19.64	7.52	85.3	0.17	34.53

slightly greater than the GCV, for all the traits under study thus indicating the environmental influence over the traits. The magnitude of genotypic as well as phenotypic coefficient of variances were high for number of spikes per plant followed by leaf breadth and number of tillers per plant. Concomitant results were obtained by Gore *et al.,* (2016) and Santosh *et al.,* (2017). Moderate value for GCV and PCV was observed for green fodder yield and leaf length. Similar results was observed by Adlin *et al.,* (2018). The moderate genotypic coefficients of variation indicating that moderate improvement of these traits by selection. The selection will be effective based on the heritable nature of these traits. While low estimates were observed for plant height, crude protein percent, dry matter percent and days to 50% flowering. Similarly the least difference between GCV and PCV was observed for crude protein percent indicating the maximum reflection of genotype into phenotype. Furthermore, Vijaylaxmi *et al.,* (2019) also reported a varying level of GCV and PCV for various traits in forage sorghum along with a wider difference between both values.

Maximum heritability (b.s.%) was observed for crude protein percent (99.2%) and minimum heritability for spike breadth (47.5%). High heritability (>60 %) was observed for all the characters under study except days to 50% flowering (54.2%) and spike breadth (47.5%) which shows moderate heritability. High heritability indicated less environmental influence on the characters and recorded high transmission index. High genetic advance was found for number of spikes per plant, tillers per plant and plant height, whereas it was lowest for green fodder yield. However genetic advance as percent of mean was high for number of spikes per plant (102.85), leaf breadth (45.36), number of tillers per plant (44.50), spike length (39.01), spikelets per spike (35.10), green fodder yield (34.53), number of leaves per tiller (34.19), leaf length (23.65) and spike breadth (22.97).

TABLE 3
Genotypic direct and indirect effect of yield components on green forage yield in Anjan grass

S. No.	Characters	Days to 50% flowering	Plant height (cm)	Tillers/ plant (Nos.)	No. of leaves/ tiller	Leaf length (cm)	Leaf breadth (cm)	Spike length (cm)	Spike breadth (cm)	No. of spikes/ plant	Spikelets/ spike	Dry matter (%)	Crude protein (%)	Genotypes correlation with GFY
1.	Days to 50 % flowering	**0.977**	0.038	-0.082	0.198	0.222	0.306	-0.128	0.036	-0.964	-0.227	-0.131	-0.155	0.090
2.	Plant height (cm)	0.069	**0.539**	-0.138	0.2339	1.005	0.368	-0.291	0.020	-0.858	-0.231	-0.286	-0.041	0.390**
3.	Tillers per plant (Nos.)	-0.202	-0.189	**0.395**	-0.284	-0.155	-0.225	0.212	-0.004	1.059	0.158	-0.265	-0.063	0.438**
4.	Number of leaves per tiller	0.273	0.178	-0.159	**0.707**	0.342	0.399	-0.228	0.069	-1.150	-0.187	-0.120	0.125	0.250
5.	Leaf length (cm)	0.169	0.423	-0.048	0.189	**1.279**	0.362	-0.296	0.069	-1.054	-0.179	-0.408	0.035	0.541**
6.	Leaf breadth (cm)	0.409	0.272	-0.122	0.387	0.635	**0.729**	-0.423	0.094	-1.066	-0.243	-0.384	0.072	0.363**
7.	Spike length(cm)	0.223	0.279	-0.149	0.287	0.674	0.549	**-0.561**	0.074	-0.574	-0.261	-0.334	0.201	0.408**
8.	Spike breadth (cm)	0.1597	0.049	-0.007	0.221	0.395	0.309	-0.188	**0.222**	-0.538	-0.076	-0.239	0.168	0.476**
9.	No. of spikes per plant	-0.513	-0.252	0.228	-0.443	-0.734	-0.423	0.175	-0.065	**1.836**	0.147	0.023	-0.031	-0.051
10.	Spikelets pe spike	0.497	0.279	-0.141	0.297	0.515	0.398	-0.329	0.038	-0.607	**-0.445**	-0.198	-0.021	0.286*
11.	Dry matter (%)	0.194	0.234	0.159	0.129	0.791	0.424	-0.284	0.081	-0.064	-0.133	**-0.659**	0.093	0.964**
12.	Crude protein (%)	0.257	0.037	0.042	-0.149	-0.075	-0.089	0.191	-0.063	0.096	-0.015	0.104	**-0.589**	-0.255*

Diagonal values in bold represents direct effects and others indirect effects R = 0.473 (R = Residual effect).

It was observed that the traits number of tillers per plant, number of leaves per tiller, leaf length, leaf breadth, spike length, number of spikes per plant, spikelets per spike and green fodder yield showed high estimates of heritability (b.s.%) accompanied by high genetic advance as percentage of mean indicating that these traits could be prominently governed by additive gene action and selection of these traits could be more effective for desired genetic improvement. Similar findings were reported by Patel (2002) and Adlin *et al.,* (2018).

Correlation coefficient

Correlation coefficient is a statistical measure which is used to find out the degree and direction of relationship between two or more variable. In forage crops like Anjan grass, green fodder yield which is ultimately harvested is influenced by number of vegetative plant characters. The knowledge of association between yield and other biometrical characters and the association among the component traits themselves would greatly help in indirect effective selection for high fodder yield. It was revealed from the present study that, the genotypic correlation coefficients between most of the characters were higher in magnitude than the phenotypic correlation coefficients indicating strong inherent association between various characters studied and that the genotypic expression of the correlation was comparatively less influenced by the environmental conditions. The data presented in Table 3 revealed that the green forage yield had significant and positive correlation both at genotypic and phenotypic level with plant height (rg=0.390, rp=0.463), tillers per plant (rg=0.438, rp=0.475), leaf length (rg=0.541, rp=0.475), leaf breadth (rg=0.363, rp=0.371), spike length (rg=0.408, rp=0.396), spike breadth (rg=0.476, rp=0.309), spikelets per spike (rg=0.286, rp=0.263) and dry matter percent (rg=0.964, rp=0.857). Similar trend were also reported by Patel (2002), Patel *et al.,* (2007), Jindal and Satpal (2020) and Thant *et al.,* (2021).

Path Coefficient

Green fodder yield, a complex character depends upon other component characters, which exert their effects directly and indirectly. Direct effect of any character on forage yield gives an idea about effective selection that can be made to bring improvement in the latter. The indirect effect indicates the interrelationship of component characters towards contribution to yield. In present investigation number of spikes per plant showed highest positive direct effect (1.836) on green forage yield (Table 4) followed by leaf length (1.279), days to 50% flowering (0.977), leaf breadth (0.729), number of leaves per tiller (0.707), plant height (0.539), number of tillers per plant (0.395)

TABLE 3
Genotypic and Phenotypic correlation coefficients of green forage yield with yield contributing characters in Anjan grass

S. No.	Characters		Days to 50% flowering	Plant height (cm)	Tillers/ plant (Nos.)	No. of leaves/ tiller	Leaf length (cm)	Leaf breadth (cm)	Spike length (cm)	Spike breadth (cm)	No. of spikes/ plant	Spikelets/ spike	Dry matter (%)	Crude protein (%)	GFY (kg/ tussock)
1.	Days to 50 % flowering	G	-	0.071	-0.207	0.279*	0.174	0.419**	0.228	0.163	-0.525**	0.509**	0.199	0.263*	0.090
		P		0.123	-0.108	0.227	0.216	0.316*	0.144	0.206	-0.308*	0.309*	0.124	0.178	0.104
2.	Plant height (cm)	G		-	-0.350**	0.331**	0.786**	0.505**	0.519**	0.091	-0.467**	-0.519**	0.434**	0.069	0.390**
		P			-0.214	0.307*	0.683**	0.471**	0.474**	0.036	-0.363**	0.434**	0.437**	0.057	0.463**
3.	Tillers per plant (Nos.)	G			-	-0.402**	-0.121	-0.309*	-0.378**	-0.017	0.577**	-0.356**	0.402**	0.107	0.438**
		P				-0.357**	-0.108	-0.253	-0.319*	0.018	0.546**	-0.247	0.394**	0.095	0.475**
4.	No. of leaves per tiller	G				-	0.267*	0.548**	0.406**	0.313*	-0.626**	0.419**	0.182	-0.212	0.250
		P					0.203	0.511**	0.372**	0.191	-0.521**	0.275*	0.144	-0.190	0.231
5.	Leaf length (cm)	G					-	0.497**	0.527**	0.309*	-0.574**	0.403**	0.619**	-0.059	0.541**
		P						0.473**	0.402**	0.066	-0.504**	0.297*	0.447**	-0.051	0.475**
6.	Leaf breadth (cm)	G						-	0.753**	0.424**	-0.580**	0.545**	0.582**	-0.122	0.363**
		P							0.678**	0.260*	-0.476**	0.396**	0.492**	-0.107	0.371**
7.	Spike length(cm)	G							-	0.335**	-0.313*	0.586**	0.506**	-0.340**	0.408**
		P								0.314*	-0.261*	0.552**	0.469**	-0.312*	0.396**
8.	Spike breadth (cm)	G								-	-0.293*	0.171	0.363**	-0.285*	0.476**
		P									-0.125	0.206	0.314*	-0.197	0.309*
9.	No. of spikes per plant	G									-	-0.330**	-0.035	0.052	-0.051
		P										-0.287*	0.021	0.050	-0.012
10.	Spikelets per spike	G										-	0.299*	0.0349	0.286*
		P											0.270*	0.039	0.263*
11.	Dry matter (%)	G											-	-0.157	0.964**
		P												-0.137	0.857**
12.	Crude protein (%)	G												-	-0.255*
		P													-0.236

* and ** Indicates significant at 5% and 1% level of significance, respectively.

and spike breadth (0.222) indicating importance of direct selection for these traits. Whereas dry matter percent (-0.659) showed highest negative direct effects on green forage yield followed by crude protein percent (-0.589), spike length (-0.561), spikelets per spike (-0.445). Significant and positive association of the green fodder yield is found with plant height (0.390), tillers per plant (0.438), leaf length (0.541), leaf breadth (0.363), spike length (0.408), spike breadth (0.476), spikelets per spike (0.286), dry matter percent (0.964). The residual effect at genotypic level was 0.473 which suggested that there might be few more component traits responsible to influence the green fodder yield per plant than those studied. High direct effects along with significant and positive correlation with green forage yield were observed for leaf length (1.279, 0.541), leaf breadth (0.729, 0.363), plant height (0.539, 0.390), tillers per plant (0.395, 0.438), spike breadth (0.222, 0.476). Hence emphasis should be given on these characters for improvement for green forage yield in *Cenchrus ciliaris*. Similar findings were reported by Gore *et al.,* (2016) and Sanadya *et al.,* (2019).

In the present investigation out of thirty genotypes, three genotypes *viz*., RHRGS-CC-8, RHRGS-CC-10 and RHRGS-CC-16 were promising for green forage yield and its attribution and hence these genotypes could be further evaluated in multilocation trials.

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