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Study on Genetic Variability, Heritability and Genetic Advance in Forage Sorghum (*Sorghum bicolor* L. Moench)

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ABSTRACT: The present study was an analysis of genetic variability, heritability and genetic advance for ten quantitative traits using forty five F_1s, obtained by crossing ten genotypes *i.e*., CSV-21, HC-260, Pusa Chari-615, GFS-5, G-48, Rajasthan Chari-1, UP Chari-3, HC-136, CSV-17 and Pant Chari-8 of forage sorghum in half-diallel mating design. These forty-five crosses were grown the following year in a Randomized Block Design (RBD) with ten of their parents and three replications. The mean sum of squares due to treatment was determined to be highly significant for all ten traits under study. In this study the higher phenotypic co-efficient of variation was recorded than the genotypic co-efficient of variation for all the measured characters, which indicate that major influenced by environment. In comparison of high heritability coupled with high genetic advance as percent of mean was observed for leaf breadth followed by stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids and green fodder yield whereas, moderate genetic advance was observed for plant height, leaf length and days to 50% flowering. Based on the present study, results based on high variability and higher heritability found with high genetic advance for higher qualitative traits which can be used for improvement of fodder yield its contributed traits. Loss of genetic variability is the major challenge of plant breeder for crop improvement.

Keywords: *Sorghum bicolor*, Variability, Heritability and Genetic advance.

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) originated in northeastern quadrant of Africa and it is highly adapted to drought prone areas. Archeological evidence has identified regions in Sudan, Ethiopia, and West Africa as centers of origin of sorghum, with evidence for more than one domestication event. Sorghum is an often cross-pollinated crop with a chromosome number 2n = 20 and It belongs to the Poaceae family. Sorghum ranks first among cereal fodder crops and is preferred over maize and pearl millet forage because of its high tolerance to wide variation in soil and moisture conditions and better regeneration capacity. World over sorghum is cultivated in nearly 42.10 million ha with an annual production of 59.30 million tones and among sorghum producing countries, India ranks first in terms of area but fourth to the USA and for total production. India produces 4.80 million tonnes of sorghum from 4.96 million ha of land. In India, two distinct adaptive types- *kharif* (rainy) and *rabi* (post-rainy) sorghum are cultivated. *Kharif* sorghum is mainly used for green fodder purposes, while *rabi* sorghum is entirely consumed as food grain. Approximately 3.8 million tonnes of sorghum grain is produced from 4.6 million ha during the *rabi* (Patroti *et al.* 2021). Plant breeding programme's success in developing improved varieties depends on the better understanding of nature and magnitude of genetic variability present within the breeding material. Heritability and genetic advance of a trait is important in determining its response to selection and assists breeders to allocate resources necessary to effectively select for desired traits and to achieve maximum genetic gain with little time and resources (Falconer and Mackay 1996).

MATERIAL AND METHODS

The experimental material forty five F_1 crosses were made using among ten parents during *kharif* season 2021 and a set of fifty five F_1s and ten parents were grown in randomized block design with three replication. Each genotype was grown in two rows each 5meter length with spacing 30 × 15 cm at the experimental field of the CRC, SVPUAT, Meerut, (UP), India during *kharif* season 2022. All recommended agronomical practices has been followed to retained good crop. The data were recorded on five random plants from each genotype in each replication for ten characters *viz.*, days to 50% flowering(day), plant height (cm), leaf length (cm), leaf breadth (cm), stem girth (mm), leaves per plant, leaf area $(cm)^2$, leaf stem ratio, total soluble solids (%), green fodder yield (g/plant). Flowering day was recorded as the number of days after sowing, 50 percent of plants in each plot flowered while leaf area (cm) ^{2} = leaf length (cm) × leaf breadth × 0.71 and leaf stem ratio calculated using the formula, Leaf stem ratio = Fresh weight of all the leaves/Fresh weight of stems. The data collected for each character and means were computed for subjected to analysis of variance (ANOVA) using randomized complete block design to test the variations among genotypes (Panse and Sukhatme 1967) with coefficient of variation as suggested by Burton (1952) and broad sense heritability calculated as the ratio of genotypic to phenotypic variance. The genetic advance (GA) of the traits was calculated based as (Johnson *et al*., 1955). All analysis the statistical analysis was conducted by Indostate statistical programe.

RESULT AND DISCUSSION

The analysis of variance (ANOVA) for the experiment with fifty five treatments for all the green fodder yield attributes *viz.*, Days to 50% flowering, plant height, leaf length, leaf breadth, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids and green fodder yield were observed the significant differences among the genotypes are used in the present study, which allude that wide range of variation among the genotypes. The variance due to treatments was further partitioned in to their orthogonal components like parents, crosses and parents vs crosses. Parents, crosses and parents vs crosses were found highly significant differences for all the characters (Table-1).The similar findings, high amount of genetic variability for these traits has been reported earlier by Kumar *et al.* (2019), Singh *et al.* (2021); Kumar *et al.* (2022).

Table 1: Analysis of variance (ANOVA) for fodder yield components in forage sorghum.

Characters	Source of variation		
	Replication (df=2)	Treatment (df=54)	Error (df=108)
Days to 50% flowering	3.18	93.72**	3.95
Plant height (cm)	330.9	2497.74**	104.39
Leaf length (cm)	5.96	114.15**	3.51
Leaf breath (cm)	0.02	2.89**	0.05
Stem girth (cm)	0.2	20.47**	0.53
Leaves per plant	1.05	11.99**	0.43
Leaf area (cm)^2	371.56	16165.39**	158.89
Leaf stem ratio	0.03	0.08**	0.01
Total soluble solids (%)	2.56	13.11**	0.58
Green fodder yield (g/plant)	2716.73	43108.20**	362.36

Table 2: List of mean and range performance parents and hybrid.

Character	Mean	Minimum	Maximum
Days to 50% flowering	87.91	73.67(Pusa Chari-615)	95.33(HC-136 × CSV-17)
Plant height (cm)	337.56	251.89(UP Chari-3)	392.11(Pusa Chari-615 ×Rajathan Chari-1)
Leaf length (cm)	80.27	69.22(CSV-17)	94.00(GFS-5 × CSV-17)
Leaf breath (cm)	5.78	3.74(CSV-21 × GFS-5)	8.25(HC-260 ×Pusa Chari-615)
Stem girth (cm)	14.66	10.85(G-48 × Pant Chari-8)	19.51(HC-260 ×Pusa Chari-615)
Leaves per plant	12.65	6.45(CSV-17)	17.33(CSV-21 × HC-136)
Leaf area (cm)^2	332.08	188.45(CSV-21 × GFS-5)	540.02(CSV-21 × Pant Chari-8)
Leaf stem ratio	0.18	0.09(Pusa Chari-615 × HC-136)	0.38(G-48 × Pant Chari-8)
Total soluble solids (%)	12.05	6.83(HC-260 × HC-136)	16.10(Rajathan Chari-1 × UP CHARI-3)
Green fodder yield (g/plant)	317.61	119.89(G-48 × Pant Chari-8)	596.56(GSF-5 × G-48)

The mean and range performance of parents and F_1 crosses for all ten characters, have been presented with the help of Table 2.

In the study of phenotypic coefficient of variation (PCV) is recorded as higher than genotypic coefficient of variation (GCV) for all the characters while, the difference between PCV and GCV was smaller and its indicating that environmental factors impact on phenotypic expression is also less (Table 3). The high genotypic and phenotypic coefficient of variation was observed for green fodder yield (GCV=37.58; PCV=38.06) followed by leaf stem ratio (GCV=29.33; PCV=29.84) and leaf area (GCV=22.00; PCV=22.32) which indicating that more variability and prefer of selection for improving these characters. The similar result of green fodder yield in sorghum was observed by Karadi and Kajjidoni (2019); Vinodhini *et al.* (2022). In other side, moderate GCV and PCV were recorded for stem girth (GCV=17.58; PCV=18.27), Total soluble solid (GCV=16.96; PCV=18.10), leaf breath (GCV=16.84; PCV=17.30) and leaves per plant (GCV=15.52; PCV=16.36). Whereas low PCV and GCV were recorded with Days to 50% flowering (GCV=6.22; PCV=6.62) followed by leaf length (GCV=7.57; PCV=7.92) and plant height (GCV=8.37; PCV=8.90) indicating narrow range of variability for these traits there by restricting or limiting the scope for selection which were also reported by Ranjith *et al.* (2017).

The broad-sense heritability was recorded for all ten observations which are presented in the (Table 3). The high heritability (>80%) exhibited for all the attributes i.e., green fodder yield (97.52) following by leaf area (97.11), leaf stem ratio (96.62), leaf breadth (94.73), stem girth (92.65), leaf length (91.30), leaves per plant (89.99), plant height (88.43), days to 50% flowering (88.35) and total soluble solids (87.79). The similar findings were observed by Yadav *et al.* (2019); Kolekar *et al*. (2021); Kumar *et al.* (2022).

The high genetic advance expressed as percentage of mean was recorded (> 20%) for leaf breadth (33.77) followed by stem girth (34.86), leaves per plant (30.32), leaf area (44.65), leaf stem ratio (59.39), total soluble solid (32.74) and green fodder yield (76.46) while moderate genetic advance as percentage of mean (10-20%) was observed for days to 50% flowering (12.05), plant height (16.21) and leaf length (14.89).

Table 3: Estimation of mean, range, coefficient of variation, heritability (broad-sense) and genetic advance as percent of mean performance parents and hybrid.

Genotypes		Range		Variance		Coefficient of variation		Heritability (broad sense) (%)	GA as 5 % mean	GA mean 1%
	Mean	Min	Max	Genotypic	Phenotypic	GCV	PCV			
Days to 50% Flowering	87.91	73.67	95.33	29.92	33.87	6.22	6.62	88.35	12.05	15.44
Plant height (cm)	337.56	251.89	392.11	797.78	902.18	8.37	8.90	88.43	16.21	20.77
Leaf length (cm)	80.27	69.22	94.00	36.88	40.39	7.57	7.92	91.30	14.89	19.09
Leaf breadth (cm)	5.78	3.74	8.25	0.95	1.00	16.84	17.30	94.73	33.77	43.27
Stem girth (mm)	14.66	10.85	19.51	6.65	7.18	17.58	18.27	92.65	34.86	44.68
Leaves Per Plant	12.65	6.45	17.33	3.86	4.28	15.52	16.36	89.99	30.32	38.86
Leaf area (cm)2	332.08	188.45	540.02	5335.50	5494.40	22.00	22.32	97.11	44.65	57.22
Leaf stem ratio	0.18	0.09	0.38	0.00	0.00	29.33	29.84	96.62	59.39	76.11
Total soluble solid (%)	12.05	6.83	16.10	4.18	4.76	16.96	18.10	87.79	32.74	41.95
Green fodder yield (g/plant)	317.61	119.89	596.56	14248.61	14610.99	37.58	38.06	97.52	76.46	97.98

High heritability together with high genetic advance as percent of mean was noted for green fodder yield (97.52 and 76.46) followed by leaf area (97.11 and 44.65) and leaf stem ratio (96.62 and 59.39) whereas, moderate heritability accompanied with moderate genetic advance as per cent of mean was found in leaf breadth (94.73 and 33.77), stem girth (92.65 and 34.86), leaves per plant (89.99 and 30.32) and total soluble solids (87.79 and 32.74). In other hand, moderate heritability coupled with low genetic advance as per cent of mean was observed for leaf length (91.30 and 14.89), plant height (88.43 and 16.21) and days to 50% flowering (88.35 and 12.05). Prasad and Sridhar (2020), Arvinth *et al.* (2021); Kumar *et al.* (2022) also found the similar result.

CONCLUSIONS

In this study for green fodder yield, its contributing traits as well as one quality traits, these are found the highly significant differences among the materials. Analysis of variance for parents and crosses showed highly differed significantly for all the ten characters. Indicated that wide genotypic differences among the parental lines and F_1's hybrids. High heritability accompanied with high genetic advance as percent of mean was noted for green fodder yield followed by leaf area and leaf stem ratio. Indicating that through the character is least influenced by the environment effects, the selection may not be useful, because broad-sense character may not be useful, because broad-sense is based on total genetic variance which include both additive (fixable) and non-additive or non-fixable (dominance and epistasis). In other side, low heritability observed for some traits, like total soluble solids, days to 50% flowering and plant height which characters are highly influenced by the environmental effects, so genetic improvement through selection will be difficult. Because genotypic effect influenced by the masking effect of environment. The highly observed of genetic advance expressed as per cent of mean have been observed for leaf breadth, stem girth, leaves per plant, leaf area, leaf stem ratio and green fodder yield per plant indicating that the character is governed by additive genes, thereby, suggesting good response for selection based on *per se* performance. Whereas, low genetic advanced was found for the estimation for Plant height, leaf length and days to 50% flowering, which are indicating these character governed by non-additive (non-fixable) genes, so this indicate that heterosis breeding is beneficial for high green fodder yield. High heritability coupled with high genetic advance as a percent of mean indicate the heritability is due to additive genes effects, so selection may be fruitful. Finally, this result of high heritability with high genetic advance as a per cent of mean for green fodder yield was noted.

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