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Genetic variability, character association and path analysis in forage sorghum

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Abstract

Estimates analysis of variance for parents and crosses showed highly differed significantly for all the ten characters *i.e.*, days to 50% flowering, plant height, leaf breadth, leaf length, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids and green fodder yield. Parents vs crosses were found highly significant for all the traits, indicated that wide genotypic differences among the parental lines and F_1's hybrids. High genotypic and phenotypic coefficient of variation was observed (more than 25%) for the attributes *viz*., for leaf breadth, stem girth, leaf area, total soluble solids and green fodder yield, suggested that there is a possibility of improvement of fodder yield through direct selection. High heritability coupled with high genetic advance as percent of mean was observed for the characters *i.e.*, days to 50% flowering, plant height, leaf breadth, leaf length, stem girth, leaf area, total soluble solids and green fodder yield, suggesting that the genes governing these characters may have additive effect. Green fodder yield exhibited significant stable and positive correlation with plant height, leaf length, stem girth, leaves per plant and leaf area at genotypic and phenotypic level, suggesting that selection of these characters may be practiced for gain higher fodder yield in forage sorghum. stem girth displayed high order of direct effect on green fodder yield per plant followed by leaf stem ratio, leaf breadth, leaves per plant and days to 50% flowering at phenotypic and genotypic level, indicated that these characters may contribute for increased fodder yield in forage sorghum.

Keywords: *Sorghum bicolor*, genetic variability, character association, path analysis

Introduction

At present sorghum is mainly used for grain and fodder and is one of the common grain sorghum which are rich in sugar juice can be used for sugar production. This crop is belongs to C_4 type of photosynthesis mature earlier under high temperature and short days. Cultivated sorghum are grouped into four main types based on primarily use of sorghum *viz.*, Grain sorghum, Sweet sorghum, Broom sorghum and Sudan grass etc. it also has greater potential for alcohol production by virtue of their high stem sugar concentration. In some developed countries it is used for preparation of syrup and alcohol for industrial purpose (Wadikar *et al.*, 2018) [27]. High performance of farm animals, especially dairy cows depend on the availability of adequate amounts of quality fodder and in developing countries, inadequacy of quality of forage is the critical limitation to profitable animal production. Among the many option for overcoming the shortage the forage, the introduction the high yielding crop verities rank highly however, in many countries, because of the ever growing need for food for human, only limited cultivated land can be allocated to produced fodder for livestock. Annual summer crops such as forage sorghum hybrids for use as alternative forage crops in drier areas in order to bridge the feed shortage gap. Sugar graze hybrid, is a popular forage source among the livestock farmers of Sri Lanka and is still in the initial stages of introduction. Sugar graze is late flowering cultivars with high yields a crude protein concentration of 12-18% and a high sugar content that boosts feed quality palatability, resulting in minimal feed wastage. In addition, the crop is resistant to a wide range of disease. Mature sugar graze promotes good weight grain and provide adequate energy for livestock. Jumbo plus, a forage sorghum hybrids cultivar, has excellent regrowth potential and high productivity and is adapted to both dry land and irrigated situation. it has similar crude protein concentration sugar graze with 56-64% dry matter digestibility when the plant is 55-60 days old or at 5-10% flowering stage and can be used for grazing silage making and rotational cropping (Gnanagobal and Sinniah, 2018) [10]. The area under high forage yielding with good nutritional qualities varieties is negligible in western Uttar Pradesh. Hence, it is essential to develop superior dual purpose varieties with a significant superiority in term of good nutritional qualities and green fodder yield. For achieving this goal promising genotypes has to develop through creation and manipulation of genetic variability followed by selection. Heritability provides the assessment of transmissible genetic variability to total variability happens to the most important basic factor in determining the genetic improvement and response to selection and genetic advance is more reliable index for understanding the effectiveness of selection to improve the traits. Correlation coefficient provides symmetrical measurement of degree of association between two characters help in understanding the nature and magnitude of association among yield and its components. Direct and indirect effects of independent component traits on yield measures by path coefficient analysis which is fruitful for genetic improvement because direct selection is not effective for low heritable polygenic traits like yield. Under present study heritability, genetic advance, correlation and path analysis carried out to evaluate the forty genotypes of forage sorghum for advance in breeding programme.

Material and methods

The materials for the present investigation comprised ten genotypes of forage sorghum *i.e.*, HC-171, Pratap Chari-1080, MP Chari, HJ-513, CSV-21, Gwalior Local, HC-260, Pant Chari-7, Pusa Chari-23 and Varsha collected from the MPUA&T, Udaipur. All the homozygous parents were sown at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut during the season of *Kharif* 2017. All the possible 45 F_1's hybrids, excluding reciprocals were made among these ten parents. All the 45 F_1's crosses were made diallel fission (10x10) with ten parents were sown in a complete Randomized Block Design with three replications at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut during the season of *Kharif* 2018. Seed of each of the parents and F_1's were sown by hand dibbling method in two rows plot. The rows were 5 m long and spaced 30 cm apart and the plant to plant spacing was maintained at 10 cm. Observations were recorded on five competitive plants for 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 per plant. The coefficients of variation, heritability in broad sense and expected genetic advance were estimated as suggested by Panse and Sukhatme (1969), Burton (1952) [2], Crumpacker and Allard (1962) [6], Robinson *et al.* (1949) [26] and Johnson *et al.* (1955) [14]. Correlation coefficients were calculated as per the methods suggested by Croxton and Couden (1964) [5] and path coefficient were worked out as per the method of Dewey and Lu (1959) [9].

Table 1: Analysis of variance for fodder yield and yield components in forage sorghum

Source of variation	df	Days to 50% flowering	Plant height (cm)	Leaf breadth (cm)	Leaf length (cm)	Stem girth (mm)	Leaves per Plant	Leaf area (cm^2)	Leaf stem ratio	Total soluble solids (%)	Green fodder yield (g/plant)
Replication	2	1.02	14.62	0.52	6.11	4.80	1.61	11.19	0.06	0.75	344.01
Treatment	54	499.62**	6990.65**	8.96**	302.14**	33.86**	17.16**	64980.46**	0.53**	44.55**	87643.69**
Parents	9	567.76**	7171.19**	5.88**	265.86**	24.64**	10.71**	35624.25**	0.49**	50.49**	85791.45**
Crosses	44	414.01**	5700.03**	9.44**	305.80**	33.25**	17.65**	68993.86**	0.67**	43.87**	88266.33**
Parents vs Crosses	1	3653.34**	62161.56**	15.63**	467.27**	143.75**	53.23**	152618.45**	0.91**	21.08**	76922.82**
Error	108	2.11	14.30	0.01	1.00	0.23	0.17	8.29	0.08	0.06	94.31

*, ** significant at 5% and 1% level, respectively

Table 2: Phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance as % of mean in forage sorghum

Parameters	PCV (%)	GCV (%)	Heritability (%)	Genetic Advance	Genetic Advance value % means
Days to 50% flowering	12.08	12.10	98.74	26.36	24.57
Plant height (cm)	18.12	18.16	99.39	29.04	37.10
Leaf breadth (cm)	26.42	26.57	99.61	3.55	54.21
Leaf length (cm)	14.13	14.26	99.02	20.54	28.81
Stem girth (mm)	25.54	26.29	97.98	6.83	49.52
Leaves per Plant	17.31	17.46	97.08	4.83	4.62
Leaf area (cm^2)	31.53	33.52	99.96	33.10	64.92
Leaf stem ratio	22.36	24.81	95.13	0.14	3.82
Total soluble solids (%)	35.40	35.94	99.62	7.92	72.66
Green fodder yield (g/plant)	53.08	54.16	99.68	51.34	29.00

Table 3: Estimates of genotypic (G) and Phenotypic (P) correlation coefficients for different traits in forage sorghum

Parameters		Days to 50% flowering	Plant height (cm)	Leaf breadth (cm)	Leaf length (cm)	Stem girth (mm)	Leaves per plant	Leaf area (cm^2)	Leaf stem ratio	Total soluble solids (%)	Green fodder yield (g/plant)
Days to 50% flowering	G	1.00	0.52**	0.52**	-0.06	0.50**	0.62**	0.94**	0.85**	-0.01	0.21
	P	1.00	0.53**	0.62**	-0.06	0.53**	0.66**	0.94**	0.85**	-0.03	0.20
Plant height (cm)	G		1.00	-0.14	0.12	0.14	0.23	-0.78**	0.57**	0.08	0.63**
	P		1.00	-0.14	0.11	0.14	0.23	-0.78**	0.56**	0.09	0.63**
Leaf breadth (cm)	G			1.00	0.43**	0.63**	0.48**	0.99**	0.57**	0.52**	0.19
	P			1.00	0.45**	0.62**	0.49**	0.97**	0.63**	0.53**	0.28
Leaf length (cm)	G				1.00	0.24	0.34	0.57**	0.19	0.15	0.52**
	P				1.00	0.23	0.34	0.57**	0.18	0.16	0.51**
Stem girth (mm)	G					1.00	0.44**	0.59**	0.06	0.04	0.75**
	P					1.00	0.43**	0.58**	0.10	0.12	0.78**
Leaves per Plant	G						1.00	0.45**	-0.65**	0.05	0.66**
	P						1.00	0.44**	-0.62**	0.12	0.67**
Leaf area (cm^2)	G							1.00	0.51**	0.04	0.90**

	P							1.00	0.47**	0.13	0.93**
Leaf stem ratio	G								1.00	-0.19	0.05
	P								1.00	-0.25	0.09
Total soluble solids (%)	G									1.00	-0.16
	P									1.00	-0.17
Green fodder yield (g/plant)	G										1.00
	P										1.00

Table 4: Estimates of direct and indirect effect of different characters on green fodder yield per plant in forage sorghum

Parameters		Days to 50% flowering	Plant height (cm)	Leaf breadth (cm)	Leaf length (cm)	Stem girth (mm)	Leaves per plant	Leaf area (cm^2)	Leaf stem ratio	Total soluble solids (%)
Days to 50% flowering	G	0.68	0.95	0.63	-0.06	0.08	0.19	0.59	0.06	-0.06
	P	0.72	0.97	0.74	-0.23	0.06	0.16	0.74	0.07	-0.04
Plant height (cm)	G	-0.22	0.03	-0.01	0.17	-0.03	-0.05	0.78	-0.04	0.01
	P	-0.17	0.05	-0.03	0.20	-0.07	-0.08	0.61	-0.05	0.10
Leaf breadth (cm)	G	0.09	0.66	0.78	0.14	-0.09	-0.16	0.69	0.09	0.02
	P	0.07	0.74	0.84	0.23	-0.05	-0.05	0.72	0.10	0.08
Leaf length (cm)	G	-0.04	0.92	0.05	0.16	-0.04	-0.05	0.69	0.08	0.03
	P	-0.04	0.82	0.03	0.19	-0.07	-0.06	0.75	0.09	0.09
Stem girth (mm)	G	-0.07	0.25	0.05	0.14	0.85	-0.22	0.69	0.09	0.25
	P	-0.05	0.25	0.08	0.23	0.89	-0.11	0.78	0.05	0.21
Leaves per Plant	G	-0.05	0.76	0.07	0.16	-0.03	0.75	-0.56	-0.05	0.10
	P	-0.03	0.82	0.08	0.23	-0.07	0.77	-0.35	-0.05	0.06
Leaf area (cm^2)	G	0.06	0.75	0.06	0.28	-0.01	-0.24	-0.38	0.11	0.03
	P	0.05	0.79	0.05	0.08	-0.01	-0.12	-0.39	0.12	0.08
Leaf stem ratio	G	0.06	0.91	0.03	0.08	-0.11	0.18	0.97	0.80	-0.08
	P	0.04	0.95	0.06	0.63	-0.15	0.16	0.93	0.83	-0.05
Total soluble solids (%)	G	-0.05	0.77	0.08	0.78	-0.09	-0.03	0.88	-0.04	0.06
	P	-0.04	0.79	0.09	0.50	-0.07	-0.08	0.89	-0.04	0.08

Results and discussion

Analysis of variance for parents and crosses (Table-1) showed highly differed significantly for all the ten characters *i.e.*, days to 50% flowering (, plant height, leaf breadth, leaf length, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids and green fodder yield. Parents vs crosses were found highly significant for all the traits, indicated that wide genotypic differences among the parental lines and F_1's hybrids. High amount of genetic variability for these characters has been reported earlier by Rini *et al.* (2016) [26], Chikuta *et al.* (2017) [4] and Dehinwal *et al.* (2017) [8]. Estimates of genetics parameters which include genotypic and phenotypic coefficient of variation, heritability and expected genetic advance percentage over mean for various characters are presented in Table-2. High genotypic and phenotypic coefficient of variation was observed (more than 25%) for the attributes *viz.*, for leaf breadth (26.57 and 26.42), stem girth (26.29 and 25.29), leaf area (33.52 and 31.53), total soluble solids (35.94 and 35.40) and green fodder yield (54.16 and 53.08), suggested that there is a possibility of improvement of fodder yield through direct selection. Similar results were found by Singh *et al.* (2016) [23] and Jain *et al.* (2017) [13]. Genotypic coefficient of variation had generally higher than their corresponding phenotypic coefficient of variation for all the traits, indicated that the existence of strong influence of inherent association for the various characters. Earlier researcher Khandelwal *et al.* (2015) [15] has reported similar findings with respect to phenotypic and genotypic coefficient of variation. Estimate of high (>60%) heritability (broad sense) was observed for all the characters namely, days to 50% flowering (98.74), plant height (99.39), leaf breadth (99.02), leaf length (99.02), stem girth (97.98), leaves per plant (97.08), leaf area (99.96), leaf stem ratio (95.13), total soluble solids (99.62) and green fodder yield (99.68), indicated that these characters would respond positively to selection because of their high heritability. Similar observations were also reported by Jain and Patel (2013) [12] and Shivani and Sreelakshmi (2013) [22]. For an effective selection, the knowledge alone on the estimates of heritability is not sufficient and genetic advance if studied along with heritability is more useful. High (>20%) estimates of genetic advance expressed as per cent of mean have been recorded for days to 50% flowering (24.57), plant height (37.10), leaf breadth (54.21), leaf length (28.81), stem girth (49.52), leaf area (64.92), total soluble solids (72.66) and green fodder yield (29.00), thereby, suggested that good response for selection based on *per se* performance. These findings were in agreement with those of Kusalkar *et al.* (2009) [18] and Chavan *et al.* (2010) [3]. High heritability coupled with high genetic advance as percent of mean was observed for the characters *i.e.*, days to 50% flowering, plant height, leaf breadth, leaf length, stem girth, leaf area, total soluble solids and green fodder yield, suggesting that the genes governing these characters may have additive effect. High heritability coupled with high genetic advance for these characters have also been reported earlier by Damor *et al.* (2018) [7] and Wadikar *et al.* (2018) [27]. The correlation studies taken alone are often misleading and the actual dependence of yield on the correlated yield component characters needs confirmation, which can easily be untangled and unraveled by path coefficient analysis. The path coefficient analysis is simply a standardized partial regression coefficient and such it measures the direct influence of one variable upon the other and permits the separation of correlation coefficients into components of direct and indirect effects. The genotypic and phenotypic correlations coefficients for ten characters are presented in Table-3. In general, phenotypic correlation estimates were similar in direction and slightly higher than genotypic correlation, which indicated influenced by the environmental factors, however the higher genotypic expression indicating the inherent relationship among the characters. Similar results were obtained by Damor *et al.* (2018) [7] and Malaghan and Kajjidoni (2019) [19]. Green fodder yield exhibited significant stable and positive correlation with plant height (0.63 and 0.63), leaf length (0.52 and 0.51), stem girth (0.75 and 0.78), leaves per plant (0.66

and 0.67) and leaf area (0.90 and 0.93) at genotypic and phenotypic level, suggesting that selection of these characters may be practiced for gain higher fodder yield in forage sorghum. These results are similar to earlier reports of Khandelwal *et al.* (2015) [15] and Arunah *et al.* (2015) [1]. Path analysis is helpful in studying direct and indirect effects of various yield contributing traits on yield or any other attributes. Phenotypic performance is the outcome of a particular genotype selection merely based on simple correlation only, will not give the correct picture. Yield is influenced by its attributes directly as well as indirectly, the in depth understanding of the pattern of association needs path coefficient analysis, considering the direct effect of each yield contributing traits on green fodder yield. Direct and indirect effects of ten characters on green fodder yield are given in Table-4. Results showed that stem girth (0.89 and 0.85) displayed high order of direct effect on green fodder yield per plant followed by leaf stem ratio (0.83 and 0.80), leaf breadth (0.84 and 0.78), leaves per plant (0.77 and 0.75) and days to 50% flowering (0.72 and 0.68) at phenotypic and genotypic level, indicated that these characters may contribute for increased fodder yield in forage sorghum. These findings are in accordance with the results obtained in sorghum Jain *et al.* (2017) [13], Singh *et al.* (2017) [24], Damor *et al.* (2018) [7] and Malaghan and Kajjidoni (2019) [19]. The high indirect contribution of plant height through days to 50% flowering, leaf breadth, leaf length, leaves per plant, leaf area, leaf stem ratio and total soluble solids; Leaf breadth via days to 50% flowering; Leaf length through total soluble solids and Leaf area via days to50% flowering, plant height, leaf breadth, leaf length, stem girth, leaf stem ratio and total soluble solids. In such situation indirect causal factors can be used for selection. These findings are in accordance with the results obtained in sorghum by Singh *et al.* (2009) [25], Kumar *et al.* (2010) [10], Warkad *et al.* (2010) [28], Jain and Patel (2012) [11] and Kumar and Singh (2012) [17]. In order to exercise a suitable selection programme it would be worth to concentrate traits like stem girth, leaf stem ratio, leaf breadth, leaves per plant and days to 50% flowering governing fodder yield directly, while controlling the green fodder yield indirectly via plant height and leaf area. The contribution of residual effect was low at both genotypic and phenotypic levels in the present analysis, which indicated that almost all the important yield attributes were taken in to consideration.

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