RESEARCH ARTICLE

CORRELATION AND PATH ANALYSIS STUDIES IN FORAGE SORGHUM

S.K. Singh*[1], Mohit Singh[2], Navneet Kumar[3] and P. Kumar[1]

[1]S.V.P.U.A. & T., Meerut - 250 110,
[2]SHUATS, Prayagraj – 211007
[3]Aakanksha College, Meerapur, Muzaffarnagar - 251315
Email: shivkumar301968@gmail.com

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Abstract: Analysis of variance for all the characters *viz.*, days to 50% flowering, plant height, leaf breadth, leaf length, leaf area, stem girth, leaves per plant, leaf stem ratio, total soluble solids and green fodder yield, revealed significantly high variation, indicating that presence of great deal of diversity among the parents with respect to fodder yield and yield contributing attributes. Genotypic and phenotypic coefficient of variation was found high (more than 25%) for leaves per plant, leaf stem ratio and green fodder yield, which indicated that more variability and scope for selection in improving these traits. High heritability coupled with high genetic advance as percent of mean was recorded for plant height, leaf area, stem girth, leaves per plant, leaf stem ratio, total soluble solids and green fodder yield per plant which indicated that these traits were highly heritable and selection of high performing genotypes is possible to improve these attributes. Green fodder yield exhibited significant stable and positive correlation with stem girth, leaves per plant and leaf stem ratio at genotypic and phenotypic level. These characters may be considered as important yield component in forage sorghum. Leaf breadth displayed high order of direct effect on green fodder yield per plant followed by leaf area, plant height and leaves per plant at phenotypic and genotypic level, which indicating that the contribution of individual characters to fodder yield is of importance in planning a sound breeding programme for developing for high yielding varieties in forage sorghum.

Keywords: *Sorghum bicolor*, Variability, Correlation, Path analysis

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is an often cross pollinating crop with a genome, about 25 per cent the size of maize or sugarcane and having diploid (2n=2x=20) chromosomes. It is a C_4 plant with higher photosynthetic efficiency and higher tolerance to abiotic stress. It is the third most important food grain crop in India, next to rice and wheat. Sorghum stands first among the cereal fodder because of its faster growing habit, high yield potential, suitability to cultivate throughout the year, palatable and nutritious fodder quality, higher digestibility and various forms of its utilization like green chop, stover, silage, hay, *etc***.** It is one of the most important grain crops grown worldwide, with Nigeria, Sudan, Ethiopia and Niger leading in terms of production in Africa. In South Africa, the Free State and Mpumalanga provinces are the largest producers. Sorghum is also produced in other provinces such as Limpopo, North West, Gauteng and Northern Cape. This crop thrives well in tropics and sub-tropics where other crops such as maize and wheat fail. It remains the subsistence crop for small-scale farmers. Sorghum is one of the most important fodder crops in the rainfed conditions of India as well as in Uttar Pradesh. Sorghum being a short duration, drought and salt tolerant, well adaptive to arid regions is considered promising fodder crop. It is a palatable and nutritious fodder crop for animals and there is enormous demand for green and dry fodder particularly during lean winter and summer seasons in the arid and semi arid region. During the last 30 years the role of sorghum as a major source of fodder has not diminished while it’s important as a forage crop has increased. The average fodder yield of sorghum in Uttar Pradesh is low because major area is covered by local and out dated varieties and selection which are not responsive to improved high fodder yielding varieties for Uttar Pradesh. Low fodder production and lesser feed availability is the major limiting factor for increasing livestock productivity in India. Improvement in livestock production depends on the proper quality and quantity of feed and fodder. It is estimated that the 60-70 per cent of total cost in livestock production is due to feed and fodder. In India, hardly 5 per cent of the cropped area is utilized to grow fodder. India is deficit in dry fodder by 11 per cent, green fodder by 35 per cent and concentrates feed by 28 per cent. The average fodder yield of sorghum in Uttar Pradesh is low because major area covered by local and out dated varieties and selection which are not responsive to improved cultural and fertility practices (Parmar *et al.*, 2019). The total area, production and productivity of sorghum are 5.14 million hectare, 4.57 million tonnes and 889 Kg per hectare respectively in India and the total area, production and productivity are 0.18 million hectare, 0.18 million tonnes and 1000 Kg per hectare in U.P. respectively (Agriculture statistics at a glance, 2017). The area under high forage yielding varieties is negligible in western Uttar Pradesh. Hence, it is essential to develop superior varieties with a significant superiority in term of green fodder yield. Knowledge about variability, heritability and genetic advance under selection help the plant breeder in selection of elite genotype from diverse genetic

*Corresponding Author

population. Correlation coefficient and path analysis provide the mutual relationship between various plants and the association of these characters with yield. Hence the present study to find the genetic parameter, association of certain characters, their direct contribution to yield and indirect effects through other characters on yield of forage sorghum and their F_1 were carried out.

MATERIALS AND METHODS

The experimental material of the present investigation comprising of 45 F_1s along with 10 parents diallel fashion design were evaluated in a completely randomized block design with three replications during *kharif* at Sardar Vallabhbhai Patel University, Crop Research Centre, Meerut U.P. Each of 45 F_1s was planted in five meter long two rows plot and the parents were planted in two rows. The rows were spaced 30 cm apart and plant to plant distance was maintained 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), Crumpacker and Allard (1962), Robinson *et al*. (1949) and Johnson *et al.* (1955). Correlation coefficients were calculated as per the methods suggested by Croxton and Couden (1964) and path coefficient were worked out as per the method of Dewey and Lu (1959).

Table 1. Analysis of variance for fodder yield its components in forage sorghum (*Sorghum bicolor* L. Moench)

Source of variation	d.f.	Days to 50% flowering	Plant height (cm)	Leaf breadth (cm)	Leaf length (cm)	Leaf area (cm^2)	Stem girth (mm)	Leaves per plant	Leaf stem ratio	Total soluble solids (%)	Green fodder yield (g/plant)
Parents	9	110.01**	3082.03**	1.60**	71.20**	9693.07**	8.67**	8.31**	0.91*	3.42**	19728.36**
Treatment	54	77.17**	2651.00**	1.45**	71.34**	5832.09**	12.27**	8.32**	0.68*	3.00**	14798.03**
Crosses	44	72.00**	2438.28**	1.74**	63.96**	5170.09**	11.59**	8.52**	0.75*	2.97**	12358.00**
Parent vs Cross	1	7.36**	166.90**	0.93**	26.31**	263.56**	1.87**	1.84**	0.09	1.09**	77765.18**
Replication	2	16.12	262.47	0.59	43.08	3547.00	7.88	2.70	0.19	0.06	3880.51
Error	108	3.55	73.22	0.06	4.84	278.59	0.66	0.36	0.26	0.16	222.00

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

Table 2. Phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance as % of mean in forage sorghum (*Sorghum bicolor* L. Moench).

Parameters	PCV	GCV	Heritability (%)	Genetic Advance	Genetic Advance as percent of mean
Days to 50% flowering	7.17	8.78	87.00	10.71	12.87
Plant height (cm)	21.99	24.00	91.20	67.28	22.77
Leaf breadth (cm)	9.99	10.02	87.08	2.23	19.33
Leaf length (cm)	7.59	7.89	80.41	9.99	13.91
Leaf area (cm2)	14.75	15.86	81.55	73.75	23.99
Stem girth (mm)	10.85	11.88	90.58	4.65	21.72
Leaves per plant	28.94	32.85	91.19	4.44	24.33
Leaf stem ratio	37.69	36.82	94.40	0.58	73.12
Total soluble solids (%)	12.37	12.99	80.95	1.91	21.56
Green fodder yield (g/plant)	29.00	33.22	90.90	99.36	33.00

Table 3. Estimates genotypic and phenotypic correlation coefficients for different characters in forage sorghum (*Sorghum bicolor* L. Moench)

Parameters		Days to 50% flowering	Plant height (cm)	Leaf breadth (cm)	Leaf length (cm)	Leaf area (cm^2)	Stem girth (mm)	Leaves per plant	Leaf stem ratio	Total soluble solids (%)	Green fodder yield (g/plant)
Days to 50% flowering	G	1.00	0.17	-0.31**	0.14	0.96*	0.08	-0.08	0.24	0.49**	-0.46
	P	1.00	0.21	-0.36**	0.16	0.95*	0.08	-0.11	0.25	0.52**	-0.44
Plant height (cm)	G		1.00	0.75**	0.88**	0.22	0.78**	0.66**	0.64**	0.64**	-0.10
	P		1.00	0.76**	0.90**	0.31	0.79**	0.68**	0.66**	0.67**	-0.11
Leaf breadth (cm)	G			1.00	0.72**	0.78**	0.17	0.09	-0.09	0.06	0.12

	P			1.00	0.74**	0.80**	0.19	0.10	-0.10	0.06	0.12
Leaf length (cm)	G				1.00	0.65**	0.11	0.73**	0.15	0.67**	-0.03
	P				1.00	0.66**	0.16	0.74**	0.15	0.68**	-0.04
Leaf area (cm2)	G					1.00	-0.14	0.71**	-0.07	0.14	0.11
	P					1.00	-0.15	0.74**	-0.02	0.16	0.12
Stem girth (mm)	G						1.00	0.84**	0.46	0.33	0.96**
	P						1.00	0.87**	0.48	0.34	0.98**
Leaves per plant	G							1.00	0.09	0.54**	0.87**
	P							1.00	0.10	0.56**	0.89**
Leaf stem ratio	G								1.00	0.05	0.88**
	P								1.00	0.05	0.89**
Total soluble solids (%)	G									1.00	0.06
	P									1.00	0.08
Green fodder yield (g/plant)	G										1.00
	P										1.00

*significant at 5% probability level ** significant at 1% probability level

Table 4. Estimates of direct and indirect effect of different characters on forage yield per plant in forage sorghum (*Sorghum bicolor* L. Moench)

Parameters		Days to 50% flowering	Plant height (cm)	Leaf breadth (cm)	Leaf length (cm)	Leaf area (cm^2)	Stem girth (mm)	Leaves per plant	Leaf stem ratio	Total soluble solids (%)
Days to 50% flowering	G	**-0.16**	-0.50	0.06	-0.40	-0.06	0.50	0.02	0.16	0.30
	P	**-0.19**	-0.52	0.07	-0.41	-0.08	0.53	0.03	0.20	0.33
Plant height (cm)	G	0.70	**0.82**	0.05	-0.46	0.04	0.22	-0.26	0.02	0.07
	P	0.80	**0.83**	0.08	-0.48	0.06	0.24	-0.28	0.05	0.09
Leaf breadth (cm)	G	0.16	0.33	**0.90**	-0.69	0.02	0.75	-0.03	-0.02	0.05
	P	0.17	0.36	**0.91**	-0.71	0.09	0.78	-0.05	-0.05	0.07
Leaf length (cm)	G	0.69	-0.37	-0.05	**-0.01**	0.66	0.60	-0.32	0.06	0.05
	P	0.79	-0.39	-0.07	**-0.05**	0.68	0.63	-0.35	0.05	0.03
Leaf area (cm2)	G	0.12	-0.76	-0.09	-0.21	**0.84**	0.70	-0.07	-0.04	0.18
	P	0.13	-0.78	-0.09	-0.23	**0.85**	0.74	-0.08	-0.05	0.20
Stem girth (mm)	G	0.55	0.81	0.30	0.64	0.90	**0.08**	0.69	0.60	0.23
	P	0.64	0.83	0.32	0.66	0.92	**0.09**	0.73	0.70	0.25
Leaves per plant	G	0.20	-0.56	-0.43	-0.03	0.05	0.43	**0.80**	0.02	0.10
	P	0.22	-0.60	-0.45	-0.03	0.08	0.45	**0.81**	0.05	0.12
Leaf stem ratio	G	-0.04	-0.78	0.30	-0.30	-0.04	0.66	-0.05	**0.05**	0.35
	P	-0.05	-0.87	0.32	-0.40	-0.06	0.78	-0.03	**0.06**	0.39
Total soluble solids (%)	G	-0.03	-0.17	-0.51	-0.04	0.87	0.40	-0.30	0.07	**-0.02**
	P	-0.05	-0.27	-0.60	-0.08	0.88	0.56	-0.35	0.04	**-0.03**

*Significant at 5% probability level ** Significant at 1% probability level

RESULTS AND DISCUSSION

Analysis of variance exhibited significant variability among the parents and hybrids for all the characters namely days to 50% flowering, plant height, leaf breadth, leaf length, leaf area, stem girth, leaves per plant, leaf stem ratio, total soluble solids and green fodder yield (Table-1). High amount of genetic variability for these characters has also been reported earlier by Wadikar *et al.* (2018) and Parmar *et al.* (2019). Genotypic and phenotypic variances are of little meaning as they do not have any clear limit or ceiling, and at the same time, the categorization of the genotypic variance as low or high is difficult, rendering them unsuitable for comparison of two populations with desired precision when expressed in absolute values. To overcome this difficulty, the genotypic and phenotypic coefficients of variation that are free from the unit of measurement, can be conveniently employed for making comparison between populations and different metric traits of population. Phenotypic and genotypic coefficient of variation was high (more than 25%) observed for leaves per plant (28.94 and 32.85), leaf stem ratio (37.69 and 36.82) and green fodder yield (29.00 and 33.22), which indicating that more variability and scope for selection in improving these characters (Table-2). Similar results were found by Nyadanu and Dikera (2014). Genotypic coefficient of variation had generally higher than their corresponding phenotypic coefficient of variation for most of the characters studied, indicated that the variability existing in these traits was due to genetic factors and they were little affected by environmental factors. Earlier researchers Jain *et al.* (2017) have reported similar findings with respect to phenotypic and genotypic coefficient of variation. Estimate of high (>60%) heritability (broad sense) was observed for all the traits *viz*., days to 50% flowering (87.00), plant height (91.20), leaf breadth (87.08), leaf length (80.41), leaf area (81.55), stem girth (90.58), leaves per plant (91.19), leaf stem ratio (94.40), total soluble solids (80.95) and green fodder yield (90.90), suggested that these characters are under genotypic control (Table-2). Similar observations were also reported by Damor *et al.* (2018**)**. High (> 20%) estimates of genetic advance expressed as per cent of mean have been observed for plant height (22.77), leaf area (23.99), stem girth (21.72), leaves per plant (24.33), leaf stem ratio (73.13), total soluble solids (21.56) and green fodder yield per plant (33.00), thereby, suggesting good response for selection based on *per se* performance (Table-2). These findings were in agreement with those of Kumar and Sahib (2003) and Parmar *et al.* (201**9)**. High heritability accompanied with high genetic advance as percent of mean was noted for plant height, leaf area, stem girth, leaves per plant, leaf stem ratio, total soluble solids and green fodder yield per plant. This indicated that these traits were highly heritable and selection of high performing genotypes is possible to improve these attributes. High heritability coupled with high genetic advance for these characters have also been reported earlier by Malik *et al.* (2015). Therefore, on the basis of study of all the variability parameters, it may be interpreted that maximum improvement through direct selection can be brought for these attributes. In general, phenotypic correlation estimates (Table-3) 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 Kumar and Singh (2012) and Khandelwal *et al.* (2015). Green fodder yield exhibited significant stable and positive correlation with stem girth (0.96 and 0.98), leaves per plant (0.87 and 0.89) and leaf stem ratio (0.88 and 0.89) at both genotypic and phenotypic level. These attributes may be considered as important yield component in forage sorghum (Table-3). These results are similar to earlier reports of Damor *et al.* (2018) and Malaghan and Kajjidoni (2019). Leaf breadth (0.90 and 0.91) displayed high order of direct effect on green fodder yield per plant followed by leaf area (0.84 and 0.85), plant height (0.82 and 0.83) and leaves per plant (0.80 and 0.81) at both phenotypic and genotypic level (Table-4), which indicated that the contribution of individual attributes to fodder yield is of importance in planning a sound breeding programme for developing for high yielding varieties in forage sorghum. These findings are in accordance with the results obtained in sorghum by Patil *et al.* (2014) and Jain *et al.* (2017). The high indirect contribution of days to 50 % flowering via plant height, leaf length and stem girth; Plant height through stem girth; Leaf length via stem girth; leaf area through stem girth and leaf length; Stem girth via days to50% flowering, leaf breadth, leaf length, leaf area, leaves per plant and leaf stem ratio; Leaves per plant through stem girth and leaf stem ratio via stem girth was also observed which is in line with Yadav *et al.* (2003) and Jain *et al.* (2017). In order to exercise a suitable selection programme it would be worth to concentrate traits like leaf breadth, leaf area, plant height and leaves per plant governing fodder yield directly, while controlling the green fodder yield indirectly via stem girth. 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.

REFERENCES

Agriculture statistics at a glance (2017). Ministry of Agriculture, P 97-99.

Burton, G.W. (1952). Quantitative inheritance in grasses. Proc. 6^{th} Int. Grassland Cong. 1:227-283.

Croxton and Cowden (1964). *Applied General Statistics*, New Delhi, Prentice-Hall of India.

Crumpacker, D.W. and Allard, R.W. (1962). A diallel cross analysis of heading date in wheat. *Helgardia.* 32: 275-318.

Damor, H.I., Parmar, H.P., Gohil, D.P. and Patel, A.A. (2018). Genetic variability, character association, path coefficient in forage sorghum (Sorghum bicolour L. Moench), *Green Farming* Vol. 9(2): 218-233.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. *Argon. Journal* 1: 515-518.

Jain, S.K., Elangovan, M. and Patel, N.V. (2017). Correlation and path coefficient analysis for agronomical traits in forage sorghum [*Sorghum bicolor* (L.) Moench] *Indian Journal. Plant Genet. Resou,* 23(1):15-18.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetics and environmental variability in soybean. *Journal of Agronomy.* 47: (1) 314-318.

Kumar, M.H. and Sahib, K.H. (2003). Genetic studies and correlations of biomass related characters in forage sorghum. *Journal of Research ANGRAU,* 31(3): 35-39.

Kumar, A. and Singh, U. (2012). Fertility status of Haryana cow. *Indian Veterinary Journal* 86: 807-809.

Khandelwal, V., Shukla, M., Jodha, B.S., Nathawat, V.S. and Dashora, S.K. (2015). Genetic Parameters and character association in sorghum (*Sorghum bicolor* (L.) Moench). *Indian Journal of Science and Technology,* 8(22): 974- 988.

Malaghan, Shilpa and Kajjidoni, S.T. (2019). Character association and path analysis of grain yield in rabi sorghum (*Sorghum bicolour* (L.) Moench) *International journal of Chemical Studies*: 7(1) 2309-2313.

Malik, A., Singh, S.K., Chand, P., Singh, B. and Singh, D.K. (2015). Genetic variability, heritability and genetic advance studies on forage sorghum. *Progressive Agriculture,* 15(1): 92-94.

Nyadanu, D. and Dikera, E. (2014). Exploring variation, relationships and heritability of traits among selected accessions of sorghum (*sorghum bicolor* L. Moench) in the upper east region of Ghana. *Journal of Plant Breeding and Genetics,* 2(3): 101-107.

Panse, V.G. and Sukhatme, P.V. (1969). Statistical methods for agricultural workers. *Indian Council of Agricultural Research, New Delhi 4th edition* 235-257.

Parmar, N.R., Patel, M.P. and Patel, N.B. (2019). Combining ability studies in forage sorghum [*Sorghum bicolour* (L.) Moench] for yield and quality parameters. *Int. J. Curr. Microbiol. App. Sci.* 8(4): 1439-1444.

Patil, C.N., Rathod, A.H., Vaghela, P.O., Yadav, S.R., Patade, S.S. and Shinde, A.S. (2014). Study of correlation and path analysis in dual purpose sorghum [*Sorghum bicolor* (L.) Moench]. *International Journal of Agricultural Sciences,* 10(2): 608-611.

Robinson, H.F., Comstock, R.E. and Harvey, P.H. (1949). Estimates of heritability and the degree of dominance in corn. *Agron. J.* 41:353-359.

Wadikar, P.B., Ubale, D.L., Magar, M.R. and Thorat, G.S. (2018). Genetic variability studies in sweet sorghum (*Sorghum bicolor* L. Moench). *International Journal of Current Microbiology and Applied Sciences*, 6: 920-923.

Yadav, R., Pahuja, S.K., Grewal, R.P.S. and Yadav, R. (2003). Evaluation of phenotypic variability in forage sorghum genotypes. *Forage Research*, 29(3): 123-128.