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Estimation of Genetic Variability, Correlation and Path Analysis for Quality and Agronomic Traits in in Forage Sorghum

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Ten genotypes i.e., CSV-15, Pusa Chari-6, HC-308, Pant Chari-4, G-48, HJ-513, UP Chari4, HC-171, SSG-59-3 and ICSV-700 studied for genetic variability, correlation and path analysis for days to 50% flowering, plant height, leaf length, leaf breadth, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids, protein content, fiber content, HCN content and green fodder yield. The analysis of variance for the experiment with fifty-five treatments for all the thirteen attributes revealed significant differences among the material used in the present investigation, which indicated that wide spectrum of variation among the genotypes. Genotypic and phenotypic coefficient of variation were found higher for leaf stem ratio and green fodder yield, which indicating

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that more variability and scope for selection in improving these characters. High heritability accompanied with high genetic advance as percent of mean noted for leaf breadth, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids and green fodder yield. This 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 days to 50% flowering, plant height, leaf length, leaf breadth, stem girth, leaves per plant and leaf area 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 leaves per plant, leaf length and stem girth at phenotypic and genotypic level, 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.

Keywords: Sorghum bicolor; variability; correlation; path coefficient analysis.

1. INTRODUCTION

Sorghum, scientifically known as Sorghum bicolor, is a versatile and resilient cereal grain that has been cultivated for millennia. Originating from Africa, it has spread across the globe due to its adaptability to diverse climates and its numerous uses ranging from food and feed to industrial applications. It belongs to the grass family, Poaceae, and is classified under the genus Sorghum. Sorghum has a robust root system, which aids in its ability to withstand drought and grow in regions with limited water availability. Sorghum produces large terminal panicles that contain seeds varying in size and color, depending on the variety. Its ability to grow in semiarid and arid regions made it a staple crop for many communities around the world. The crop is adaptable to different soil types but thrives in well drained soils with good organic matter content. Its tolerance to heat and drought makes it suitable for regions where other cereal crops might fail. The economic importance of sorghum extends beyond its role as a staple food. It is used in various industrial applications such as the production of biofuels, biodegradable plastics and alcoholic beverages. In recent years, sorghum has gained attention as a potential crop for sustainable bioenergy production due to its high biomass yield and efficient use of water. Sorghum is highly nutritious, containing essential nutrients such as carbohydrates, proteins, fiber, vitamins, and minerals. It is gluten free, making it suitable for individuals with gluten intolerance or celiac disease. Additionally, sorghum's efficient use of water makes it a resilient crop in the face of climate change and water scarcity, offering food security to millions of people worldwide. India is one of the largest producers of jowar globally and production in India has fluctuated over the years based on various factors such as weather conditions, government policies, and market demand. The need for genetic improvement of sorghum for increased yields and nutritive value of fodder is having high priority. It can be used as part of a crop rotation strategy to improve soil health and reduce pests and diseases in subsequent crops. Some varieties of sorghum have been studied for their potential in biofuel production, contributing to its versatility and potential economic benefits beyond traditional forage use. Nevertheless, the utilization of sorghum in animal production faces hurdles of dhurrin (a cyanogenic glycoside) poisoning. While dhurrin serves as a protective secondary metabolite during sorghum growth, the resulting highly toxic hydrogen cyanide poses a significant threat to animal safety. It delves into the impact of dhurrin on animal production and explores measures to mitigate its content, aiming to provide insights for advancing research on dhurrin regulation in sorghum and its rational utilization in animal production [1]. The fodder sorghum is grown in 8.3 million ha mainly in Western U.P., Haryana, Punjab and Rajasthan and fulfils more than 65 per cent of the fodder demand during kharif season. The area under fodder cultivation is estimated to be about four per cent of the gross cropped area, which remained static for the last four decades. The traditional grazing lands are gradually diminishing because of urbanization, expansion of cultivable area, grazing pressure and industrialization etc. In India, only 4.4% area is under fodder crops, out of which fodder sorghum is grown on 2.3 million ha. India faces a net deficit of 36% and 11% of green fodder and dry fodder, respectively. To reduce the demand and supply gap, the production and productivity of fodder crops needs to be enhanced. The horizontal expansion of cultivable area under fodder crops is difficult due to severe competition from food crops. A part from vertical expansion, utilization of non cultivable areas for pastures is one of the most viable options to balance the demand. One of the reasons reported to stumble the green fodder production is non availability of quality seed in sufficient quantities. As per estimation only 25 - 30 per cent of required quantity of quality seed is available in cultivated fodders and produce abundant [2].

2. MATERIALS AND METHODS

The experimental material for the present investigation was comprised of ten promising diverse parents viz., CSV-15, Pusa Chari-6, HC-308, Pant Chari-4, G-48, HJ-513, UP Chari-4, HC- 171, SSG-59-3 and ICSV-700 and their all possible $45\ F_1$'s, developed through crossing ten parental lines in diallel mating design (excluding reciprocals). All genotypes were evaluated in a complete randomized block design with three replications at Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, during kharif season 2022 and 2023. The observations were recorded on thirteen traits viz., days to 50% flowering, plant height, leaf length, leaf breadth, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids, protein content, fiber content, HCN content and green fodder yield. The data recorded on all these traits were subjected to various statistical and biometrical analyses like to work out analysis of genetic variability, correlation and path analysis. Seeds of ten parents and F_1 's sown by hand dibbling method and the length of each row was kept 4 m with inter and intra row distances of 30 cm and 10 cm, respectively. The coefficients of variation, correlation and path coefficient analysis calculated by the formula given by Burton [3] and Johnson et al. [4] Crumpacker and Allard [5] Robinson et al. [6], Fisher (1918) and Dewey and Lu [7].

3. RESULTS AND DISCUSSION

The analysis of variance for the experiment with fifty five treatments for all the thirteen 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, protein content, fiber content, HCN content and green fodder yield revealed significant differences among the material used in the present investigation, which indicated that wide spectrum of variation among the genotypes. The variance due to treatments was further partitioned in to their orthogonal components i.e., parents, crosses and parents vs crosses. Parents and crosses recorded highly significant differences for all the thirteen traits whereas parent's vs crosses were found highly significant differences for all the characters except protein content and fiber content (Table 1). Estimates of coefficient of variation viz., genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) along with heritability and genetic advance as percent of mean for different characters are presented in Table 2. Low genotypic coefficient of variation ($< 10\%$) recorded for days to 50% flowering (5.94), plant height (8.45), leaf length (7.54), protein content (7.31), fiber content (2.00) and HCN content (5.11) and moderate (10-25%) noted for leaf breadth (16.36), stem girth (16.80), leaves per plant (13.38), leaf area (21.34) and total soluble solids (16.51) whereas high percentage of genotypic coefficient of variation (more than 25%) observed for leaf stem ratio (28.31) and green fodder yield (37.69) whereas which indicating that more variability and scope for selection in improving these characters. Similar results were found by Singh et al. [8] and Shafiqurrahaman et al. [9] High percentage of phenotypic coefficient of variation (more than 25%) estimated for leaf stem ratio (30.39) and green fodder yield (38.31) while moderate (10-25%) showed for leaf breadth (16.79), stem girth (17.65), leaves per plant (14.95), leaf area (21.77) and total soluble solids (17.77). Low phenotypic coefficient of variation ($< 10\%$) revealed for days to 50% flowering (6.39), plant height (8.97), leaf length (8.16), protein content (7.79), fiber content (3.26) and HCN content (7.11), indicated that these traits are less influenced by environmental factors. Earlier researchers Wadikar et al. [10] and Dev et al. [11] High heritability (> 60%) exhibited for days to 50% flowering (86.52), plant height (88.69), leaf length (85.29), leaf breadth (94.94), stem girth (90.67), leaves per plant (80.09), leaf area (96.08), leaf stem ratio (86.75), total soluble solids (86.34), protein content (88.04) and green fodder yield (96.82) whereas recorded medium heritability $(30-60\%)$ for fiber content (37.66) and HCN content (51.72) suggested that these characters are under genotypic control. Similar observations were also reported by Diwakar et al. [12] Singh et al. [13] and Jain et al. [14] Expected genetic advance expressed as percentage of mean revealed high ($> 20\%$) for leaf breadth (32.84), stem girth (32.96), leaves per plant (24.67), leaf area (43.09), leaf stem ratio (54.31), total soluble solids (31.36) and green fodder yield (76.40) while moderate genetic advance as percentage of mean (10-20%) observed for days to 50% flowering

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

Source of variation	df	Days to 50% flowering	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Stem girth (mm)	Leaves per plant	Leaf area (cm)2	Leaf stem ratio	Total soluble solid (%)	Protein content (%)	Fiber content (%)	HCN content (ppm)	Grean fodder yield (g/plant)
Replication	2	0.55	403.46	2.73	0.26	0.29	0.11	663.47	0.03	2.54	1.04	0.57	694.66	1718.96
Treatment	54	86.70**	2544.44**	115.95**	2.76* *	18.78**	9.47**	15063.03**	0.08**	12.49**	1.21**	1.39**	406.01**	42492.95**
Parents	9	106.95**	2163.56**	89.90**	1.45* *	11.25**	9.37**	10106.12**	0.05**	13.10**	1.21**	1.77**	1093.41**	8641.11**
Crosses	44	74.69**	1940.55**	106.80**	2.71**	17.86**	8.83**	13615.09**	0.07**	12.51**	1.23**	1.34**	252.15**	40343.43**
Parents vs Crosses	1	432.99**	32533.03**	753.40**	16.74 **	127.09**	38.56**	123384.44**	0.02**	5.85**	0.22	0.04	989.16**	441735.78**
Error	108	4.28	103.77	6.31	0.05	0.62	0.72	202.20	0.04	0.63	0.05	0.49	96.34	460.62

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

Sl. No.	Genotypes	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance	Genetic Advance as % of mean
1.	Days to 50% flowering	5.94	6.39	86.52	10.04	11.39
2.	Plant height (cm)	8.45	8.97	88.69	55.33	16.39
3.	Leaf length (cm)	7.54	8.16	85.29	11.50	14.34
4.	Leaf breadth (cm)	16.36	16.79	94.94	1.91	32.84
5.	Stem girth (mm)	16.80	17.65	90.67	4.83	32.96
6.	Leaves per plant	13.38	14.95	80.09	3.15	24.67
7.	Leaf area (cm)2	21.34	21.77	96.08	142.12	43.09
8.	Leaf stem ratio	28.31	30.39	86.75	0.10	54.31
9.	Total soluble solid (%)	16.51	17.77	86.34	3.81	31.60
10.	Protein content (%)	7.31	7.79	88.04	1.20	14.12
11.	Fiber content (%)	2.00	3.26	37.66	0.69	2.53
12.	HCN content (ppm)	5.11	7.11	51.72	15.05	7.57
13.	Grean fodder yield (g/plant)	37.69	38.31	96.82	239.92	76.40

Table 3. Estimates of Genotypic (G) and Phenotypic (P) correlation coefficients for different traits in forage sorghum (Sorghum bicolor L. Moench)

Parameters		Days to 50% flowering	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Stem girth (mm)	Leaves per plant	Leaf area (cm)2	Leaf stem ratio	Total soluble solid (%)	Protein content (%)	Fiber content (%)	HCN content (ppm)	Grean fodder yield (g/plant)
Days to 50% flowering	G	1.00	0.07	0.20**	0.19*	0.15*	0.09	0.20**	0.22**	-0.06	-0.19*	-0.05	-0.03	0.15*
	P	1.00	0.07	0.17*	0.17*	0.15*	0.09	0.18*	0.21**	-0.09	-0.18*	-0.02	-0.02	0.15*
Plant height (cm)	G		1.00	0.24**	0.33**	0.44**	0.13	0.34**	-0.23**	-0.07	-0.08	-0.03	-0.10	0.39**
	P		1.00	0.20**	0.31**	0.40**	0.13	0.32**	-0.20**	-0.04	-0.06	-0.05	-0.13	0.36**
Leaf length (cm)	G			1.00	0.47**	0.60**	0.43**	0.74**	-0.04	-0.02	-0.10	-0.04	-0.01	0.53**
	P			1.00	0.42**	0.54**	0.34**	0.69**	-0.04	-0.09	-0.09	-0.08	0.02	0.48**
Leaf breadth (cm)	G				1.00	0.73**	0.55**	0.94**	0.22**	-0.16*	-0.14	0.09	0.09	0.63**
	P				1.00	0.69**	0.48**	0.91**	0.20**	-0.14*	-0.12	0.04	0.08	0.61**
Stem girth (mm)	G					1.00	0.63**	0.80**	-0.01	-0.07	-0.04	-0.14	0.14	0.76**
	P					1.00	0.52**	0.76**	-0.02	-0.06	-0.02	-0.05	0.11	0.73**
Leaves per plant	G						1.00	0.55**	0.10	-0.01	0.05	0.03	0.13	0.61**
	P						1.00	0.50**	0.12	-0.05	0.05	0.03	0.07	0.54**
Leaf area (cm)2	G							1.00	0.12	-0.11	-0.15	0.03	0.11	0.67**
	P							1.00	0.12	-0.10	-0.13	-0.03	0.07	0.64**
Leaf stem ratio	G								1.00	-0.18*	-0.05	-0.09	0.10	-0.17*
	P								1.00	-0.15*	-0.04	-0.04	0.08	-0.18*
Total soluble solid (%)	G									1.00	0.01	-0.07	0.13	-0.07
	P									1.00	0.09	-0.06	0.09	-0.06
Protein content (%)	G										1.00	-0.13	-0.04	-0.19*
	P										1.00	-0.08	-0.08	-0.16*
Fiber content (%)	G											1.00	-0.58**	0.01
	P											1.00	-0.20**	0.01
HCN content (ppm)	G												1.00	-0.08
	P												1.00	-0.06
Grean fodder yield (g/plant)	G													1.00
	P													1.00

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

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

Parameters		Days to 50% flowering	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Stem girth (mm)	Leaves per plant	Leaf area $(cm)^2$	Leaf stem ratio	Total soluble solid (%)	Protein content (%)	Fiber content (%)	HCN content (ppm)
Days to 50% Flowering	G	0.08	-0.05	0.03	-0.05	0.02	0.06	0.83	- 0.04	0.04	0.04	0.02	0.02
	P	0.03	-0.01	0.02	0.07	0.07	0.02	0.60	- 0.05	0.03	0.03	0.01	0.03
Plant height (cm)	G	0.07	-0.06	0.09	-0.06	0.06	0.09	0.44	0.04	0.04	0.01	0.01	0.11
	P	0.02	-0.01	0.03	0.13	0.19	0.03	0.16	0.05	0.02	0.01	0.02	0.02
Leaf length (cm)	G	0.01	-0.05	0.60	-0.17	0.08	0.38	0.99	0.09	0.03	0.02	0.01	0.01
	P	0.05	-0.02	0.59	0.18	0.09	0.08	0.26	0.01	0.04	0.01	0.03	-0.04
Leaf breadth (cm)	G	0.01	-0.02	-0.06	0.67	0.01	0.36	0.92	- 0.04	0.08	0.03	-0.03	-0.05
	P	0.05	-0.03	-0.06	0.43	0.02	0.11	0.29	- 0.05	0.05	0.02	-0.02	-0.01
Stem girth (mm)	G	0.01	-0.02	-0.27	-0.12	0.43	0.41	0.36	0.03	0.04	-0.01	0.05	-0.09
	P	0.05	-0.04	0.08	0.30	0.47	0.12	0.24	0.07	0.02	0.02	0.02	-0.01
Leaves Per Plant	G	0.08	-0.08	-0.20	-0.09	0.08	0.65	0.30	- 0.02	0.01	-0.01	-0.01	-0.08
	P	0.03	-0.01	0.05	0.21	0.09	0.42	0.16	- 0.03	0.01	-0.01	-0.01	-0.01
Leaf area (cm)2	G	0.01	-0.02	-0.19	-0.10	0.51	0.36	-0.17	- 0.02	0.06	0.03	-0.01	-0.07
	P	0.06	-0.03	0.11	0.39	0.35	0.12	-0.32	- 0.03	0.03	0.02	0.02	-0.01
Leaf stem ratio	G	0.01	0.01	0.06	-0.06	-0.02	0.06	0.53	-0.21	0.01	0.01	0.03	-0.06
	P	0.07	0.02	-0.07	0.09	-0.01	0.03	0.04	- 0.25	0.05	0.08	0.02	-0.01
Total soluble solid (%)	G	-0.06	0.05	0.03	0.05	-0.01	0.04	-0.47	0.03	-0.05	0.03	0.06	-0.10
	P	-0.03	0.01	-0.01	-0.06	-0.02	-0.01	-0.03	0.03	-0.03	-0.02	0.03	-0.01
Protein content (%)	G	-0.01	0.05	0.16	0.04	0.01	0.03	-0.05	0.01	0.01	-0.22	0.05	0.02
	P	-0.05	0.01	-0.01	-0.05	-0.01	0.01	-0.04	0.01	0.01	-0.18	0.04	0.01
Fiber content (%)	G	-0.05	0.02	0.06	-0.26	-0.02	0.02	0.16	0.02	0.09	0.03	-0.08	0.37
	P	-0.01	0.01	-0.01	0.02	-0.02	0.07	0.01	0.01	0.02	0.01	-0.03	0.03
HCN Content (ppm)	G	-0.03	0.01	0.01	-0.26	0.01	0.08	0.49	- 0.02	-0.09	0.01	0.22	-0.40
	P	0.05	0.01	0.04	0.03	0.05	0.01	0.52	- 0.02	-0.03	0.02	0.08	-0.56

*Residual values (G) = 0.02, Residual values (P) = 0.02 Bold values indicate direct effects *, ** significant at 5% and 1% level, respectively*

(11.39), plant height (16.39), leaf length (14.34) and protein content (14.12). Low genetic advance expressed as percentage of mean ($< 10\%$) was found for fiber content (2.53) and HCN content (7.57).

This indicated that these traits were highly heritable and selection of these traits is possible to improve these attributes. High heritability coupled with high genetic advance for these characters have also been reported earlier by Srivastava et al. [15] Singh et al. [16] and Sirohi et al. [17] Results on correlation coefficients, computed at phenotypic and genotypic both levels for all possible paired combinations among thirteen attributes and the values are given in Table 3. The genotypic correlation, in general was similar in sign and slightly higher in magnitude than their phenotypic correlation. At the genotypic level, the estimates of correlation coefficients were generally similar to that observed at the phenotypic level, though, their magnitude was slightly lower than the corresponding phenotypic correlations. Here, also green fodder yield per plant showed significant and positive correlation with stem girth (0.76) followed by leaf area (0.67), leaf breadth (0.63), leaves per plant (0.61), leaf length (0.53), plant height (0.39) and days to 50% flowering (0.15) whereas showed significant negative correlation with leaf stem ratio (-0.17) and protein content (-0.19). Green fodder yield exhibited significant stable and positive correlation with days to 50% flowering, plant height, leaf length, leaf breadth, stem girth, leaves per plant and leaf area at genotypic and phenotypic level. These characters may be considered as important yield component in forage sorghum. These results are similar to earlier reports of Dubey et al. [18] Singh et al. [19] Sirohi et al. [17] and Dev et al. [11]. The results obtained at both genotypic and phenotypic levels are presented in Table 4. At genotypic level, leaf breadth (0.67) displayed high order of direct effect on green fodder yield followed by leaves per plant (0.65), leaf length (0.60) and stem girth (0.43). However the character which contributed indirect effects toward green fodder yield per plant observed stem girth through leaf area; leaves per plant via leaf length, leaf breadth, stem girth and leaf area; leaf area through days to 50% flowering, plant height, leaf length, leaf breadth, stem girth, leaves per plant, leaf stem ratio and HCN content. At phenotypic level, leaf length (0.59) displayed high order of direct effect on green fodder yield followed by stem girth (0.47), leaf breadth (0.43) and leaves per plant (0.42) whereas, the attribute which contributed indirect effects toward green fodder yield per plant observed leaf breadth through stem girth, leaves per plant and leaf area; stem girth via plant height and leaf area; leaf area through days to 50% flowering, plant height, leaf length, leaf breadth, stem girth, leaves per plant and HCN content. Magnitudes of residual effects at both phenotypic and genotypic level were found to be low. Leaf breadth displayed high order of direct effect on green fodder yield per plant followed by leaves per plant, leaf length and stem girth at phenotypic and genotypic level, which indicated that the contribution of individual attributes to fodder yield is of importance in planning an effective breeding programme for developing for high yielding varieties. These findings are in accordance with the results obtained in sorghum by Malik et al. [20] Girish et al. [21] Malaghan and Kajjidoni [22] Sirohi et al. [17] and Srivastava et al. [10,23].

4. CONCLUSION

Genotypic and phenotypic coefficient of variation was high (more than 25%) observed for leaf stem ratio and green fodder yield, which indicating that more variability and scope for selection in improving these characters. High heritability accompanied with high genetic advance as percent of mean noted for leaf breadth, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids and green fodder yield. This 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 days to 50% flowering, plant height, leaf length, leaf breadth, stem girth, leaves per plant and leaf area 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 leaves per plant, leaf length and stem girth at phenotypic and genotypic level, 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.

On the basis of overall results and per se performance the manifestation of high degree of heterosis over better and mid parent in certain F_1 's hybrids i.e., CSV-15 x G-48, Pusa Chari-6 x G-48, HC-308 x HJ-513 and Pant Chari-4x G-48 identified that great possibility of developing hybrid for commercial cultivation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Wang B, Xiong W, Guo Y. Dhurrin in sorghum: Biosynthesis, regulation, biological function and challenges for animal production. Plants. 2024; 13(16):2291.
2. Kumar R, Singh M, Singh SK, Singh A, Singh B, Shukla, AK. Studies on path analysis in forage sorghum. Forage Res. 2022;48(2):180-184.
3. Burton GW. Quantitative inheritance in grasses. Proc. 6^"th " Int. Grassland Cong. 1952;1:227-283.
4. Johnson HW, Robinson HF, Camstock F. Genotypic and phenotypic correlation in soybean and their implications in selection. Agron. J. 1955;47:477-483.
5. Crumpacker DW, Allard RW. A diallel cross analysis of heading date in wheat. Helgardia. 1962;32: 275-318.
6. Robinson HF, Comstock RE, Harvey PH. Genotypic and phenotypic correlation in com, their importance in selection, Agron, J. 1949;43:282-287.
7. Dewey DR, Lu KH. A correlation and path coefficient analysis components of crested wheat grass. Journal of Agronomy. 1959;51:515-518.
8. Singh SK, Singh M, Gangwar LK, Singh B. Study on path analysis in forage sorghum [*Sorghum bicolor* (L) moench]. International Journal of Farm Sciences. 2023;13(1):81
9. Shafıqurrahaman M, Dahıya GS, Dehınwal AK, Kumar V. Genetic diversity analysis for morphological traits in Sorghum (*Sorghum bicolor* (L.) Moench). Ekin Journal of Crop Breeding and Genetics. 2024;10(1):27-35.
10. Wadikar PB, Ubale DL, Magar MR, Thorat GS. Genetic variability studies in sweet sorghum [*Sorghum bicolor* (L.) Moench]. Int. J. Curr. Microbiol. App. Sci. Special. 2018;6:920-923.
11. Dev A, Singh SK, Chand P, Kumar M, Kumar M, Poonia M, Srivastava M. Genetic variability, character association and path analysis in forage sorghum. Journal of Pharmacognosy and Phytochemistry. 2019;8(5):1135-1139.
12. Diwakar A, Ranwah BR, Sharma DB, Sinha SK. Study of variability parameters in forage sorghum [*Sorghum bicolor* (L.) Moench]. Research of Environment Life Science. 2016;9(5):528-530.
13. Singh SK, Singh A, Kumar R. Genetic variability, character association and path analysis in forage sorghum. Progressive Agriculture. 2016;16(2):214-218.
14. Jain SK, Elangovan M, Patel NV. Correlation and path coefficient analysis for agronomical traits in forage sorghum [*Sorghum bicolor* (L.) Moench] Indian J ournal. Plant Genet. Resou. 2017;23(1):15-18.
15. Srivastava M, Singh SK, Chand P, Kumar M, Kumar M, Gangwar HK, Dev A. Studies on path analysis in forage sorghum [*Sorghum bicolor* (L.) Moench]. Journal of Pharmacognosy and Phytochemistry. 20196;8(5):993-996.
16. Singh SK, Gangwar LK, Chaudhary M. Studies on character association and path analysis in forage sorghum. International Journal of Chemical Studies. 2019;7(5): 2939-2942.
17. Sirohi M, Singh SK., Chand P, Kumar, M, Gupta S, Kumar M. Character association and path analysis in forage Sorghum. Journal of Experimental Zoology India. 2019;22(1):1469-1473.
18. Dubey MK, Pandey PK, Shrotria PK, Chauhan P, Pandey G. A ssessment of variability, correlation and path analysis for yield and yield related traits in sorghum genotypes. Green Farming. 2016;7(6): 1291-1295.
19. Singh A, Singh SK. Studies on combining ability in forage sorghum for yield and quality parameters. Journal of Plant Development Sciences. 2017;9(8):782-785.
20. Malik A, Singh SK, Chand P, Singh B, Singh DK. Correlation and path analysisin

forage sorghum. Progressive Agriculture. 2023;13(1):234-238.

21. Girish G, Kiran SB, Lokesh R, Vikas Kulkarni V, Rachappa V, Yogesh LN, Talwar AM. Character association and path analysis in advanced breeding lines of rabi sorghum [*Sorghum bicolor* (L.) Moench]. Journal of Applied and Natural Science. 2016;8(1):35-39.
22. Malaghan S, Kajjidoni ST. Character association and path analysis of grain yield in rabi sorghum [*Sorghum bicolor* (L.) Moench]. International Journal of Chemical Studies. 2019;7(1): 2309-2313.
23. Allard RW. Estimation of prepotency from lilma bean diallel cross data. Agron. J. 1956;48:537-543.

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