Study on correlation and path analysis in forage sorghum [*Sorghum bicolor* (L.) Moench]

Abstract

The study examined the character association and path coefficient analysis using 35 genotypes of forage sorghum at the Crop Research Center of the Sardar Vallabhbhai Patel University of Agriculture and Technology in Meerut. In Kharif 2022, testing of all 35 genotypes of forage sorghum was conducted using a randomized block design with three replications. Observations were recorded for days to 50% flowering, plant height (cm), leaf breadth (cm), leaf length (cm), number of leaves per plant, total soluble solids (%), leaf area (cm^2), stem girth (mm), leaf stem ratioand green fodder yield per plant (g). Green fodder yield per plant was found highly significant positiveassociation with leaf breadth, stem girth, leaf area, leaf length, number of leaves per plant, plant height and leaf stem ratio at both genotypic and phenotypic level, indicated that selection of these attributes may be helpful to increase fodder yield in sorghum. Green fodder yield per plant and its contributing characters were analyzed using genotypic and phenotypic path coefficients. The results indicated that stem girth had a strong positive direct effect on green fodder yield per plant, followed by leaf breadth and number of leaves per plant at both genotypic and phenotypic levels. Improving these attributes was suggested to increase fodder yield.

Key words: Association, path analysis, sorghum, genotypic, phenotypic

Introduction

One of the main multipurpose crops farmed for both grain and fodder is sorghum. In the grass family, the genus Sorghum contains roughly 25 species of flowering plants. Sorghum is also known as orshallu, milo, durra, and Indian millet. Along with calcium, trace levels of iron, vitamin B1, niacin, and 10% protein and 3.4% fat, it is high in carbohydrates . Due to its several economically significant potential applications, including food (grain), feed (grain and biomass), fuel (ethanol production), fiber (paper), fermentation (ethanol production), and fertilizer (using organic by products), it is one of the five principal cultivated species in the world.The majority of types are nitrogen-efficient, resistant to heat and drought, and particularly significant in dry regions where the grain is a staple food for the impoverished and rural populations [1]. The world's most important grain crop after wheat (Triticum aestivum), rice (Oryza sativa), maize (Zea mays), and barley (Hordeum vulgare) is sorghum [Sorghum bicolor (L.) Moench]. Along with maize and pearl millet (Pennisetum glaucum L.), it is a significant dry land cereal crop in the semi-arid tropics.

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With an annual grain yield of roughly 58 million tons, it is produced on an area of 37 million hectares in at least 80 nations with 1.5 t/h average productivity [2]. Due to changes in the climate, there has been a significant droughts were seen during past year and huge decline in soil fertility . Despite being the world's greatest producer of milk, there is still a scarcity of milk and its byproducts [3]. There is more pressure on the import of powdered milk in this circumstance. The analysis of correlations among quantitative traits is essential to ascertain whether numerous qualities can be selected at the same time and, if so, how selection for secondary traits influences the genetic gain for the main feature that is being studied. When two desirable features have a positive genetic correlation, plant breeders have an easier time concurrently increasing both traits. The correlation study of several factors offers insight into the significance of both direct and indirect selection in influencing the ultimate yield of crop species. The direct and indirect causes of association provide estimates of the relative importance of each causative element, and the path coefficient analysis is a particularly powerful tool for identifying specific forces that act to produce strong correlations. Thus, in order to simultaneously improve yield and yield components, one must be aware of the associations between features and the route coefficient.A path coefficient analysis was done to determine the yield's direct and indirect contributors.

Materials and Methods

Thirty-five different genotypes of forage sorghum used as the experimental material for this study. The genotypes are listed in the accompanying table.

***Varieties of forage sorghum listed*:**

Sl. No.	Genotype	Sl. No.	Genotype	Sl. No.	Genotype
1.	Pant Chari-3	**13.**	Pratap Chari-1080	**25.**	UP Chari-2
2.	Jawahar Chari-6	**14.**	Pusa Chari-6	**26.**	Pant Chari-8
3.	SSG-59-3	**15.**	CSV-17	**27.**	Rajasthan Chari-1
4.	MP Chari	**16.**	Pant Chari-2	**28.**	UP Chari-1
5.	Pant Chari-4	**17.**	HC-260	**29.**	G-48
6.	Pant Chari-5	**18.**	HC-136	**30.**	CSV-21
7.	CSV-15	**19.**	Pusa Chari-615	**31.**	GFS-5
8.	HJ-513	**20.**	UP Chari-3	**32.**	IC-0597651
9.	SSV-84	**21.**	Pant Chari-7	**33.**	IC-0347571
10.	Varsha	**22.**	Pusa Chari-23	**34.**	IC-056030
11.	UP Chari-4	**23.**	HC-171	**35.**	IC-0568396
12.	Rajasthan Chari-2	**24.**	Pusa Chari-9		

A well-prepared field plot was used to seed 35 genotypes of the experimental materials. In the kharif season of 2022, the experiment was set up in a randomized block design with three replications. It was sowed on June 28, 2022, in a 4-row plot that measured five meters in length. Observations were recorded for days to 50% flowering, plant height (cm), leaf breadth (cm), leaf length (cm), number of leaves per plant, total soluble solids (%), leaf area (cm^2), stem girth (mm), leaf stem ratioand green fodder yield per plant (g). Five plants were randomly selected and harvested from each plot and then observations for different characters were recorded on these plants. According to Fisher (1918), [4] the correlations was calculated using the analysis of variance and covariance. The investigiationof path-coefficient was carried out in accordance withWright (1921)[5] andDewey and Lu (1959) [6] clarifications.

Results and Discussions

Correlation coefficient estimation

Correlation coefficients for each of the 35 genotypes for the attributes were computed at the genotypic and phenotypic levels, and the results are displayed in Table 1.

At the phenotypic level, there was a strong positive association between the amount of green fodder produced per plant and the stem girth (0.857). This was followed by the leaf stem ratio (0.263), plant height (0.354), leaf breadth (0.851), leaf area (0.841), and leaf length (0.833). The findings of Kumar et al. (2019) [7] and Pal et al. (2022) [8] are generally supported by these results.

On the other hand, days to 50% flowering (-0.021) and green fodder yield per plant had a slight but non-significant correlation. There was a positive but non-significant correlation between total soluble solids and green fodder yield per plant (0.101). Days until 50% flowering showed a positive and significant correlation (0.198) with the number of leaves per plant.Plant height exhibited a significant positive relationship with leaf length (0.467), leaf area (0.469), leaf number (0.317), stem girth (0.351), and green fodder yield per plant (0.354), but not with total soluble solids (0.117) or leaf stem ratio (0.172). This is in contrast to a non-significant negative association with plant height (-0.022), leaf breadth (-0.091), leaf length (-0.089), leaf area (-0.078), stem girth (-0.021), and green fodder yield per plant (-0.021). This was consistent with what Jain et al. (2017) found [9]. It was observed that there was a positive and statistically significant correlation between leaf breadth and the following variables: leaf length (0.791), number of leaves per plant (0.706), leaf area (0.831), stem girth (0.683), leaf stem ratio (0.252), and green fodder yield per plant (0.851). favorable and negligible association with total soluble solids (0.004); The number of leaves per plant (0.710), leaf length, leaf area (0.751), stem girth (0.497), leaf area (0.864), stem girth (0.767), leaf stem ratio (0.385), and green fodder yield per plant (0.833) all exhibited positive and significant correlations. These results are consistent with past research published by Patil *et al.* (2014), [10] Khandelwal*et al.* (2016) [11]Similar to the weak negative correlation (0.024) found between the number of leaves per plant and the amount of green fodder yield per plant, there is a weak negative correlation (0.012) between these variables and total soluble solids. While the leaf stem ratio (0.326) revealed a significant negative association with total soluble solids, the number of leaf areas (0.013), stem girth (0.168), and green fodder yield per plant (0.101) all exhibited positive but non-significant correlations with total soluble solids; The following parameters demonstrated a positive and substantial connection with leaf area: stem girth (0.738), leaf stem ratio (0.377), and green fodder yield per plant (0.841); For stem girth (0.857), there was a positive and significant association between leaf stem ratio and green fodder yield per plant (0.263), whereas there was a positive but non-significant correlation between leaf stem ratio and green fodder yield per plant (0.176). Similar results were also attained by Sumonthant*et al.* (2021) [12].

The yield of green fodder per plant was significantly correlated at the genotypic level with leaf breadth (0.891), stem girth (0.885), leaf area (0.874), leaf length (0.871), number of leaves per plant (0.744), plant height (0.432), and leaf stem ratio (0.317). Days to 50% flowering (-0.032) had a negative but not statistically significant correlation with the yield of green fodder per plant. Total soluble solids and green fodder output per plant had a positive but negligible correlation (0.111). These outcomes generally concur with the findings. Kumar *et al*. (2019) and Pal *et al.* (2022).

Path coefficient analysis

Table 2 shows the analysis's findings in relation to the genotypic and phenotypic path coefficients to show the direct and indirect effects of each feature on the amount of green fodder yield by each plant. The genotypic correlation was further divided into direct and indirect effects using path coefficient analysis to obtain a clear picture of the relationship between the dependent variable and independent/contributing qualities.

The greatest positive direct effect was observed for plant height (-0.063) at the genotypic level, with leaf length (-0.023) and leaf area (-0.007) following closely behind. Stem girth (-0.063), leaf breadth (-0.417), and the number of leaves per plant (-0.175) had the largest detrimental direct effects. Numerous scientists reported similar findings and recommendations, viz.,Kavya *et al.* (2020).Certain traits significantly influenced each plant's capacity to produce green fodder indirectly. The number of

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Comment [FRANK4]: Incoherent citation leaves per plant as determined by leaf area, length, and breadth can be found using plant height, leaf breadth, leaf length, number of leaves per plant, leaf area, and leaf stem ratio. These factors can also be used to calculate stem girth. The largest direct influence on the amount of green fodder yield per plant at the phenotypic level was found in stem girth (0.448), which was followed by leaf breadth (0.351) and leaf count (0.109). The most negative direct impact was seen in plant height (0.065), which was followed by leaf area (-0.096) and leaf length (-0.079). was noted, supporting the findings of Chavhan et al. (2022) and Sumonthant et al. (2021). The direct and indirect effects reported at the genotypic level were substantially similar to those observed at the phenotypic level, with only slight differences in magnitude. The residual effects were found to have modest magnitudes at both the genotypic and phenotypic levels.

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Conclusion

The study revealed a highly significant positive association between the number of leaves per plant, plant height, leaf stem ratio, leaf breadth, stem girth, leaf area, and leaf length. This suggests that selecting for these attributes could potentially increase the yield of fodder in sorghum. The association was observed at both the genotypic and phenotypic levels.

Green fodder yield per plant and its contributing characters were analyzed using genotypic and phenotypic path coefficient analysis. The results indicated that stem girth had a high positive direct effect on green fodder yield per plant, followed by leaf breadth and number of leaves per plant at both genotypic and phenotypic levels. Improving these attributes was suggested to increase fodder yield.

Table-1: Estimates of the correlation coefficients between various characteristics of forage sorghum (*Sorghum bicolor*L.Moench) at the genotypic (G) and phenotypic (P) levels.

Characters		Days to 50% flowering	Plant height (cm)	Leaf breadth (cm)	Leaf length (cm)	No.of leaves per plant	Total soluble solids (%)	Leaf area (cm^2)	Stem girth (mm)	Leaf stem ratio	Green fodder yield per plant (g)
Days to 50% flowering	G	1.000	-0.084	-0.137	-0.081	0.045	0.202	-0.126	-0.028	0.263*	-0.032
	P	1.000	-0.022	-0.091	-0.089	0.037	0.146	-0.078	-0.021	0.198*	-0.021
Plant height (cm)	G		1.000	0.483**	0.589**	0.374**	0.117	0.576**	0.447**	0.172	0.432**
	P		1.000	0.398**	0.467**	0.317**	0.100	0.469**	0.351**	0.180	0.354**
Leaf breadth (cm)	G			1.000	0.863**	0.780**	0.004	0.885**	0.729**	0.301**	0.891**
	P			1.000	0.791**	0.706**	0.004	0.831**	0.683**	0.252*	0.851**
Leaf length (cm)	G				1.000	0.772**	-0.015	0.925**	0.810**	0.469**	0.871**
	P				1.000	0.710**	-0.012	0.864**	0.767**	0.385**	0.833**
No. of leaves per plant	G					1.000	-0.027	0.826**	0.527**	0.372**	0.744**
	P					1.000	-0.024	0.751**	0.497**	0.311**	0.691**
Total soluble solids (%)	G						1.000	0.028	0.181	-0.382**	0.111
	P						1.000	0.013	0.168	-0.326**	0.101
Leaf area (cm^2)	G							1.000	0.776**	0.423**	0.874**
	P							1.000	0.738**	0.377**	0.841**
Stem girth (mm)	G								1.000	0.232	0.885**
	P								1.000	0.176	0.857**
Leaf stem ratio	G									1.000	0.317**
	P									1.000	0.263*
Green fodder yield per plant (g)	G										1.000
	P										1.000

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

Table-2: Path coefficient study demonstrating the genotypic and phenotypic effects of ten characters on the green fodder yield in forage sorghum (*Sorghum bicolor* L. Moench).

Characters		Days to 50% flowering	Plant height (cm)	Leaf breadth (cm)	Leaf length (cm)	No. of leaves per plant	Total soluble solids (%)	Leaf area (cm^2)	Stem girth (mm)	Leaf stem ratio
Days to 50% flowering	G	**0.004**	0.005	-0.057	0.002	0.008	0.009	0.001	-0.015	0.012
	P	**0.021**	0.001	-0.032	-0.007	0.004	0.005	-0.008	-0.009	0.003
Plant height (cm)	G	0.001	**-0.063**	0.202	-0.013	0.065	0.005	-0.004	0.233	0.008
	P	-0.002	**-0.065**	0.140	0.037	0.034	0.004	0.045	0.157	0.003
Leaf breadth (cm)	G	-0.001	-0.031	**0.417**	-0.020	0.136	0.003	-0.007	0.381	0.013
	P	-0.002	-0.026	**0.351**	0.062	0.077	0.005	0.080	0.306	0.004
Leaf length (cm)	G	0.001	-0.037	0.360	**-0.023**	0.135	-0.001	-0.007	0.423	0.021
	P	-0.002	-0.030	0.278	**-0.079**	0.077	0.001	0.083	0.344	0.006
No. of leaves per Plant	G	0.001	-0.024	0.326	-0.018	**0.175**	-0.002	-0.006	0.276	0.017
	P	0.003	-0.020	0.248	0.056	**0.109**	-0.001	0.072	0.222	0.005
Total soluble solids (%)	G	0.001	-0.007	0.002	0.000	-0.005	**0.043**	0.001	0.095	-0.017
	P	0.003	-0.007	0.001	-0.001	-0.003	**0.035**	0.002	0.075	-0.005
Leaf area (cm^2)	G	0.001	-0.037	0.369	-0.021	0.144	0.001	**-0.007**	0.406	0.019
	P	-0.002	-0.030	0.292	0.068	0.082	0.001	**-0.096**	0.330	0.005
Stem girth (mm)	G	0.002	-0.028	0.304	-0.018	0.092	0.008	-0.006	**0.523**	0.010
	P	0.003	-0.023	0.240	0.060	0.054	0.006	0.071	**0.448**	0.003
Leaf stem ratio	G	0.001	-0.011	0.126	-0.011	0.065	-0.016	-0.003	0.121	**0.045**
	P	0.004	-0.012	0.089	0.030	0.034	-0.011	0.036	0.079	**0.014**

Residual values (G) = 0.070 Residual values (P) = 0.113, Bold values indicate direct effects

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