International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 2939-2942

Received: 10-07-2019
Accepted: 12-08-2019

Studies on character association and path analysis in forage sorghum

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Abstract
Present investigation was carried out during Kharif season at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. The analysis of variance revealed highly significant variance for all the nine traits *viz.*, days to 50% flowering, plant height, number of leaves per plant, stem girth, leaf length, leaf breadth, total soluble solids, leaf area and green fodder yield depicting greater variability in the existing material. Genotypic and phenotypic coefficient of variation were found high (more than 25%) for plant height, stem girth and green fodder yield, which indicating that more variability and scope for selection in improving these characters. High heritability coupled with high genetic advance were exhibited for plant height, leaf area, stem girth and green fodder yield, which indicates that preponderance of additive gene effects for these attributes and hence may prove useful for effective selection. Correlation coefficient studies indicated that phenotypic correlation coefficient was found to be higher than genotypic correlation coefficients for all the characters which, indicates phenotypic expression of the association were influenced by the environmental factors among the various traits. Green fodder yield recorded significant and strong positive correlation with leaf area followed by stem girth, plant height, leaf length and number of leaves per plant at both genotypic and phenotypic level. Therefore, these attributes is useful to the breeders in selecting suitable plant type. Path coefficient analysis showed high positive and direct 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,* character association, path analysis

Introduction

The 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) [18]. Sorghum is the crop for grain for human and animal consumption. Sorghum is produced in areas that are too hot, a minimum average temperature of 25^0C is necessary to ensure maximum grain production. The morphological characteristics of the culture make it one of the currently cultivated cereals that have the best drought tolerance. During the drought, it rolls its leaves to reduce water loss due to perspiration. If the drought continues, it becomes dormant instead of dying. The leaves are protected by a waxy cuticle to reduce vapour transpiration. Sorghum grains are used by these people (especially farmers), who often do not have the means to feed themselves with food sources of energy, rich in protein, vitamins, minerals.

Sorghum grains are rich in energy and non-energy nutrients. In these areas they are intended for consumption as pasta, boiled and tradition beverages. By cons in industrialized countries, it is used in the form of grain or fodder in animal feed and for the production of bio ethanol. The sorghum demand increases more in many developing countries (Ramatoulaye *et al*., 2016) [13].

Materials and Methods

Thirty two genotypes of forage sorghum collected from different agriculture universities of India were studied during *kharif* season 2018. The crop was grown at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut in randomized block design with three replications. Observations were recorded on days to 50% flowering, plant height, number of leaves per plant, stem girth, leaf length, leaf breadth, total soluble solids, leaf area and green fodder yield. Five randomly tagged plants in each treatment were used for recording observations. The data was analyzed statistically for genotypic and phenotypic coefficients of variation, heritability (Allard, 1960) [1] and genetic advance (Johnson *et al*., 1955) [8]. Correlation was estimated by (Searle 1961) and path-coefficient was suggested by Wright (1921) [18] and as elaborated by Dewey and Lu (1959) [3].

Results and Discussion

The genetic components for different characters (Table-1) indicate a wide range of variation for all the nine characters *i.e.*, days to 50% flowering (159.99), plant height (956.22), number of leaves per plant (4.56), stem girth (18.36), leaf length (60.75), leaf breadth (1.45), total soluble solids (2.68), leaf area (4523.31) and green fodder yield (34112.56) studied. High amount of genetic variability for these characters has also been reported earlier by Damor *et al.* (2018) [2] and Wadikar *et al.* (2018) [18]. High (more than 25%) genotypic and phenotypic coefficient of variation were recorded for plant height (30.30 and 32.00), stem girth (30.15 and 31.29) and green fodder yield (25.21 and 25.76) (Table-2). This indicates the higher magnitude of variability present in the germplasm and selection may therefore be effective for the improvement of these attributes. Low genotypic and phenotypic coefficient of variation were recorded by days to 50% flowering, leaf length, leaf breadth, number of leaves per plant, leaf area and total soluble solids. Similar results were found by Nyadanu and Dikera (2014) [10] and Ghorade *et al.* (2015) [6]. High (>60%) heritability estimates in broad sense was recorded for days to 50% flowering (98.00), plant height (88.40), number of leaves per plant(79.00), stem girth (88.00), leaf length (89.00), leaf breadth (97.00), total soluble solids (81.00), leaf area (95.70) and green fodder yield (99.00), suggested that these characters are under genotypic control. Similar observations were also reported by Rajarajan *et al.* (2018) [12], Damor *et al.* (2018) [2] and Wadikar *et al.* (2018) [17]. High (> 20%) genetic advance expressed as per cent of mean was observed for plant height (22.87), leaf area (28.34), stem girth (20.20) and green fodder yield per plant (41.54) thereby, suggesting good response for selection based on *per se* performance. These findings were in agreement with those of Kadam *et al.* (2001) [4] and Kumar and Sahib (2003) [5]. High heritability coupled with high genetic advance as percent of mean was noted for plant height (88.40), leaf area (95.70), stem girth (88.00) and green fodder yield per plant (99.00), indicating the influence of additive gene action and, consequently, a possibility of improving these traits through selection. High heritability coupled with high genetic advance for these characters have also been reported earlier by Damor *et al.* (2018) [2] and Wadikar *et al.* (2018) [17]. Green fodder yield exhibited significant stable and positive correlation with leaf area (0.41 and 0.44) followed by stem girth (0.34 and 0.36), plant height (0.32 and 0.34), leaf length (0.30 and 0.35) and leaves per plant (0.30 and 0.33) at genotypic and phenotypic level (Table-3). These characters may be considered as important yield component in forage sorghum. These results are similar to earlier reports of Singh *et al.* (2017) [16], and Malaghan and Kajjidoni (2019) [9]. Leaf area displayed high order of direct effect on green fodder yield per plant followed by leaf area (0.87 and 0.82), leaf length (0.81 and 0.73), plant height (0.67 and 0.63) and number of leaves per plant (0.54 and 0.50) at 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. These findings are in accordance with the results obtained in sorghum by Patil *et al.* (2014) [11] and Raza and Naheed (2014) [14].

Table 1: Analysis of variance for nine characters in parents and F_1 generation of forage sorghum

Source of variance	d.f.	Days to 50% flowering	Plant height (cm)	No. of leaves per plant	Stem girth (mm)	Leaf length (cm)	Leaf Breadth (cm)	Total soluble solids (%)	Leaf Area (cm^2)	Green fodder yield (g)
Replication	2	1.91	61089	0.69	0.25	0.42	0.07	0.05	89.32	236.12
Treatment	63	159.99**	956.22**	4.56**	18.36**	60.75**	1.45**	2.68**	4523.31**	34112.56**
Error	126	0.99	156.22	0.93	1.88	2.77	0.09	0.44	145.37	399.58

* Significant at 5% level and ** Significant at 1% level

Table 2: Mean performance and parameters of variability for various traits studied in forage sorghum

Sl. No.	Character	GCV (%)	PCV (%)	Genetic Advance	GA as % mean	Heritability (%)
1.	Days to 50% Flowering	7.45	8.22	14.60	16.70	98.00
2.	Plant height (cm)	30.30	32.00	26.43	22.87	88.40
3.	Leaf length(cm)	5.67	5.89	9.32	10.87	89.00
4.	Leaf breadth(cm)	7.15	7.33	1.56	16.24	97.00
5.	No. of leaves per plant	7.08	8.65	1.43	13.29	79.00
6.	Leaf area (cm^2)	8.75	9.78	22.30	28.34	95.70
7.	Stem girth (mm)	30.15	31.29	23.40	20.20	88.00
8.	Total Soluble Solids (%)	9.56	9.89	1.90	16.20	81.00
9.	Green fodder yield per plant (g)	25.21	25.76	25.34	41.54	99.00

Table 3: Estimates of correlation coefficient for genotypic (G) and phenotypic (P) levels among different in forage sorghum

Character		Days to 50% flowering	Plant height (cm)	Leaf Length (cm)	Leaf breadth (cm)	No. of leaves per plant	Leaf area (cm^2)	Stem girth (cm)	Total Soluble Solids (%)	Green fodder yield per plant (g)
Days to 50% flowering	G P	1.00 1.00	0.14 0.19	0.29** 0.31**	0.42** 0.37**	0.48** 0.36**	0.14 0.16	- 0.04 - 0.05	- 0.16 - 0.18	0.02 0.04
Plant height (cm)	G P		1.00 1.00	0.22* 0.36*	0.22* 0.30*	- 0.03 - 0.07	0.28** 0.30**	0.28* 0.29*	0.34** 0.29**	0.32** 0.34**
Leaf length (cm)	G P			1.00 1.00	- 0.05 - 0.06	0.07 0.08	0.41** 0.47**	- 0.06 - 0.08	0.10 0.16	0.30** 0.35**
Leaf breadth (cm)	G P				1.00 1.00	- 0.26* - 0.29*	0.76** 0.84**	0.18 0.19	0.11 0.14	0.14 0.16
No. of leaves per plant	G P					1.00 1.00	- 0.15 - 0.17	0.05 0.07	0.44** 0.54**	0.30** 0.33**
Leaf area (cm^2)	G P						1.00 1.00	0.08 0.09	0.17 0.19	0.41** 0.44**
Stem girth (cm)	G P							1.00 1.00	0.09 0.19	0.34** 0.36**
Total Soluble Solids (%)	G P								1.00 1.00	0.23 0.27

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

Table 4: Estimates of direct and indirect effects for various traits studied towards green fodder yield in forage sorghum

Character		Days To 50% flowering	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	No. of leaves per plant	Leaf area (cm^2)	Stem girth (mm)	Total soluble solids (%)	Correlated with green fodder yield per plant
Days to 50% flowering	G P	0.14 0.17	0.04 0.06	- 0.04 - 0.06	0.06 0.07	- 0.14 - 0.06	0.02 0.03	- 0.02 - 0.03	- 0.02 - 0.03	0.02 0.04
Plant height (cm)	G P	0.04 0.06	0.63 0.67	0.02 0.05	0.05 0.07	- 0.02 - 0.04	0.13 0.13	0.04 0.06	0.15 0.21	0.32** 0.34**
Leaf length (cm)	G P	0.22 0.26	- 0.22 - 0.28	0.73 0.81	0.03 0.07	- 0.06 - 0.07	- 0.17 - 0.19	- 0.03 - 0.05	- 0.12 - 0.14	0.30** 0.35**
Leaf breadth (cm)	G P	0.50 0.60	- 0.30 - 0.33	- 0.03 - 0.05	0.14 0.16	0.40 0.47	0.13 0.15	- 0.24 - 0.27	- 0.21 - 0.24	0.14 0.16
No. of leaves per plant	G P	- 0.13 - 0.17	- 0.03 - 0.05	0.02 0.05	- 0.11 - 0.12	0.50 0.54	- 0.14 - 0.16	0.01 0.04	0.20 0.28	0.30** 0.33**
Leaf area (cm^2)	G P	0.05 0.12	0.11 0.17	0.14 0.17	0.01 0.04	0.11 0.14	0.82 0.87	0.12 0.26	0.13 0.15	0.41** 0.44**
Stem girth (mm)	G P	- 0.03 - 0.06	0.04 0.06	- 0.01 - 0.05	0.06 0.09	0.04 0.06	0.02 0.04	0.11 0.14	0.04 0.05	0.34** 0.36**
Total soluble solid (%)	G P	0.02 0.06	- 0.02 - 0.03	- 0.04 - 0.06	- 0.02 - 0.03	0.03 0.05	- 0.01 - 0.04	- 0.02 - 0.03	- 0.04 - 0.06	0.23 0.27

Residual effect (Genotypic) = 0. 42 and (Phenotypic) = 0.46 Bold values indicate direct effect

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