Original Research Article

Sorghum: Correlation and Path analysis

Abstract

Ninety-six sorghum accessions were evaluated and characterized for various yield component traits and morphological parameters at the Instructional Dairy Farm of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India during *Kharif* 2017.A positive and significantcorrelation coefficient of component traits ensures their potential for selection in order to maximize fodder yield. In the present study green fodder yield and dry fodder yield were found to be significantly and positively associated with plant height (0.389, 0.351) and stem girth (0.476, 0.418).leaf length (0.011), stem girth (0.007), leaf width (0.001) and plant height (0.002) were observed to have a positive direct effect on green fodder yield.The findings of the research reveal noteworthy relationships between green fodder yield, dry fodder yield and specific morphological attributes. Therefore, these characters provide enormous opportunity for selection to improveyield.The present study has implications in current breeding programmes for developing improved varieties by highlighting the specific traits and parameters that can contribute significantly to higher fodder yield, breeders can strategically target these characteristics during the selection and breeding process. By identifying features that have a direct beneficial influence on yield, the study gives practical insights that can benefit fodder production and as a result, the livestock and agriculture industries.

Comment [D1]: Include the study design used for the study and the statistical analysis performed.

Keywords: Correlation, path analysis, germplasm, evaluation, fodder yield, morphologicaltraits

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is a diploid species with somatic chromosome number of 2*n* = 20 and belongs to family Poaceae (Spangler *et al.* 1999). It has originated in Northeastern Africa about 5000 – 8000 years ago (De Candolle 1884;Jean 2008).The secondary centre of origin of sorghum is the Indian Subcontinent, with evidence for early cereal cultivation dating back about 4500 years (Mutegi 2010).Sorghum is adapted to a broad range of environmental conditions from the highlands of Ethiopia to the semi-arid Sahel. Tribal group has distributed the five different races of sorghum (Bicolor, Caudatum, Durra, Guinea, and Kafir) to wide range of places due to theirmovement in Africa (Keerthana*et al.* 2022; Rani*et al.* 2022). Sorghum is the fifth most important cereal crop which provides fodder and food throughout the world (Doggett 1988).Millions of poor rural people in the semiarid tropics of Asia and Africa are eating sorghum as staple foods (Rani*et al.* 2022). Sorghum grain is rich in protein (11.3%),fat (3.3%), iron, zinc, phosphorus and B-complex vitamins. Red-grained sorghum is rich in tannins (antioxidants) that protects against cell damage (Salah *et al.* 2004; Proietti*et al.* 2015;Khoddami*et al.* 2023).Forage sorghum can be used to make

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silage, hay and pasture for animal feed. The demand for fodder sorghum is expanding rapidly. To fulfil demand, there must be an increase in output, which should come from it or from a smaller area given the current scenario of dwindling agricultural land (Prakash *et al.* 2010). The development of a broad genetic base, stable and high-yielding sorghum cultivars need a steady supply of fresh germplasm as a source of desirable genes in breeding operations. The diversified germplasm is an excellent resource for improving plant adaptability and other agronomic features (Huang 2004).

It is adapted to a wider range of ecological conditions with low soil moisture, hot and dry for other crops because of its tolerance to heat and drought stress (Poehlman 1987;Wagaw 2019).It is known as a high-energy crop because of its high water use efficiency and conversion of solar energy. It is mainly grown for fodder and food purpose. Sorghum grain is a staple food in parts of Africa, Asia and other low-income regions, as well as a fodder and feed crop for livestock (Proietti*et al.* 2015).The prime aim of any plant breeding programme is the proper exploitation of the available variability in the crop to identify and select superior genotypes having desirable traits from a broad range of breeding material. Mutual relationship among different characters can be studied with correlation coefficients to formulate suitable selection criteria whereaspath coefficient analysis provides the effective way to find out the direct and indirect causes of association among the dependent and independent variables. Both correlation and path analysis are requiredto initiate an effective selection programmeto assess the association of various component characters and their direct and indirect effects on yield contributing characters.

Material and method

The ~~present~~ study was conducted at the Instructional Dairy Farm of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India during *Kharif* 2017. Ninety-six germplasm accessions were planted in an Augmented Block Design with each accession in two rows of 3-meter length with a row spacing of 45cm. All the recommended package of practices were followed for cultivation. Data was recorded on time to 50% flowering (days), number of nodes per plant, leaf length (cm), plant height (cm), leaf width (cm), flag leaf length(cm), flag leaf width(cm), panicle length (cm), stem girth (cm), panicle width(cm), HCN content (ppm), days to maturity, Brix%, protein content (%), dry matter %, 1000 grain weight per panicle(gm), dry fodder yield(g/plant) and green fodder yield(g/plant).Correlation coefficient and phenotypic path analysis was statistically estimated by a method suggested by Searle (1961) and Dewey and Lu(1959).Note

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Result and discussion

Correlation between the yield component characters and estimates of direct and indirect effects of component characters on yield can be advantageously used in prediction of the correlated response to directional selection as well as in the identification of some characters which may not have value in themselves but are useful indices for consideration in the improvement of yield. Green fodder yield showed positive correlation with the traits leaf width, plant height, stem girth, number of nodes, flag leaf width, flag leaf lengthand dry fodder yield (Table1). Therefore, these characters provide enormous amount of opportunity for selection to improve green fodder yield. Positive and significant association between plant height and green fodder yield per plant was observed and similar results were also reported by Iyanar*et al.* (2010), Jain and patel (2013), Khurd (2013), Singh *et al.* (2018) andAswini*et al.* (2022). Green fodder yield was found to be significantly and positively associated with leaf length, plant height, stem thickness and dry matter content by Khurd *et al.* (2018).Aswini*et al.* 2022 and Keerthana*et al.* 2022 reported a significant and positive association of plant height and stem girth with green forage yield. Dry fodder yield per plant was found to exhibit a highly significant and positive correlation with plant height and stem girth by Singh *et al.* 2014 and Rani *et al.* 2022. Leaf length and dry matter content were also found to be positively and significantly correlated with the green fodder yield by Kumar *et al.* (2017). The other trait like plant height was found to be positively associated with panicle length and panicle width by Mofokeng *et al.* (2019).Navaselvakkumaran*et al.* (2019) in fodder cowpeafound a positive association between number of leaves and green fodder yield.Path analysis is used to state the directed dependencies among a set of variables. Positive and high direct effect of a character on green fodder yield reveals the effectiveness of a character for direct selection by phenotypic path analysis. Character with high direct effect and positive and high indirect effects through other characters creates the best condition for selection in a breeding programme. In the present study days to 50% flowering, stem girth (cm), plant height (cm), number of nodes, leaf length (cm), leaf width (cm) and flag leaf length (cm) are the characters which can be used in selection programmes to get the higher fodder yield. Positive direct effect of stem girth on green fodder yield was observed during the study (Table2) and similar results were reported by Prakash *et al.* (2010), Jain (2010) and Ramdevsinh (2012). Leaf width was found to be exhibiting positive direct effect on green forage yield by Khurd *et al.* (2018). Singh *et al.* (2018) reported positivedirect effect of leaf length, plant height and stem girth on green fodder yield. The residual effect as associated with a value of standard partial regression of 0.0133 indicates a relatively minute contribution of the remaining factors other than those studied.

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Table 1: Correlation coefficient among nineteen characters of sorghum genotype.

Correlation Cofficient Analysis

Min. | 0 | Max.

	Days to 50% flowering	Plant height (cm)	Stem girth (cm)	Number of nodes	Leaf length (cm)	Leaf width (cm)	Flag leaf length (cm)	Flag leaf width (cm)	Panicle length (cm)	Panicle width (cm)	Days to maturity	HCN (ppm)	Protein content%	Brix %	IVDMD	Dry matter %	1000 seed weight (g)	Dry fodder yield (g/plant)	Green fodder yield (g/plant)
Days to 50% flowering	1																		
Plant height (cm)	0.132	1																	
Stem girth (cm)	0.019	0.267	1																
Number of nodes	0.341	0.571	0.407	1															
Leaf length (cm)	-0.029	0.347	0.258	0.34	1														
Leaf width (cm)	0.02	0.209	0.393	0.266	0.014	1													
Flag leaf length (cm)	0.142	0.357	0.33	0.177	0.163	0.164	1												
Flag leaf width (cm)	0.171	0.242	0.486	0.189	0.165	0.445	0.636	1											
Panicle length (cm)	-0.145	0.415	-0.016	0.149	0.164	0.062	0.043	-0.148	1										
Panicle width (cm)	-0.018	0.397	0.302	0.363	0.087	0.306	0.087	0.09	0.471	1									
Days to maturity	0.73	0.11	0.008	0.325	-0.059	-0.026	0.164	0.144	-0.043	0.038	1								
HCN (ppm)	0.06	0.032	0.089	0.206	0.179	0.09	-0.096	-0.036	-0.038	0.057	0.152	1							
Protein content%	-0.003	-0.059	0.075	-0.046	0	0.044	-0.036	0.026	-0.077	0.08	-0.116	-0.006	1						
Brix %	0.042	0.103	-0.056	0.014	0.15	-0.027	0.093	0.175	0.074	0.1	0.028	0.239	-0.043	1					
IVDMD	-0.047	-0.13	-0.076	-0.096	0.088	0.098	0.064	0.127	0.095	0.006	-0.087	0.007	0.03	0.273	1				
Dry matter %	-0.463	0.001	-0.006	-0.188	0.042	0.019	-0.111	-0.166	0.194	0.148	-0.318	-0.054	0.198	-0.065	-0.021	1			
1000 seed weight (g)	0.113	0.066	0.187	0.218	0.286	0.215	0.014	0.114	0.098	0.083	0.027	0.215	-0.037	0.326	0.055	-0.077	1		
Dry fodder yield (g/plant)	-0.093	0.351	0.418	0.184	0.149	0.263	0.252	0.2	0.149	0.17	-0.101	0.159	0.039	0.207	0.08	0.468	0.133	1	
Green fodder yield (g/plant)	0.144	0.389	0.476	0.288	0.134	0.291	0.376	0.333	0.067	0.115	0.045	0.188	-0.048	0.259	0.126	0.009	0.171	0.88	1

Table 2: Phenotypic path coefficient analysis is showing the direct and indirect effect of 18 characters on green fodder yield.

Path coefficient analysis

Min.		0		Max.

	Correlation with yield	Direct effect	Days to 50% flowering	Plant height (cm)	Stem girth (cm)	Number of nodes	Leaf length (cm)	Leaf width (cm)	Flag leaf length (cm)	Flag leaf width (cm)	Panicle length (cm)	Panicle width (cm)	Days to maturity	HCN (ppm)	Protein content %	Brix %	IVDMD	Dry matter %	1000 seed weight (g).	Dry fodder yield (g/plant)
Days to 50 % flowering	0.144	0.041		-0.002	0.001	-0.005	0.001	0.001	0.006	-0.003	-0.001	-0.001	-0.023	0.001	-0.001	-0.001	-0.001	0.231	-0.001	-0.102
Plant height (cm)	0.389	0.002	0.005		0.002	-0.009	-0.003	0.003	0.016	-0.005	0.001	0.002	-0.003	0.001	-0.001	-0.001	-0.003	-0.003	-0.001	0.387
Stem girth (cm)	0.476	0.007	0.001	-0.001		-0.006	-0.002	0.003	0.014	-0.001	-0.001	0.001	-0.001	0.001	0.002	0.004	-0.002	0.003	-0.002	0.462
Number of nodes	0.288	0.015	0.014	-0.001	0.003		-0.003	0.004	0.007	-0.004	0.004	0.001	-0.01	0.003	-0.001	-0.001	-0.002	0.093	-0.002	0.203
Leaf length (cm)	0.134	0.011	-0.001	-0.007	-0.001	-0.005		0.002	0.007	-0.003	0.004	0.004	0.001	0.003	0.001	-0.001	0.002	-0.02	-0.003	0.165
Leaf width (cm)	0.291	0.001	0.008	-0.004	0.002	-0.004	-0.001		0.007	-0.001	0.001	0.001	0.008	0.001	0.001	0.002	0.002	-0.009	-0.002	0.291
Flag leaf length (cm)	0.376	0.045	0.005	-0.007	0.002	-0.002	-0.001	0.002		-0.001	0.001	0.004	-0.005	-0.001	-0.001	-0.008	0.001	0.055	-0.001	0.278
Flag leaf width (cm)	0.333	-0.002	0.007	-0.005	0.003	-0.003	-0.001	0.007	0.028		-0.004	0.004	-0.004	-0.006	0.007	-0.001	0.003	0.083	-0.001	0.221
Panicle length (cm)	0.067	0.001	-0.005	-0.008	-0.001	-0.002	-0.001	0.001	0.001	0.003		0.002	0.001	-0.001	-0.002	-0.006	0.002	-0.096	0.001	0.165
Panicle width (cm)	0.115	0.005	-0.007	-0.008	0.002	-0.005	-0.009	0.004	0.003	-0.002	0.001		-0.001	0.001	0.002	-0.008	0.001	-0.073	-0.001	0.187
Days to maturity	0.045	-0.032	0.03	-0.002	0.001	-0.005	0.006	-0.001	0.007	-0.003	-0.001	0.002		0.002	-0.003	-0.002	-0.002	0.158	-0.003	-0.111
HCN (ppm)	0.188	0.001	0.002	-0.001	0.001	-0.003	-0.002	0.001	-0.004	0.001	-0.001	0.003	-0.004		-0.001	-0.002	0.001	0.026	-0.002	0.175
Protein content %	-0.048	-0.002	-0.001	0.001	0.005	0.007	-0.001	0.001	-0.001	-0.001	-0.002	0.004	0.003	-0.001		0.003	0.007	-0.098	0.005	0.042
Brix %	0.259	-0.008	0.001	-0.002	-0.004	-0.002	-0.001	-0.001	0.004	-0.003	0.001	0.005	-0.009	0.004	-0.001		0.007	0.032	-0.004	0.229
IVDMD	0.126	0.026	-0.001	0.002	-0.005	0.001	-0.001	0.001	0.002	-0.002	0.001	0.001	0.002	0.001	0.001	-0.002		0.01	-0.007	0.087
Dry matter %	0.009	-0.499	-0.019	-0.001	-0.001	0.002	-0.004	0.001	-0.005	0.003	0.005	0.007	0.01	-0.001	0.005	0.005	-0.005		0.001	0.517
1000 seed weight (g)	0.171	-0.013	0.004	-0.001	0.001	-0.003	-0.003	0.003	0.006	-0.002	-0.001	0.001	-0.008	0.003	-0.001	-0.002	0.001	0.038		0.147
Dry fodder yield (g/plant)	0.88	0.105	-0.003	-0.007	0.003	-0.002	-0.001	0.004	0.011	-0.004	0.001	0.009	0.003	0.002	0.001	-0.001	0.002	-0.233	-0.001	

Residual factor = 0.013