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EVALUATION OF F_3 AND F_4 POPULATION OF CROSS HJ 513 X IS 2205 FOR CORRELATION AND PATH COEFFICIENT STUDIES AMONG FODDER YIELD AND ITS COMPONENT CHARACTERS

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SUMMARY

The goal of the present study was to evaluate, categories, and classify 200 stem borer (SB) lines of the cross HJ 513 x IS 2205 for traits related to fodder yield during the *Kharif* 2017 and 2018 at the research area of the forage section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University. Data on 11 morphological characters, were observed. The results of a correlation analysis showed that characters like dry fodder yield had a highly significant positive association with the amount of green fodder produced on each plot, whereas traits like plant height had a significant correlation with the amount of green fodder produced on each plot. Estimates of path coefficients in F_3 and F_4 population revealed direct positive effects on green fodder yield exhibited by dry fodder yield per plot and leaf breadth.

Key words: Sorghum, selection, correlation and path coefficient

Sorghum [*Sorghum bicolour* (L.)] Moench) popularly known as "King of Millet" or "Great Millet", is an important fodder crop in the world. It is the fifth most important crop in the world after wheat, rice, maize and barley. At global level during year 2023-24, the total sorghum production is about 52.8 million tonnes with U.S.A. followed by Nigeria as the top producers with total production of 8.07 million tonnes and 6.70 million tonnes, respectively. India with the production of 4.4 million tonnes and area 3.97 million hectares ranked fourth in world during year 2023-24 (ANGRAU, 2023-24). Sorghum cultivation is concentrated mainly in areas where corn production is restricted because of insufficient rainfall or uneven distribution and where temperatures are too high (Reddy *et al*., 2004). The crop also tolerates longer durations of water logging better than maize (Dillon *et al*., 2007). It provides fodder for livestock during lean period of *Kharif* season. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are the measures of variability present in the germplasm of any crop. High estimates of GCV and PCV generally indicates significant variation for the characters, but it doesn't determine the magnitude of its heritable proportion (Nguyen *et al*., 2019). For effective selection heritability coupled with genetic advance must be studied together. Yield is determined by several component characters making it a complex character. Therefore, prior knowledge of correlation between yield and its attributing characters is essential before initiating a breeding programme. The correlation study must also be assisted with path analysis which splits the correlation into indirect and direct effects of independent characters on dependent character (Oo *et al*., 2023, Panchta *et al*., 2020). Nutritionally, sorghum is having high digestibility, high starch, sugars and crude protein. Then, it becomes imperative to associate the other characters with yield which are less influenced by non-biological or environmental factors (Kalpande *et al*., 2014).Considering the above mentioned facts present study was conducted to determine the extent of genetic variability and character association among the yield and its attributing traits.

MATERIALS AND METHODS

The following experiment was conducted in *kharif* season of the year 2017-18 and 2018-19 for evaluation of 200 lines of F_3 and F_4 populations of cross HJ 513 x IS 2205.In this parent HJ 513 is susceptible while IS 2205 resistance to stem borer. The female parent HJ 513 is susceptible to sorghum

stem borer and non-sweet in nature. In contrast the male IS 2205 is resistant to stem borer and non-sweet.

The crop was planted at Forage Section, Department of Genetics and Plant Breeding CCSHAU, Hisar for the evaluation of morphological traits. The sowing was done on July 12, 2017 and July 18, 2018. It is situated in semi-arid sub-tropical region at 29.09^0N latitude and 75.43^0E longitude with elevation of 215 m (705 ft) above mean sea level. Each plot comprised of two rows of 2 m length with row-to-row distance 45 cm and plant to plant distance of 15 cm. All the recommended cultural package of practices was followed from sowing to harvesting of the crop.

Plant height (cm), plant population/ row, days to 50% flowering, numbers of tillers/ plant, numbers of leaves/ plant, leaf length (cm), leaf breadth (cm), stem diameter (mm), leaf: Stem ratio, green fodder yield (GFY) in kg/ plot , dry fodder yield (DFY) in kg/ plot.

All the observations were recorded as per according to agronomical practices. The Green fodder yield was recorded from each of the randomly selected plant of each replication at the time of 50% flowering. The plants harvested for recording green plant weight were first sun dried and then oven dried for recording dry fodder yield. The correlation coefficient between characters was determined as per the method given by Al-Jibouri *et al.* (1958). Path coefficient analysis was carried out using phenotypic correlation values of yield components on yield as illustrated by Dewey and Lu (1959). All the analysis was carried out using INDOSTAT.

RESULTS AND DISCUSSION

The analysis of variance indicated that the 200 lines were found to be highly significant for all the characters studied during both years, which justified further genetic analysis of the data. Results revealed that considerable amount of genetic variability were present in the experimental material, which can be exploited for improvement of sorghum. Grand mean and range for 11 characters were observed in 200 lines in F_3 and F_4 population (Table 1 & 2). The magnitudes of the phenotypic coefficient of variation (PCV) were higher than the genotypic coefficient of variation (GCV) for all the characters, indicating that these variations were not only governed by genotypic factors, but there was considerable influence by the environment. High estimates of PCV and GCV was exhibited by GFY, DFY and stem diameter both in F_3 and F_4 population indicating considerable variations for the characters studied. Remaining character shown either moderate or low estimates of GCV and PCV. Thus, there is good scope for further improvement through genetic manipulation. Above findings confirmed the results for various characters from previous studies (Kumari *et al.*, 2022, Kumar *et al.*, 2022, Goswami *et al.*, 2022, Kolekar *et al.*, 2021, Thant *et al.*, 2021, Dev *et al.*, 2019, Deep *et al.*, 2019. High heritability coupled with high genetic advance as per cent of mean (GAM) for the characters like, GFY and DFY suggests presence of predominant additive variation and hence, these characters could be improved through direct selection (Table 1 & 2). These findings were substantiated by Kumari *et al.*, 2022, Kumar *et al.*, 2022, Thant *et al.*, 2021, Dev *et al.*, 2019, Deep *et al.*, 2019.

Correlation coefficients were calculated to study the association among different morphological characters in F_1 and F_2 population are presented in Table 3 and Table 4. In F_1 and F_1 population GFY was found to be positively associated with DFY, plant population/row and plant height. This suggests that

TABLE 1
Genetic parameters for morphological and bio-chemical traits in F? population in year 2017-18

Genetic parameters	Mean	Range	GCV	PCV	Heritability	GA	GAM (%)
Plant Population/row	13.03	6.72-17.23	13.83	15.40	80.61	3.33	25.58
Days to 50% flowering	67.19	53.75-82.00	6.73	7.64	77.49	8.18	12.20
Plant height(cm)	232.75	126.65-381.85	11.87	13.59	76.24	49.66	21.35
Number of tillers/plant	2.27	1.26-2.83	8.55	9.37	83.26	0.36	16.07
No. of leaves/plant	12.75	7.40-21.06	14.81	17.36	72.81	3.32	26.04
Leaf length (cm)	62.94	40.10-85.20	12.18	13.07	86.83	14.67	23.38
Leaf breadth (cm)	5.62	2.19-8.32	16.49	18.12	82.86	1.73	30.93
Stem diameter(mm)	16.77	8.10-39.55	24.52	27.85	77.51	7.46	44.48
Leaf : Stem ratio	0.40	0.29-0.51	7.97	9.32	73.22	0.05	14.05
Green fodder yield(kg/plot)	19.80	9.85-23.90	26.07	27.90	87.32	11.35	50.18
Dry fodder yield (kg/plot)	5.21	2.59-06.55	26.07	27.90	87.30	2.98	50.18

TABLE 2
Genetic parameters for morphological and bio-chemical traits in F4 population in year 2018-19

Genetic parameters	Mean	Range	GCV	PCV	Heritability	GA	GAM (%)
Plant Population/row	13.25	6.53-16.53	12.59	13.91	81.92	3.11	23.47
Days to 50% flowering	67.07	54.15-82.60	6.46	7.23	79.88	7.96	11.90
Plant height(cm)	219.31	124.45-327.95	11.88	13.50	77.48	47.30	21.55
Number of tillers/plant	2.17	1.27-2.77	10.73	12.32	75.84	0.41	19.25
No. of leaves/plant	11.28	7.28-15.78	13.38	15.72	72.41	2.64	23.45
Leaf length (cm)	60.67	38.50-86.00	11.67	12.88	82.12	13.18	21.80
Leaf breadth (cm)	5.54	2.90-8.35	15.41	16.67	85.55	1.62	29.38
Stem diameter(mm)	16.18	10.17-33.80	20.22	23.78	72.28	5.72	35.41
Leaf : Stem ratio	0.38	0.28-0.46	7.13	8.41	71.95	0.04	12.47
Green fodder yield (kg/plot)	19.50	9.11-22.96	24.93	26.42	89.00	11.02	48.45
Dry fodder yield(kg/plot)	4.67	2.31-5.46	25.43	26.40	92.81	2.93	50.47

selection based on these traits will be improve the GFY. Similar results reported by Sihag *et al*., 2023, Kumari *et al*., 2022, Kolekar *et al*., 2021, Thant *et al*., 2021, Rohilla *et al*., 2020, Dev *et al*., 2019, Deep *et al*., 2019.

The information on the magnitudes and direction of association between yield and its component characters are essential for making improvement in desired direction. This information may be useful in the predication of correlated response to directional selection in the construction of selection indices and in the detection of some characters having no values in them but may provide desired improvement in combination. For selection purpose, practically correlation is useful along with the separately estimated genetic and environmental correlation between pairs of characters. The correlation coefficient is a measure to estimate the extent and direction of association among the studied characters. Correlation coefficients were calculated between ten characters and emphasis have given on discussing genotypic association between traits, related to major breeding objectives in forage sorghum.

Path coefficient analysis presents the portioning of correlation into direct and indirect effects through other attributes (Wright, 1921), hence in the present investigation path coefficient analysis for green fodder contributing traits in F_1 and F_2 population was estimated which is presented in Table 5 and Table 6.

In the present investigation, dry fodder yield, number of tillers/plant and leaf width exhibited major and positive direct effect on the expression of green fodder yield in F_3 but in F_4 population except positive direct effect of dry fodder yield the contribution of other traits in green fodder yield was negligible. These results indicated that DFY can be used as positive selection indices for breeding of higher green fodder yield. Indirect effects of various traits on green fodder

TABLE 3
Correlation matrix for different traits in forage sorghum F3 Populations in year 2017-18

	PP	NOD	PH	NOT	NOL	LL	LW	SD	L:S	DFY	GFY
PP	1										
NOD	0.569**	1									
PH	0.023	0.730**	1								
NOT	0.966**	0.418**	-0.158*	1							
NOL	0.958**	0.570**	0.052	0.950**	1						
LL	0.512**	0.787**	0.640**	0.397**	0.531**	1					
LW	0.960**	0.500**	-0.048	0.970**	0.983**	0.434**	1				
SD	-0.049	-0.186*	-0.177*	-0.024	0.015	-0.127	0.043	1			
L:S	0.002	0.043	0.082	-0.026	0.125*	-0.239**	0.162*	0.308**	1		
DFY	0.140*	0.021	0.163*	0.023	0.021	0.045	0.029	0.097	-0.019	1	
GFY	0.190*	0.002	0.144*	0.032	0.033	0.011	0.032	0.085	-0.003	0.931**	1

PP: Plant Population/row; NOD: Days to 50% flowering; PH: Plant height (cm); NOT: Number of tillers/plant; NOL: Number of leaves/plant; LL: Leaf length (cm); LW: Leaf breadth (cm); SD: Stem diameter (mm); L: S: Leaf Stem ratio; GFY: Green fodder yield (kg/plot); DFY: Dry fodder yield (kg/plot).

TABLE 4
Correlation of different morphological of SB lines of F4 population in year 2018-19

	PP	NOD	PH	NOT	NOL	LL	LW	SD	L:S	DFY	GFY
PP	1										
NOD	0.019	1									
PH	0.131	0.533**	1								
NOT	0.880**	0.715**	-0.374**	1							
NOL	0.592**	0.593**	0.089	0.149*	1						
LL	0.131*	0.498**	0.771**	0.260**	0.609**	1					
LW	0.136*	0.516**	-0.267	0.816**	0.643**	0.106*	1				
SD	-0.074	-0.165*	-0.155*	-0.052	0.091	-0.123	0.030	1			
L:S	0.003	0.028	0.037	-0.454	0.854**	-0.267**	0.842**	0.844**	1		
DFY	0.146*	0.024	0.151*	0.021	0.017	0.016	0.031	0.020	-0.030	1	
GFY	0.156*	0.006	0.102*	0.043	0.009	0.049	0.021	0.016	-0.010	0.868**	1

PP: Plant Population/row; NOD: Days to 50% flowering; PH: Plant height (cm); NOT: Number of tillers/plant; NOL: Number of leaves/plant; LL: Leaf length (cm); LW: Leaf breadth (cm); SD: Stem diameter (mm); L: S: Leaf Stem ratio; GFY: Green fodder yield (kg/plot); DFY: Dry fodder yield (kg/plot).

TABLE 5
Direct (diagonal) and indirect (off diagonal) path coefficient on green fodder yield of F? population in year 2017-18(Residual effect: 0.179)

	PP	NOD	PH	NOT	NOL	LL	LW	SD	LS Ratio	DFY
PP	**0.075**	0.042	0.018	0.072	0.072	0.038	0.072	-0.037	0.002	0.011
NOD	-0.041	**-0.072**	-0.053	-0.030	-0.041	-0.057	-0.036	0.013	-0.003	-0.001
PH	-0.010	-0.037	**0.050**	0.008	-0.003	-0.032	0.002	0.009	-0.004	-0.003
NOT	-0.244	-0.105	0.040	**0.253**	-0.240	-0.100	-0.245	0.062	0.066	0.065
NOL	0.004	0.002	0.000	0.004	**0.004**	0.002	0.004	0.000	0.000	0.000
LL	-0.033	-0.051	-0.041	-0.026	-0.034	**0.065**	-0.028	0.084	0.015	-0.029
LW	0.199	0.103	-0.010	0.201	0.204	0.090	**0.207**	0.089	0.033	-0.060
SD	0.013	0.050	0.048	0.007	-0.004	0.035	-0.012	**0.027**	-0.083	0.026
LS Ratio	-0.003	-0.057	-0.010	0.034	-0.016	0.031	-0.021	-0.040	**0.130**	0.025
DFY	-0.099	0.056	0.178	-0.072	-0.059	0.127	-0.082	-0.273	-0.053	**2.824**
GFY	0.075	0.042	0.018	0.072	0.072	0.038	0.072	-0.037	0.002	0.011

PP: Plant Population/row; NOD: Days to 50% flowering; PH: Plant height (cm); NOT: Number of tillers/plant; NOL: Number of leaves/plant; LL: Leaf length (cm); LW: Leaf breadth (cm); SD: Stem diameter (mm); L: S: Leaf Stem ratio; GFY: Green fodder yield (kg/plot); DFY: Dry fodder yield (kg/plot).

TABLE 6
Direct (diagonal) and indirect (off diagonal) path coefficient on green fodder yield of F4 population in year 2018-19(Residual effect: 0.238)

	PP	NOD	PH	NOT	NOL	LL	LW	SD	LS Ratio	DFY
PP	**0.028**	-0.005	-0.037	0.025	-0.017	-0.037	0.010	-0.021	0.001	0.013
NOD	-0.007	**-0.036**	-0.019	0.026	-0.034	-0.018	0.018	-0.024	0.084	-0.009
PH	-0.040	-0.016	**0.030**	0.011	-0.027	-0.233	0.081	-0.047	0.072	-0.016
NOT	0.017	0.144	0.075	**0.202**	-0.030	0.052	-0.165	-0.030	-0.091	0.044
NOL	0.020	0.031	0.030	0.050	**0.033**	0.020	0.021	0.030	0.028	-0.006
LL	0.039	0.014	0.022	-0.077	0.018	**0.029**	0.031	0.018	0.079	0.005
LW	-0.010	-0.156	-0.080	0.247	0.194	0.032	**0.303**	0.191	0.255	-0.094
SD	-0.072	-0.063	-0.015	-0.014	-0.088	-0.060	-0.061	**0.097**	-0.082	0.020
LS Ratio	0.002	0.016	0.017	-0.033	-0.062	-0.019	-0.061	-0.061	**0.072**	0.022
DFY	-0.205	0.107	0.230	-0.097	-0.078	0.073	-0.139	-0.091	-0.136	**4.478**
GFY	0.075	0.042	0.018	0.072	0.072	0.038	0.072	-0.037	0.002	0.011

PP: Plant Population/row; NOD: Days to 50% flowering; PH: Plant height (cm); NOT: Number of tillers/plant; NOL: Number of leaves/plant; LL: Leaf length (cm); LW: Leaf breadth (cm); SD: Stem diameter (mm); L: S: Leaf Stem ratio; GFY: Green fodder yield (kg/plot); DFY: Dry fodder yield (kg/plot).

yield, the traits like plant height, stem diameter, exhibited positive effect *via* dry fodder yield. These results indicated the importance of various traits in the development of selection indices for higher green fodder yield Plant height showed positive indirect effect on green fodder yield through number of tillers/ plant, DFY. Considering the green fodder yield as dependent traits the effect of other (independent) traits was studied in the population of sorghum. The residual effects were 0.179 in F_3 population and 0.238 in F_4 population indicating the explanation of dependent variable by all the independent variables. These results were in conformation with studies by Kolekar *et al.*, 2021, Thant *et al.*, 2021, Rohilla *et al.*, 2020, and Kalpande *et al.*, (2014).

CONCLUSION

In the current study, wide variation along with high heritability and genetic advance as per cent of mean was exhibited by 200 lines both in F_3 and F_4 generation for most of the characters especially for GFY and DFY. The results of association studies revealed positive association of GFY with DFY, plant population/row and plant height and direct positive effect of DFY along with number of tillers/plant and leaf width on GFY. Therefore, in order to improve high GFY, one should consider these characters in sorghum breeding programme.

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