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Variability and Correlation studies in F_2 generation of Sorghum (*Sorghum bicolor* (L. Moench)

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ABSTRACT

The analysis of variance showed significant differences among the genotypes for all the traits indicated wide range of variability among genotypes for yield and yield contributing characters and ample scope of improvement by selection. High estimates of genotypic and phenotypic coefficient of variation were recorded for plant height, number of primaries per panicle, panicle length, grain yield per plant, fodder yield per plant and threshed grade score. While, traits with moderate GCV and PCV values were panicle width and 100-seed weight and finally days to 50% flowering was categorized as low. Accordingly, high heritability was computed for Days to 50% flowering, Plant height (cm), No. of primaries /panicle, No. of grains /primary, and Grain yield /plant (g). The characters plant height, panicle length, No. of primaries /panicle, No. of grains /primary and grain yield, expressed high estimate of heritability accompanied with moderate to high genetic advance indicating additive gene action and thus selection for these characters in genetically diverse material would be more effective for desired genetic improvement.

Keywords: *Sorghum Variability, Heritability and Genetic advance*

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INTRODUCTION

Genetic variability for economic traits is the pre-requisite for any successful breeding programmers as the degree of response to selection depends on the quantum of variability. In any crop, yield being a complex character influenced by many of its contributing characters controlled by polygene and the environmental factors. So, an understanding of genetics of yield and its component traits, association between each component trait and yield is necessary for planning effective selection procedure in developing high yielding genotypes. However, the inheritance of quantitative traits is often influenced by variation in other character which may be due to pleiotropy or genetic linkage. Hence, knowledge of association between yield and its attributes obtained through estimation of genotypic and phenotypic correlation helps in determining the extent of improvement that could be brought about in the characters and also in selecting suitable genotypes. Correlation coefficients nearly describe the existence of association between characters. It is rather difficult to explain a system of correlation as the indirect association of the character increase. The method of path coefficient developed by Wright [16] is helpful in assessing whether association of characters with yield is having direct or indirect effect on yield or is a consequence in indirect effect through some other traits.

MATERIAL AND METHODS

Experimental material for present investigation consists of 14 F_2 populations derived from double crosses of elite *kharif* sorghum genotypes and one check PVK 809. These genotypes were evaluated at Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *Kharif* 2017-18. 30 plants from each of the F_2 were randomly selected for recording observations. The experiment was laid in Randomised Block Design with three replications. 10 rows of each F_2s in each replication were sown following a spacing of 45cm and 15 cm between and within rows. Observations were recorded for the eleven characters. The analysis of variance was done as suggested by [11]. Transgressive segregant will be judged on the basis of individual plant performance showing extreme phenotypes for a trait over their parental mean. Transgressive segregant (%) = No. of Transgressive Segregant /Total No of plants x 100.

Table 1 List of genotypes of *kharif* sorghum used for the study

Cross No.	F_2 Population
I	(IVT 4001 x 47708) x (AKR 426 x 47708)
II	(98B x 8B) x (296B x 232B)
III	(KR 123 x 135413) x (AKSV 181 x SFR 8)
IV	(KR 123 x 135413) x (PVK 400 x SFR 8)
V	(71B x 135413) X (KR 123 x 135413)
VI	(AKR 426 x 9825 REC) x (KR 126 x I 26)
VII	(C43 x KR133) x (ICSR 14001 x WANI HURDA)
VIII	(8B x 135413) x (KR 123 x 135391)
IX	(71 B x 1017 B) x (28B x 38 B)
X	(71B x 135413) x (PVK 400 x SFR 8)
XI	(C 43 x AKR 426) x (AKR 492 x KR 196)
XII	(AKR 426 x KR 196) x (I 26 x KR 196)
XIII	(C 43 x KR 133) x (C 43 x KR 125)
XIV	(KR 123 x 135391) x (AKR 492 x KR 125)

RESULTS AND DISCUSSION

The analysis of variance showed significant differences among the genotypes for all the characters. This indicates that wide range of variability among genotypes is present for yield and yield contributing characters and ample scope of improvement by selection (Table 1). Similar results were recorded by Sanchez *et al.* (12). On the basis of mean performance (Table 2), cross I, cross III and cross XI were found early for days to 50 per cent flowering. In F_2 population cross I, cross II, cross III and cross IX recorded higher plant height than check. With regards to panicle length cross I, cross III and cross XI recorded highest panicle length followed by cross IX, cross XII and cross XIV. Cross II and cross XI recorded highest score for panicle width. Cross I, cross II and cross III recorded highest number of primaries per panicle which were followed by cross VI and cross VII. Among F_2 population, Cross I, cross XI and cross X recorded highest test weight. Cross I, cross II and cross XI recorded maximum grain yield, among F_2 population followed by cross IX, cross V and cross VI. Among the F_2 population cross II, cross III and cross XI recorded maximum fodder yield per plant than rest of the crossess and checks PVK 809, which were followed by cross IVcross V. The F_2 cross I and cross XI recorded highest threshed grade score than the others genotypes.According to Deshmukh *et al.* [5], phenotypic coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV) can be categorized as low (<10%), moderate (10-20%) and high (>20%). In the present study, high estimates of genotypic and phenotypic coefficient of variation were recorded for plant height, number of primaries per panicle, panicle length, grain yield per plant, fodder yield per plant and threshed grade score. While, traits with moderate GCV and PCV values were panicle width and 100-seed weight and finally days to 50% flowering was categorized as low. The PCV was relatively greater than GCV for the traits; however, the magnitude of the difference was low for all the traits except days to 50 %, flowering, plant height and grain yield per plant. This suggested that the influence of environmental factors for the phenotypic expression of genotypes was low and the higher chance of improvement of these traits through selection based on the phenotype performance. The narrow differences between PCV and GCV (Fig 1) suggested their relative resistance to environmental alterations. The high values of GCV and PCV for plant height, panicle length and grain yield per plant suggested that there was a possibility of improvement of these traits through direct selection [1, 3,15, 6]. Heritability of a trait is considered as very high or high when the values is 80% or more and moderate when it ranged from 40-80% and when it is less than 40%, it is low. Accordingly, high heritability was computed for Days to 50% flowering, Plant height (cm), No. of primaries /panicle, No. of grains /primary, and Grain yield /plant (g) (Table 3). High degree of heritability estimates suggested that the characters were under genotypic control and selection could be fairly easy and improvement is possible using selection breeding for these traits improvement. In present investigation, heritability ranged from 16.1 to 99.3 per cent.

Genetic advance as percent mean ranged from 7.240 for field grade score to 36.88 for plant height. Deshmukh *et al.* (5) classified genetic advance as percent of mean as low (<10%), moderate (10-20%) and high (>20%). Based on this classification, Plant height (cm). No. of grains /primary, Test weight (g) and Grain yield /plant (g) had high genetic advance as percent of mean in the current study.

It was suggested that the importance of considering both the genetic advance and heritability of traits rather than considering separately in determining how much can progress be made through selection (5).

The heritability estimates along with expected genetic advance are more useful for predicting yield under phenotypic selection than heritability estimates alone. High heritability accompanied with high genetic advance indicates preponderance of additive gene effect, in such case selection may be effective.
The characters plant height, panicle length, No. of primaries /panicle, No. of grains /primary and grain yield, expressed high estimate of heritability accompanied with moderate to high genetic advance indicating additive gene action and thus selection for these characters in genetically diverse material would be more effective for desired genetic improvement.

Table 1: Analysis of variance for various characters in double cross F_2 population of sorghum

Sources of variation	DF	Mean sum of squares										
		Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle width (cm)	No. of primaries/panic	No. of grains / primary	Test weight (g)	Grain yield / plant (g)	Fodder yield / plant(g)	Field grade score (1-9)	Threshed grade score (1-9)
Replication	1	0.107	4.033	1.633	0.300	10.800	4.033	0.027	5.633	374.533	1.200	0.033
Treatments	13	30.176**	2398.58**	21.604**	2.747**	57.485**	68.247**	0.160*	140.157**	1025.914**	1.176*	2.628**
Error	13	2.785	16.461	5.776	1.157	3.371	3.961	0.048	4.061	418.819	0.985	0.961

Table 2: The Mean performances of eleven characters for various traits in double cross F_2 population of *Kharif* sorghum

Cross No.	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle width (cm)	No. of primaries/pa nicle	No. of grains / primary	Test weight (g)	Grain yield / plant (g)	Fodder yield / plant(g)	Field grade score (1-9)	Threshed grade score (1-9)
I	67	244	32	10.5	71	44	2.45	59.5	159	2.5	5.5
II	70.5	237	30	11	69.5	45	1.75	59	168	3.5	4.5
III	62	230.5	33	10	72	46.5	1.8	54	181	3	4.5
IV	76	222.5	22	9.5	57	36.5	1.65	43.5	144.5	4	2.5
V	71.5	212.5	25	8.5	59	38.5	1.6	47	144	3	2.5
VI	75	179	25.5	8	63.5	36.5	1.5	46.5	175	3.5	5.5
VII	76.5	181	24	8	62	34.5	1.55	38	123.5	2.5	4.5
VIII	76	139.5	25.5	8.5	63.5	38	1.8	34	106	4.5	2.5
IX	72.5	222	27	10	66.5	45.5	2.1	58.5	142.5	2.5	5
X	75	178	28.5	7.5	60	42	1.5	40	136.5	4.5	4.5
XI	71	185	30	10.5	67.5	44	2.05	59	177.5	3	5
XII	71.5	148	26	7.5	54.5	30	1.45	46	155	4	4
XIII	74	142	23.5	8	56.5	33.5	1.5	49	132.5	4.5	5.5
XIV	75	167.5	27.5	8.5	61	30	1.85	56	156.5	3.5	3
GM	72..446	192.100	27.366	9.033	63.200	38.366	48.900	48.900	147.800	3.533	4.300
SE±	1.180	2.869	1.699	0.760	1.298	1.407	0.149	1.425	14.471	0.702	0.693
CD at 5%	3.579	8.702	5.154	2.280	3.938	4.269	0.454	4.322	43.893	2.106	2.103

High heritability with low genetic advance reveals preponderance of non additive gene action. Further, days to 50% flowering showed moderate heritability but, did not show equally high genetic advance. The characters with high heritability coupled with high genetic advance would respond to selection better than those with high heritability and low genetic advance. days to 50 per cent flowering, panicle length, number of primaries per panicle, number of grains per primary and grain yield per plant had high heritability with low genetic advance suggesting the variability for these characters is governed by non-additive gene action indicating the limited scope for improving these characters through phenotypic selection (13, 6). Heritability, which is a ratio of genotypic and phenotypic variance, is mainly due to the additive gene effects in narrow sense, but in the broad sense it includes both additive as well as non additive gene effects. The heritability values estimated in the present study are expressed in broad sense. Broad sense heritability, however gives only a rough estimate. If heritability was mainly due to additive effects, it would be associated with high genetic gain and if it is due to non-additive, genetic gain would be low (11).

In the present investigation, significant and positive correlation of grain yield were observed with characters *viz.,* plant height, panicle length, panicle width, number of primaries per panicle, number of grains per primary, test weight and fodder yield per plant. Plant height, panicle length, number of primaries per panicle, number of grains per primary, test weight and fodder yield per plant positive direct effect on grain yield per plant at both genotypic and phenotypic level (Table 4 and 5). These results are in agreement with the results reported by Lamani *et al.* (10) and Khandelwal *et al.* (8) for number of primaries per panicle, plant height and fodder yield per plant.

Thus, it may be concluded from the present study that the traits like panicle length, panicle width, number of primaries per panicle, number of grains per primaries and 100-seed weight had greater importance for indirect selection for grain yield. Hence, due consideration should be given to these characters, while planning a breeding strategy for increased grain yield in *kharif* sorghum. The residual effect was found to be moderate which indicates that there may be some more components that are contributing towards dependent traits.

Table 3: Genetic variability parameters for yield and yield contributing characters in double cross F_2 population of *Kharif* sorghum

Sr. No.	Characters	Range		Mean	σ^2 (g) (Genotypic variance)	σ^2 (p) (Phenotypic variance)	GCV (%)	PCV (%)	h^2b.s.(%)	GA	GA as % of mean
		Minimum	Maximum								
1	Days to 50% flowering	67	77	72.466	13.695	15.088	5.106	5.360	90.7	7.263	10.022
2	Plant height (cm)	142	244	192.100	1191.061	1199.292	17.965	18.027	99.3	70.849	36.881
3	Panicle length (cm)	22	33	27.366	7.914	10.802	10.279	12.009	73.2	4.960	18.125
4	Panicle width (cm	7.5	11	9.033	0.795	1.373	9.871	12.975	57.8	1.397	15.472
5	No. of primaries /panicle	54	71	63.200	27.057	28.742	8.230	8.483	94.1	10.396	16.450
6	No. of grains /primary	30	46.50	38.366	32.142	34.123	14.777	15.225	93.1	11.335	29.544
7	Test weight (g)	1.4	2.45	1.770	0.057	0.080	13.589	16.008	72.0	0.420	23.764
8	Grain yield /plant (g)	34	60	48.900	68.047	70.078	16.869	17.119	97.1	16.745	34.243
9	Fodder yield /plant (g)	132	181	147.800	303.547	512.957	11.788	15.323	59.1	27.609	18.680
10	Field grade score **(1-9)**	2.5	4.5	3.533	0.095	0.588	8.734	21.704	16.1	0.255	7.240
11	Threshed grade score	2.5	5.5	4.300	0.833	1.314	21.229	26.661	63.4	1.497	34.823

Table 4: Genotypic and phenotypic correlation coefficient for eleven characters studied in sorghum

		Plant height (cm)	Days to 50% flowering	Panicle length(cm)	Panicle width (cm)	No. of primaries/ panicle	No. of grains/ primary	Test weight (g)	Fodder yield / plant(g)	Field grade score (1-9)	Threshed grade score (1-9)	Grain yield / Plant (g)
Plant height (cm)	G	1	-0.4025	0.5312 **	0.7126 **	0.3919 **	0.4874 **	0.5177 **	0.4336 **	-0.2472	-0.0125	0.3235 **
	P	1	-0.2909	0.3612 **	0.3922 **	0.3581 **	0.4330 **	0.4104 **	0.3603 **	-0.1960	-0.0046	0.2947 **
Days to 50% flowering	G		1	-0.6625	-0.5934	-0.5369	-0.2545	-0.3666	-0.2521	0.3827 **	-0.0975	-0.3609
	P		1	-0.3660	-0.2941	-0.3815	-0.1922	-0.2399	-0.2069	0.2560 *	-0.0422	-0.2807
Panicle length(cm)	G			1	0.8951 **	0.7707 **	0.4418 **	0.5188 **	0.5776 **	-0.3847	-0.0429	0.3728 **
	P			1	0.3118 **	0.5171 **	0.3424 **	0.3592 **	0.4954 **	-0.3088	0.0277	0.2992 **
Panicle width (cm)	G				1	0.9176 **	0.7252 **	0.9565 **	0.6765 **	-0.4050	0.1784	0.6963 **
	P				1	0.2561 *	0.4137 **	0.5194 **	0.4171 **	-0.1124	-0.0636	0.4515 **
No. of primaries/ panicle	G					1	0.5759 **	0.6192 **	0.4553 **	-0.4621	0.3714 **	0.5013 **
	P					1	0.5027 **	0.4502 **	0.3798 **	-0.3489	0.2658 *	0.4404 **
No. of grains/primary	G						1	0.4108 **	0.6699 **	-0.2030	0.2463 *	0.6777 **
	P						1	0.2831 **	0.0568	-0.1703	0.1753	0.6210 **
Test weight (g)	G							1	0.5719 **	-0.3934	0.0802	0.4627 **
	P							1	0.4260 **	-0.1642	0.1017	0.3739 **
Fodder yield / plant(g)	G								1	-0.0755	0.1628	0.5837 **
	P								1	-0.0850	0.0690	0.5080 **
Field grade score (1-9)	G									1	0.1251	-0.4910
	P									1	0.0765	-0.3532
Threshed grade score (1-9)	G										1	0.1776
	P										1	0.1496

***, ** = Significant at 5 % and 1% level of significance, respectively**

Table 5 Direct (diagonal) and indirect effects (Genotypic) of different characters on seed yield in sorghum

	Plant height (cm)	Days to 50% flowering	Panicle length (cm)	Panicle width (cm)	No. of primaries/ panicle	No. of grains/ Primary	Test weight (g)	Fodder yield/ Plant (g)	Field grade score (1-9)	Threshed grade score (1-9)
Plant height (cm)	**0.0923**	0.0371	-0.0490	-0.0657	-0.0361	-0.0450	-0.0478	-0.0400	0.0228	0.0012
Days to 50% flowering	0.0775	**-0.1926**	0.1276	0.1143	0.1034	0.0490	0.0706	0.0485	-0.0737	0.0188
Panicle length (cm)	0.0188	-0.0234	**0.0353**	0.0316	0.0272	0.0156	0.0183	0.0204	-0.0136	-0.0015
Panicle width (cm)	-0.3927	0.3270	-0.4932	**0.5511**	-0.5057	-0.3996	-0.5271	-0.3728	0.2232	-0.0983
No. of primaries	-0.0067	0.0091	-0.0131	-0.0156	**0.0170**	-0.0098	-0.0105	-0.0078	0.0079	-0.0063

/panicle										
No. of grains/primary	0.3230	-0.1687	0.2928	0.4807	0.3817	**0.6628**	0.2723	0.4440	-0.1345	0.1632
Test weight (g)	0.2186	-0.1548	0.2191	0.4039	0.2615	0.1735	**0.4223**	0.2415	-0.1661	0.0339
Fodder yield/plant (g)	0.0915	-0.0532	0.1219	0.1427	0.0961	0.1413	0.1207	**0.2110**	-0.0159	0.0344
Field grade score (1-9)	0.0867	-0.1342	0.1348	0.1419	0.1620	0.0711	0.1379	0.0265	**-0.3505**	-0.0438
Threshed grade score (1-9)	-0.0010	-0.0074	-0.0033	0.0136	0.0283	0.0188	0.0061	0.0124	0.0095	**0.0763**
Grain yield /plant (g)	0.3235	-0.3609	0.3728	0.6963	0.5013	0.6777	0.4627	0.5837	-0.4910	0.1776

***, ** = Significant at 5 % and 1% level of significance, respectively**

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