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Genetic variability, correlation and path analysis studies in B parental lines of *kharif* sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract

The field experiment was conducted to evaluate 15 B *kharif* parental lines for variability, correlation and path analysis studies for eleven yield and yield attributing traits *viz.* plant height, days to 50 % flowering, pollen fertility, days to maturity, number of primaries per cob, number of grains per primary, panicle length, panicle width, 1000 grain weight, grain yield and fodder yield per plant. Grain yield and fodder yield per plant expressed high estimates of GCV and PCV. Number of primaries per cob, number of grains per primary, panicle length, panicle width and 1000 grain weight had positive correlation with grain yield per plant through direct and indirect effects. Also, these characters exhibited high heritability coupled with high genetic advance. AKMS 33 B, AKMS 90 B, 49 B, 98 B, PMS 100 B showed better performance for all characters thus, should be utilized for development of hybrid combinations in breeding programmes.

Keywords: *kharif* sorghum, genetic variability, correlation, path analysis, B lines

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench.) is one of the important crops of semi-arid tropics. In India, sorghum is an essential staple food for the people occupied in dry regions of the country. It is cultivated during rainy (*Kharif)* and winter (*Rabi)* season. It is originated from Africa and it's closely related wild species are found in southern region of Sahara Desert (Legwaila *et al*. 2003) [20]. It is a member of tribe *Andropogoneae* and family *Poaceae*. According to USDA (United States Department of Agriculture) India shared an area of 4100 thousand hectare with production of 4740 thousand metric tonnes and yield of 1.2 metric tonnes per hectare in year 2020-2021 (USDA, Economic Research Service 2020-2021). It is cultivated in Maharashtra both for grain and fodder during *kharif* with an area of 281 thousand ha with productivity of 207 thousand metric tonnes. *Kharif* sorghum is becoming popular for poultry and animal feed. The prime objective of any plant breeding programme is to increase the yield and improve the quality. A choice of the suitable parents for successful development of superior varieties or hybrids is a major concern to plant breeder. For this purpose, utilization of variability and selection of genotypes is necessary.

Heritability and GAM (Mean Genetic Advance) are the important selection parameters. It helps in predicting the gain under selection. High heritability coupled with high GAM exhibit additive gene action and further selection is effective, whereas the traits showing low heritability and low GAM exhibits the high influence of environment, thereby selection proves to be ineffective.

Yield and its contributing characters have complex gene action and governed by polygenes hence needs a comprehensive understanding on the nature and magnitude of gene action. Correlation analysis measures the mutual relationship between plant character and determine its component characters for genetic improvement in yield. Though this Correlation study provides the extent of association between characters and yield but fails to provide information of effects of these components. Path analysis splits Correlation coefficient into direct and indirect effects. Thus, it measures cause of association between two variables and effect situation. These biometrical techniques are thus useful in the selection of elite genotypes in plant breeding population especially in B lines in hybrid development programme.

The discovery and utilisation of the male sterility system have led to the successful commercial exploitation of heterosis. For the development of hybrid parents using B Lines, its identification is important resulting in selection of superior traits along with higher yields in sorghum hybrid production.

Materials and Methods

The study was carried out during *Kharif* (2020) at Sorghum Research station, VNMKV, Parbhani. The experimental material consists of 15 B Parental lines received from IIMR-Hyderabad, ICRISAT-Hyderabad and Akola listed in table: 1. The study was laid out on Randomized Block Design with three replications having spacing of 45cm x 15cm in row to row: plant to plant respectively. The experimental material was sown by dibbling 2-3 seeds per hill on the plot size of 2 rows of 3m length. The recommended agronomical and plant protection practices were followed regularly. The observations were recorded for eleven characters *viz.* plant height (cm), days to 50% flowering, pollen fertility (%), days to maturity, number of primaries per cob, number of grains per primary, panicle length (cm), panicle width (cm), 1000 grain weight (g), grain yield per plant (g) and fodder yield per plant (g). For statistical analysis the mean values of five randomly selected plants were taken in each replication. The data were subjected to statistical analysis as per the description of Panse and Sukhatme (1985) [21]. The genotypic and phenotypic variance was calculated by using mean square from variance table (Burton 1952).

Table 1: List of B parental lines used for this study

S. No.	B Line (parental lines)	Source	S. No.	B Line (parental lines)	Source
1.	2219 B	IIMR, Hyderabad	9	127B	Parbhani
2.	101 B	ICRISAT, Hyderabad	10	AKMS 30B	Akola
3.	28 B	Parbhani	11	AKMS 33B	Akola
4.	25625 B	Parbhani	12	AKMS 70B	Akola
5.	237 B	Parbhani	13	AKMS 90B	Akola
6.	90 B	Parbhani	14	PMS 100B	Parbhani
7.	49 B	Parbhani	15	PMS 237B	Parbhani
8.	98 B	Parbhani			

Results and Discussion

Analysis of variance showed significant differences for all the characters studied for B lines which revealed that traits had wide range of variability for yield and yield contributing traits and had good scope of improvement through selection.

The best performance on the basis of mean values for grain yield per plant was observed for PMS 100 B (38.26g), 28 B (35.17g) and 25625 B (32.71g). 98 B (33.73g) showed maximum panicle length while 101 B (9.23 cm) was observed with maximum panicle width. The genotype 28 B (65.33 primaries per cob) was observed with high number of primaries. 49 B (96.93 grains) exhibited high number of grains per primary. Also, 49 B (31.14 g) was observed with bold seed having maximum test weight.

Wide range of variability was observed for majority of yield contributing characters for B lines. Range of variation on the basis of mean performance displayed considerable amount of differences but variation was more for characters *viz.*, plant height, fodder yield per plant, number of grains per primaries, panicle length and panicle width. Similar results were reported by Arunkumar *et al.* (2004), Sharma *et al.* (2004) and Godbharle *et al.* (2010) [14]. The genetic parameters are represented in Table 2.

According to Sivasubramanian and Menon (1973) [26] GCV and PCV were categorized as Low (0-10%), moderate (10-20%) and High (20% and above). The GCV was lower than PCV for all characters studied. High estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was observed for traits *viz.* grain yield per plant and fodder yield per plant whereas moderate GCV and PCV was observed for number of primaries per cob, number of grains per primary, panicle length and panicle width. Similar results were reported by Chavan *et al.* (2010) [7], Arun kumar *et al.* (2013) [4], Jain *et al.* (2016) [16], Gebregergs *et al.* (2020) [11].

According to Johnson *et al.* (1955) [18], Heritability was categorized as Low (0-30%), Medium (31-60%) and High (61% and above). Johnson (1955) [18] classified genetic advance as per cent of mean (GAM) in categories of Low (< 10%), Moderate (10-20%) and High (>20%). Thus, these categories were considered in this study. High heritability coupled with high genetic advance were recorded for characters *viz.* Number of primaries per cob, number of grains per primary, panicle length, panicle width, grain yield per plant and fodder yield per plant for B lines. The results were in accordance with findings of Chavan *et al.* (2010) [7] for Number of primaries per cob, number of grains per primary and Khandelwal *et al.* (2016) [19], Bhagasara *et al.* (2017) [5], Jimmy *et al.* (2017) [17], Sabiel *et al.* (2015) [23] for panicle length and panicle width, while similar results were obtained by Sharma *et al.* (2006) [25], Deepalakshmi *et al.* (2007) [9], Amare *et al.* (2015) [3], Ghorade *et al.* (2015) [13], Jain *et al.* (2016) [16], Gebregergs *et al.* (2020) [11] for grain yield per plant and Arun kumar *et al.* (2013) [4] for fodder yield per plant. These traits are expected to respond to selection better in plant breeding programme as compared to traits with high heritability and low genetic advance. High heritability and low genetic advance was recorded for character days to maturity, similar findings were obtained by Deepalakshmi *et al.* (2007) [9], Amare *et al.* (2015) [3], Dhutmal *et al.* (2020) [10].

Table 2: Genetic variability parameters for eleven characters of B parental lines of *kharif* sorghum

Parameters	Plant height (cm)	Days to 50% flowering	Pollen fertility (%)	Days to maturity	No. of primaries/ cob	No. of grains/ primaries	Panicle length (cm)	Panicle width (cm)	Grain yield/plant (g)	Fodder yield/plant (g)	1000 grain weight (g)
Mean	182.23	73.01	89.42	107.14	52.24	78.11	28.47	7.30	28.15	85.67	28.42
Range Lowest	140.00	67.00	71.67	101.67	42.00	51.13	21.93	6.10	21.81	56.67	23.03
Range Highest	242.00	80.33	95.00	112.33	62.00	102.73	35.67	8.77	39.40	123.33	31.82
GCV	12.635	6.327	17.987	3.112	13.819	14.366	15.559	15.489	20.164	24.741	7.093
PCV	16.114	7.716	18.411	3.5	14.471	14.94	16.591	16.057	20.852	31.436	8.079
h^2(Broad Sense)	61.5	67.2	95.4	79.1	91.2	92.5	88	93	93.5	61.9	77.1
Gen. Adv 5%	36.968	7.743	28.195	6.09	14.113	21.925	8.508	2.227	10.902	32.534	3.622
Gen. Adv as % of mean 5%	20.409	10.688	36.199	5.701	27.187	28.456	30.059	30.777	40.167	40.11	12.827

Correlation

In the present study as represented in table 3, for B lines, the genotypic and phenotypic correlation of grain yield with number of primaries per cob, number of grains per primary, panicle length and panicle width were positive and significant, indicating increase in one or more of these characters will further increase grain yield. Similar findings were obtained by Dhutmal *et al.* (2020) [10] for number of primaries per cob, Arun kumar *et al.* (2013) [4], Ramaling *et al.* (2016) [22] for panicle length. Similar results were reported by Al-Naggar *et al.* (2018) [2] for number of grains per primaries while fodder yield per plant was significant and positively correlated with grain yield at genotypic level only as reported by Godbharle *et al.* (2010) [14], Arun kumar *et al.* (2013) [4].

Table 3: Genotypic and phenotypic correlation coefficient matrix for B lines

Characters		Plant height (cm)	Days to 50% flowering	Pollen fertility (%)	Days to maturity	No. of primaries/cob	No. of grains per primary	Panicle length (cm)	Panicle width (cm)	Fodder yield per plant (g)	1000 grain weight (g)	Grain yield per pl
		1	2	3	4	5	6	7	8	9	10	11
Plant height (cm)	G	1	-0.1848	0.429**	0.2261	-0.0528	0.380*	0.402**	0.618**	0.0002	0.474**	0.0779
	P		0.0403	0.3331 *	0.1975	-0.0644	0.2658	0.3523 *	0.5347 ***	0.122	0.2907	0.0281
Days to 50% flowering	G		1	-0.384**	0.630**	0.369*	0.2129	-0.1219	0.1926	-0.1996	-0.0194	0.1451
	P			-0.2746	0.5728 ***	0.3367 *	0.1609	-0.0555	0.1854	-0.2062	-0.0139	0.0999
Pollen fertility (%)	G			1	-0.680**	0.073	0.0814	0.1776	0.1551	0.1699	-0.2744	-0.0686
	P				-0.5602 ***	0.0758	0.0832	0.1406	0.1408	0.1207	-0.236	-0.0541
Days to maturity	G				1	0.0056	0.1809	0.0728	0.394**	-0.313*	0.2711	-0.0428
	P					0.0184	0.1619	0.083	0.3403 *	-0.3100 *	0.2149	-0.0351
No. of primaries/cob	G					1	0.2609	0.359*	0.440**	0.0654	0.0392	0.709**
	P						0.2338	0.3178 *	0.4063 **	0.04	-0.0202	0.654**
No. of grains per primary	G						1	0.824**	0.472**	-0.387**	0.484**	0.395**
	P							0.7287 ***	0.4242 **	-0.3598 *	0.4037 **	0.372*
Panicle length (cm)	G							1	0.578**	-0.2219	0.580**	0.454**
	P								0.5274 ***	-0.1617	0.5075 ***	0.413**
Panicle width (cm)	G								1	0.0138	0.258	0.596**
	P									0.0287	0.1964	0.520**
Fodder yield per plant (g)	G									1	-0.2685	0.370*
	P										-0.1993	0.2824
1000 grain weight (g)	G										1	0.1926
	P											0.1829
Grain yield per pl	G											1
	P											

*Indicates significance at 5 per cent level.
** Indicates significance at 1 per cent level.
***Indicates significance at 0.1 per cent level.

Path analysis

The path coefficient analysis revealed that direct and positive effect on grain yield per plant was obtained for characters *viz.* Number of primaries per cob, number of grains per primary panicle width, 1000 grain weight, fodder yield per plant at both genotypic and phenotypic level (Table 4 and 5). The results were in accordance with findings of Chaudhary *et al.* (2001) [8], Deepalakshmi *et al.* (2007) [9], Subhashini *et al.* (2019) for number of primaries, Chaudhary *et al.* (2001) [8], Sharma *et al.* (2006) [25], Akatwijuka *et al.* (2019) [1] for panicle width, Ramaling *et al.* (2016) [22] for 1000 grain weight while negative direct effect for grain yield was obtained for pollen fertility, plant height, panicle length, days to maturity at both genotypic and phenotypic level. Similar findings were obtained by Chaudhary *et al.* (2001) [8], Ramaling *et al.* (2016) [22], Subalakhshmi *et al.* (2019) [27] for plant height, Deepalakshmi *et al.* (2007) [9], Khandelwal *et al.* (2016) [19] for days to maturity.

In genotypic level, negative direct effect was observed for days to 50 per cent flowering whereas positive direct effect was observed at phenotypic level only. Results were in accordance with findings of Chaudhary *et al.* (2001) [8], Zinzala *et al.* (2018) [28], Akatwijuka *et al.* (2019) [1], Subalakhshmi *et al.* (2019) [27] for days to 50 per cent flowering at genotypic level and at phenotypic level. The residual effects were moderate which indicate that more attributes are contributing for yield.

Positive indirect effects on grain yield were obtained for characters *viz.* Plant height, days to 50 per cent flowering, days to maturity, number of grains per primary, number of primaries per cob, panicle length, Panicle width, fodder yield per plant and 1000 grain weight at both genotypic and phenotypic level. Similar results were given by Dhutmal *et al.* (2020) [10] for plant height and 1000 grain weight, Khandelwal *et al.* (2016) [19], Ramaling *et al.* (2016) [22] for days to 50 per cent flowering and 1000 grain weight, Subalakhshmi *et al.* (2019) [27] for number of primaries per cob, Gebreyohannes *et al.* (2018) [12] for number of grains per primary, Chaudhary *et al.* (2001) [8], Arun kumar *et al.* (2013) [4], Khandelwal *et al.* (2016) [19], Subalakshmi *et al.* (2019) for panicle length and panicle width. Whereas pollen fertility had negative indirect effect on grain yield for genotypic and phenotypic level.

Table 4: Direct and indirect effects of yield components on grain yield for B lines at genotypic level

Characters	Plant height (cm)	Days to 50% flowering	Pollen fertility (%)	Days to maturity	No. of primaries/ cob	No. of grains /primary	Panicle length (cm)	Panicle width (cm)	Fodder yield/plant (g)	1000 grain weight (g)	Grain yield/plant (g)
Plant height (cm)	-0.2237	0.0413	-0.0959	-0.0506	0.0118	-0.0849	-0.0898	-0.1384	0	-0.106	0.0779
Days to 50% flowering	0.0291	-0.1574	0.0604	-0.0992	-0.0581	-0.0335	0.0192	-0.0303	0.0314	0.0031	0.1451
Pollen fertility (%)	-0.0992	0.0887	-0.2314	0.1572	-0.0169	-0.0188	-0.0411	-0.0359	-0.0393	0.0635	-0.0686
Days to maturity	-0.0784	-0.2184	0.2355	-0.3466	-0.0019	-0.0627	-0.0252	-0.1365	0.1083	-0.094	-0.0428
No. of primaries/cob	-0.0444	0.3101	0.0614	0.0047	0.8402	0.2192	0.3016	0.3694	0.055	0.0329	0.709**
No. of grains/primary	0.4501	0.2526	0.0965	0.2146	0.3094	1.186	0.9772	0.5598	-0.4588	0.5744	0.395**
Panicle length (cm)	-0.4115	0.125	-0.1821	-0.0747	-0.368	-0.8446	-1.0251	-0.5928	0.2275	-0.5946	0.454**
Panicle width (cm)	0.266	0.0829	0.0667	0.1694	0.1891	0.2031	0.2488	0.4302	0.0059	0.111	0.596**
Fodder yield/plant (g)	0.0001	-0.1226	0.1044	-0.1921	0.0402	-0.2377	-0.1363	0.0085	0.6143	-0.165	0.370*
1000 grain weight (g)	0.1109	-0.0045	-0.0642	0.0634	0.0092	0.1133	0.1357	0.0604	-0.0628	0.234	0.1926
Grain yield/plant (g)	0.0779	0.1451	-0.0686	-0.0428	0.7088	0.3951	0.4542	0.5955	0.3697	0.1926	1
Partial R^2	-0.0174	-0.0228	0.0159	0.0148	0.5955	0.4686	-0.4656	0.2562	0.2271	0.0451	

Table 5: Direct and indirect effects of yield components on grain yield for B lines at phenotypic level

Characters	Plant height (cm)	Days to 50% flowering	Pollen fertility (%)	Days to maturity	No. of primaries/ cob	No. of grains/ primary	Panicle length (cm)	Panicle width	Fodder yield/plant (g)	1000 grain weight (g)	Grain yield/pl (g)
Plant height (cm)	-0.2558	-0.0103	-0.0852	-0.0505	0.0165	-0.068	-0.0901	-0.1368	-0.0312	-0.0744	0.0281
Days to 50% flowering	0.0026	0.0649	-0.0178	0.0372	0.0218	0.0104	-0.0036	0.012	-0.0134	-0.0009	0.0999
Pollen fertility (%)	-0.0547	0.0451	-0.1642	0.092	-0.0124	-0.0137	-0.0231	-0.0231	-0.0198	0.0387	-0.0541
Days to maturity	-0.0488	-0.1415	0.1385	-0.2471	-0.0046	-0.04	-0.0205	-0.0841	0.0766	-0.0531	-0.0351
No. of primaries/cob	-0.0344	0.1801	0.0406	0.0099	0.5349	0.125	0.17	0.2174	0.0214	-0.0108	0.654**
No. of grains/primary	0.1014	0.0614	0.0317	0.0618	0.0892	0.3815	0.278	0.1618	-0.1373	0.154	0.372*
Panicle length (cm)	-0.0041	0.0006	-0.0016	-0.001	-0.0037	-0.0085	-0.0117	-0.0062	0.0019	-0.0059	0.413**
Panicle width (cm)	0.2122	0.0736	0.0559	0.135	0.1612	0.1683	0.2093	0.3968	0.0114	0.0779	0.520**
Fodder yield/plant (g)	0.045	-0.0761	0.0445	-0.1143	0.0148	-0.1327	-0.0597	0.0106	0.3688	-0.0735	0.2824
1000 grain weight (g)	0.0355	-0.0017	-0.0288	0.0263	-0.0025	0.0493	0.062	0.024	-0.0244	0.1222	0.1829
Grain yield/pl (g)	0.0281	0.0999	-0.0541	-0.0351	0.6537	0.372	0.4132	0.5196	0.2824	0.1829	1
Partial R^2	-0.0072	0.0065	0.0089	0.0087	0.3497	0.1419	-0.0048	0.2062	0.1042	0.0224	

*Indicates significance at 5 per cent level.
** indicates significance at 1 per cent level and Genotypic and phenotypic residual effect: 0.383 and 0.487 respectively.

Conclusion

The present study revealed that B lines *viz.* AKMS 33B, AKMS 90B, 49B, 98B, PMS 100B showed better performances for nearly all characters. The characters *viz.* number of primaries per cob, number of grains per primary, panicle length, panicle width and 1000 grain weight had positive correlation with grain yield per plant through direct and indirect effects. Also, these characters exhibited high heritability coupled with high genetic advance. Further selection of these characters will improve the breeding efficiency of the genotypes. Hence, due consideration should be given for the traits while selecting parental lines.

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