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Genetic variability and correlation studies for productivity traits in *Rabi* sorghum [*Sorghum bicolor* (L.) Moench]

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Abstract
The genetic variability and nature of character association was studied in 122 *Rabi* sorghum genotypes. The phenotypic variance was higher than the genotypic variance for all the characters. High genotypic and phenotypic variance was observed for the characters *viz.*, stover weight, panicle length, panicle weight and grain yield. High magnitude of heritability coupled with high magnitude of genetic advance over mean was obtained for the characters *viz.*, days to 50 per cent flowering, plant height, panicle length, panicle girth, panicle weight, stover weight, grain yield and 1000-grain weight. There was positive and significant correlation between grain yield and days to 50 per cent flowering, days to physiological maturity, plant height, panicle girth, panicle weight, stover weight and 1000-grain weight. But, in present study grain yield is negatively and non-significantly correlated with panicle length. A strong correlation of these traits with grain yield indicated that simultaneous improvement of all the characters is possible.

Keywords: *Rabi* sorghum, productivity traits, genetic variability, correlation

Introduction
Sorghum is an important staple food for more than 300 million people and feed for cattle living in Asia and Africa. Sorghum is being cultivated in both the *kharif* and *Rabi* seasons. *Rabi* sorghum is highly valued because of its excellent grain and fodder quality. The most important factor affecting the utilization of *rabi* sorghum is its low productivity, this is mainly because of the varieties developed and released did not become popular because of yield advantage was not substantial over M-35-1 and the hybrids released were susceptible to shoot fly and hence leads to poor grain quality.

Progress in plant breeding depends on the extent of genetic variability present in a population. Therefore, the first step in any plant breeding program is to assess the magnitude of genetic variability present in the population. The genetic facts are inferred from phenotypic observations, which are the results of interactions of genotype and the environment. The variability available in breeding material is the prime requirement for the improvement and selection of elite genotypes. However, the quantitative characters are influenced by environment and necessitate the partitioning of overall variances as heritable and non-heritable components. The Yield is a complex character, which depends upon many independent contributing characters. Knowledge on type of association between yield and its components themselves greatly help in evaluating the contribution of different components towards yield, information on the nature of association between yield and its components help in simultaneous selection for many characters associated with yield improvements. The present investigation was carried out with the objective to estimate the extent of variability, heritability, genetic advance and nature of association between yield and its components.

Materials and methods
The present investigation was carried out during *Rabi* season 2013-14 at Regional Agricultural Research Station, Vijayapur (Karnataka, India). A total of 122 genotypes (IS lines, selected B and R lines) along with checks collected from All India Co-ordinated Sorghum Improvement Project, RARS, Vijayapur were used for the study. The design adopted was Randomized Block Design with two replications, with a spacing of 60 x 15 cm. Recommended package of practices were followed, and the crop growth was satisfactory. Three competitive plants were selected randomly from each row in each replication for recording the observations on various yield and component characters except for the characters days to 50 per cent flowering and days to physiological maturity which were recorded on plot basis.

The data was subjected to statistical analysis using WINDOSTAT software to estimate mean, range, ANOVA, variability parameters and correlation.

Results and Discussion

The mean sum of squares of different characters pertaining to yield and yield components were highly significant for all the 11 characters studied indicating the presence of sufficient amount of variability of these characters which provides ample scope for selection of superior and desirable genotypes for plant breeder for further genetic improvement (Table 1).

Table 1: Mean sum of squares for yield and yield components in 122 *Rabi* sorghum genotypes (IS lines, selected B and R lines) at Vijayapur during 2013-14.

Traits	Replication	Genotypes	Error	S.Em.±	CD 5%
Degrees of freedom	1	121	121		
Days to 50% flowering	5.31	134.26**	7.79	1.97	5.53
Days to physiological maturity	36.99	51.89**	9.49	2.17	6.10
SPAD at flowering	0.10	59.19**	36.48	4.25	11.96
SPAD at physiological maturity	0.36	33.21*	22.67	3.35	9.43
Plant height (cm)	2149.39	1794.87**	624.45	17.60	49.47
Panicle length (cm)	6.86	33.99**	4.12	1.43	4.02
Panicle girth (cm)	1.08	9.21**	3.18	1.26	3.53
Panicle weight per plant (g)	494.96	610.52**	127.88	7.96	22.39
Stover weight per plant (g)	490.95	3581.77**	706.88	18.72	52.64
Grain yield per plant (g)	215.37	330.72**	73.86	6.05	17.02
1000-grain weight (g)	8.58	89.64**	27.21	3.67	10.33

* - Significant at 5%, ** - Significant at 1%

Genotypic and Phenotypic variation

The present investigation indicated wide range of values for all the characters studied (Table 2), the phenotypic coefficient of variation (PCV) was though higher than genotypic coefficient of variation (GCV) for all the characters under study but the narrow range of difference indicated that most of the characters were least influenced by the environment. High values of GCV and PCV were obtained for the characters like stover weight (32.32% & 36.07%), panicle weight (28.92% & 32.53%), grain yield (27.59% & 31.30%) and panicle length (26.07% & 27.80%) indicating variation for these characters contributed markedly to the total variability. Similar, results were reported by Biradar *et al.* (1996) [1], Reddy *et al.* (1996) [2], Godbharle *et al.* (2010) [3] and Seetharam and Ganesamurthy (2013) [4].

Table 2: Comparison of variability parameters for yield and yield components in 122 *Rabi* sorghum genotypes (IS lines, selected B and R lines).

Traits	Mean	Min.	Max.	GCV	PCV	h^2 (%)	GA	GAM
Days to 50% flowering	78.51	59	92	10.13	10.44	94.20	15.90	20.95
Days to physiological maturity	124.10	102	135	3.71	4.10	81.71	8.57	6.91
SPAD at flowering	44.79	32.76	57.08	7.52	12.15	38.37	4.30	9.60
SPAD at physiological maturity	24.21	13.17	30.98	9.48	16.83	31.74	2.66	11.01
Plant height (cm)	165.62	101.83	231.17	14.61	18.09	65.21	40.24	24.30
Panicle length (cm)	14.83	8.08	29.67	26.07	27.80	87.89	7.46	50.34
Panicle girth (cm)	13.07	7.12	17.83	13.29	16.42	65.50	2.90	22.16
Panicle weight per plant (g)	53.71	24.08	136.00	28.92	32.53	79.05	28.45	52.97
Stover weight per plant(g)	117.32	12.47	217.33	32.32	36.07	80.26	69.97	59.64
Grain yield per plant (g)	41.08	16.08	80.01	27.59	31.30	77.66	20.57	50.08
1000-grain weight (g)	34.98	16.86	52.78	15.97	19.14	69.64	9.60	27.46

GCV - Genotypic coefficient of variance	**GA** – Genetic advance
PCV - Phenotypic coefficient of variance	**GAM** - Genetic advance as per cent over mean
h^2 – Heritability in broad sense	

Moderate GCV and PCV values were recorded for the characters like, 1000-grain weight (15.97% & 19.14%), plant height (14.61% & 18.09%), panicle girth (13.29% & 16.42%) and days to 50 per cent flowering (10.13% & 10.44%), these results were in accordance with Tiwari *et al.* (2003) [5] and Negash *et al.* (2005) [6] for plant height; Prabhakar (2001) [7], Veerabadhiran and Kennedy (2001) [8]; Seetharam and Ganesamurthy (2013) [4] for days to 50 per cent flowering. On the other hand, low GCV and PCV values were recorded for days to physiological maturity (3.71% & 4.10%).

Heritability and Genetic Advance

High magnitude of heritability coupled with high magnitude of genetic advance over mean (Table 2) was obtained for the characters *viz.*, days to 50 per cent flowering (94.20% & 20.95), plant height (65.21% & 24.30%), panicle length (87.89% & 50.34%), panicle girth (65.50% & 22.16%), panicle weight (79.05% & 52.97%), stover weight (80.26% & 59.64%), grain yield (77.66% & 50.08%) and 1000-grain weight (69.64% & 27.46%). Hence, selection made through these characters would be effective as they are more predominantly controlled by additive gene effect and thus while expecting genetic variability, due emphasis should be given to these characters. These results are in confirmation with the results of Seetharam and Ganesamurthy (2013) [4], Negash *et al.* (2005) [6], Bello *et al.* (2007) [9] and Deepalakshmi and Ganesamurthy [10].

However, days to physiological maturity (81.71% & 6.91%) showed high heritability coupled with low genetic advance indicating the preponderance of non-additive gene effects and high genotype and environment (G x E) interaction. This again reiterate the fact that it is difficult to make the progress in developing early maturing and high yielding genotypes and also limited scope for selection.

Correlation studies

In the present investigation, correlation is worked out among eleven characters. These traits could be considered as important traits for improving grain yield per plant and the results obtained are presented in Table 3. The grain yield had positive and significant correlation with days to 50 per cent flowering, days to physiological maturity, plant height, panicle girth, panicle weight, stover weight and 1000-grain weight. Among these, grain yield and panicle weight had highest positive significant value of r = 0.848.

A strong correlation of these traits with grain yield indicated that simultaneous improvement of all the characters is possible. This is in agreement with the reports of Ezeaku and Mohammed (2006) [11], Deepalakshmi and Ganesamurthy [10] and Aruna and Audilakshmi (2008) [12] reported that there is significant positive association between panicle weight and grain yield per plant. Ezeaku and Mohammed (2006) [11], Aruna and Audilakshmi (2008) [12], Sharma *et al*. (2006) [13], Elangovan *et al.* (2007) [14] and Warkad *et al.* (2010) [15] reported 100-seed weight is positively and significantly associated with grain yield per plant.

Table 3: Estimates of Phenotypic correlation coefficients for yield and yield components in 122 *Rabi* sorghum genotypes.

Traits	DFF	DPM	SPAD I	SPAD II	PH	PL	PG	PW	SW	1000 G wt.	GY
DFF	1.000	0.615**	0.131*	0.545**	0.114	0.339**	-0.063	0.083	-0.107	-0.235**	0.138*
DPM		1.000	0.243**	0.223**	0.239**	0.253**	-0.0010	0.091	0.057	-0.161*	0.182**
SPAD I			1.000	0.090	0.004	0.396**	-0.122	-0.029	-0.159*	-0.303**	0.024
SPAD II				1.000	-0.049	0.328**	-0.063	0.147*	-0.049	-0.140*	0.101
PH					1.000	0.015	0.204**	0.339**	0.459**	0.167**	0.363**
PL						1.000	-0.399**	-0.056	-0.362**	-0.472**	-0.056
PG							1.000	0.758**	0.525**	0.483**	0.660**
PW								1.000	0.534**	0.447**	0.848**
SW									1.000	0.541**	0.448**
1000 G wt.										1.000	0.503**
GY											1.000

*-Significant @ 5% (r=0.1256) probability level, **-Significant @ 1% (r=0.1646) probability level

DFF:	Days to 50% flowering (days)	PH:	Plant height (cm)	SW:	Stover weight/plant (g)
DPM:	Days to physiological maturity(days)	PL:	Panicle length (cm)	GY:	Grain yield/plant (g)
SPAD I:	SPAD at DFF	PG:	Panicle girth (cm)	1000 G wt.:	1000-grain weight (g)
SPAD II:	SPAD at DPM	PW:	Panicle weight/plant (g)		

Aruna and Audilakshmi (2008) [12] and Mahajan *et al*. (2010) [16] reported that, there is significant positive association between panicle length and grain yield per plant. But, in present study grain yield is negative and non-significantly correlated with panicle length.

From the correlation studies, it was inferred that grain yield per plant had significant and positive association with days to 50 per cent flowering, days to physiological maturity, plant height, panicle girth, panicle weight, stover weight and 1000-grain weight. Hence, in the further improvement programme due importance may be given for these traits to improve genetic yield potential in *Rabi* sorghum.

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