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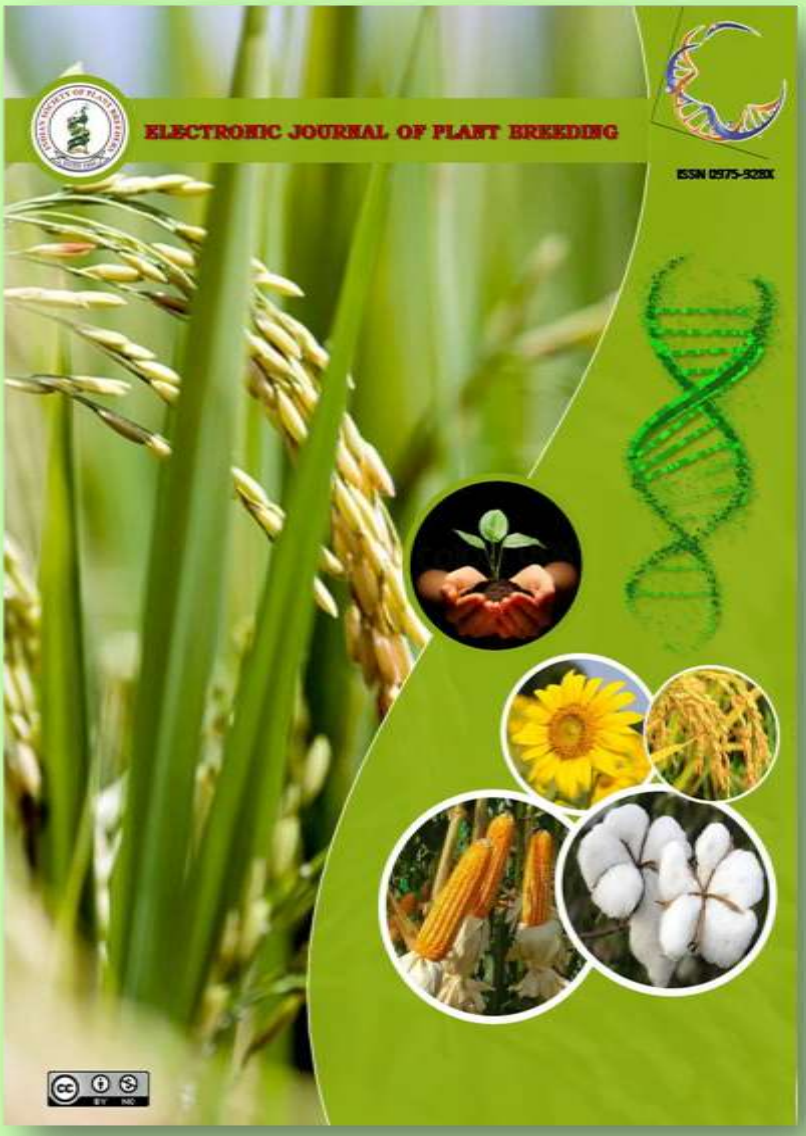

ISSN: 0975-928X

Volume: 10

Number:2

EJPB (2019) 10(2):483-489

DOI: 10.5958/0975-928X.2019.00061.9

https://ejplantbreeding.org

Electronic Journal of Plant Breeding, 10 (2): 483-489 (Jun 2019) DOI: 10.5958/0975-928X.2019.00061.9
ISSN 0975-928X

Research Article

Association and variability studies in F_2 population of sorghum (*Sorghum bicolor* (L.) Moench)

S. Subhashini* and B. Selvi
Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore-641003
E-Mail: subhagokul199646@gmail.com

(Received: 10 Mar 2019; Revised: 21 May 2019; Accepted: 21 May 2019)

Abstract
A field experiment was conducted to evaluate Sorghum (*Sorghum bicolor* (L.) Moench) F_2 population of CO 30 x SPV 2308 and CO 30 x SPV 2307 crosses raised during the *Kharif* 2018. Variability and association were studied for nine morphological traits *viz.*, Plant height, Days to flowering, Number of leaves, Flag leaf length, Flag leaf width, Panicle length, Panicle weight, Number of primaries, 100 seed weight in relation with yield. Both the crosses had positive significant correlation for grain yield with traits namely, Flag leaf length, Panicle length, Panicle weight, No. of primaries and 100 grain weight. This suggests that the selection for these traits would increase the grain yield. Based on the variability parameters, both the crosses showed high GCV (Genotypic coefficient of variation) for Flag leaf width, Panicle weight and grain yield exhibiting lower environmental influence and high PCV (Phenotypic coefficient of variation) was observed for the traits *viz.*, Flag leaf length, Flag leaf width, Panicle length, Panicle weight, Number of primaries, 100 seed weight and grain yield/plant. High GCV was also observed for Flag leaf length in the cross CO 30 x SPV 2308. High heritability and high genetic advance as percent mean were observed in Flag leaf width in both the crosses indicated the presence of additive gene action. Plant height, Panicle weight and grain yield per plant of the cross CO 30 x SPV 2308 alone showed high heritability and genetic advance as percent mean. Hence, these traits could be considered for selection of superior segregants to be forwarded in the next generation for the development of promising parental lines.

Keywords
Association- Variability Studies- F_2 Population-Sorghum

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) belonging to Poaceae family is the fifth most important crop after Rice, Wheat, Maize and Barley. In India, Sorghum is having 5.86 m ha area, 4.57 mt production and 779.6 kg/ha productivity in the year 2017 (FAO STAT 2017). Hence a positive genetic correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously. On the other hand, a negative correlation between two desirable traits impedes or makes it impossible to achieve a significant improvement in both traits. Genetic improvement for quantitative and qualitative traits depends on the nature and amount of variability present in the genetic stock. Indian sorghum accessions possess a wide range of genetic variability. Information on the variability was studied by the GCV, PCV, heritability and genetic gain for individual quantitative characters. Heritability is a measure of the phenotypic variance attributable to genetic causes. It provides information to the extent to which a phenotype can be transmitted to successive generations. Knowledge on heritability helps plant breeder to decide suitable selection method for improving the character, to predict gain from selection and to determine the relative importance of genetic effects. However, it has been accentuated that heritability alone has no practical importance without genetic advance. Genetic advance shows the degree of gain obtained in a character under particular selection pressure. High genetic advance coupled with high heritability estimates offers the most suitable condition for selection. The limitation of estimating heritability in narrow sense, as it included both additive and epistatic gene effects and thereby suggested that heritability estimates in the broad sense will be reliable if accompanied by a high genetic advancement. Therefore, the availability of good knowledge of these genetic parameters existing in different yield contributing characters is a pre-requisite for effective crop improvement. Hence, the objective of this study was to assess correlation, genetic variability and estimates of heritability in Sorghum crosses CO 30 x SPV 2307 and CO 30 x SPV 2308 during the *Kharif* season. The study of this investigation may provide good information for an

advanced understanding of the selection criteria and further breeding program in sorghum improvement.

Materials and Methods

The study was carried out during the *Kharif* 2018 at Tamil Nadu Agricultural University- Coimbatore. The seeds of CO 30, SPV 2307 and SPV 2308 (parents) and their F_1 were obtained from the Department of Millets, Tamil Nadu Agricultural University. These materials were preferred by the farmers, for their good food, feed and malting traits. The sowing was carried out during the month of September-2018 along with the parents. The F_2 of each cross was raised in 20 rows of 4 m length with a spacing of 0.45m between rows and 0.15m between plants. Two seeds were sown per hill and later one plant stand per hill was maintained two weeks after emergence. All the crop management package of practices were followed as per recommendation.

Observations were recorded for 176 individual F_2 plants in the cross CO 30 x SPV 2308 and 204 F_2 plants in the cross CO 30 x SPV 2307, for plant height (m), days to flowering, number of leaves, flag leaf length (cm), flag leaf width (cm), panicle length (cm), panicle weight (cm), number of primaries, hundred seed weight (g) and grain yield/plant (g). The statistical analysis was carried out using the SPSS software.

Results and Discussion

The cross CO 30 x SPV 2308 showed high GCV for the traits *viz.*, Flag leaf length (25.45%), Flag leaf width (77.56%), Panicle weight (58.103%) and Grain yield per plant (87.757%).The cross showed high PCV for traits such as Plant height (21.718%), Flag leaf length (34.940%), Flag leaf width (80.963%), Panicle length (22.656%), Panicle weight (70.773%), Number of primaries (25.045%) and 100 grain weight (28.797%) and Grain yield per plant (96.164%).The cross exhibited high heritability for the traits such as Plant height (61.916%), Flag leaf width (91.760%), Panicle weight (67.399%) and grain yield per plant (83.279%). High GAM were observed in the same traits namely Plant height (27.701%),Flag leaf length (38.177%), Flag leaf width (153.042%), Panicle weight (98.263%) and grain yield per plant (164.974%). The characters such as Plant height, Flag leaf length, Flag leaf width, Panicle weight and grain yield per plant was observed to have both high heritability and GAM, hence can be used for selection with more of additive gene action.

The cross CO 30 x SPV 2307 the GCV observed for the traits *viz.*, Flag leaf width (62.430%), Panicle weight (21.226%) and Grain yield per plant (33.277%).The cross showed high PCV for traits such as Flag leaf length (34.767%), Flag leaf width (66.350%), Panicle length (20.824%), Panicle weight (71.128%), Number of primaries (23.951%) and 100 grain weight (32.079%) and Grain yield per plant (94.358%). The cross exhibited high heritability for the traits such as Flag leaf width (88.533%). High GAM was observed in the same traits namely, Flag leaf length (21.570%), Flag leaf width (121.007%) and grain yield per plant (164.974%). The traits that exhibited high GCV would be heritable and effective for selection since contributed by the genotype. The traits that showed high PCV would be non-heritable and ineffective for selection since contributed by the environment.

The cross CO 30 x SPV 2308 recorded moderate GCV for plant height. Similar results were recorded by Jain *et al.*,(2012), Arunkumar *et al.*,(2013), Pedda Swamy (2013), Deepalakshmi *et al.*,(2007), Chavan *et al.*,(2010), Dhutmal *et al.*,(2014). High heritability and high GAM for plant height was observed only in CO 30 x SPV 2308.Similar findings of Dhutmal *et al.*,(2014), Jain *et al.*,(2012), Arunkumar *et al.*,(2013). Pedda swamy(2013), Deepalakshmi *et al.*,(2007), Chavan *et al.*,(2010) observed high heritability and Jain *et al.*,(2012), Pedda swamy (2013), Chavan *et al.*,(2010) observed high GAM for plant height. The traits that exhibited high GCV would be heritable and effective for selection since contributed by the genotype.

The cross CO 30 x SPV 2307 recorded low GCV. Similar results were recorded by Sujatha *et al.*,(2017), Mallinath *et al* (2004), Arunkumar *et al.*,(2013). This cross recorded moderate PCV for the same trait. Similar results were recorded by Jain *et al.*,(2012), Arunkumar *et al.*,(2013), Pedda swamy(2013), Deepalakshmi *et al.*,(2007), Chavan *et al.*,(2010), Dhutmal *et al.*,(2014). This cross exhibited moderate heritability and moderate GAM for this trait. Similar results were recorded for high GAM by Deepalakshmi *et al.*,(2007), Dhutmal *et al.*,(2014)

The cross CO 30 x SPV 2308 recorded low PCV and low GCV for days to flowering. Low heritability and low GAM was observes for this trait. The cross CO 30 x SPV 2307 recorded moderate PCV and low GCV for days to flowering. In this cross moderate heritability and moderate GAM was observes for this trait.

Both crosses recorded low GCV for the number of leaves. Similar results were recorded by Dhutmal *et al.*,(2014). The cross CO 30 x SPV 2308 recorded moderate PCV for the number of leaves. Similar results were recorded by Jain *et al.*,(2012), Deepalakshmi *et al.*,(2007), Dhutmal *et al.*,(2014). Low heritability and low GAM was observed for this trait. The cross CO 30 x SPV 2307 recorded low PCV for the number of leaves. This cross exhibited moderate heritability and low GAM. Similar results were recorded by Dhutmal *et al.*,(2014) for moderate heritability.

The cross CO 30 x SPV 2308 recorded high GCV and high PCV for the flag leaf length. The cross CO 30 x SPV 2307 recorded moderate GCV and high PCV for this trait. Both the crosses exhibited moderate heritability and high GAM for this trait Both the crosses recorded high GCV and high PCV for the flag leaf width. Both the crosses exhibited high heritability and high GAM for this trait.

Both the crosses exhibited low GCV and high PCV for this trait. Similar results for low GCV for panicle length were recorded by Arunkumar *et al.*,(2013), Deepalakshmi *et al.*,(2007). Similar results for high PCV for panicle length were recorded by Sujatha *et al.*,(2017), Jain *et al.*,(2012), Pedda swamy (2013).Both the crosses exhibited low heritability and low GAM. Both the crosses exhibited high GCV and high PCV for this trait. Such similar results were recorded by Pedda swamy (2013).The cross CO 30 x SPV 2308 exhibited high heritability and GAM for this trait. Similar results for high heritability was recorded by Pedda swamy(2013), , Deepalakshmi *et al.*,(2007). Similar results for high GAM was recorded by Pedda swamy(2013), , Deepalakshmi *et al.*,(2007).The cross CO 30 x SPV 2307 exhibited low heritability and moderate GAM for this trait. Both the crosses exhibited low GCV and high PCV for this trait. Both the crosses exhibited low heritability and low GAM.

The cross CO 30 x SPV 2308 recorded moderate GCV and high PCV for 100 grain weight. Similar results for moderate GCV for seed weight were recorded by Ghorade *et al.*,(2015), Deepalakshmi *et al.*,(2007), Chavan *et al.*,(2010).Similar results for high PCV for seed weight were recorded by Sujatha *et al.*,(2017), Arunkumar *et al.*,(2013), Pedda swamy (2013).The cross CO 30 x SPV 2308 recorded low GCV and high PCV for 100 grain weight. Similar results for low GCV for seed weight were recorded by Deepalakshmi *et al.*,(2007), Dhutmal *et al.*,(2014). Both the crosses exhibited low heritability and low GAM for this trait. Similar results for low GAM for seed weight were recorded by Ghorade *et al.*,(2015).

Both the crosses recorded high GCV and high PCV for100 grain weight. Similar results for high GCV for this trait were recorded by Sujatha *et al.*,(2017), Ghorade *et al.*,(2015), Pedda swamy (2013), Chavan *et al.*,(2010), Dhutmal *et al.*,(2014). Similar results for high PCV for this trait were recorded by Sujatha *et al.*,(2017), Arunkumar *et al.*,(2013), Ghorade *et al.*,(2015), Pedda swamy (2013), Chavan *et al.*, (2010),Dhutmal *et al.*, (2014). The cross CO 30 x SPV 2308 exhibited high heritability and high GAM for this trait. Similar results for high heritability and high GAM for this trait were recorded by Arunkumar *et al.*,(2013), Ghorade *et al.*,(2015), Pedda swamy (2013), Deepalakshmi *et al.*,(2007), Chavan *et al.*,(2010), Dhutmal *et al.*,(2014).The cross CO 30 x SPV 2307 exhibited low heritability and high GAM for this trait. Similar results for high GAM for this trait were recorded by Arunkumar *et al.*,(2013), Ghorade *et al.*,(2015), Pedda swamy (2013),Deepalakshmi *et al.*,(2007), Chavan *et al.*,(2010), Dhutmal *et al.*,(2014).

High heritability accompanied with high genetic advance indicates that most likely the heritability is due to additive gene effects. In this study for the cross CO 30 x SPV 2308, selection would be effective for the traits namely, plant height, flag leaf width and grain yield which showed high heritability and high GAM. Similarly for the cross CO 30 x SPV 2307 selection would be effective for the flag leaf width.

The cross CO 30 x SPV 2308 showed positive significant correlation @5% for the characters such as Plant height (r=0.375), Number of primaries(r=0.288), 100 grain weight (r=0.380), Panicle length(r=0.202), Panicle weight(high significant correlation) (r=0.917).The character Flag leaf length showed a positive significant correlation (r=0.185) with yield @1%. Hence selection would be effective if such characters are taken as the characters of the selection criterion. These results are in close agreement with findings of Sushil kumar (2017), Kalpande *et al.*,(2014), Mallinath *et al.*,(2004), Rajani Verma *et al.*,(2016), Sowmy *et al.*,(2013), Pedda swamy (2013) for plant height. Similar results for the positive correlation of panicle length was observed by Mallinath *et al.*,(2004), Sowmy *et al.*,(2013), Deepalakshmi *et al.*,(2007). Arunkumar *et al.*,(2013), Deepalakshmi *et al.*,(2007) reported the same finding for grain weight.

Days to flowering(r=-0.281) showed a negative significant correlation with yield. Hence, it should not be taken as the selection criterion. Similar findings were quoted by Sowmy *et al*.,(2013). The number of leaves showed positive non- significant correlation with yield and Flag leaf width showed negative non-significant with yield per plant.

Plant height is significantly positively associated with Number of leaves, Flag leaf length, Flag leaf width, and Panicle weight. Flag leaf length is significantly positively associated with the plant height, Flag leaf width and Panicle weight. Panicle length is significantly positively associated with the Panicle weight and Number of primaries. Panicle weight is significantly positively associated with the number of primaries and 100 grain weight.

The cross CO 30 x SPV 2307 showed positive significant correlation @5% for the characters such as Plant height(r=0.189), Flag leaf length(r=0.293), Number of primaries(r=0.237), 100 grain weight(r=0.293), Panicle length(r=0.214), Panicle weight (high significant correlation)(r=0.849). Hence, selection would be effective if these characters are considered for the selection criterion. Similar results for positive correlation of panicle length was observed by Mallinath *et al*.,(2004), Sowmy *et al*.,(2013), Deepalakshmi *et al*.,(2007).

Days to flowering(r=-0.399) showed a negative significant correlation with yield. Similar findings were quoted by Sowmy *et al*.,(2013). Hence, it should not be taken as the selection criterion. The number of leaves showed negative non- significant correlation with yield. Flag leaf width showed positive non-significant correlation with grain yield per plant. Plant height is significantly positively associated with Flag leaf length and Panicle weight. Flag leaf length is significantly positively associated with the Flag leaf width, Panicle length, Panicle weight and Number of primaries. Panicle length is significantly positively associated with the Panicle weight and Number of primaries. Panicle weight is significantly positively associated with the number of primaries.

Both the crosses exhibited positive significant correlation @5% for the characters such as Plant height, Flag leaf length, Number of primaries, 100 grain weight, Panicle length and Panicle weight. Selection of traits that showed positive correlation would be effective since these traits significantly contributed to the yield of the plant.

Acknowledgment

The F_2 population of cross CO 30 X SPV 2308 and CO 30 X SPV 2307 along with the parental seed materials were provided by the Department of Millets, Centre of Plant Breeding and Genetics, TNAU. We thank for the experimental materials provided.

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Electronic Journal of Plant Breeding, 10 (2): 483-489 (Jun 2019) DOI: 10.5958/0975-928X.2019.00061.9
ISSN 0975-928X

Table 1. Variability studies in F_2 generation of crosses CO 30 x SPV 2308 and CO 30 x SPV 2307

S.No	Traits	Cross	Mean	Variance		PCV	GCV	h^2(bs)	GA	GAM
				σ^2_p	σ^2_g					
1	Plant height	CO 30 x SPV 2308	191.261	1725.47	1068.34	21.718	17.089	61.916	52.982	27.701
		CO 30 x SPV 2307	185.809	756.792	380.459	14.805	10.498	50.273	28.490	15.333
2	Days to flowering	CO 30 x SPV 2308	71.301	55.460	9.670	10.445	4.361	17.437	2.675	3.752
		CO 30 x SPV 2307	67.113	68.894	30.750	12.368	8.263	44.634	7.632	11.372
3	Number of Leaves	CO 30 x SPV 2308	11.011	1.761235	0.263403	12.052	4.661	14.956	0.409	3.713
		CO 30 x SPV 2307	10.824	1.067	0.554	9.543	6.879	51.964	1.106	10.215
4	Flag Leaf length	CO 30 x SPV 2308	31.001	117.3312	62.23316	34.940	25.446	53.041	11.835	38.177
		CO 30 x SPV 2307	32.548	128.050	38.565	34.767	19.080	30.117	7.020	21.570
5	Flag Leaf width	CO 30 x SPV 2308	4.648	14.16329	12.99628	80.963	77.556	91.760	7.114	153.042
		CO 30 x SPV 2307	4.665	9.581	8.483	66.350	62.430	88.533	5.645	121.007
6	Panicle length	CO 30 x SPV 2308	21.448	23.61386	1.249985	22.656	5.213	5.293	0.530	2.470
		CO 30 x SPV 2307	20.770	18.707	0.232	20.824	2.319	1.240	0.111	0.532
7	Panicle width	CO 30 x SPV 2308	28.517	407.3293	274.5359	70.773	58.103	67.399	28.022	98.263
		CO 30 x SPV 2307	27.656	386.962	34.462	71.128	21.226	8.906	3.609	13.049
8	Number of primaries	CO 30 x SPV 2308	41.232	106.6446	8.137989	25.045	6.919	7.631	1.623	3.937
		CO 30 x SPV 2307	39.539	89.680	6.261	23.951	6.329	6.982	1.362	3.445
9	100 seed weight	CO 30 x SPV 2308	1.741	0.251485	0.03768	28.797	11.147	14.983	0.155	8.888
		CO 30 x SPV 2307	1.816	0.339	0.032	32.079	9.782	9.298	0.112	6.144
10	Grain yield per plant	CO 30 x SPV 2308	15.574	224.322	186.8134	96.164	87.757	83.279	25.694	164.974
		CO 30 x SPV 2307	16.692	248.081	30.854	94.358	33.277	12.437	4.035	24.175

Electronic Journal of Plant Breeding, 10 (2): 483-489 (Jun 2019) DOI: 10.5958/0975-928X.2019.00061.9
ISSN 0975-928X

Table 2. The simple correlation coefficient between yield and yield attributes in F2 generation of crosses CO 30 x SPV 2308 and CO 30 x SPV 2307

	Cross	PH	DF	NL	FLL	FLW	PL	PW	NOP	GW
DF	C1	-.548**								
	C2	-.334**								
NL	C1	.204**	-.041							
	C2	.035	-.008							
FLL	C1	.246**	-.402**	-.059						
	C2	.212**	-.561**	.010						
FLW	C1	.153*	-.223**	.000	.300**					
	C2	.032	-.029	-.230**	.138*					
PL	C1	.052	.073	.091	-.003	.042				
	C2	.126	-.129	-.133	.209**	.086				
PW	C1	.456**	-.387**	.100	.285**	.070	.264**			
	C2	.239**	-.478**	-.115	.371**	.089	.343**			
NOP	C1	.105	-.016	.093	.053	.058	.868**	.370**		
	C2	.126	-.148*	-.114	.176*	.074	.837**	.372**		
GW	C1	.041	-.062	.113	.075	-.085	.098	.335**	.102	
	C2	-.002	-.040	-.041	-.038	-.149*	-.130	.136	-.106	
GYP	C1	.375**	-.281**	.114	.185*	-.056	.202**	.917**	.288**	.380**
	C2	.189**	-.399**	-.099	.293**	.047	.214**	.849**	.237**	.293**

C1 - CO 30 x SPV 2308; C2 - CO 30 x SPV 2307

(PH - Plant height, NL - Number of leaves, DF - Days to flowering, FLL - Flag leaf length, FLW - Flag leaf width, PL - Panicle length, PW - Panicle width, NOP - Number of primaries, GW - 100 grain weight and GYP - grain yield per plant)

*,** indicates the significance at 1% and 5% respectively

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