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Evaluation of Parental Lines and Their F1-hybrids for Grain Yield and Contributing Characters in Tarai Region of Uttarakhand in Sorghum (*Sorghum bicolor L.*)

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ABSTRACT
A two-year study was conducted during the cropping season of 2014 and 2015 at G.B. Pant University of Agriculture and Technology, Pantnagar (29^{0}N, 79.3^{0}E). The study was conducted to determine mean performances for yield and yield component characters in 13 parental lines and 40 hybrids of sorghum, formulated by a line x tester design along with 2 checks of national level. All the crosses showed a wide range of variability for most of the characters. Almost all the hybrids performed better than their respective parental lines for all the characters. In terms of days to 50% flowering and maturity, MR750A$_2$ x CSV 15 was found to be better (64.33 and 123 days, respectively) with relatively higher test weight (32.20 g). Highest grain yield per plant was recorded in ICSA 467 x RS29 (127.43g) followed by 11A$_2$ x UPC2 (121.37) and ICSA 467 x CS3541 (117.05) with the test weight of 26.13, 31.88 and 30.67, respectively. The grain yield/plant, number of seed/panicle, and plant height in this study has been identified as selection criteria for obtaining good parental lines and hybrids in a pearl millet breeding program.
Key words: *pearl millet, total grain yield, correlation, path analysis, parental lines, hybrid*

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INTRODUCTION

Sorghum (*Sorghum bicolor*) is an important food and feed crop grown in more than 90 countries. Globally it is grown on over 40 million ha predominantly in tropical Africa and India for food and in temperate areas (Americas, Europe and Australia) as a feed crop (8).It is fifth major cereal crop of world following wheat, rice, maize and barley in terms of production and utilization. In India, it is third major cereal after rice and wheat and cultivated in both kharif and rabi seasons.

The development of an effective plant breeding programme is depending upon the assessment of polygenic variation, selection of elite genotypes, choice of parents and breeding procedures. Crop improvement depends upon the magnitude of genetic variability and the extent to which desirable characters are heritable. Genetic variability for yield and yield components is essential in the base population for successful crop improvement (1). In sorghum, we can create genetic variability through hybridization which could be favourably utilized in developing a genotype with all desirable characters. In this study, 40 F1's and their 13 parents differed significantly for all the characters. The results obtained on Variability as per mean performances are discussed here. The objectives of this study were to compare seed yield and other contributing traits between parents and their F1s and to evaluate the hybrids in terms of grain yield for the improvement of sorghum cultivars.

MATERIAL AND METHODS

The field experiments for present investigation were conducted at the Instructional Dairy Farm of the G.B. Pant University of Agriculture and Technology, Pantnagar (U.S. Nagar) India, during *Kharif* season in the

years 2013-2014 and 2014-2015. The location falls in the humid subtropical zone and is situated in the *Tarai* region at the foothills of Shivalik range of Himalayas, geographically at the 29^{0}N latitude and 79.3^{0}E longitude with an altitude of 243.84 meters above mean sea level. The experimental materials for the present study consist of forty F_1 crosses developed through line × tester mating design involving five diverse CMS lines (female) and eight sorghum pollinator (male) lines. The experimental materials obtained through above mentioned crossing were planted in two *Kharif* seasons of 2013-2014 and 2014-2015. The details of parental lines (lines and testers) have been presented in Table:

Table 1: Parentage, origin/source and important characteristic features of parental lines used for the study

Name of the Parental line	Parentage	Origin/Source	Tillering/ Non-Tillering	Plant Type Tan/Purple
CMS lines (Female Lines)				
ICSA 467	-	ICRISAT	Non-tillering	Tan
ICSA 469	[(ICSB 37 x ICSV 702) x PS 19349B]3-3-4-2	ICRISAT	Non-tillering	Tan
ICSA 276	(ICSB 101 x TRL 74/C 57) x PM17467B]2-5-1-3-3	ICRISAT	Non-tillering	Tan
$11A_2$	Non-milo	DSR, Hyderabad	Non-tillering	Tan
MR $750A_2$	Non-milo	DSR, Hyderabad	Non-tillering	Tan
pollinators (Male Lines)				
Pant Chari 5	CS 3541 x IS 6953	Pantnagar	Non-tillering	Tan
UPC 2	VIDISHA 60-1x ISC 953	Pantnagar	Non-tillering	Tan
CSV15	SPV 475 x SPV 462	DSR, Hyderabad	Non-tillering	Tan
CS3541	IS 3675 x IS3541	DSR, Hyderabad	Non-tillering	Tan
RS 29	IS 108 x SPV 126	DSR, Hyderabad	Non-tillering	Tan
M 35-1	Selection from Maldandi landraces	Mahol	Non-tillering	Tan
JJ1041	-	Indore	Non-tillering	Tan
SPV1616	-	DSR, Hyderabad	Non-tillering	Tan
Checks (Hybrids)				
CSH-20MF (National)	2219A x UPMC-503	Pantnagar	Tillering	Tan
CSH-24MF (National)	ICSA 467 X PC6	Pantnagar	Tillering	Tan

Ten competitive plants were randomly taken, from each treatment/genotype in each replication in both the years. All the selected plants were tagged and observations for all the characters were taken on these plants.The means of different characters for the purpose of statistical analysis were calculated on the basis of the individual data recorded for each character, in each replication separately, for each cross. Analysis of variance (ANOVA) for different characters was carriedout following the procedure of Complete Randomized Block Design analysis (7).

RESULTS AND DISCUSSION

The analysis of variance for simple RBD for various characters in respect to parents (lines and testers) and crosses during pooled over years is given in the **Table 2**. The mean performance and range of variation for different characters with respect to parents and their crosses (F_1) are given in **table 3** for the years 2013-14 (Y_1), 2014-15 (Y_2) and pooled over years.

During first year, the mean performance of different genotypes for days to 50 per cent flowering was found to range between 63.00 days in cross ICSA276x SPV1616 to 87.00 days in parent PC 5 with the general mean of 71.33. Nine crosses performed statistically *at par* with the lowest performing cross for days to 50 per cent flowering. Five crosses gave better performance over best check i.e. CSH 20 MF (64.33) *viz.,* MR$750A_2$ x RS29 (64), ICSB276 x RS29 (63.33), $11A_2$ x SPV1616 (63.33), MR$750A_2$ x SPV1616 (64), ICSA276 x SPV1616 (63). During second year, the mean performance for days to 50 per cent flowering was found to range between 62.33 days in cross ICSA276x SPV1616 to 83 days in parent M35-1. Under pooled over year analysis, the mean performance of different genotypes for days to 50 per cent flowering was found to range between 62.67 days in ICSA276 x SPV1616 to 82.50 days in M35-1 with the general mean of 70.03.

Table 2: Analysis of variance for simple RBD with respect to different characters during the pooled over years (P)

Source of variation	Df	Days to 50% flowering	Days to maturity	Plant height (cm)	Penicle length (cm)	Penicle width (cm)	Penicle weight (g)	Flag leaf length (cm)	Flag leaf width (cm)	Seed Yield per plant (g)	1000 seed weight (g)
Replication	2	0.34	0.89	0.32	0.28	1.00	0.49	1.06	2.08	0.89	0.04
Environments	1	500.90**	343.03**	102.6**	281.7**	179.1**	773.7**	69.35**	130.7**	1333.5**	0.24
Interactions	2	0.22	0.55	0.08	0.12	0.71	0.12	0.26	0.12	0.15	0.79
Overall Sum	5	23.00**	38.71**	1.99**	7.23**	26.33**	19.6**	4018**	4.20**	41.9**	0.37**
Treatment	54	28.74**	10.46**	15.2**	4.02**	5.23**	11.6**	19.5**	16.95**	9.4**	347**
Error	108	4.85	6.09	705.7	7.36	1.60	685.1	7.3	0.30	369	0.32
SEm±		0.89	0.99	10.7	1.09	0.51	10.58	0.22	1.10	0.22	7.77
CV %		3.14	1.93	9.97	9.93	17.67	23.3	8.11	7.44	8.11	26.3
CD at 1%		2.50	2.80	30.1	3.08	1.44	29.7	0.63	3.09	0.63	21.8
CD at 5 %		1.75	1.96	21.1	2.16	1.00	20.8	0.44	2.16	0.44	15.3

*, ** Significant at 5% and 1% levels of probability, respectively

Table 3: Mean performance of different Parents and crosses for different characters during the year 2013-14 (Y_1), 2014-15 (Y_2) and pooled over years

S.No.	Character	Days to 50% Flowering			Days to maturity			Plant height (cm)			Panicle length (cm)			Panicle width (cm)		
		Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled
1.	ICSA 467 x PC5	73.33	68.33	70.83	126.33	127.67	127.00	321.50	287.83	304.67	27.33	76.30	27.30	6.27	8.71	7.49
2.	ICSA 469 x PC5	79.33	75.33	77.33	129.67	127.33	128.50	322.17	287.33	304.75	24.37	64.63	25.45	5.50	7.20	6.35
3.	ICSA 276 x PC5	76.00	74.00	75.00	126.33	126.00	126.17	266.00	219.33	242.67	24.50	62.00	25.95	5.92	8.53	7.22
4.	$11A_2$ x PC5	80.67	76.00	78.33	126.33	124.00	125.17	342.83	348.33	345.58	25.95	70.37	27.29	6.70	7.33	7.02
5.	$MR750A_2$ x PC5	67.67	64.33	66.00	124.00	120.67	122.33	288.33	291.00	289.67	26.23	70.13	26.40	6.00	6.70	6.35
6.	ICSA 467 x UPC2	76.33	73.67	75.00	125.67	124.00	124.83	354.00	323.00	338.50	32.93	80.57	32.77	10.47	10.58	10.52
7.	ICSA469 x UPC2	75.33	74.33	74.83	134.33	125.67	130.00	346.67	301.33	324.00	30.80	68.93	29.77	8.43	7.90	8.17
8.	ICSA 276 x UPC2	72.67	72.67	72.67	133.67	123.33	128.50	320.63	288.00	304.32	28.80	74.80	28.62	7.62	8.76	8.19
9.	$11A_2$ x UPC2	74.33	74.00	74.17	130.33	122.00	126.17	320.00	306.50	313.25	30.22	74.63	30.70	9.55	11.22	10.39
10.	$MR750_A2$ x UPC2	71.33	69.67	70.50	125.00	123.33	124.17	309.33	270.33	289.83	32.13	73.77	32.20	8.97	9.23	9.10
11.	ICSA 467 x CSV15	66.67	64.33	65.50	129.67	125.67	127.67	283.83	289.83	286.83	26.33	56.67	24.92	5.27	8.43	6.85
12.	ICSA 469 x CSV15	72.00	67.33	69.67	130.67	122.33	126.50	276.33	304.00	290.17	27.23	64.63	28.13	5.00	5.77	5.38
13.	ICSA 276 x CSV15	66.00	64.67	65.33	134.00	130.67	132.33	285.33	263.97	274.65	28.03	67.50	27.70	5.83	6.47	6.15
14.	$11A_2$ x CSV15	71.00	65.67	68.33	128.00	126.67	127.33	260.00	257.75	258.88	26.13	69.20	27.05	4.97	6.27	5.62
15.	$MR750A_2$ x CSV15	64.67	64.00	64.33	124.00	122.00	123.00	248.50	261.50	255.00	29.07	68.80	29.25	6.17	6.23	6.20
16.	ICSA 467 x CS3541	69.67	66.67	68.17	125.33	123.67	124.50	288.67	253.17	270.92	24.20	65.68	24.57	6.30	8.37	7.33
17.	ICSA 469 x CS3541	68.00	65.33	66.67	129.33	124.33	126.83	279.67	215.00	247.33	26.00	66.97	25.73	5.23	7.22	6.22
18.	ICSBA276 x CS3541	69.67	66.67	68.17	129.00	126.33	127.67	260.90	258.66	259.78	23.53	70.17	26.32	6.30	10.99	8.64
19.	$11A_2$ x CS3541	66.67	64.67	65.67	126.33	122.33	124.33	244.50	306.87	275.68	24.78	72.60	26.61	6.22	6.23	6.22
20.	$MR750A_2$ x CS3541	68.33	67.00	67.67	123.67	120.00	121.83	228.17	238.00	233.08	20.87	70.70	22.87	5.62	6.83	6.22
21.	ICSA 467 x	72.00	64.67	68.33	124.33	123.33	123.83	289.20	227.00	258.10	26.13	70.45	27.63	6.17	9.72	7.94

	RS29															
22.	ICSA 469 x RS29	71.00	68.00	69.50	127.00	126.00	126.50	289.57	285.67	287.62	25.27	65.93	26.00	6.47	9.18	7.82
23.	ICSA 276 x RS29	63.33	63.00	63.17	131.33	128.33	129.83	295.50	261.67	278.58	28.80	63.53	29.12	6.80	8.19	7.49
24.	$11A_2$ x RS29	71.00	65.33	68.17	130.33	125.33	127.83	248.67	267.00	257.83	25.60	69.40	27.78	7.27	6.87	7.07
25.	$MR750A_2$ x RS29	64.00	64.33	64.17	123.67	120.33	122.00	256.67	258.17	257.42	27.20	70.37	27.87	6.65	6.83	6.74
26.	ICSA 467 x M35-1	76.67	70.67	73.67	126.33	120.67	123.50	322.00	341.00	331.50	25.73	60.30	25.93	6.83	6.23	6.53
27.	ICSA 469 x M35-1	79.67	78.33	79.00	130.00	131.00	130.50	321.33	263.00	292.17	28.27	64.80	29.10	7.03	7.73	7.38
28.	ICSA 276 x M35-1	73.67	72.67	73.17	134.33	125.67	130.00	287.33	276.00	281.67	28.67	72.60	28.43	6.87	7.90	7.38
29.	$11A_2$ x M35-1	76.33	73.67	75.00	132.00	125.00	128.50	337.33	328.13	332.73	25.53	61.90	25.65	6.19	6.87	6.53
30.	$MR750A_2$ x M35-1	75.00	69.00	72.00	127.33	127.33	127.33	294.67	307.33	301.00	27.53	66.70	28.58	7.80	8.13	7.97
31.	ICSA 467 x JJ1041	71.67	64.00	67.83	130.33	126.33	128.33	243.67	226.33	235.00	26.50	53.63	27.25	5.83	8.47	7.15
32.	ICSA 469 x JJ1041	67.33	66.67	67.00	125.33	124.67	125.00	287.83	267.67	277.75	28.95	73.33	29.83	5.31	7.67	6.49
33.	ICSA 276 x JJ1041	66.00	65.67	65.83	131.33	128.67	130.00	284.33	246.33	265.33	27.67	64.97	27.15	7.50	7.57	7.53
34.	$11A_2$ x JJ1041	79.00	74.67	76.83	134.00	130.33	132.17	236.67	232.00	234.33	25.92	59.73	26.21	5.42	5.77	5.59
35.	$MR750A_2$ x JJ1041	66.33	64.67	65.50	124.67	122.00	123.33	246.00	250.33	248.17	27.00	60.30	27.30	8.00	8.30	8.15
36.	ICSA 467 x SPV1616	68.33	66.00	67.17	132.67	130.33	131.50	281.67	314.00	297.83	28.20	68.83	29.52	6.27	7.20	6.73
37.	ICSA 469 x SPV1616	68.00	66.33	67.17	128.67	128.67	128.67	304.33	283.83	294.08	33.33	79.87	34.00	7.33	9.10	8.22
38.	ICSA 276 x SPV1616	63.00	62.33	62.67	135.33	126.67	131.00	320.00	304.60	312.30	27.58	68.65	29.88	5.93	6.99	6.46
39.	$11A_2$ x SPV1616	63.33	62.67	63.00	134.67	126.67	130.67	254.00	274.67	264.33	24.78	68.93	26.71	5.30	5.20	5.25
40.	$MR750A_2$ x SPV1616	63.33	63.33	63.33	124.67	124.00	124.33	242.67	277.33	260.00	26.33	52.57	28.65	6.07	7.03	6.55
41.	PC5	87.00	76.67	81.83	127.00	126.00	126.50	325.17	318.40	321.78	23.42	68.50	25.22	5.02	5.53	5.28
42.	UPC2	81.33	71.00	76.17	134.33	124.67	129.50	307.90	211.76	259.83	27.47	66.29	28.40	6.67	9.45	8.06
43.	CSV15	68.00	68.67	68.33	136.33	127.67	132.00	254.33	248.53	251.43	25.27	67.47	25.57	6.67	8.80	7.73
44.	CS3541	73.33	71.33	72.33	131.33	129.67	130.50	202.67	183.33	193.00	23.67	70.25	26.29	6.30	11.82	9.06
45.	RS29	72.00	75.33	73.67	125.67	127.67	126.67	221.67	256.33	239.00	22.73	69.70	27.60	5.75	12.67	9.21
46.	M35-1	82.00	83.00	82.50	133.00	130.33	131.67	286.57	221.33	253.95	18.93	61.87	25.75	4.17	7.87	6.02
47.	JJ1041	69.67	68.67	69.17	135.00	130.67	132.83	261.00	269.67	265.33	23.53	67.93	25.28	5.72	6.50	6.11
48.	SPV1616	67.00	67.33	67.17	137.67	130.67	134.17	274.67	210.00	242.33	24.33	65.17	24.25	6.17	7.25	6.71
49.	ICSA 467	75.00	71.33	73.17	129.33	125.33	127.33	184.00	165.33	174.67	30.27	65.80	29.32	8.80	5.39	7.10
50.	ICSA 469	74.00	66.00	70.00	135.33	126.67	131.00	136.67	235.83	186.25	26.20	75.27	26.70	6.07	10.10	8.08
51.	ICSA 276	69.33	68.67	69.00	138.33	128.00	133.17	190.33	209.33	199.83	27.10	65.80	26.92	4.33	10.08	7.21
52.	11A2	73.67	69.00	71.33	126.00	126.00	126.00	151.33	191.17	171.25	24.70	74.67	26.56	5.48	9.83	7.66
53.	MR750A2	68.33	66.67	67.50	127.67	123.67	125.67	162.17	173.92	168.04	20.75	67.00	23.15	4.73	6.83	5.78
54.	CSH20MF ©	64.33	64.67	64.50	123.67	121.00	122.33	223.33	226.83	225.08	24.50	64.27	23.95	5.40	5.67	5.53
55.	CSH24MF ©	69.33	67.67	68.50	123.67	120.67	122.17	210.17	211.10	210.63	26.17	84.67	25.23	6.13	9.92	8.02
	Mean	71.33	68.74	70.03	**129.35**	**125.60**	**127.48**	**270.60**	**261.76**	**266.18**	**26.43**	**68.01**	**27.32**	**6.38**	**7.96**	**7.17**
	C.V.	2.75	2.32	3.14	1.48	1.58	1.94	7.97	7.77	9.98	9.71	6.42	9.94	14.11	10.89	17.68
	F ratio	22.78	24.87	28.75	13.95	7.00	10.46	15.54	12.81	15.26	3.54	5.74	4.02	5.69	11.60	5.24
	F Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S.E.	1.13	0.92	0.90	1.11	1.14	1.01	12.45	11.75	10.84	1.48	2.52	1.11	0.52	0.50	0.52
	C.D. 5%	3.18	2.58	2.50	3.11	3.21	2.81	34.89	32.93	30.18	4.15	7.06	3.09	1.46	1.40	1.44
	C.D. 1%	4.20	3.41	3.30	4.11	4.24	3.70	46.16	43.56	39.77	5.49	9.35	4.07	1.93	1.85	1.90
	Range Lowest	63.00	62.33	62.67	123.67	120.00	121.83	136.67	165.33	168.04	18.93	52.57	22.87	4.17	5.20	5.25
	Range Highest	87.00	83.00	82.50	138.33	131.00	134.17	354.00	348.33	345.58	33.33	84.67	34.00	10.47	12.67	10.52

Continued.....

S.No.	Character	Panicle weight (g)			Flag leaf length (cm)			Flag leaf width (cm)			Grain yield per plant (g)			1000 seed weight (g)		
		Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled
1.	ICSA 467 x PC5	83.33	109.00	96.17	35.00	32.48	33.74	6.23	5.72	5.97	37.33	87.83	62.58	26.50	26.17	26.33
2.	ICSA 469 x PC5	96.67	158.33	127.50	42.50	41.97	42.23	5.36	4.49	4.93	38.33	108.70	73.52	26.00	26.00	26.00
3.	ICSA 276 x PC5	98.50	106.67	102.58	32.77	32.27	32.52	5.78	5.95	5.86	62.00	67.13	64.57	27.43	27.77	27.60
4.	$11A_2$ x PC5	142.33	159.83	151.08	37.37	40.63	39.00	7.30	7.20	7.25	88.00	119.00	103.50	30.17	29.23	29.70
5.	$MR750A_2$ x PC5	106.67	142.33	124.50	36.57	34.70	35.63	6.33	6.33	6.33	72.67	109.10	90.88	31.10	31.17	31.13
6.	ICSA 467 x UPC2	246.67	134.67	190.67	45.37	42.13	43.75	7.63	7.97	7.80	102.67	114.27	108.47	29.23	28.67	28.95
7.	ICSA469 x UPC2	148.67	147.33	148.00	34.10	33.87	33.98	5.90	5.73	5.82	71.33	104.75	88.04	24.47	24.87	24.67
8.	ICSA 276 x UPC2	142.00	157.87	149.93	37.33	36.93	37.13	6.07	6.13	6.10	72.33	99.03	85.68	28.30	27.77	28.03
9.	$11A_2$ x UPC2	186.50	230.33	208.42	40.50	37.73	39.12	7.17	7.46	7.32	92.67	150.07	121.37	31.63	32.13	31.88
10.	$MR750_A2$ x UPC2	167.33	230.33	198.83	44.00	42.67	43.33	9.37	8.93	9.15	97.33	105.93	101.63	28.63	27.63	28.13
11.	ICSA 467 x CSV15	85.57	86.33	85.95	29.03	28.33	28.68	6.30	6.10	6.20	35.00	58.10	46.55	30.83	31.17	31.00
12.	ICSA 469 x CSV15	70.00	94.47	82.23	42.80	42.73	42.77	6.83	6.23	6.53	40.67	71.63	56.15	33.97	34.17	34.07
13.	ICSA 276 x CSV15	55.30	83.67	69.48	34.43	34.80	34.62	6.57	6.27	6.42	33.67	46.15	39.91	26.10	26.17	26.13
14.	$11A_2$ x CSV15	50.00	83.33	66.67	43.60	39.80	41.70	7.85	7.47	7.66	33.00	56.07	44.53	31.67	32.50	32.08
15.	$MR750A_2$ x CSV15	71.00	72.33	71.67	26.70	26.20	26.45	5.90	5.80	5.85	37.33	44.97	41.15	32.60	31.80	32.20
16.	ICSA 467 x CS3541	126.00	211.67	168.83	39.37	34.03	36.70	5.93	5.37	5.65	66.67	167.43	117.05	30.60	30.73	30.67
17.	ICSA 469 x CS3541	84.33	121.33	102.83	38.40	37.73	38.07	8.72	7.87	8.29	48.67	94.97	71.82	33.37	33.87	33.62
18.	ICSBA276 x CS3541	125.33	134.22	129.78	44.93	38.87	41.90	8.79	8.51	8.65	77.33	79.43	78.38	25.73	25.83	25.78
19.	$11A_2$ x CS3541	95.23	126.00	110.62	37.70	39.47	38.58	8.03	7.81	7.92	57.67	102.93	80.30	29.57	29.90	29.73
20.	$MR750A_2$ x CS3541	67.67	63.33	65.50	28.47	26.60	27.53	6.87	6.33	6.60	37.67	33.80	35.73	26.33	26.27	26.30
21.	ICSA 467 x RS29	103.67	246.67	175.17	37.27	31.80	34.53	6.03	6.43	6.23	55.33	199.53	127.43	26.23	26.03	26.13
22.	ICSA 469 x RS29	92.33	102.67	97.50	36.07	37.43	36.75	6.83	6.29	6.56	59.00	59.20	59.10	30.47	30.40	30.43
23.	ICSA 276 x RS29	102.67	95.56	99.11	42.50	39.89	41.19	7.45	7.93	7.69	74.00	57.20	65.60	25.27	25.47	25.37
24.	$11A_2$ x RS29	105.33	163.67	134.50	38.23	38.33	38.28	6.47	6.77	6.62	71.33	132.87	102.10	31.03	31.87	31.45
25.	$MR750A_2$ x RS29	95.67	111.67	103.67	45.23	43.63	44.43	8.27	8.03	8.15	73.67	86.07	79.87	27.40	27.37	27.38
26.	ICSA 467 x M35-1	124.67	145.00	134.83	29.90	31.43	30.67	6.90	5.90	6.40	77.33	107.15	92.24	33.97	33.93	33.95
27.	ICSA 469 x M35-1	107.00	194.33	150.67	37.17	36.40	36.78	7.20	7.17	7.18	71.00	127.88	99.44	27.07	27.83	27.45
28.	ICSA 276 x M35-1	80.00	103.33	91.67	35.67	35.93	35.80	7.50	7.27	7.38	39.33	61.93	50.63	25.37	25.87	25.62
29.	$11A_2$ x M35-1	92.43	183.33	137.88	27.93	27.67	27.80	5.30	5.01	5.16	54.00	146.07	100.03	31.47	31.43	31.45
30.	$MR750A_2$ x M35-1	105.33	113.00	109.17	28.63	28.03	28.33	8.17	7.97	8.07	87.33	95.29	91.31	32.67	32.20	32.43
31.	ICSA 467 x JJ1041	81.67	124.33	103.00	35.60	35.33	35.47	6.67	6.20	6.43	41.00	97.07	69.03	32.57	32.70	32.63
32.	ICSA 469 x JJ1041	72.67	146.67	109.67	39.57	37.70	38.63	7.79	6.77	7.28	44.00	120.20	82.10	33.57	33.17	33.37
33.	ICSA 276 x JJ1041	85.00	151.67	118.33	35.33	34.97	35.15	7.10	7.70	7.40	55.00	119.13	87.07	31.17	31.27	31.22

34.	$11A_2$ x JJ1041	63.33	85.00	74.17	43.57	42.07	42.82	7.70	7.16	7.43	44.00	60.13	52.07	37.73	37.30	37.52
35.	$MR750A_2$ x JJ1041	82.00	99.33	90.67	37.87	37.57	37.72	6.93	6.10	6.52	43.67	83.77	63.72	33.33	32.90	33.12
36.	ICSA 467 x SPV1616	96.17	101.50	98.83	30.40	28.90	29.65	6.08	5.83	5.96	52.00	71.50	61.75	32.03	32.97	32.50
37.	ICSA 469 x SPV1616	128.33	93.33	110.83	39.17	38.10	38.63	7.43	7.20	7.32	81.33	63.83	72.58	30.50	29.90	30.20
38.	ICSA 276 x SPV1616	116.00	103.33	109.67	43.67	44.33	44.00	7.98	7.60	7.79	84.33	75.77	80.05	33.17	33.07	33.12
39.	$11A_2$ x SPV1616	56.67	80.00	68.33	31.00	31.53	31.27	5.87	5.75	5.81	41.67	58.97	50.32	35.63	35.90	35.77
40.	$MR750A_2$ x SPV1616	62.33	66.07	64.20	36.13	34.57	35.35	5.37	6.20	5.78	37.00	37.80	37.40	29.70	29.10	29.40
41.	PC5	52.50	66.72	59.61	36.77	35.25	36.01	7.27	6.53	6.90	37.07	42.80	39.93	26.80	26.47	26.63
42.	UPC2	79.10	104.22	91.66	46.90	44.27	45.58	6.51	6.61	6.56	32.50	59.67	46.08	20.73	20.73	20.73
43.	CSV15	104.00	183.43	143.72	41.83	41.07	41.45	8.10	6.50	7.30	67.40	124.20	95.80	30.97	30.93	30.95
44.	CS3541	86.67	79.33	83.00	44.83	42.17	43.50	9.27	8.50	8.88	46.23	54.57	50.40	22.97	22.57	22.77
45.	RS29	72.33	187.67	130.00	37.33	37.87	37.60	7.90	7.57	7.73	48.80	117.47	83.13	21.47	20.30	20.88
46.	M35-1	47.33	59.67	53.50	31.07	25.77	28.42	6.30	5.90	6.10	29.33	33.33	31.33	15.92	16.13	16.03
47.	JJ1041	72.67	82.00	77.33	33.80	30.67	32.23	6.63	6.47	6.55	36.67	51.60	44.13	29.07	28.83	28.95
48.	SPV1616	65.33	105.00	85.17	34.37	32.33	33.35	6.86	6.82	6.84	40.67	83.70	62.18	32.30	33.00	32.65
49.	ICSA 467	154.67	111.00	132.83	31.20	30.13	30.67	6.60	6.35	6.47	113.17	75.67	94.42	27.73	27.50	27.62
50.	ICSA 469	72.00	148.17	110.08	36.03	35.18	35.61	5.07	5.23	5.15	62.67	67.87	65.27	19.00	20.37	19.68
51.	ICSA 276	44.33	119.67	82.00	38.07	36.17	37.12	6.88	6.58	6.73	30.00	57.33	43.67	21.37	21.13	21.25
52.	11A2	101.00	136.67	118.83	35.80	38.00	36.90	7.27	7.29	7.28	73.67	104.83	89.25	30.83	30.43	30.63
53.	MR750A2	42.50	109.00	75.75	32.83	31.32	32.08	8.13	7.20	7.67	26.57	74.27	50.42	26.03	27.83	26.93
54.	CSH20MF ©	129.00	129.83	129.42	42.53	37.80	40.17	6.40	6.90	6.65	68.67	98.90	83.78	24.43	24.90	24.67
55.	CSH24MF ©	168.33	167.67	168.00	39.63	36.90	38.27	6.57	6.60	6.58	66.33	116.60	91.47	23.47	23.57	23.52
	Mean	**98.08**	**126.43**	**112.25**	**37.18**	**35.90**	**36.54**	**6.98**	**6.73**	**6.85**	**57.61**	**88.10**	**72.85**	**28.68**	**28.71**	**28.70**
	C.V.	14.47	12.83	23.32	4.90	9.82	7.44	7.43	8.81	8.12	9.79	13.15	26.38	1.64	2.06	1.98
	F ratio	22.45	22.76	11.70	23.50	5.80	19.54	10.98	7.40	16.96	41.99	27.25	9.42	254.86	159.50	347.01
	F Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S.E.	8.19	9.37	10.69	1.05	2.04	1.11	0.30	0.34	0.23	3.26	6.69	7.85	0.27	0.34	0.23
	C.D. 5%	22.96	26.26	29.75	2.95	5.71	3.09	0.84	0.96	0.63	9.13	18.75	21.85	0.76	0.96	0.65
	C.D. 1%	30.38	34.73	39.20	3.90	7.55	4.07	1.11	1.27	0.83	12.08	24.81	28.79	1.01	1.27	0.85
	Range Lowest	42.50	59.67	53.50	26.70	25.77	26.45	5.07	4.49	4.93	26.57	33.33	31.33	15.92	16.13	16.03
	Range Highest	246.67	246.67	208.42	46.90	44.33	45.58	9.37	8.93	9.15	113.17	199.53	127.43	37.73	37.30	37.52

It was also reported earlier by other workers in their sorghum studies that the crosses exhibited the wider range of variation (mean performance) for most of the yield contributing characters as compared to their parents (9).

The mean performance of different genotypes for days to maturity was found to range between 123.67 days in cross $MR750A_2$ x CS3541 to 138.33 days in parent ICSA276, during first year and found to be ranged between 120 days in cross $MR750A_2$ x CS3541 to 131 days in ICSA469 x M35-1 in next year. Under pooled over year analysis, the mean performance for days to maturity was found to range between 121.83 days in $MR750A_2$ x CS3541 to 134.17 days in SPV1616 with the general mean of 127.48. $MR750A_2$ x RS29 (122), $MR750A_2$ x JJ1041 (123.33) and ICSA467x M35-1(123.5) were statistically *at par* with the lowest performing cross.

Plant height was found to range between 136.67 in ICSA469 to 354.00 in ICSA467 x UPC2 with the general mean of 270.60 during first year. During second year, the mean performance was ranged between 165.33 in ICSA467 to 385.33 in cross $11A_2$ x PC5 with general mean of 261.76. Under pooled over year

analysis, the mean performance of different genotypes for plant height was found to range between 168.04 in $MR750A_2$ to 345.58 in cross $11A_2$ x PC5 with the general mean of 266.18.

The mean performance of different genotypes for panicle length was found to range between 18.93 in parent M35-1 to 33.33 in cross ICSA469 x SPV1616 with the general mean of 26.43, during first year and during second year, it was found to range from 23.40 in CSH20MF to 34.67 in ICSA469 x SPV1616. Three crosses gave at par performance with check *viz.,* $MR750A_2$ x CSV15 (24.93), ICSA467x CSV15 (23.50), $MR750A_2$ x CS3541 (24.87). In pooled over years, the length was found to range between 22.87 in $MR750A_2$ x CS3541 to 34.00 in ICSA469 x SPV1616 with the general mean of 27.32. Panicle width was found highest in M35-1 (4.17) followed by $11A_2$ x CSV15 (4.97) and lowest in ICSA467 x UPC2 (10.47) with the general mean of 6.38, during first year and from 5.20 ($11A_2$ x SPV1616) to 12.67 (RS29) in second year with the general mean of 7.96.

The mean performance of different genotypes for panicle weight was found to range between 42.50 in parent $MR750A_2$ to 246.67 in cross ICSA467 x UPC2 with the general mean of 98.08, during first year.During second year, the best results for panicle weight were recorded in ICSA467 x RS 29 (246.67) while the poorest performance in M35-1 (59.67) with the general mean of 126.43. In pooled over year analysis of different genotypes it was found to range between 53.50 in M35-1 to 208.42 in $11A_2$ x UPC2 with the general mean of 112.25.

The mean values of different genotypes for flag leaf length was found in between 26.70 ($MR750A_2$ x CSV15) to 46.90(UPC2) with the general mean of 37.18, during first year and ranged between 25.77 in M35-1 to 44.33 (ICSA276 x SPV1616) with the general mean of 35.90 during second year. The highest value for flag leaf length was recorded in $MR750A_2$ x CSV15 followed by $MR750A_2$ x RS29 (44.43), ICSA467 x UPC2 (43.75) and $MR750A_2$ x UPC2 (43.33) during pooled over years. The mean performance of different genotypes was found between 4.93 (ICSA469 x PC5) to 9.15 ($MR750A_2$ x UPC2) with the general mean of 6.85 for flag leaf width during pooled over years.

The mean values of all genotypes for grain yield was found in between 26.57 ($MR750A_2$) to 113.17(ICSA467) with the general mean of 57.61, during first year. Two crosses performed *at par* with the highest value viz., ICSA467 x UPC2 (102.67) and $MR750A_2$ x UPC2 (97.33). During second year, the mean performance for grain yield was found to be in range between 33.33 in M35-1 to 199.53 (ICSA467 x UPC2) with the general mean of 88.10. During pooled over years, it was recorded between 31.33 (M35-1) to 127.33 (ICSA467 x RS29) with the general mean of 72.85. The higher value for grain yield was recorded in $11A_2$ x UPC2 (121.37) and ICSA467 x UPC2 (127.43).

1000 seed weight was found to range between 15.92 in parent M35-1 to 37.73 in cross $11A_2$ x JJ1041 with the general mean of 28.68, during first year. During second year, the poorest results for 1000 seed weight was recorded in M 35-1(16.13) while the highest performance in $11A_2$ x JJ1041 (37.30) with the general mean of 28.71. 1000 seed weight was found to range between 16.03 in M35-1 to 37.52 in $11A_2$ x JJ1041 with the general mean of 28.70 during pooled over years.

Genetic improvement of any crop is largely depends on the extent of genetic variability and its judicious exploitation through suitable breeding techniques, various parameters may be used for assessing the inherent genetic variability. In the present investigation analysis of variance, mean values and their range of variation for different characters have been used as the parameters for assessing the extent of genetic variability present in the experimental materials.

Highly significant estimates of genotype mean squares supported with wide range of mean values for all the characters under study, suggest substantial inherent genetic variability in the experimental material (lines, tester and crosses). It was also apparent that the experimental material has the ability to utilize effectively the existing environments for the expression of characters of economic importance in forage sorghum.

In the earlier reports also, sufficient genetic variability for yield and components traits in sorghum have been reported. Yield being the complex trait and influenced by the environment, exhibited a lot of variability and wide range of means for yield and its component traits in the present investigation, which is in conformity with earlier findings (1,3,4,5,6).

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