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Studies on Combining Ability for Grain Yield and Early Maturity in *Rabi* Sorghum

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ABSTRACT

Combining ability for grain yield and earliness traits in rabi sorghum was studied using eleven diverse lines and eight testers in line x tester (11L x 8T) design at AICSIP, MARS, UAS, Dharwad during 2015-16 rabi. Mean sum of squares due to lines, testers and line × tester were highly significant indicating the existence of high variability for most of the characters. The estimates of general combining ability (GCA) and specific combining ability (SCA) variances indicated the presence of higher magnitude non-additive gene action for number of nodes per plant, leaf blade breadth, days to physiological maturity, grain and fodder yield per plant. Whereas additive genetic action for plant height, number of leaves per plant, leaf blade length and days to 50 % flowering. The gca and sca effects indicated that the genotypes SEVS-8, Barsi Jawar, Kodamurki local and CSV-18 were good general combiners for grain and fodder yields. Line SEVS-8 and EP-9 were most desirable general combiners for both yield and early maturity traits. While the sca effects showed that the crosses Barsi Jawar x CSV-18 (34.81), Madabhavi Local x EP-117 (54.01) and Madabhavi Local x EP-94 (-6.05) were best specific combiners for grain, fodder yield and early maturity respectively.

Key words: *Combining ability, GCA variance, SCA variance, Physiological maturity*

INTRODUCTION

Sorghum [*Sorghum bicolor* (L) Moench] is one of the fifth major important cereal crops after rice, wheat, maize, barley, and serves as staple food for more than 300 million people and as feed for cattle living in Asia and Africa. Presently it is cultivated in tropical, sub tropical and temperate regions of the world extending as many as six continents as 'great millet'. In India it is grown as a dual purpose crop serving both grain and fodder requirements of the farming community. Being C_4 plant sorghum is most hardy, dependable and adaptive crop to changing climatic conditions and hence play major role in increasing food production in the semi-arid tropics.

In India, Maharashtra, Karnataka and Madhya Pradesh are the first three largest producing states.

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Sorghum is cultivated in both the *kharif* and *rabi* seasons, where karief yields are higher than in rabi but most of the consumers prefer post rainy season sorghum for its superior grain quality attributing to good *roti* quality. Post-rainy sorghum is grown on the stored soil moisture and this moisture is receding hence it experiences terminal drought situation during its crop season. This moisture stress mostly affect the plant at flowering and grain filling stage, which drastically reduce the yield potential of *rabi* sorghum.

Early maturity is desirable in *rabi* sorghum as early maturing genotypes escape the terminal moisture stress condition thereby reducing the adverse effect of the low moisture on the yield potential. Hence early varieties are needed in *rabi* sorghum to harvest good yields in dry spells. For this identification of the suitable parental lines having potential for earliness and high grain yield needs to be done.

The estimates of combining ability are useful to predict the relative performance of different lines in hybrid combinations. Combining ability also provides necessary information on nature and magnitude of gene action which is important in understanding genetic potential of population. The line x tester mating design helps in assessing the combining ability of parents there by selection of superior parents as well as cross combinations. In the present investigation, the promising parental lines for high grain yield and earliness were sorted out based on their general combining ability effects.

MATERIAL AND METHODS

The experimental material for study consisted of nineteen diverse sorghum genotypes (Table 1). Which were crossed in line x tester (11 x 8) fashion[6] to obtain hybrids during post rainy season 2014-15. These 88 hybrids along with 19 parents and check M-35-1 were grown in randomized block design[9] with two replications in post rainy season 2015-16 *rabi* at All India Co-ordinated Sorghum Improvement Project, Main Agricultural Research Station, Dharwad (Karnataka). Each replication was divided in to two tiers to reduce soil heterogeneity. Each genotype planted in two rows with row length 4m and spacing 45cm x 15cm. Observations were recorded for plant height, number of nodes, number of leaves, leaf length, leaf width, days to 50 % flowering, days to maturity, grain yield/plant and fodder yield/plant from five random plants from each entry and replication. Average values of five plant observations were used for statistical analysis.

RESULTS AND DISCUSSION

Analysis of variance for combining ability is presented in table 2. The variations due to lines (females) were highly significant for all the characters; where as variation due to testers (males) were significant for plant height, number of leaves per plant, leaf blade length and days to 50 % flowering. However highly significant variation due to hybrids (lines x tester interaction effects) was observed for all the traits.

The estimates of variance due to GCA and SCA are also depicted in table 2. It is evident from the study that, the estimates of variances for SCA were higher in magnitude than GCA variances for number of nodes per plant, leaf blade breadth, days to physiological maturity, grain yield per plant and fodder yield per plant. Tarique *et al*.[11], Kumar and Chand[8], also reported the predominance of SCA variance for fodder yield and leaf breadth. The present results were in accordance with the findings of Ambalika *et al.*[2] for leaf breadth. The GCA and SCA variance ratio was less than unity for these traits, indicating predominance of non-additive variance and non-additive gene action which is essential for exploitation of heterosis through hybrid breeding. Premalatha *et al*.[10] reported greater specific combining ability variances than general combining ability variances and described the non-additive type of gene actions for different traits in sorghum.

Whereas the magnitude of GCA variances were greater than SCA variance for traits like plant height, number of leaves per plant, leaf blade length and days to 50 % flowering, which indicates the prevalence of additive gene action acting up on these characters. Suggesting for intra-population improvement and open-pollinated variety

(OPV) development through recurrent selection would be highly effective. Present findings were in accordance with the findings of Girma *et al.*[4] for plant height, leaf number per plant, leaf length.

The estimates of general combining ability effects of the lines and testers are presented in table 3 and the estimates of specific combining ability effects of crosses are represented in table 4. Estimates of *gca* effects reflect true genotypic value of a line, as these are estimated as mean effect of a line in a series of crosses[3]. *Per se* performances of the parents with high *gca* effects provide criteria for choice of the parents for hybridization and they are desirable for obtaining useful segregants in early generations[5]. In sorghum, positive *gca* effects is desirable for grain and fodder yield per plant while for maturity traits (days to 50% flowering and days to maturity) negative *gca* effects are desirable.

From present study it is reflected that, six lines EP-9 (-5.40) followed by IS-23586 (-3.47), SEVS-8 (-1.78), DCCR-22 (-1.40), M 35-1 (-1.09) and Lingasgur-2 (-0.97), three testers *viz.*, IS-4515 (-2.47), DSV-4 (-1.1) and IS-5094 (-0.74) showed negative significant *gca* effects for days to 50 % flowering which is desirable. As regard to days to maturity, five lines SEVS-8 (-5.76) followed by EP-9 (-1.89), Lingasgur-2 (-1.26), HL (-0.76) and DCCR-22 (-0.57) recorded significant *gca* effects in desired direction, among testers IS-5094 (-1.84) and IS-4515 (-0.43) recorded significant *gca* effects for days to maturity in desired direction.

Four lines *viz.*, EP-9, SEVS-8, DCCR-22, and Lingasgur-2, three testers *viz.,* EP-94, IS-4515, and IS-5094 exhibited negative significant *gca* effects for both days to 50% flowering and for days to physiological maturity. Revealing good general combiners identified for early flowering can also be good general combiners for early maturity. Ambalika *et al.*[1] and Kumar and Chand[8] have also reported common good general combiners for days to maturity as well as for days to 50 % flowering.

The study of *sca* effects indicated that 13 and 42 hybrids exhibited negative significant *sca* effects for days to 50 % flowering and days to physiological maturity respectively. Kulkarni and Patil[7] also observed negative significant *sca* effect for days to maturity. The cross Lingasgur-2 x IS-4515 (-5.22), SEVS-8 x DSV-4 (-3.77), SEVS-8 x CSV-216R (-3.45) were identified with high negative *sca* effects for early flowering and the crosses, Madabhavi Local x EP-94 (-6.05), Tandur Local x Phule Revati (-5.60), Madabhavi Local x IS-4515 (-3.82), IS-23586 x IS-4515 (-3.44), Barsi Jawar x DSV-4 (-3.43), Lingasgur-2 x CSV-216R (-3.42) and Kodamurki Local x IS-5094 (-3.03) were identified for early maturity.

In sorghum morphological characters like plant height, number of nodes per plant, number of leaves per plant, leaf blade length and breadth are important traits governing grain as well as fodder yields, by virtue of their role in increasing photosynthetic area (source) which decides the yielding ability in terms of photosynthates accumulated as grain (sink). Hence significant positive *gca* effects for these traits would indirectly help in selecting parents for grain and fodder yield improvement programmes. In this respect, line Tandur Local recorded positive significant *gca* effects for all these morphological traits along with grain yield. There was no single cross which was good specific combiner for all five plant morphological traits under study. However the cross EP-9 x Phule Revati was good specific combiner with significant positive *sca* effects for plant height, number of leaves per plant, number of nodes per plant and leaf blade breadth. In addition to this, the cross HL x IS-5094 recorded positive significant *sca* effects for plant height, number of leaves per plant and number of nodes per plant.

For grain yield per plant is considered, six lines, Barsi Jawar (12.50), Madabhavi local (9.40), Kodamurki local (9.22), Tandur local (8.67), IS-23586 (3.34), SEVS-8 (2.14), and three testers CSV-18 (5.79), CSV-216R (4.84), Phule Revati (2.82) recorded significant positive *gca* effects. These genotype were good general combiners not only with positive significant *gca* effects, also had good *per se* performance for grain yield per plant, which was further evidenced by, high mean performance of hybrid having at least one of the above mentioned parents in their cross combinations.

Total of 28 out of 88 crosses were with significant positive *sca* effects for grain yield per plant. Of which, maximum significant positive *sca* effect was expressed by the cross Barsi Jawar x CSV-18 (34.81) followed by SEVS-8 x IS-5094 (25.51) and Kodamurki Local x DSV-4 (23.19). These crosses had high mean performances along with significant *sca* effects for grain yield indicating isolation of high yielding genotypes from early segregating generations of these crosses.

Among nineteen parents, seven *viz.*, SEVS-8, Barsi Jawar, Kodamurki local, EP-9, DSV-4, EP-117 and CSV-18 were good general combiners for fodder yield per plant. Highest positive significant *sca* effect was recorded by the cross Madabhavi Local x EP-117 (54.01) followed by SEVS-8 x IS-4515 (52.53), Tandur Local x IS-4515 (47.23) and Lingasgur-2 x DSV-4 (40.51).

Genotype SEVS-8, Barsi Jawar and CSV -18 were good combiners with positive significant *gca* effects and high *per se* of more than 100 g fodder yield per plant indicating, better *per se* performances of the parents with significant *gca* effects indicating choice of the parents for hybridization would be useful to obtain useful segregants in early generations[5].

From present study it is interesting to note that, the parents SEVS-8, Barsi Jawar, Kodamurki local and CSV-18 were good general combiners for grain and fodder yields. This implies, developing dual purpose genotypes in *rabi* sorghum is possible by utilising these parents. Line SEVS-8 was most suitable for developing high yielding and early maturing hybrids in *rabi* sorghum which posses positive significant *gca* effects for grain yield (2.14) along with negative significant *gca* effects for days to 50 % flowering (-1.78) and days to maturity (-5.76). Crosses Madabhavi Local x EP-94, Tandur Local x Phule Revati, Madabhavi Local x IS-4515, IS-23586 x IS-4515, Barsi Jawar x DSV-4, Lingasgur-2 x CSV-216R and Kodamurki Local x IS-5094 illustrated possibility of exploiting these crosses and above parents in isolating high yielding genotypes which can mature early, either through hybrid breeding or population improvement approach.

Table 1: List of parents and check used in combining ability (11L x 8T) study

Lines/Testers		Genotype
Lines (female parents)	L1	SEVS-8
	L2	Barsi Jawar
	L3	Kodamurki Local
	L4	Madabhavi Local
	L5	Lingasgur-2
	L6	EP-9
	L7	DCCR-22
	L8	HL
	L9	IS-23586
	L10	Tandur Local
	L11	M 35-1
Testers (male parents)	T1	DSV-4
	T2	Phule Revati
	T3	CSV-216R
	T4	EP-94
	T5	EP-117
	T6	CSV-18
	T7	IS-5094
	T8	IS-4515
Check	C	M 35-1

Table 2: Analysis of variance (ANOVA) for combining ability for plant morphological, yield and maturity traits in *rabi* sorghum

Source of variance	d.f.	Plant height	No. of leaves	No. of nodes	Leaf blade length	Leaf blade breadth	Days to 50 % flowering	Days to physiological maturity	Grain yield per plant	Fodder yield per plant
Replication	1	91.50*	3.19**	0.03	53.16*	0.03	4.14	0.00	2.34	327.82*
Female	10	2902.11**	14.51**	13.73**	73.06**	1.61*	164.35**	101.56**	2420.95**	3519.14**
Male	7	1299.26**	1.75**	0.76	160.15**	1.36	44.73**	16.27	387.40	1419.67
Female x Male	70	203.56**	0.51**	0.80**	19.24*	0.76**	6.74**	12.15**	272.21**	980.37**
Error	87	15.04	0.18	0.02	12.94	0.05	1.44	0.02	7.36	63.65
$\sigma^2 gca$		109.74**	0.42**	0.38**	5.48**	0.08**	5.43**	3.10**	73.53**	126.77**
$\sigma^2 sca$		93.97**	0.14**	0.39**	3.40*	0.36**	2.69**	6.06**	132.58**	459.76**
$\sigma^2 gca/\sigma^2 sca$		1.17	2.90	0.98	1.60	0.21	2.02	0.51	0.55	0.28
Per cent contribution										
Lines		55.42	75.18	69.23	22.84	20.34	67.68	51.30	52.66	30.94
Testers		17.37	6.34	2.67	35.05	12.04	12.90	5.75	5.90	8.74
Line × tester		27.21	18.48	28.10	42.10	67.63	19.43	42.95	41.45	60.33

*- significant at 5 % level of probability; **- significant at 1 % level of probability

Table 3: Estimates of general combining ability (*gca*) effects of lines and testers for plant morphological, yield and maturity traits in *rabi* sorghum

L/T	Parents	Plant height	No. of leaves	No. of nodes	Leaf length	Leaf breadth	Days to 50 % flowering	Days to physiological maturity	Fodder yield per plant	Grain yield per plant
L1	SEVS-8	6.79**	-0.21	-0.26**	-0.74	0.04	-1.78**	-5.76**	17.26**	2.14**
L2	Barsi Jawar	1.03	0.83**	0.69**	1.21	0.49**	2.60**	0.43**	15.26**	12.50**
L3	Kodamurki Local	7.09**	1.03**	0.98**	0.29	0.01	2.60**	1.99**	14.41**	9.22**
L4	Madabhavi Local	5.52**	0.43**	0.52**	0.04	-0.10	0.85**	2.36**	-11.28**	9.40**
L5	Lingasgur-2	25.35**	0.19	0.48**	-2.70**	-0.34**	-0.97**	-1.26**	2.75	-3.08**
L6	EP-9	-20.11**	-1.74**	-1.81**	-1.25	-0.06	-5.40**	-1.89**	22.10**	-32.40**
L7	DCCR-22	-9.22**	-0.17	-0.36**	-2.60**	-0.58**	-1.40**	-0.57**	-7.64**	-4.13**
L8	HL	-10.91**	-0.34**	-0.10**	1.30	-0.05	2.10**	-0.76**	-7.10**	-2.53**
L9	IS-23586	-14.86**	-1.30**	-1.33**	2.34**	0.55**	-3.47**	1.99**	-13.92**	3.34**
L10	Tandur Local	13.90**	1.47**	1.18**	4.11**	0.13*	5.97**	3.24**	-12.10**	8.67**
L11	M 35-1	-4.59**	-0.21	0.00	-7.97	-0.08	-1.09**	0.24**	-19.70**	-3.12**
	S.Em. ±	0.99	0.12	0.03	0.88	0.05	0.29	0.03	1.95	0.66
	C.D. @ 5 %	1.96	0.23	0.07	1.75	0.11	0.58	0.07	3.88	1.32
	C.D. @ 1 %	2.60	0.31	0.09	2.32	0.14	0.77	0.09	5.14	1.75
T1	DSV-4	4.65**	0.01	0.02	6.11**	0.15**	-1.11**	0.61**	3.96*	0.73
T2	Phule Revati	9.72**	0.39**	0.37**	0.52	-0.15**	1.07**	0.48**	-1.65	2.82**
T3	CSV-216R	11.76**	0.40**	0.02	0.01	0.07	2.07**	0.80**	-9.77**	4.84**
T4	EP-94	-6.39**	0.06	-0.06*	-1.54*	0.15**	-0.02	-0.20**	0.63	-4.73**
T5	EP-117	-5.23**	-0.14	-0.01	-1.87*	-0.31**	0.30	0.02	10.07**	-4.95**
T6	CSV-18	-7.60**	-0.19	-0.09**	-0.30	0.42**	0.89**	0.57**	11.33**	5.79**
T7	IS-5094	-1.33	-0.13	0.05	-0.20	-0.29**	-0.74**	-1.84**	-8.18**	-1.61**
T8	IS-4515	-5.59**	-0.41**	-0.29**	-2.72**	-0.04	-2.47**	-0.43**	-6.38**	-2.89**
	S.Em. ±	0.84	0.10	0.03	0.75	0.05	0.25	0.03	1.66	0.57
	C.D. @ 5 %	1.67	0.20	0.06	1.49	0.09	0.49	0.06	3.31	1.13
	C.D. @ 1 %	2.22	0.26	0.08	1.98	0.12	0.65	0.08	4.38	1.49

*- significant at 5 % level of probability; **- significant at 1 % level of probability

Table 4: Estimates of specific combining ability (*sca*) effects of crosses for plant morphological, yield and maturity traits in *rabi* sorghum

Sl. No.	Hybrid	Plant height	No. of leaves	No. of nodes	Leaf length	Leaf breadth	Days to 50 % flowering	Days to physiological maturity	Fodder yield per plant	Grain yield per plant
1	SEVS-8 x DSV-4	-23.62**	-0.81*	-0.85**	-1.67	-0.19	-3.77**	1.26**	-33.91**	-14.23**
2	SEVS-8 x Phule Revati	1.11	0.38	-0.30**	0.12	-0.19	0.05	-0.60**	-25.30**	-3.12
3	SEVS-8 x CSV-216R	-7.88**	-0.42	-0.85**	-1.87	-0.61**	-3.45**	-1.92**	-10.18	-18.34**
4	SEVS-8 x EP-94	22.57**	0.14	0.69**	5.04*	-0.03	1.14	-0.92**	-23.68**	11.73**
5	SEVS-8 x EP-117	-7.09*	0.03	0.18	4.37	0.78**	0.32	-2.15**	4.18	2.75
6	SEVS-8 x CSV-18	4.78	0.25	0.43**	-1.57	-0.46**	2.23**	0.31**	13.52*	-5.09**
7	SEVS-8 x IS-5094	10.01**	0.43	0.32**	-5.17*	-0.15	3.37**	1.72**	22.83**	25.51**
8	SEVS-8 x IS-4515	0.12	0.01	0.37**	0.75	0.85**	0.10	2.31**	52.53**	0.79
9	Barsi Jawar x DSV-4	7.14*	-0.40	-0.80**	5.59*	0.86**	-2.64**	-3.43**	-35.81**	4.21*
10	Barsi Jawar x Phule Revati	0.72	0.12	0.25*	-4.16	0.74**	-2.32**	1.21**	17.60**	16.01**
11	Barsi Jawar x CSV-216R	-7.97**	-0.22	0.20*	-4.31	-2.07**	1.176	1.39**	-8.98	-15.61**
12	Barsi Jawar x EP-94	-10.52**	-0.21	-0.55**	0.07	-0.72**	-1.23	-2.61**	11.52*	-14.87**
13	Barsi Jawar x EP-117	6.52*	-0.18	0.63**	2.56	0.32*	-0.55	-2.34**	-20.52**	-10.52**
14	Barsi Jawar x CSV-18	9.73**	0.65	0.80**	5.16*	0.50**	2.86**	4.12**	30.32**	34.81**
15	Barsi Jawar x IS-5094	0.52	-0.02	-0.43**	-5.61*	-0.48**	-0.01	-0.47**	5.33	-2.66
16	Barsi Jawar x IS-4515	-6.12*	0.26	-0.09	0.71	0.85**	2.72**	2.12**	0.53	-11.38**
17	Kodamurki Local x DSV-4	5.57*	0.31	0.71**	-0.67	0.69**	-0.14	-2.49**	4.04	23.19**
18	Kodamurki Local x Phule Revati	-12.60**	0.55	-0.44**	-0.42	-0.35*	2.18**	0.65**	-27.85**	-7.21**
19	Kodamurki Local x CSV-216R	0.26	-0.25	-0.09	-2.90	0.59**	1.176	1.33**	1.07	3.90*
20	Kodamurki Local x EP-94	-8.39**	-0.07	-0.21*	1.81	-0.23	-1.23	3.33**	19.87**	-8.62**
21	Kodamurki Local x EP-117	8.80**	0.12	-0.58**	-2.52	0.06	1.45	1.10**	5.43	-18.03**
22	Kodamurki Local x CSV-18	11.17**	-0.49	0.59**	0.40	-0.26	-2.14*	-1.44**	29.17**	-7.37**

Contd……

Sl. No.	Hybrid	Plant height	No. of leaves	No. of nodes	Leaf length	Leaf breadth	Days to 50 % flowering	Days to physiological maturity	Fodder yield per plant	Grain yield per plant
23	Kodamurki Local x IS-5094	-8.15**	-0.55	-0.22*	3.81	-0.05	-1.51	-3.03**	-18.72**	-2.47
24	Kodamurki Local x IS-4515	3.32	0.39	0.23*	0.49	-0.46**	0.22	0.56**	-13.02*	16.61**
25	Madabhavi Local x DSV-4	-2.86	-0.25	0.37**	-2.09	-0.38*	-0.89	3.14**	-23.77**	-4.49*
26	Madabhavi Local x Phule Revati	-5.58*	-0.47	-0.88**	2.50	-0.08	0.93	4.27**	28.64**	-4.69*
27	Madabhavi Local x CSV-216R	-4.97	0.02	0.95**	0.85	1.03**	2.43**	0.96**	-5.84	10.10**
28	Madabhavi Local x EP-94	0.68	0.03	-0.06	-0.11	-0.29	-1.98*	-6.05**	7.36	-12.64**
29	Madabhavi Local x EP-117	-2.98	-0.28	-0.03	-0.11	-0.25	-0.30	1.73**	54.01**	-16.81**
30	Madabhavi Local x CSV-18	5.19	0.44	-0.03	-0.18	-0.24	-1.39	-0.82**	-23.34**	15.25**
31	Madabhavi Local x IS-5094	0.62	0.35	-0.17	-0.61	0.14	0.24	0.59**	-3.83	18.05**
32	Madabhavi Local x IS-4515	9.89**	0.16	-0.15	-0.26	0.06	0.97	-3.82**	-33.23**	-4.77*
33	Lingasgur-2 x DSV-4	-2.68	-0.34	-0.47**	2.15	0.11	2.92**	5.76**	40.51**	0.99
34	Lingasgur-2 x Phule Revati	2.25	-0.40	-0.53**	6.58**	0.07	-0.26	-1.10**	27.82**	-3.90*
35	Lingasgur-2 x CSV-216R	-9.79**	0.43	-0.38**	-1.41	-0.07	0.239	-3.42**	-8.67	13.58**
36	Lingasgur-2 x EP-94	-13.30**	0.11	-0.02	-1.37	1.10**	0.33	-1.42**	-12.57*	4.05*
37	Lingasgur-2 x EP-117	17.05**	0.29	0.76**	0.47	-0.69**	1.011	-0.65**	1.29	-6.99**
38	Lingasgur-2 x CSV-18	8.07**	-0.99**	0.02	-1.61	-0.49**	-1.08	-1.19**	-27.57**	-9.67**
39	Lingasgur-2 x IS-5094	-8.30**	0.50	0.29**	-5.46*	-0.41**	2.06*	2.216**	-11.16*	1.93
40	Lingasgur-2 x IS-4515	6.71*	0.40	0.28**	0.64	0.38*	-5.22**	-0.19*	-9.66	0.01
41	EP-9 x DSV-4	4.27	0.75*	0.71**	-3.63	-0.75**	-1.64*	-0.61**	26.56**	-0.89
42	EP-9 x Phule Revati	16.85**	0.69*	1.35**	-0.37	1.21**	-0.82	-1.48**	8.47	3.71
43	EP-9 x CSV-216R	8.16**	0.52	0.26**	2.81	1.24**	-0.32	-1.80**	1.08	-3.10
44	EP-9 x EP-94	-16.19**	-0.64	-0.66**	-0.82	-0.16	0.77	0.21*	-4.82	1.36
45	EP-9 x EP-117	2.65	0.05	-0.04	0.35	-0.54**	-0.55	1.98**	-12.96*	8.19**

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Sl. No.	Hybrid	Plant height	No. of leaves	No. of nodes	Leaf length	Leaf breadth	Days to 50 % flowering	Days to physiological maturity	Fodder yield per plant	Grain yield per plant
46	EP-9 x CSV-18	4.17	-0.07	-0.45**	-1.40	0.31	-0.14	-0.57**	-4.52	-5.05**
47	EP-9 x IS-5094	-12.10**	-0.95**	-0.92**	6.35*	-0.24	1.49	0.84**	-2.01	-2.05
48	EP-9 x IS-4515	-7.83**	-0.35	-0.25*	-3.30	-1.06**	1.22	1.43**	-11.81*	-2.17
49	DCCR-22 x DSV-4	-7.27*	0.85*	0.35**	2.39	0.01	-1.64*	0.07	30.89**	0.74
50	DCCR-22 x Phule Revati	-3.99	-0.21	-0.04	-2.85	-0.60**	0.18	1.21**	-26.10**	-10.16**
51	DCCR-22 x CSV-216R	21.47**	0.45	0.74**	-0.50	0.01	1.18	-1.11**	19.32**	-5.68**
52	DCCR-22 x EP-94	7.08*	-0.37	0.23*	-0.29	-0.15	0.77	-1.11**	9.12	6.89**
53	DCCR-22 x EP-117	-0.74	0.66	0.28**	-0.96	-0.44**	-0.05	-2.34**	9.48	12.81**
54	DCCR-22 x CSV-18	-7.52**	-0.13	-0.32**	0.30	0.66**	0.86	5.12**	-13.48*	-0.93
55	DCCR-22 x IS-5094	-1.14	-0.18	-0.21*	4.54	0.46**	-1.51	-0.97**	-6.87	-12.63**
56	DCCR-22 x IS-4515	-7.88**	-1.08**	-1.04**	-2.62	0.04	0.22	-0.88**	-22.38**	8.96**
57	HL x DSV-4	9.57**	-0.82*	-0.28**	0.17	-0.01	-0.14	-2.74**	-9.54	-0.56
58	HL x Phule Revati	-2.30	-0.54	0.12	-3.58	0.20	0.18	-1.60**	6.67	-1.89
59	HL x CSV-216R	-6.69*	-0.21	-0.53**	-0.73	0.31*	-0.32	-0.92**	13.68*	7.03**
60	HL x EP-94	0.61	0.13	-0.03	1.97	0.07	0.77	2.08**	-25.62**	1.10
61	HL x EP-117	2.30	0.32	0.75**	-3.03	0.03	-2.05*	2.85**	-10.06	-2.98
62	HL x CSV-18	-13.38**	-0.46	-1.00**	2.24	0.1	0.36	-1.69**	-7.72	2.06
63	HL x IS-5094	8.90**	1.32**	0.53**	-1.36	-0.58**	-0.51	-0.28**	3.99	-12.42**
64	HL x IS-4515	0.97	0.26	0.43**	4.32	-0.16	1.72*	2.31**	28.59**	7.66**
65	IS-23586 x DSV-4	-0.78	-0.19	-0.55**	-2.21	-0.16	1.92*	0.51**	-6.13	-0.53
66	IS-23586 x Phule Revati	9.45**	0.42	0.10	1.71	0.39*	1.24	1.65**	17.68**	7.78**
67	IS-23586 x CSV-216R	10.41**	-0.42	-0.04	2.39	-0.25	-0.26	2.33**	18.80**	13.16**
68	IS-23586 x EP-94	6.71*	0.26	0.04	0.27	0.26	0.83	1.33**	-1.40	-0.57

Contd……

Sl. No.	Hybrid	Plant height	No. of leaves	No. of nodes	Leaf length	Leaf breadth	Days to 50 % flowering	Days to physiological maturity	Fodder yield per plant	Grain yield per plant
69	IS-23586 x EP-117	-7.25*	-0.22	0.50**	-1.40	-0.20	1.01	0.10	-10.25	8.05**
70	IS-23586 x CSV-18	-7.38**	0.50	0.07	-0.138	-0.60**	-1.58	-1.44**	12.90*	1.71
71	IS-23586 x IS-5094	-8.15**	-0.56	0.47**	-0.07	0.70**	-2.44**	-1.03**	-7.79	-22.99**
72	IS-23586 x IS-4515	-3.03	0.22	-0.58**	-0.55	-0.13	-0.72	-3.44**	-23.79**	-6.61**
73	Tandur Local x DSV-4	5.76*	0.37	0.11	-4.65	0.06	5.98**	1.26**	-6.61	2.64
74	Tandur Local x Phule Revati	2.04	-0.52	1.26**	0.11	-1.48**	-1.20	-5.60**	-32.80**	-2.16
75	Tandur Local x CSV-216R	-11.65**	-0.19	-0.39**	3.45	-0.20	-1.70*	1.08**	-26.08**	-7.07**
76	Tandur Local x EP-94	16.45**	0.32	0.20*	-2.67	0.31*	-0.11	1.08**	8.22	8.59**
77	Tandur Local x EP-117	-5.56*	-0.66	-2.26**	0.33	0.27	0.074	-0.15	-6.02	19.32**
78	Tandur Local x CSV-18	-9.64**	0.23	0.31**	1.93	0.87**	-0.52	0.31**	0.02	-19.63**
79	Tandur Local x IS-5094	13.74**	0.34	0.25**	-0.84	0.16	-0.38	1.72**	16.03**	5.38**
80	Tandur Local x IS-4515	-11.15**	0.12	0.51**	2.35	-0.01	-2.15*	0.31**	47.23**	-7.07**
81	M 35-1x DSV-4	4.90	0.54	0.63**	4.62	-0.24	0.05	-2.74**	13.76*	-11.07**
82	M 35-1x Phule Revati	-7.97**	-0.02	-0.89**	0.38	0.07	-0.14	1.40**	5.17	5.64**
83	M 35-1x CSV-216R	8.64**	0.31	0.13	2.23	0.01	-0.14	2.08**	5.78	2.02
84	M 35-1x EP-94	-5.71*	0.32	0.38**	-3.90	-0.15	-0.05	4.08**	11.98*	2.99
85	M 35-1x EP-117	-13.72**	-0.16	-0.18	-0.07	0.65**	-0.36	-0.15	-14.56**	4.21*
86	M 35-1x CSV-18	-5.20	0.06	-0.42**	-5.14*	-0.42**	0.55	-2.69**	-9.32	-6.08**
87	M 35-1x IS-5094	4.04	-0.68*	0.09	4.43	0.45**	-0.82	-1.28**	2.19	4.35*
88	M 35-1x IS-4515	15.00**	-0.58	0.27**	-2.55	-0.389*	0.91	-0.69**	-15.01**	-2.05
S.Em. ±		2.80	0.33	0.10	2.49	0.16	0.82	0.10	5.52	1.88
C.D. 5 %		5.56	0.66	0.19	4.96	0.31	1.64	0.19	10.96	3.73
C.D. 1 %		7.36	0.88	0.25	6.57	0.41	2.17	0.26	14.53	4.95

*- significant at 5 % level of probability; **- significant at 1 % level of probability

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