Genetic analysis for the improvement of grain yield, yield contributing traits and quality in *Rabi* sorghum [*Sorghum bicolor* (L.) Moench]

ABSTRACT:

Anexperiment was conducted,the hybrids and their parents were evaluated using thirty F_1 hybrids of *rabi* sorghum (*Sorghum bicolor* (L.) Moench) developed by crossing three lines and ten testers in line × tester fashion. for their combining ability and also to check the superiority of hybrids (heterosis) over parents with respect to quality traits, grain yield and its components. Among thirty hybrids, two potential hybrids M-35-2A x RSV 2388 and 104A x Phule Vasudha were found to be good specific combiners with highest standard heterosis and *per se* performance for grain yield over checks CSH 15R. AKMS-66-2A and 104A were the good general combiner with males *viz.* Phule Vasudha, RSV 2388, PhuleRevati and RSV 1910. The estimates of general combing ability and specific combining ability revealed the presence of both additive and non-additive genetic components for most of the traits under study.

KEY WORDS: Rabi Sorghum, L×T, Heterosis, Combining ability.

INTRODUCTION:

Sorghum (*Sorghum bicolor* (L.) Moench) plays a vital role in providing nutrition to human race along with wheat, rice and maize. It is the source of food, fodder and predominantly cultivated in states of Maharashtra, Karnataka and Tamil Nadu. Rabi sorghum is cultivated over 4.24 mha in India with an annual production of 4.78 mt. In Maharashtra, *rabi* sorghum are being cultivated over 16.6 lakh ha with an annual production of 20.36 lakh ton (Anonymous ,2022). The grain yield and its contributing traits are governed by polygenes with complex gene action and hence understanding the nature and magnitude of gene action help the breeder in selection of an appropriate breeding method.For improvement in such an important crop, the most important prerequisite is the selection of suitable parents,which could combine well and produce desirable hybrids.Combining ability analysis helps in identifying the betterparents, and these parents can be used for hybridization program in order to produce superior hybrids (Ingle *et al*., 2018). As a general rule, general combining ability (GCA) is the result of additive gene effects, while the specific combining ability (SCA) is the result of non-allelic interactions (Jinks, 1954; Ingle *et al*., 2018). In the present study, an attempt has been made to estimate the heterosis in F1 hybrids with respect yield,yieldcontributing and quality traitsthe combining ability and gene action governing the quantitative and qualitative traits in sorghum.

MATERIAL AND METHODS:

Thirteen genotypes of sorghum consist of three lines namely 104A, AKMS-662 A and M-35-2A and ten testers namely, RSV 2388, RSV 2371, RSV 1910, RSV 1988, RSV 2394, RSV 2482,RSV 2595, Phule Vasudha, Phule Suchitra and PhuleRevatiwere uses as parental lines. These parents were crossed in a line×tester mating design and developed 30 hybrids. All the hybrids along with their parents and standard check CSH 15R were tested during rabi 2022-23. Heterosis was assessed over the better parent (heterobeltosis) and standard check (standard heterosis).Estimation of these two types heterosis were done for following characters *viz.*days to 50 per cent flowering, days to maturity, plant height, 1000 seed weight, grain yield per plot, dry fodder yield per plot, total sugar %, crude protein % and crude fiber %. The heterosis was estimated out as per the method suggested by Singh and Narayanan (1993). The hybrids and parents were also evaluated to study the combining ability and gene action for nine characters. The combining ability analysis was carried out as per the method suggested by Kempthorne (1957).

RESULTS AND DISCUSSION:

The analysis of variance for quality, yield and yield components traits studied are presented in **Table 1**. Variance due to parents was highly significant for all the traits indicating good amount of genetic differences among the parents. Variance due to hybrids was also significant for all the nine traits. Variance due to lines was significant for all traits except days to 50% flowering and crude protein. Variance due to tester was significant for all traits except days to 50% flowering. Variance due to line × testers tester was significant for days to 50% flowering, days tomaturity, plant height and total sugar content and remaining foundnon-significant. The relative estimation of variance due to general combing ability and specific combining ability revealed the presence of both additive and non-additive genetic components for most of the traits(Ingle, *et al* 2018). The predominance of non-additive gene action were recorded in traits viz. Thousand grain weight, grain yield total sugar and crude protein. These findings were confirmed byChaudhary and Narkhede (2004), Gaddameedi*et al* (2020) and Totre *al* (2021).Whereas predominance of additive gene action were shown by the traits *viz*. days to flowering,days to maturity, plant height, dry fodder yield and crude protein. Similar findings were reported byJain and Patel (2014) and Aru *et al* (2019).

The analysis of variance for combining ability for quality, yield and yield components traits studied are presented in **Table2**. Harer and Bapat (1982) stated that the per se performance of the parents with the nature of combining ability provide the criteria for the choice of parents. On the basis, those parents which performed well for *per se* and *gca* effects can be consider as good combiner.

Among the lines,AKMS -66 2A recorded low mean value and negative *gca* effects **(Table 3)**for days to 50% flowering(80,-1.30**) and maturity(120.5,-1.25**) coupled with high mean value as well as positive *gca* effects for grain yield(0.505,0.04) ,total sugar (2.47, 0.11**)and crude protein content(10.45, 0.21**) which might be useful earliness,high productive with more nutritional properties.The line 104A shows high mean value for dry fodder yield(1.580,0.34**) with desirable *gca* effects indicating,it is suitable for more fodder yield. Among the testers, RSV 2388,RSV 1910,RSV 2371, Phule Vasudha and PhuleRevati were found to be good combiner for quality and yield components traits. A perusal of mean performance and general combining abilities of parent exhibited relationship amongst them, thisfinding corroborates with that of Nandanwankar (2010).

The results of *sca* effects are presented in **Table 4**.Among the hybrids M-35-2A(low) × RSV 2388(low)[0.27**] and 104A (low) × Phule Vasudha (high) [0.16**]recorded maximum sca effects for grain yield. The hybrids M-35-2A(low) × Phule Vasudha(high)[0.54**] and 104A(high) × RSV 2371(low) [0.21**]showed significant *sca* effects for dry fodder yield.The hybrid M-35-2A (high)× RSV 2371(high)[-1.38**] earliness for flowering with more *sca* effects. The hybrid M-35-2A (low)× RSV 2394 (high)[-1.95**] matures early with more *sca* effects. The hybrid 104A (average) × RSV 2595 (high)[8.73**] recorded more plant height with maximum sca effects.Similar results were also observed by Chaudhary and Narkhede (2004) and Takalkar (2010).

The hybrid 104A (average) ×PhuleRevati (high)[6.99**] recorded more thousand grain weight with maximum *sca* effects.AKMS 66-2A(high)×RSV 2388(average)recorded high total sugar(0.28**) and crude fibre content(0.40**) with more *sca* effects. The hybrid 104A (low) × RSV 1988 (average) recorded morecrude protein content(0.59**) with high *sca* effects.The derivatives of low × low, low × high,low × average ,average ×low and high ×low parental combinations shows non additive gene action. The derivatives of high × high parental combinations showadditive gene action. In case of non-additive gen action later generation selection is suitable whereas for additive gene action desirable segregants can be selected in early generations.

In the estimation of heterosis, Sharma (1994) opinioned that heterosis over the best check could be considered as better criteria for evaluation of hybrids. The present study revealed the distribution of heterosis in both positive and negative directions for all the traits.The hybrid might be judged by comparing the *per se* performance and heterotic vigour.Close association per se performance of hybrids and heterosis was observed in most of the traits.

Sorghum hybrids, such a 104A × RSV 1910 (-5.66**, -2.43**) and 104A × RSV 2371(-4.40**, -2.49**) are recorded the significant negative standard heterosis over the check CSH-15-R were recorded for flowering and maturity**(Table 5).** Similar results also reported by Umakanth*et al.* (2006) ,Madhusudhan*et al.*, (2013) and Totre and *et al* (2021). The hybrids M-35-2A × P. Suchitra(13.15**)and M-35-2A × RSV 1988(10.38**). recorded the maximum significant standard heterosis in the positive direction for plant height. These results confirmed by Umakanth*et al.*(2006) and Nirde (2014).Among the hybrids 104A × P. Revati (19.36 %) recorded significantly superior standard heterosis for 1000 seed weight. A positive heterosis for this trait was also reported by Prabhakar et al. (2013).The hybrid 104A × P. Vasudha(33.33**)showed the highest significant standard heterosis for grain yield . Similar results were obtained by Umakanth*et al.* (2006) and Kulkarni and Patil (2004).The hybrids M-35-2A × P. Vasudha(63.64**)and M-35-2A × RSV 2388(63.6**) displayed the maximum standard heterosis for dry fodder yield in the positive direction compared to the check CSH-15R .Similar results obtained by Chavan *etal.*,(2016) , Prakash *et al.* (2010) and Ghorade*et al.* (2014). In case of quality trait,the hybrid 104A × P. Vasudha showed the highest significant standard heterosis for total sugar(44.15**) and crude protein(6.56**). These results confirms the earlier findings of Chavan *etal.*(2016).The heterosis is closely related to *sca*, thus hybrids with high *sca* show high heterosis.

CONCLUSION:

The present study revealed that hybrids exhibited heterosis for grain yield were not heterotic for all the traits. The general combining ability of the female 104B and AKMS-66-2B were the best , while the male parent P. Vasudha and RSV 2388 were the best general combiners and could be exploited for future breeding programme of *rabi* sorghum. The results indicate that exploitation of the heterosis or hybrid vigour might be one of the promising methods to effect crop improvement in sorghum for grain purpose. The **104 A × P. Vasudha** and **M-35-2A × RSV 2388** were for grain yield and for dry fodder yield hybrids namely**M-35-2A × RSV 2388** and **M-35-2A × P. Vasudha** were the most promising hybrids along with mean performance, standard heterosis and GCA & SCA effect of the parents and hybrids.These hybrids can be exploited and utilized commercially after further multi-environment testing .

Disclaimer (Artificial intelligence)

Option 1: **NO generative AI technologies used**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Table 1. Analysis of variance for parents and hybrids for yield, yield components and quality traits in sorghum.

Sources of variation	d.f.	Mean sum of squares								
		Days to 50% flowering	Days to maturity	Plant height	1000 seed weight	Grain yield	Dry fodder yield	Total sugar	Crude protein	Crude fiber
		1	2	3	4	5	6	7	8	9
Parents	12	3.250**	5.371**	625.153**	15.068**	0.145**	0.477**	0.559**	0.531**	0.286**
Line	2	0.166	3.166**	2076.500**	11.727**	0.018	0.354**	0.488**	0.181	0.329**
Testers	9	1.383	4.827**	73.005**	17.473**	0.184**	0.557**	0.361**	0.667**	0.308**
Line vs Tester	1	26.216**	14.678**	2691.796**	0.102	0.043	0.001	2.478**	0.001	0.001
Parents vs Crosses	1	14.693**	2.737	6498.096**	47.780**	0.362**	0.309**	0.026	0.171	0.041
Crosses	29	4.048**	4.867**	1434.315**	20.500**	0.048**	0.233**	0.205**	0.319**	0.193**
Error	42	0.821	1.403	10.121	3.920	0.014	0.006	0.047	0.088	0.017

****,** *Significant at 1% and 5% level respectively

Table2: Analysis of variance for combing ability for yield, yield components and quality traits in sorghum.

Sources of variation	d.f.	Mean sum of squares								
		Days to 50 % flowering	**Days to maturity**	**Plant height (cm)**	**1000 seed weight (g)**	**Grain yield (kg/ plot)**	**Dry fodder yield (Kg/ plot)**	**Total sugar content (%)**	**Crude protein content (%)**	**Crude fibre content (%)**
Line	2	25.550**	24.050**	19861.40**	10.55**	0.025*	1.778**	0.385**	0.740**	0.171**
Tester	9	2.489**	2.906**	103.24**	21.65**	0.059**	0.092**	0.144**	0.419**	0.093**
Line * Tester	18	2.439**	3.717*	52.40**	21.03**	0.047**	0.133**	0.217**	0.222**	0.246**
Error	29	0.667	1.419	8.59	4.50	0.016	0.006	0.031	0.080	0.015
gca		2.03	1.86	1534.18	1.87	0.004	0.14	0.03	0.08	0.02
sca		0.81	1.15	21.14	8.55	0.016	0.06	0.09	0.07	0.11
gca/sca		2.51	1.61	72.57	0.22	0.256	2.26	0.39	1.12	0.15

****,** *Significant at 1% and 5% level respectively

Table 3: General Combining ability of parents

Sr. No.	Lines/testers	Days to 50 % flowering	Days to maturity	Plant height (cm)	1000 seed weight (g)	Grain yield (kg/ plot)	Dry fodder yield (Kg/ plot)	Total sugar content (%)	Crude protein content (%)	Crude fibre content (%)
1	104 B	0.55**	0.45	36.20**	0.05	-0.02	0.34**	-0.15**	-0.17**	-0.10**
2	AKMS -66-2B	-1.30**	-1.25**	-14.90**	0.70	0.04	-0.12**	0.11**	0.21**	0.01
3	M-35-2B	0.75**	0.80**	-21.30**	-0.75	-0.02	-0.22**	0.04	-0.04	0.09**
	SE ±	0.20	0.26	0.71	0.44	0.03	0.02	0.05	0.07	0.03
	CD at 5 %	0.41	0.54	1.45	0.90	0.05	0.04	0.10	0.14	0.06
	CD at 1 %	0.56	0.73	1.96	1.22	0.07	0.05	0.13	0.18	0.08
Testers(Males)										
1.	RSV 2388	-0.93**	-1.35**	-2.98**	-1.81*	-0.08	0.25**	0.06	-0.02	0.02
2.	RSV 2371	-0.27	-0.02	-0.15	-1.73*	-0.11*	-0.15**	0.17*	0.45**	0.09*
3.	RSV 1910	-0.10	-0.35	-3.48**	0.01	0.01	0.06*	-0.04	-0.02	-0.21**
4.	RSV 1988	0.57*	0.32	6.18**	1.00	0.08	0.03	-0.12	0.01	-0.14**
5.	RSV 2394	0.23	0.65	-6.32**	0.37	0.12*	0.01	-0.16*	-0.47**	0.02
6.	RSV 2482	-0.77*	-0.18	-0.82	-3.88**	-0.16**	-0.13**	-0.12	-0.27*	0.18**
7.	P. Suchitra	-0.43	0.98*	6.52**	2.03*	-0.02	-0.05	-0.12	-0.20*	0.15**
8.	P.Revati	-0.10	-0.02	2.02	1.82*	0.08	-0.05	0.09	0.15	0.02
9.	P. Vasudha	0.90**	0.65	1.52	1.43	0.12*	0.13**	0.32**	0.20	-0.04
10.	RSV 2595	0.90**	-0.68	-2.48*	0.75	-0.03	-0.10**	-0.09	0.19	-0.08
	SE ±	0.37	0.48	1.30	0.80	0.05	0.03	0.09	0.12	0.05
	CD at 5 %	0.76	0.99	2.66	1.65	0.10	0.07	0.18	0.25	0.11
	CD at 1 %	1.02	1.33	3.58	2.23	0.13	0.09	0.23	0.33	0.15

Note:* Significantat5% levelof significance&Significant at1% level ofsignificance**

Table 4. Specific combining ability effects of hybrids

Sr. No.	Hybrids	Days to 50 % flowering	Days to maturity	Plant height (cm)	1000 seed weight (g)	Grain yield (kg/ plot)	Dry fodder yield (Kg/ plot)	Total sugar content (%)	Crude protein content (%)	Crude fibre content (%)
1	M-35-2A X RSV 2388	-0.72	0.55	-0.87	-0.17	0.27**	0.42**	-0.04	-0.38*	-0.43**
2	M-35-2A X RSV 2371	**-1.38***	-0.28	6.80**	0.87	-0.05	-0.11*	0.26*	0.10	0.01
3	M-35-2A X RSV 1910	1.95**	0.55	-4.87*	-1.89	-0.15	0.05	0.09	0.15	-0.11
4	M-35-2A X RSV 1988	-0.22	0.38	2.47	0.29	0.05	-0.05	-0.17	-0.36*	-0.22**
5	M-35-2A X RSV 2394	0.12	-1.95*	0.47	1.92	-0.02	0.04	0.26*	-0.03	0.16*
6	M-35-2A X RSV 2482	-0.88	-1.12	-0.53	2.87*	0.03	-0.25**	-0.07	0.18	-0.10
7	M-35-2A X P. Suchitra	-0.22	-0.78	7.13**	1.56	-0.01	-0.37**	-0.06	0.35*	0.03
8	M-35-2A X P. Revati	0.95	1.72*	2.63	-2.47	0.14	-0.12*	0.14	-0.03	0.52**
9	M-35-2A X P. Vasudha	0.95	1.55*	-4.37*	-0.56	-0.27**	0.54**	-0.34**	-0.15	0.21*
10	M-35-2A X RSV 2595	-0.55	-0.62	-8.87**	-2.42	0.01	-0.16**	-0.05	0.17	-0.07
11	104A X RSV 2388	1.13*	-1.75*	1.23	1.13	-0.01	-0.14**	-0.23*	0.16	0.03
12	104A X RSV 2371	-0.03	-0.58	-5.60**	-6.22**	0.03	0.21**	-0.34**	0.10	0.35**
13	104A X RSV 1910	-1.20*	-0.25	4.23*	1.56	0.12	-0.02	-0.24*	0.06	0.26**
14	104A X RSV 1988	0.63	1.08	0.07	0.22	-0.12	0.02	0.08	0.59**	-0.39**
15	104A X RSV 2394	-0.03	1.25	-4.43*	-0.88	-0.09	-0.03	0.02	-0.01	-0.06
16	104A X RSV 2482	-0.03	0.08	-2.43	-1.40	-0.11	0.15**	-0.22*	-0.21	0.29**
17	104A X P. Suchitra	1.13*	0.92	-1.27	-1.72	0.06	0.13*	0.34**	-0.59**	-0.34**
18	104A X P. Revati	-1.20*	-0.58	-2.77	6.99**	0.03	0.03	0.15	-0.39*	-0.32**
19	104A X P. Vasudha	-1.20*	-1.75*	2.23	0.60	0.16*	-0.36**	0.70**	0.17	0.05
20	104A X RSV 2595	0.80	1.58*	8.73**	-0.28	-0.07	0.02	-0.26*	0.11	0.12

Sr. No.	Hybrids	Days to 50 % flowering	Days to maturity	Plant height (cm)	1000 seed weight (g)	Grain yield (kg/ plot)	Dry fodder yield (Kg/ plot)	Total sugar content (%)	Crude protein content (%)	Crude fibreconte nt (%)
21	AKMS-66-2A X RSV 2388	-0.42	1.20	-0.37	-0.96	-0.26**	-0.28**	0.28*	0.22	0.40**
22	AKMS-66-2A X RSV 2371	1.42*	0.87	-1.20	5.35**	0.03	-0.10*	0.09	-0.21	-0.37**
23	AKMS-66-2A X RSV 1910	-0.75	-0.30	0.63	0.33	0.02	-0.03	0.15	-0.21	-0.15
24	AKMS-66-2A X RSV 1988	-0.42	-1.47*	-2.53	-0.51	0.07	0.03	0.09	-0.23	0.61**
25	AKMS-66-2A X RSV 2394	-0.08	0.70	3.97*	-1.04	0.11	-0.01	-0.28*	0.04	-0.10
26	AKMS-66-2A X RSV 2482	0.92	1.03	2.97	-1.47	0.08	0.10*	0.29*	0.03	-0.20*
27	AKMS-66-2A X P. Suchitra	-0.92	-0.13	-5.87**	0.16	-0.05	0.25**	-0.28*	0.24	0.31**
28	AKMS-66-2A X P. Revati	0.25	-1.13	0.13	-4.52**	-0.17*	0.09	-0.29*	0.42*	-0.20*
29	AKMS-66-2A X P. Vasudha	0.25	0.20	2.13	-0.03	0.11	-0.18**	-0.36**	-0.03	-0.26**
30	AKMS-66-2A X RSV 2595	-0.25	-0.97	0.13	2.70*	0.06	0.14**	0.30*	-0.28	-0.05
	Range	-1.38 to 1.95	-1.95 to 1.72	-8.87 to 8.73	-6.22 to 6.99	-0.27 to 0.27	-0.37 to 0.54	-0.36 to 0.70	-0.59 to 0.59	-0.43 to 0.61
	SE	0.64	0.84	2.25	1.40	0.08	0.06	0.15	0.21	0.09
	CD at 5 %	1.31	1.71	4.60	2.86	0.17	0.12	0.31	0.43	0.19
	CD at 1 %	1.77	2.31	6.20	3.86	0.23	0.16	0.42	0.58	0.25

*,** significantat5 and 1 % level of significance respectively

Table.5. Heterosis (%) over better-parent(BP) and standard check for different characters in sorghum

Sr. No.	Hybrids	Days to 50%Flowering		Days to Maturity		Plant Height(cm)	
		1		2		3	
		BP(H1)	Check(H2)	BP(H1)	Check(H2)	BP(H1)	Check(H2)
1	M-35-2A X RSV 2388	0.00	-3.77**	1.28	-1.24	3.84*	3.55*
2	M-35-2A X RSV 2371	-1.92*	-3.77**	0.42	-0.83	2.56*	9.29**
3	M-35-2A X RSV 1910	3.23**	0.63	0.84	-0.41	1.93	1.09
4	M-35-2A X RSV 1988	1.95*	-1.26	3.43**	0.00	14.12**	10.38**
5	M-35-2A X RSV 2394	0.00	-1.26	-0.42	-1.66	3.02*	2.46
6	M-35-2A X RSV 2482	-3.16**	-3.77**	-0.42	-1.66	7.87**	4.92**
7	M-35-2A X P. Suchitra	-1.27	-2.52*	2.13*	-0.41	16.95**	13.11**
8	M-35-2A X P. Revati	0.00	-0.63	2.10*	0.83	4.76**	8.20**
9	M-35-2A X P. Vasudha	2.56*	0.63	3.39**	1.24	7.63**	4.10**
10	M-35-2A X RSV 2595	1.29	-1.26	1.72	-1.66	2.54	-0.55
11	104A X RSV 2388	0.00	-3.77**	-2.13*	-4.56**	-23.01**	-23.22**
12	104A X RSV 2371	-2.56*	-4.40**	-2.49**	-2.49**	-30.00**	-25.41**
13	104A X RSV 1910	-3.23**	-5.66**	-1.26	-2.49**	-21.21**	-21.86**
14	104A X RSV 1988	0.65	-2.52*	2.58**	-0.83	-16.10**	-18.85**
15	104A X RSV 2394	-2.55*	-3.77**	0.42	-0.41	-27.75**	-28.14**
16	104A X RSV 2482	-4.43**	-5.03**	-2.07*	-2.07*	-21.91**	-24.04**
17	104A X P. Suchitra	-1.91*	-3.14**	2.13*	-0.41	-16.67**	-19.40**
18	104A X P. Revati	-5.66**	-5.66**	-2.08*	-2.49**	-25.13**	-22.68**
19	104A X P. Vasudha	-2.56*	-4.40**	-0.85	-2.90**	-17.51**	-20.22**
20	104A X RSV 2595	0.65	-1.89*	2.15*	-1.24	-16.34**	-18.85**
21	AKMS-66-2A X RSV 2388	0.65	-3.14**	2.13*	-0.41	-31.70**	-27.60**
22	AKMS-66-2A X RSV 2371	1.92*	0.00	0.41	0.41	-31.03**	-26.50**
23	AKMS-66-2A X RSV 1910	0.00	-2.52*	0.42	-0.83	-31.44**	-27.32**
24	AKMS-66-2A X RSV 1988	1.95*	-1.26	2.15*	-1.24	-28.09**	-23.77**

Sr. No.	Hybrids	Daysto50%Flowering		DaystoMaturity		PlantHeight(cm)	
		1		2		3	
		BP(H1)	Check(H2)	BP(H1)	Check(H2)	BP(H1)	Check(H2)
25	AKMS-66-2A X RSV 2394	0.00	-1.26	1.67	0.83	-31.19**	-27.05**
26	AKMS-66-2A X RSV 2482	-0.63	-1.26	0.41	0.41	-28.87**	-24.59**
27	AKMS-66-2A X P. Suchitra	-1.91*	-3.14**	2.98**	0.41	-29.64**	-25.41**
28	AKMS-66-2A X P. Revati	-0.63	-1.26	-0.83	-1.24	-28.87**	-24.59**
29	AKMS-66-2A X P. Vasudha	1.92*	0.00	2.54**	0.41	-28.09**	-23.77**
30	AKMS-66-2A X RSV 2595	1.94*	-0.63	1.72	-1.66	-31.19**	-27.05**
	Range	-5.66 to 3.23	-5.66 to 0.63	-2.49 to 3.43	-4.56 to 1.24	-31.70 to 16.95	-28.14 to 13.11
	S.E.	0.90	0.90	1.18	1.18	3.18	3.18
	C.D. 5%	1.85	1.85	2.42	2.42	6.50	6.50
	C.D. 1%	2.50	2.50	3.26	3.26	8.77	8.77

Table contd.

Table contd.

Sr. No.	Hybrids	1000 seed weight		Grain Yield		Dry Fodder Yield	
		4		5		6	
		BP(H_1)	Check(H_2)	BP(H_1)	Check(H_2)	BP(H_1)	Check(H_2)
1	M-35-2A X RSV 2388	1.06	-10.44*	32.81	12.00	-1.98	63.64**
2	M-35-2A X RSV 2371	-1.43	-7.52	-60.24*	-34.67*	-49.64**	-13.22*
3	M-35-2A X RSV 1910	8.43	-10.16*	-19.37	-32.00*	-10.13*	17.36**
4	M-35-2A X RSV 1988	3.17	-1.93	23.72	4.33	-18.67**	6.20
5	M-35-2A X RSV 2394	21.50 **	0.66	17.39	-1.00	-13.92**	12.40*
6	M-35-2A X RSV 2482	9.96	-7.92	-18.50	-31.27*	-41.14**	-23.14**
7	M-35-2A X P. Suchitra	-1.44	4.05	-0.79	-16.33	-43.99**	-26.86**
8	M-35-2A X P. Revati	7.55	-7.00	36.76*	15.33	-28.16**	-6.20
9	M-35-2A X P. Vasudha	3.71	-3.01	43.06**	33.00*	25.32**	63.64**
10	M-35-2A X RSV 2595	-5.10	-9.62*	0.40	-15.33	-33.54**	-13.22*
11	104A X RSV 2388	0.03	-5.36	22.77	-17.33	-52.23**	-20.25**
12	104A X RSV 2371	-20.00 **	-24.30 **	-48.68**	-15.67	-56.35**	-24.79**
13	104A X RSV 1910	6.21	0.50	67.33**	12.67	-2.70	-25.62**
14	104A X RSV 1988	4.76	-0.42	33.17	-10.33	-2.70	-25.62**
15	104A X RSV 2394	0.48	-4.93	47.52*	-0.67	-14.36*	-30.99**

16	104A X RSV 2482	-12.66 *	-17.36 **	-12.87	-41.33*	-5.41	-27.69**
17	104A X P. Suchitra	-7.92	-2.79	50.50*	1.33	-21.19**	-23.14**
18	104A X P. Revati	26.15 **	19.36 **	62.38*	9.33	-13.83	-30.99**
19	104A X P. Vasudha	7.48	1.69	13.31	33.33*	-33.14**	-48.88**
20	104A X RSV 2595	2.52	-2.36	21.78	-18.00	-16.76*	-36.36**
21	AKMS-66-2A X RSV 2388	-7.84	-14.58 **	-54.55*	-58.33**	-64.85**	-41.32**
22	AKMS-66-2A X RSV 2371	8.78	2.06	-53.55**	-23.67	-76.50**	-59.50**
23	AKMS-66-2A X RSV 1910	0.90	-6.48	-0.36	-8.67	-12.56	-35.54**
24	AKMS-66-2A X RSV 1988	-1.22	-6.10	18.18	8.33	0.63	-33.88**
25	AKMS-66-2A X RSV 2394	-1.97	-9.13	28.00	17.33	-23.59**	-38.43**
26	AKMS-66-2A X RSV 2482	-15.11 *	-21.32 **	-16.73	-23.67	-10.50	-40.50**
27	AKMS-66-2A X P. Suchitra	-6.86	-1.67	-14.84	-21.93	-19.92**	-21.90**
28	AKMS-66-2A X P. Revati	-7.66	-14.41 **	-17.82	-24.67	-18.99*	-35.12**
29	AKMS-66-2A X P. Vasudha	2.94	-3.73	0.85	18.67	-12.58	-42.56**
30	AKMS-66-2A X RSV 2595	6.69	1.62	-0.36	-8.67	-1.26	-35.12**
	Range	-20.0 to 26.15	-24.30 to 19.36	-60.24 to 67.33	-58.33 to 33.33	-76.50 to 25.32	-59.50 to 63.64
	S.E.	1.98	1.98	0.12	0.12	0.08	0.08
	C.D. 5%	4.05	4.05	0.24	0.24	0.16	0.16
	C.D. 1%	5.46	5.46	0.33	0.33	0.22	0.22

Table contd.

Sr. No.	Hybrids	Total Sugar		Crude Protein		Crude Fiber	
		7		8		9	
		BP(H_1)	Check(H_2)	BP(H_1)	Check(H_2)	BP(H_1)	Check(H_2)
1	M-35-2A X RSV 2388	-12.61	-11.47	-6.53**	-4.14	-33.61**	-24.06**
2	M-35-2A X RSV 2371	-14.27*	6.14	-4.78*	4.70*	-12.37*	0.24
3	M-35-2A X RSV 1910	-11.48	-10.33	-1.72	0.79	-29.90**	-19.81**
4	M-35-2A X RSV 1988	-26.33**	-25.37**	-6.08*	-3.68	-31.55**	-21.70**
5	M-35-2A X RSV 2394	-14.47*	-8.26	-8.85**	-5.07*	-9.28*	3.77
6	M-35-2A X RSV 2482	-21.74**	-20.72*	-3.68	-1.21	-12.99**	-0.47
7	M-35-2A X P. Suchitra	-21.37**	-20.35**	-1.50	1.02	-9.07*	4.01
8	M-35-2A X P. Revati	-3.43	-2.18	-1.86	0.65	-4.11	20.99**
9	M-35-2A X P. Vasudha	-14.37*	-13.26*	-2.45	0.05	-9.69*	3.30
10	M-35-2A X RSV 2595	-19.26**	-18.21*	-2.60	3.02	-22.68**	-11.56*
11	104A X RSV 2388	-15.57**	-8.06	3.17	4.42	1.40	2.59
12	104A X RSV 2371	-26.00**	-8.39	-1.57	8.24**	20.05**	21.46**
13	104A X RSV 1910	-20.02**	-12.90	4.91*	3.49	1.40	2.59
14	104A X RSV 1988	-10.29	-2.31	11.78**	8.66**	-33.68**	-24.76**
15	104A X RSV 2394	-14.40*	-6.78	-5.27*	-1.35	-2.56	-1.42
16	104A X RSV 2482	-22.10**	-15.17*	-2.62	-1.30	21.68**	23.11**

17	104A X P. Suchitra	0.42	9.36	-1.48	-4.23	-9.32	-8.25
18	104A X P. Revati	0.95	9.93	3.73	0.84	-31.40**	-13.44*
19	104A X P. Vasudha	32.38**	44.15**	9.10**	6.56**	-10.11*	0.71
20	104A X RSV 2595	-22.53**	-15.64*	0.13	5.91*	1.63	2.83
21	AKMS-66-2A X RSV 2388	-21.75**	11.25	1.29	2.65	36.72**	23.82**
22	AKMS-66-2A X RSV 2371	-24.49**	7.36	-6.35**	2.98	18.77**	-8.96
23	AKMS-66-2A X RSV 1910	-28.83**	1.19	-2.75	-1.44	-12.94*	-12.74*
24	AKMS-66-2A X RSV 1988	-33.13**	-4.93	-2.66	-1.35	11.23*	26.18**
25	AKMS-66-2A X RSV 2394	-45.99**	-23.21**	-7.10**	-3.26	0.71	0.24
26	AKMS-66-2A X RSV 2482	-26.98**	3.81	-2.71	-1.40	35.08**	3.54
27	AKMS-66-2A X P. Suchitra	-44.47**	-21.05**	-0.28	1.07	26.00**	25.71**
28	AKMS-66-2A X P. Revati	-38.29**	-12.27	4.64*	6.05*	-24.11**	-4.25
29	AKMS-66-2A X P. Vasudha	-33.80**	-5.88	0.96	2.33	-19.79**	-10.14*
30	AKMS-66-2A X RSV 2595	-25.56**	5.84	-5.54*	-0.09	-1.89	-1.89
	Range	-45.99 to 32.38	-25.37 to 44.15	-8.85 to 11.78	-5.07 to 8.66	-33.68 to 36.72	-24.76 to 26.18
	SE(d)±	0.22	0.22	0.30	0.30	0.13	0.13
	CD (5%)	0.44	0.44	0.61	0.61	0.27	0.27
	CD (1%)	0.60	0.60	0.82	0.82	0.36	0.36

Note: * Significant at 5% level of significance & ** Significant at 1% level of significance.H2 : Heterosis over CSH-15R