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COMBINING ABILITY ANALYSIS IN DIVERSE CYTOPLASMIC MALE STERILE SOURCES OF PEARL MILLET (*PENNISETUM GLAUCUM* L. R. BR.)

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ABSTRACT

The present investigation entitled "Combining ability analysis in diverse cytoplasmic male sterile sources of pearl millet [*Pennisetum glaucum* (L.) R. Br.]" was carried out with aim to estimate the general combining ability of the parents and specific combining ability of hybrids for improving the grain yield and its attributing characters in three diverse cytoplasmic male sterile (CMS) sources A_1, A_4 and A_5. The experimental material comprised of nine female lines (Three diverse male sterile lines of three diverse cytoplasmic male sterile sources A_1, A_4 and A_5) and eight male lines as parental material with their seventy-two F_1s and standard check (GHB 1129) that evaluated in Randomized Block Design with three replications. The analysis of variance for combining ability in three diverse cytoplasmic male sterile sources A_1, A_4 and A_5 revealed that the significant difference was observed among the females, males and hybrids for most of the characters under study which indicating the existence of considerable amount of variability in the experimental material. Combining ability studies suggested that non-additive type of gene action involved in the expression of plant height, number of effective tiller per plant, ear head length, grain yield per plant, test weight, dry fodder yield per plant, harvest index, protein content, iron and zinc content in all CMS sources. Among the parents, ICMR 17555 and ICMR 19444 in CMS source A_1; ICMA 81 and ICMR 15777 in CMS source A_4 whereas, ICMA 81, ICMA 843 and ICMR 17555, ICMR 18196 and ICMR 19444 in CMS source A_5 were identified as good general combiner for grain yield per plant. The best performing hybrids namely, ICMA 843 × ICMR 19444 in CMS source A_1; ICMA 843 × ICMR 15888 in CMS source A_4 and ICMA 81 × ICMR 19444 in CMS source A_5 had highly significant and desired *sca* effect as well as high *per se* performance for grain yield per plant.
Keywords **:** General combining ability, Specific combining ability, Gene action, Cytoplasmic male sterile source A_1, Cytoplasmic male sterile source A_4, Cytoplasmic male sterile source A_5

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is an important cereal crop that mainly cultivated in the arid and semi-arid tropical regions of the world. It is diploid (2n=2x=14) in nature and belongs to grass family *poaceae,* subfamily *panicoideae*, tribe *paniceae*, and genus *pennisetum*. Pearl millet is believed to be originated in western Africa some 4000 years ago and spread to India and southern Africa some 2000–3000 years ago (Krishnaswamy, 1951). It is familiar as bajra or bajri in India and also known as cattail millet, spiked millet and bulrush millet in different parts of the world. Pearl millet is considered as the sixth most important cereal crop next to rice, wheat, maize, barley and sorghum. In India, it stands as the fourth most important cereal food crop after rice, wheat and maize. Globally, India is the leading country in terms of area and production of pearl millet which occupies an area of 7.57 million hectares with a total production of 11.43 million tonnes and average productivity of 1510 kg/ha (Anonymous, 2023). Rajasthan, Uttar Pradesh, Gujarat, Haryana, Madhya

Pradesh, Maharashtra, Karnataka and Tamil Nadu are the major states which contributes more than 90 per cent to the total national production.

The combining ability studies provide useful information regarding the selection of suitable parents for effective hybridization programme and at the same time elucidates the nature and magnitude of gene action. In the combining ability studies, general combining ability effects help in selection of superior parents and specific combining ability effects for superior hybrids. Also, the nature of general combining ability and specific combining ability variances provides the extent of additive and non-additive genetic variances (Kumar, 2014). An understanding the nature of gene action governing the expression of various traits could be helpful in predicting the effectiveness of selection. Since, the nature of gene action varies with genetic architecture of population involved in hybridization, it is necessary to evaluate the parents for their combining ability. Among the several methods, The Line × Tester mating design suggested by Kempthorne (1957) is one of the important biometrical tools to determine the combining ability for identify the promising male and female parental lines as well as to obtain necessary data on the expression of heterosis for the future. It helps in evaluating the potential of new hybrids with their parents and also widely useful in evaluation of large number of germplasm lines at a time in terms of combining ability variances and effects (Singh, 1978).

Material and Method

This study was undertaken to elicit information for general combining ability (*gca*) effects of parents and specific combining ability (*sca*) effects of hybrids for grain yield per plant and its thirteen component traits in three diverse cytoplasmic male sterile (CMS) sources A_1, A_4 and A_5 of pearl millet. The seventeen parental lines involving nine male sterile line (three different male sterile lines with three diverse cytoplasmic male sterile sources A_1, A_4 and A_5) and eight restorer lines were used to develop seventy-two F_1s using line × tester mating design during summer season 2022 at Centre for Crop Improvement, S. D. Agricultural University, Sardarkrushinagar. In the study, three set of thirty-six genotype consisting of twenty-four F_1s of each CMS source (A_1, A_4 and A_5), their eleven parents and one standard check (GHB 1129) were evaluated in Randomized Block Design with three replications. The field experiment was carried out at Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Gujarat during the summer season 2023-24. The observations were recorded for fourteen different quantitative and qualitative characters includes day to flowering, days to maturity, plant height (cm), number of effective tiller per plant, ear head length (cm), ear head girth (mm), seed setting (%), grain yield per plant (g), test weight (g), dry fodder yield per plant (g), harvest index (%), protein content (%), iron content (ppm) and zinc content (ppm).

In the present study, the observations on each genotype were recorded for grain yield and related characters on five randomly selected competitive plants from each replication, except for days to flowering, days to maturity and grain yield which were recorded on plot basis. Analysis of variance was carried out to test the differences between the genotypes for all the fourteen characters under study as per the techniques suggested by Panse and Sukhatme (1978). The variation among the hybrids was partitioned further into sources attributable to general combining ability and specific combining ability components in accordance with the procedures suggested by Kempthorne (1957).

Result and Discussion

Analysis of variance

The result of analysis of variance for combining ability of three diverse cytoplasmic male sterile sources A_1, A_4 and A_5 is presented in Table 1. The analysis of variance for combining ability by partitioning the total genetic variance into general combining ability representing additive type of gene action and specific combining ability representing non-additive type of gene action was carried out for fourteen characters. The analysis of variance for combining ability in three diverse CMS sources A_1, A_4 and A_5 revealed that mean square values due to females, males and females × males interaction were highly significant for majority of characters. Result signifying that both female and males had considerable general combining ability and contributed toward additive genetic variance. Likewise, female × male interaction suggested the significant contribution in favour of specific combing ability variance and non-additive variance. These findings suggested that experimental material possessed considerable variability and there are possibilities to improvement of various traits under study through heterosis breeding. The ratio of σ^2 GCA/σ^2 SCA was below less than unity for plant height, number of effective tiller per plant, ear head length, grain yield per plant, test weight, dry fodder yield per plant, harvest index, protein content, iron content and zinc content. These results suggested prime role of non-additive gene effects in the inheritance of all these traits. Whereas, the ratio of σ^2 GCA/σ^2 SCA was above the unity for days to flowering and days to maturity in individual CMS source A_1, A_4 and A_5 that indicated the additive gene action play important role for these characters under study. However, ear head girth and seed setting showed additive and non-additive types of interactions in different sources.

General combining ability

Among the three female and eight male parents under study, none of the parent was good general combiner for all the characters in each CMS source A_1, A_4 and A_5 (Table 2). The female parent ICMA 843 and male parent ICMR 14666 were found good general combiner for days to flowering and days to maturity in each CMS source A_1, A_4 and A_5. Similar results were supported by Gavali *et al.* (2018), Patel *et al.* (2018), Shaikh *et al.* (2020), Acharya *et al.* (2021) and Patil *et al.* (2021). The male parents ICMR 17555 and ICMR 19444 in A_1; female parent ICMA 81 and male parent ICMR 15777 in A_4 while the female parents ICMA 81, ICMA 843 and male parents ICMR 17555, ICMR 18196 and ICMR 19444 in A_5 were identified as good general combiner for grain yield per plant and at least one or more component traits. These similar findings were accordance with the previous reports by Shaikh *et al.* (2020), Acharya *et al.* (2021), Gami *et al.* (2021), Patil *et al.* (2021), Barathi and Reddy (2022), Solanki (2022), Gaoh *et al.* (2023), Kumara *et al.* (2023), Maheswari *et al.* (2023), Parveen *et al.* (2023), Rasitha *et al.* (2023), Rouamba *et al.* (2023) and Surendhar *et al.* (2023). Moreover, the male lines ICMR 14666, ICMR 15888, ICMR 17479 and ICMR 19444 for iron content while, ICMR 14666 for zinc content were good general combiner in all CMS sources A_1, A_4 and A_5. Similar results reported by Warrier *et al.* (2019), Gami *et al.* (2021), Barathi and Reddy (2022), Solanki (2022), Gajjar *et al.* (2023) and Thribhuvan *et al.* (2023). Therefore, these parents could be utilized in future breeding programmes for exploitation hybrid vigour and to generate desirable segregants for grain yield per plant and its attributing characters.

Specific combining ability

The data of specific combining ability of three diverse cytoplasmic male sterile sources A_1, A_4 and A_5 is presented in Table 3. A study of estimation of specific combining ability effects revealed that the hybrids namely, ICMA 89111 × ICMR 15777 in A_1, ICMA 843 × ICMR 14666 in A_4 and ICMA 81 × ICMR 12666 in A_5 were reported negative *sca* effect for days to flowering. The hybrid ICMA 81 × ICMR 14666 in A_1 and A_5 whereas, the hybrid ICMA 81 × ICMR 15888 in A_4 were possessed negative *sca* effect for days to maturity. The hybrids ICMA 81 × ICMR 18196 in A_1 and ICMA 843 × ICMR 19444 in A_4 were found highly significant and negative *sca* effect for plant height. In case of A_5, none of the hybrid was identified significant in desired direction for plant height. The significant and negative *sca* effect were desirable for days to flowering, days to maturity and plant height in pearl millet. The hybrid ICMA 843 × ICMR 15777 in A_1, ICMA 81 × ICMR 15777 in A_4 and ICMA 81 × ICMR 19444 in A_5 were recorded highly significant and positive *sca* effect for number of effective tiller per plant. The hybrids namely, ICMA 81 × ICMR 17555 in A_1, ICMA 81 × ICMR 19444 in A_4 and ICMA 843 × ICMR 14666 in A_5 for ear head length whereas the hybrid ICMA 89111 × ICMR 18196 in A_1, ICMA 843 × ICMR 15888 in A_4 and ICMA 89111 × ICMR 19444 in A_5 for ear head girth were reported as highest positive and significant *sca* effect. For seed setting, the hybrids ICMA 81 × ICMR 19444 in A_1, ICMA 89111 × ICMR 14666 in A_4 and ICMA 843 × ICMR 12666 in A_5 had highest positive and significant *sca* effect. Moreover, the hybrid ICMA 843 × ICMR 12666 found to be a good specific combiner for seed setting in each CMS source A_1, A_4 and A_5. The hybrids ICMA 843 × ICMR 19444 in A_1, ICMA 843 × ICMR 15888 in A_4 and ICMA 81 × ICMR 19444 in A_5 had highest positive and highly significant *sca* effect for grain yield per plant. Also, hybrids ICMA 89111 × ICMR 17555 in A_1 and A_5 while, ICMA 81 × ICMR 19444 and ICMA 843 × ICMR 15888 in A_4 and A_5 were recorded highly significant and positive *sca* effect for grain yield per plant. These similar findings for grain yield per plant were accordance with the previous reports by Saini *et al.* (2018), Kumavat *et al.* (2019), Siddique *et al.* (2019), Sharma *et al.* (2019[a]), Kumar *et al.* (2020), Shaikh *et al.* (2020), Acharya *et al.* (2021), Gami *et al.* (2021), Lenka *et al.* (2021), Patil *et al.* (2021), Prajapati *et al.* (2021), Barathi and Reddy (2022), Solanki (2022), Gaoh *et al.* (2023), Kumara *et al.* (2023), Maheswari *et al.* (2023), Parveen *et al.* (2023), Rasitha *et al.* (2023), Rouamba *et al.* (2023) and Surendhar *et al.* (2023). The Hybrids ICMA 89111 × ICMR 14666 in A_1, ICMA 89111 × ICMR 18196 in A_4 and ICMA 843 × ICMR 19444 in A_5 for test weight; ICMA 89111 × ICMR 17555 in A_1, ICMA 843 × ICMR 15888 in A_4 and ICMA 81 × ICMR 19444 in A_5 for dry fodder yield per plant; ICMA 89111 × ICMR 14666 in A_1, ICMA 843 × ICMR 17555 in A_4 and ICMA 89111 × ICMR 17555 in A_5 for harvest index were recorded significant and positive *sca* effect. The hybrid ICMA 89111 × ICMR 12666 in A_1 and A_5 while, ICMA 843 × ICMR 15888 in A_4 had highest positive and significant *sca* effect for protein content. The hybrid ICMA 81 × ICMR 15888 in A_1 and A_5

while, ICMA 843 × ICMR 18196 in A_4 were recoded highest positive and significant *sca* effect for iron content. Likewise, the hybrid ICMA 843 × ICMR 14666 in A_1, ICMA 89111 × ICMR 15888 in A_4 and ICMA 81 × ICMR 12666 in A_5 had significant and desirable *sca* effect for zinc content. Furthermore, the hybrid ICMA 89111 × ICMR 12666 for protein content; ICMA 81 × ICMR 15888, ICMA 843 × ICMR 18196 and ICMA 81 × ICMR 15777 for iron content and ICMA 843 × ICMR 14666, ICMA 89111 × ICMR 15888 and ICMA 89111 × ICMR 18196 for zinc content were identified as highly good specific combiner for individual CMS source A_1, A_4 and A_5. Similar results reported by Solanki *et al.* (2017), Gami *et al.* (2021) and Barathi and Reddy (2022). Top three hybrids namely, ICMA 843 × ICMR 19444, ICMA 89111 × ICMR 14666 and ICMA 89111 × ICMR 17555 in source A_1; ICMA 843 × ICMR 15888, ICMA 81 × ICMR 19444 and ICMA 843 × ICMR 17555 in source A_4 while, ICMA 81 × ICMR 19444, ICMA 89111 × ICMR 17555 and ICMA 843 × ICMR 15888 in source A_5 were exhibited highly significant and positive *sca* effect as well as high *per se* performance for grain yield per plant (Fig. 1, 2 and 3). Also, these desirable hybrids had significant *sca* effect in desirable direction for at least one or more yield attributing characters. Therefore, these hybrids were identified as most superior hybrids for exploitation in commercial cultivation.

Conclusion

The analysis of variance for combining ability in three diverse CMS sources A_1, A_4 and A_5 revealed that mean square values due to females, males and females × males interaction were highly significant for majority of characters which indicated that experimental material possessed considerable variability and there are possibilities to improvement of various traits under study through heterosis breeding. The ratio of σ^2 GCA/σ^2 SCA was less than unity that suggested prime role of non-additive gene effects in the inheritance of all the characters under study except for days to flowering and days to maturity in all CMS sources under study. However, ear head girth and seed setting showed both additive and non-additive types of interactions in different sources. None of the parent was good general combiner for all the characters in individual CMS source A_1, A_4 and A_5. The female parent ICMA 843 and male parent ICMR 14666 were found good general combiner for days to flowering and days to maturity in all CMS sources A_1, A_4 and A_5. The male parents ICMR 17555 and ICMR 19444 in A_1; female parent ICMA 81 and male parent ICMR 15777 in A_4 while the female parents ICMA 81, ICMA 843 and male parents ICMR 17555, ICMR 18196 and ICMR 19444 in A_5 were identified as good general combiner for grain yield per plant and at least one or more other component traits. Therefore, these parents could be utilized in future breeding programmes for exploitation hybrid vigour and to generate desirable segregants for grain yield per plant and its attributing characters. The estimates of *sca* effects revealed that the hybrids namely, ICMA 843 × ICMR 19444 in CMS source A_1; ICMA 843 × ICMR 15888 in CMS source A_4 and ICMA 81 × ICMR 19444 in CMS source A_5 were good specific combiners. These hybrids had highly significant in desirable direction *sca* effect for grain yield per plant as well as for at least one or more component traits. Also, these most promising hybrids were recorded high *per se* performance. In general, the hybrids showed high *sca* effect did not always involved both good general combiner parents with high *gca* effect, thereby suggesting importance of intra as well as inter allelic interaction. The overall result suggested that there exists ample opportunity to exploit the diverse cytoplasmic male sterile sources in pearl millet hybrid breeding to raise the productivity to greater levels due to the considerable amount of variation present in expression of combining ability of genotypes.

Table 1: Analysis of variance for combining ability of variance for various characters in three diverse cytoplasmic male sterile sources A_1, A_4 and A_5 of pearl millet

Source of variation	d.f.	Days to flowering			Days to maturity			Plant height			Number of effective tiller per plant		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
Replications	2	4.05	1.06	24.50*	1.39	1.27	0.73	48.97	42.21	105.75	0.06	0.04	0.03
Hybrids	23	17.14**	21.42**	26.91**	25.19**	36.78**	39.62**	230.86**	263.12**	99.59	0.56**	0.36**	0.63**
Females	2	75.55**	74.19**	169.80**	118.73**	163.19**	264.06**	278.37**	1316.97**	62.65	0.09*	0.02	0.06*
Males	7	18.80**	37.56**	17.14**	26.41**	52.48**	33.24**	400.04**	137.67*	183.55*	0.31**	0.39**	0.35**
Females × Males	14	7.96*	5.80	11.38*	11.22**	10.87**	10.74*	139.48**	175.29**	62.89	0.75**	0.40**	0.85**
Error	46	3.66	4.25	5.26	3.70	4.07	4.76	50.75	42.90	74.80	0.02	0.02	0.02
Estimates of variance component													
σ^2 GCA		2.38**	3.04**	4.98**	3.72*	5.88**	8.36**	12.11	33.46**	3.65	-	-	-
σ^2 SCA		1.44*	0.52	2.05*	2.51**	2.27**	2.00*	29.58**	44.14**	-	0.25**	0.13**	0.28**
σ^2 GCA/ σ^2 SCA		1.66	5.86	2.44	1.49	2.60	4.19	0.41	0.76	-	-	-	-

Table 1: Continue…

Source of variation	d.f.	Ear head length			Ear head girth			Seed setting			Grain yield per plant		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
Replications	**2**	1.95	1.30**	4.11	38.23	38.61*	21.80	1.60	3.33	4.22	41.98	8.78	6.06
Hybrids	**23**	9.59**	21.37**	13.04**	175.62**	168.12**	185.05**	1754.28**	1470.51**	1389.49**	282.84**	412.41**	246.33**
Females	**2**	41.77**	94.89**	40.45**	795.38**	535.16**	584.61**	1460.15**	16.85	1106.54**	12.60	170.05**	133.94**
Males	**7**	6.86**	18.55**	14.04**	220.36**	182.79**	128.73**	3890.90**	4644.75**	1168.58**	323.50**	121.15**	221.47**
Females × Males	**14**	6.35**	12.28**	8.63**	64.72**	108.35**	156.13**	727.98**	91.06**	1540.37**	301.11**	592.66**	274.82**
Error	**46**	1.32	0.22	3.39	15.73	8.74	10.66	12.52	10.72	9.47	18.31	15.02	8.70
Estimates of variance component													
σ^2 GCA		1.09*	2.70**	1.13	26.86**	15.19*	12.16	118.04*	135.75**	-	-	-	-
σ^2 SCA		1.68**	4.02**	1.75**	16.34**	33.21**	48.49**	238.49**	26.79**	510.31**	94.27**	192.55**	88.71**
σ^2 GCA/ σ^2 SCA		0.65	0.68	0.65	1.65	0.46	0.26	0.50	5.07	-	-	-	-

Table 1: Continue…

Source of variation	d.f.	Test weight			Dry fodder yield per plant			Harvest index		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
Replications	**2**	0.04	0.01	0.03	6.78	6.90	13.99	2.40	5.80	4.92
Hybrids	**23**	9.61**	4.82**	3.90**	157.32**	206.79**	138.25**	56.06**	120.78**	36.26**
Females	**2**	7.54**	23.57**	8.86**	14.14	162.61**	138.78**	41.20*	39.73	1.63
Males	**7**	13.44**	4.06**	5.00**	214.26**	124.66**	132.55**	65.60**	188.80**	14.84
Females × Males	**14**	7.99**	2.52**	2.65**	149.29**	254.17**	141.03**	53.40**	98.34**	51.92**
Error	**46**	0.15	0.22	0.10	6.37	10.31	5.81	11.44	19.38	9.30
Estimates of variance component										
σ^2 GCA		0.16	0.69**	0.26	-	-	-	-	0.97	-
σ^2 SCA		2.62**	0.77**	0.85**	47.65**	81.29**	45.08**	13.99**	26.33**	14.21**
σ^2 GCA/ σ^2 SCA		0.06	0.90	0.31	-	-	-	-	0.04	-

Table 1: Continue…

Source of variation	d.f.	Protein content			Iron content			Zinc content		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
Replications	**2**	0.02	0.12	0.15	0.83	3.35	5.55	0.41	0.27	3.82
Hybrids	**23**	0.27**	0.30**	0.56**	2120.27**	1669.99**	1869.34**	172.52**	124.26**	88.59**
Females	**2**	0.33**	0.01	0.89**	6.67	41.77**	34.05**	133.66**	31.87**	154.03**
Males	**7**	0.42**	0.21**	0.73**	1824.72**	1442.88**	1848.16**	337.71**	197.66**	63.89**
Females × Males	**14**	0.18**	0.38**	0.43**	2569.99**	2016.15**	2142.11**	95.48**	100.76**	91.60**
Error	**46**	0.02	0.05	0.10	11.97	7.84	7.31	1.62	2.73	2.78
Estimates of variance component										
σ^2 GCA		0.02	-	0.03	-	-	-	8.50	0.85	1.06
σ^2 SCA		0.06**	0.11**	0.12**	852.68**	669.44**	711.60**	31.29**	32.68**	29.61**
σ^2 GCA/ σ^2 SCA		0.22	-	0.22	-	-	-	0.28	0.03	0.04

* and** indicate significant at 5 per cent and 1 per cent levels of significance, respectively

Table 2: Estimates of general combining ability (*gca*) effects of parents for different characters in three diverse cytoplasmic male sterile sources A_1, A_4 and A_5 of pearl millet

Parents		Days to flowering			Days to maturity			Plant height			Number of effective tiller per plant		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
Females	**ICMA 81**	1.71**	1.97**	2.92**	2.36**	2.97**	3.69**	3.49*	8.42**	0.52	0.05	-0.02	0.04
	ICMA 843	-1.83**	-1.40**	-2.29**	-2.06**	-1.90**	-2.72**	-0.18	-2.91*	-1.81	0.02	0.02	0.01
	ICMA 89111	0.13	-0.57	-0.63	-0.31	-1.07*	-0.97*	-3.31*	-5.51**	1.29	-0.07*	-0.01	-0.05*
	S.Em.±	0.39	0.42	0.47	0.39	0.41	0.44	1.45	1.34	1.77	0.03	0.02	0.02
Males	**ICMR 12666**	1.33*	1.28	0.03	2.36**	1.78*	0.72	1.83	6.12**	1.92	0.04	-0.06	-0.13**
	ICMR 14666	-2.11**	-3.17**	-2.31**	-2.53**	-3.78**	-2.83**	-6.30*	-3.78	-0.01	-0.02	-0.17**	0.07
	ICMR 15777	0.33	1.28	0.81	0.03	0.44	1.39	-6.59**	-2.54	-4.04	0.15**	0.01	-0.15**
	ICMR 15888	-0.44	-1.17	-1.08	-0.75	-1.67*	-2.17**	-5.93*	-1.15	-2.67	0.14**	-0.08*	0.09*
	ICMR 17479	-1.78**	-2.72**	-1.19	-1.64*	-2.78**	-1.50*	-1.54	-5.28*	-6.60*	-0.40**	-0.19**	-0.29**

	ICMR 17555	1.11	1.50*	1.36	0.47	1.33	0.50	8.59**	1.50	7.11*	0.18**	0.21**	0.00
	ICMR 18196	-0.33	1.06	1.36	-0.19	2.22**	2.50**	10.62**	4.02	4.61	-0.04	0.41**	0.36**
	ICMR 19444	1.89**	1.94**	1.03	2.25**	2.44**	1.39	-0.69	1.11	-0.32	-0.04	-0.13**	0.05
S.Em.±		0.64	0.69	0.76	0.64	0.67	0.73	2.37	2.18	2.88	0.04	0.04	0.04
Range	**Min.**	-2.11	-3.17	-2.31	-2.53	-3.78	-2.83	-6.59	-5.51	-6.60	-0.40	-0.19	-0.29
	Max.	1.89	1.97	2.92	2.36	2.97	3.69	10.62	8.42	7.11	0.18	0.41	0.36
Positive		6	6	6	5	6	6	4	5	5	6	4	7
No. of +^{ve} significant		3	3	1	3	4	2	3	2	1	3	2	2
Negative		5	5	5	6	5	5	7	6	6	5	7	4
No. of -^{ve} significant		3	3	2	3	5	5	4	3	1	2	4	4

Table 2: Continue…

Parents		**Ear head length**			**Ear head girth**			**Seed setting**			**Grain yield per plant**		
		Source A_1	**Source A_4**	**Source A_5**	**Source A_1**	**Source A_4**	**Source A_5**	**Source A_1**	**Source A_4**	**Source A_5**	**Source A_1**	**Source A_4**	**Source A_5**
Females	**ICMA 81**	1.52**	2.29**	1.37**	-6.50**	-4.85**	-5.44**	6.71**	0.16	3.75**	0.36	1.67*	1.32*
	ICMA 843	-0.89**	-0.99**	-0.17	4.46**	4.58**	4.18**	-8.56**	0.75	-7.84**	0.47	1.40	1.41*
	ICMA 89111	-0.63*	-1.30**	-1.21**	2.04*	0.27	1.26	1.85*	-0.91	4.09**	-0.83	-3.07**	-2.73**
S.Em.±		0.23	0.10	0.38	0.81	0.60	0.67	0.72	0.67	0.63	0.87	0.79	0.60
Males	**ICMR 12666**	0.76	1.96**	0.64	-3.54**	-2.71**	-6.55**	-39.64**	-42.83**	0.81	-4.98**	-4.09**	-3.44**
	ICMR 14666	-1.23**	1.18**	-2.71**	-6.40**	-6.72**	-2.86*	-17.43**	-29.21**	-8.25**	0.03	-2.26	-3.50**
	ICMR 15777	-0.09	1.26**	0.59	-4.28**	-0.57	-2.66*	-0.96	9.24**	-12.89**	-1.65	8.13**	-3.84**
	ICMR 15888	-0.43	-0.38*	-0.07	1.62	-0.25	1.24	4.29**	14.15**	4.13**	-2.27	1.55	0.58
	ICMR 17479	-0.44	-2.26**	-0.48	1.42	-2.96**	0.77	16.23**	11.06**	-8.47**	-7.62**	-0.49	-6.21**
	ICMR 17555	1.59**	0.31	1.31*	-1.78	0.55	1.38	24.36**	8.86**	23.01**	8.69**	-1.39	4.12**
	ICMR 18196	-0.47	-1.26**	-0.17	4.52**	6.25**	4.59**	16.27**	10.74**	6.05**	-1.34	-0.12	7.17**
	ICMR 19444	0.32	-0.80**	0.90	8.45**	6.41**	4.11**	-3.12*	17.98**	-4.39**	9.14**	-1.32	5.11**
S.Em.±		0.38	0.16	0.61	1.32	0.99	1.09	1.18	1.09	1.03	1.43	1.29	0.98
Range	**Min.**	-1.23	-2.26	-2.71	-6.50	-6.72	-6.55	-39.64	-42.83	-12.89	-7.62	-4.09	-6.21
	Max.	1.59	2.29	1.37	8.45	6.41	4.59	24.36	17.96	23.01	9.14	8.13	7.17
Positive		4	5	5	6	5	7	6	8	6	5	4	6
No. of +^{ve} significant		2	4	2	4	3	3	6	6	5	2	2	5
Negative		7	6	6	5	6	4	5	3	5	6	7	5
No. of -^{ve} significant		3	6	2	4	4	4	4	2	5	2	2	5

Table 2: Continue…

Parents		**Test weight**			**Dry fodder yield per plant**			**Harvest index**		
		Source A_1	**Source A_4**	**Source A_5**	**Source A_1**	**Source A_4**	**Source A_5**	**Source A_1**	**Source A_4**	**Source A_5**
Females	**ICMA 81**	-0.64**	-0.35**	-0.69**	-0.71	2.60**	1.23*	1.46*	-1.07	0.07
	ICMA 843	0.38**	1.12**	0.43**	0.81	0.01	1.54**	-1.07	1.43	0.22
	ICMA 89111	0.26**	-0.77**	0.26**	-0.10	-2.61**	-2.77**	-0.39	-0.36	-0.29
S.Em.±		0.08	0.10	0.06	0.51	0.66	0.49	0.69	0.90	0.62
Males	**ICMR 12666**	-0.87**	-0.79**	-0.75**	-4.29**	0.18	-1.89*	0.39	-3.83*	-1.72
	ICMR 14666	1.37**	0.42**	-1.12**	-2.68**	-3.42**	-2.07*	2.08	2.10	-0.40
	ICMR 15777	-0.45**	0.34*	-0.30**	0.46	4.50**	-3.41**	-1.96	3.19*	-0.57
	ICMR 15888	-0.91**	-0.44**	-0.43**	-2.23*	-0.32	1.91*	0.99	-0.13	-1.48
	ICMR 17479	1.69**	0.21	0.90**	-6.42**	-7.19**	-5.59**	0.29	8.85**	0.03
	ICMR 17555	0.75**	-0.77**	0.62**	8.49**	2.16*	1.69*	-0.64	-4.37**	1.66
	ICMR 18196	-1.83**	1.17**	0.61**	3.77**	2.02	5.71**	-5.08**	-1.63	1.45
	ICMR 19444	0.25	-0.13	0.47**	2.90**	2.08	3.65**	3.93**	-4.19**	1.03
S.Em.±		0.13	0.16	0.10	0.84	1.07	0.80	1.13	1.47	1.02
Range	**Min.**	-1.83	-0.79	-1.12	-6.42	-7.19	-5.59	-5.08	-4.37	-1.72
	Max.	1.69	1.17	0.90	8.49	4.50	5.71	3.93	8.85	1.66
Positive		6	5	6	5	7	6	6	4	6
No. of +^{ve} significant		5	4	6	3	3	6	2	2	0
Negative		5	6	5	6	4	5	5	7	5
No. of -^{ve} significant		5	5	5	4	3	5	1	3	0

Table 2: Continue…

Parents		Protein content			Iron content			Zinc content		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
Females	ICMA 81	0.12**	0.00	0.22**	-0.29	-0.15	0.67	-1.65**	0.93**	-2.93**
	ICMA 843	-0.01	-0.01	-0.10	0.61	1.39*	0.71	2.70**	-1.29**	1.50**
	ICMA 89111	-0.11**	0.00	-0.12	-0.32	-1.24*	-1.37*	-1.05**	0.36	1.43**
S.Em.±		0.02	0.04	0.06	0.71	0.57	0.55	0.26	0.34	0.34
Males	ICMR 12666	-0.14**	0.02	-0.03	-17.49**	-12.76**	-16.83**	4.47**	0.35	1.81**
	ICMR 14666	-0.39**	-0.11	-0.07	16.85**	14.79**	17.39**	12.38**	8.05**	1.67**
	ICMR 15777	-0.08*	0.12	-0.30**	-4.27**	-4.43**	-8.17**	-6.55**	-3.13**	-0.99
	ICMR 15888	0.10**	-0.29**	-0.23*	14.17**	7.46**	11.50**	-4.65**	-8.01**	-5.35**
	ICMR 17479	0.11**	-0.03	-0.28**	7.29**	8.57**	9.72**	-4.81**	0.39	2.11**
	ICMR 17555	0.32**	0.02	0.38**	-16.77**	-13.21**	-14.72**	0.69	2.05**	0.10
	ICMR 18196	0.13**	0.22**	0.11	-11.63**	-14.65**	-12.50**	-0.63	2.45**	2.48**
	ICMR 19444	-0.05	0.04	0.43**	11.85**	14.24**	13.61**	-0.91*	-2.14**	-1.83**
S.Em.±		0.03	0.07	0.10	1.15	0.93	0.90	0.42	0.55	0.56
Range	Min.	-0.39	-0.29	-0.30	-17.49	-14.65	-16.83	-6.55	-8.01	-5.35
	Max.	0.32	0.22	0.43	16.85	14.79	17.39	12.38	8.05	2.48
Positive		5	7	4	5	5	6	4	7	7
No. of $+^{ve}$ significant		5	1	3	4	5	4	3	4	6
Negative		6	4	7	6	6	5	7	4	4
No. of $-^{ve}$ significant		4	1	3	4	5	5	6	4	3

* and** indicate significant at 5 per cent and 1 per cent levels of significance, respectively

Table 3: Estimates of specific combining ability (*sca*) effects of hybrids for different characters in three diverse cytoplasmic male sterile sources A_1, A_4 and A_5 of pearl millet

Sr. No.	Hybrids	Days to flowering			Days to maturity			Plant height		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
1	ICMA 81 × ICMR 12666	1.29	-0.19	-3.03*	2.97*	0.14	-2.14	4.91	-3.39	1.85
2	ICMA 81 × ICMR 14666	-1.26	-0.08	-2.03	-2.14	-1.31	-2.58*	-3.27	-4.71	-7.56
3	ICMA 81 × ICMR 15777	0.62	-0.19	0.53	1.31	0.47	0.19	4.61	-3.36	3.13
4	ICMA 81 × ICMR 15888	-0.93	-1.75	1.08	-0.58	-2.08	0.42	2.95	-4.36	-2.07
5	ICMA 81 × ICMR 17479	1.74	1.14	2.19	-0.03	-0.64	2.42	8.11	10.31**	2.47
6	ICMA 81 × ICMR 17555	-0.82	-0.08	2.31	-1.47	-1.08	0.75	-3.38	-5.71	1.52
7	ICMA 81 × ICMR 18196	-1.38	-0.64	-0.69	-1.14	2.03	1.75	-13.26**	-0.51	-0.21
8	ICMA 81 × ICMR 19444	0.74	1.81	-0.36	1.08	2.47*	-0.81	-0.67	11.72**	0.87
9	ICMA 843 × ICMR 12666	-0.17	0.18	3.18*	-1.28	0.35	2.61*	-3.76	0.44	-3.70
10	ICMA 843 × ICMR 14666	-0.72	-2.04	-0.15	-0.39	-1.76	-0.17	2.46	3.83	7.84
11	ICMA 843 × ICMR 15777	1.17	-0.15	-0.26	0.72	-0.32	-1.06	-2.75	1.04	1.68
12	ICMA 843 × ICMR 15888	1.61	2.29	-0.04	2.17	3.13**	1.17	1.85	9.65*	2.38
13	ICMA 843 × ICMR 17479	-1.39	0.18	-2.26	-0.28	1.24	-1.83	-7.56	-6.20	2.36
14	ICMA 843 × ICMR 17555	-1.61	0.63	-1.15	-1.06	0.46	-0.50	6.14	6.71	-5.66
15	ICMA 843 × ICMR 18196	1.50	0.07	-0.49	0.94	-1.76	-1.50	0.75	-0.87	-2.42
16	ICMA 843 × ICMR 19444	-0.39	-1.15	1.18	-0.83	-1.32	1.28	2.88	-14.60**	-2.48
17	ICMA 89111 × ICMR 12666	-1.13	0.01	-0.15	-1.69	-0.49	-0.47	-1.16	2.95	1.85
18	ICMA 89111 × ICMR 14666	1.99	2.13	2.18	2.53*	3.07*	2.75*	0.82	0.88	-0.28
19	ICMA 89111 × ICMR 15777	-1.79	0.35	-0.26	-2.03	-0.15	0.86	-1.86	2.33	-4.80
20	ICMA 89111 × ICMR 15888	-0.68	-0.54	-1.04	-1.58	-1.04	-1.58	-4.80	-5.30	-0.31
21	ICMA 89111 × ICMR 17479	-0.35	-1.32	0.07	0.31	-0.60	-0.58	-0.55	-4.12	-4.83
22	ICMA 89111 × ICMR 17555	2.43*	-0.54	-1.15	2.53*	0.62	-0.25	-2.76	-0.99	4.14
23	ICMA 89111 × ICMR 18196	-0.12	0.57	1.18	0.19	-0.26	-0.25	12.51**	1.38	2.63
24	ICMA 89111 × ICMR 19444	-0.35	-0.65	-0.82	-0.25	-1.15	-0.47	-2.20	2.87	1.61
Range	Min.	-1.79	-2.04	-3.03	-2.14	-2.08	-2.58	-13.26	-14.60	-7.56
	Max.	2.43	2.29	3.18	2.97	3.13	2.75	12.51	11.72	7.84
Positive		9	11	9	10	10	10	11	12	13
No. of $+^{ve}$ significant		1	0	1	3	3	2	1	3	0
Negative		15	13	15	14	14	14	13	12	11
No. of $-^{ve}$ significant		0	0	1	0	0	1	1	1	0
S.Em.±		1.10	1.19	1.32	1.11	1.16	1.26	4.11	3.78	4.99

Table 3: Continue…

Sr. No.	Hybrids	Number of effective tiller per plant			Ear head length			Ear head girth		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
1	ICMA 81 × ICMR 12666	-0.40**	0.15*	0.25**	-0.14	-1.67**	1.00	0.34	-1.44	4.19*
2	ICMA 81 × ICMR 14666	-0.06	0.13	0.38**	-0.12	2.98**	-0.60	5.49*	8.05**	6.48**
3	ICMA 81 × ICMR 15777	-0.45**	0.62**	0.00	0.18	0.27	1.61	1.82	3.48*	-1.29
4	ICMA 81 × ICMR 15888	0.27	-0.09	-0.44**	-0.06	-1.94**	-1.85	-0.93	-2.39	-5.01*
5	ICMA 81 × ICMR 17479	0.20*	0.02	0.00	-0.86	-0.27	0.67	-0.24	3.54**	1.98
6	ICMA 81 × ICMR 17555	-0.31**	-0.32**	-0.49**	2.58**	-0.98**	-1.99	-3.54	-0.84	-4.71*
7	ICMA 81 × ICMR 18196	0.44**	-0.45**	-0.57**	-0.45	-2.02**	-0.52	-0.91	-3.08	2.50
8	ICMA 81 × ICMR 19444	0.31**	-0.05	0.87**	-1.13	3.62**	1.69	-2.04	-7.31**	-4.14*
9	ICMA 843 × ICMR 12666	0.65**	-0.09	-0.12	-0.93	1.90**	-1.23	-1.72	1.33	-0.79
10	ICMA 843 × ICMR 14666	-0.22**	-0.11	-0.12	1.27	-1.96**	2.76*	-2.15	-6.14**	6.36**
11	ICMA 843 × ICMR 15777	0.88**	-0.23**	-0.03	0.32	-0.26	-0.87	-1.11	-3.25	-0.41
12	ICMA 843 × ICMR 15888	0.02**	0.06	0.79**	0.99	1.38**	0.40	3.39	8.92**	9.39**
13	ICMA 843 × ICMR 17479	-0.18*	0.11	-0.10	-0.97	-0.12	0.43	-0.53	-2.94	-2.34
14	ICMA 843 × ICMR 17555	-0.36**	0.57**	-0.32**	-2.33**	-0.16	0.64	3.72	-5.63**	-4.83*
15	ICMA 843 × ICMR 18196	-0.47**	-0.09	0.39**	-0.09	1.83**	-0.79	-7.85**	6.28**	-1.29
16	ICMA 843 × ICMR 19444	-0.33**	-0.23**	-0.50**	1.75*	-2.61**	-1.34	6.26**	1.44	-6.09**
17	ICMA 89111 × ICMR 12666	-0.25**	-0.06	-0.13	1.07	-0.23	0.23	1.38	0.10	-3.40
18	ICMA 89111 × ICMR 14666	0.27**	-0.01	-0.26**	-1.14	-1.02**	-2.16*	-3.34	-1.90	-12.84**
19	ICMA 89111 × ICMR 15777	-0.43**	-0.39**	0.03	-0.51	-0.01	-0.74	-0.71	-0.24	1.70
20	ICMA 89111 × ICMR 15888	-0.29**	0.03	-0.35**	-0.93	0.55*	1.45	-2.46	-6.52**	-4.38*
21	ICMA 89111 × ICMR 17479	-0.02	-0.13	0.09	1.83**	0.39	-1.10	0.77	-0.60	0.36
22	ICMA 89111 × ICMR 17555	0.67**	-0.26**	0.81**	-0.24	1.14**	1.35	-0.18	6.48**	9.54**
23	ICMA 89111 × ICMR 18196	0.02	0.54**	0.18**	0.54	0.20	1.31	8.76**	-3.19	-1.21
24	ICMA 89111 × ICMR 19444	0.02	0.28**	-0.37**	-0.62	-1.02**	-0.34	-4.22	5.88**	10.23**
Range	Min.	-0.47	-0.45	-0.57	-2.33	-2.61	-2.16	-7.85	-7.31	-12.84
	Max.	0.88	0.62	0.87	2.58	3.62	2.76	8.76	8.92	10.23
Positive		11	10	11	9	10	12	9	10	10
No. of +ve significant		8	5	7	3	7	1	3	7	6
Negative		13	14	13	15	14	12	15	14	14
No. of -ve significant		11	6	8	1	8	1	1	4	7
S.Em.±		0.08	0.07	0.07	0.66	0.27	1.06	2.29	1.71	1.89

Table 3: Continue…

Sr. No.	Hybrids	Seed setting			Grain yield per plant			Test weight		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
1	ICMA 81 × ICMR 12666	-6.71**	-2.83	-42.32**	-0.78	-2.95	5.29**	0.75**	0.17	0.44*
2	ICMA 81 × ICMR 14666	-5.07*	-2.84	19.71**	-4.38	8.49**	0.19	-1.12**	0.83**	-0.42*
3	ICMA 81 × ICMR 15777	-2.77	1.31	27.80**	0.38	13.17**	3.22	0.02	0.11	0.59**
4	ICMA 81 × ICMR 15888	18.34**	2.08	-19.83**	4.81	-10.60	-9.44**	0.24	0.00	0.06
5	ICMA 81 × ICMR 17479	-7.70**	1.48	-3.73*	5.51*	-3.43	-0.69	-0.09	-0.33	-0.50**
6	ICMA 81 × ICMR 17555	-13.48**	4.13*	-3.37	-11.69**	-11.80**	-9.62**	-1.11**	0.02	-0.70**
7	ICMA 81 × ICMR 18196	-5.14*	-0.99	4.13*	9.26**	-10.44**	-6.41**	1.05**	-1.82**	0.76**
8	ICMA 81 × ICMR 19444	22.53**	-2.34	17.62**	-3.12	17.58**	17.47**	0.25	1.03**	-0.23
9	ICMA 843 × ICMR 12666	8.56**	7.55**	32.11**	-1.13	3.66	-3.62*	-1.45**	0.18	-0.35
10	ICMA 843 × ICMR 14666	4.05	-8.58**	-21.68**	-10.09**	-7.94**	2.81	-1.66**	-0.67*	0.24
11	ICMA 843 × ICMR 15777	7.11**	4.44*	-11.39**	7.58**	-12.24**	0.34	-0.33	0.47	0.18
12	ICMA 843 × ICMR 15888	-35.37**	-2.11	1.07	0.49	23.13**	13.74**	0.52*	-0.23	0.41*
13	ICMA 843 × ICMR 17479	7.53**	-3.43	8.01**	-4.56	-10.10**	0.33	2.11**	0.59*	0.23
14	ICMA 843 × ICMR 17555	11.40**	-0.34	10.03**	-0.58	16.83**	-5.80**	-0.39	0.58*	-0.67**
15	ICMA 843 × ICMR 18196	7.23**	1.72	7.39**	-7.38**	2.05	3.83*	-0.58*	0.48	-1.51**
16	ICMA 843 × ICMR 19444	-10.50**	0.75	-25.54**	15.67**	-15.40**	-11.64**	1.77**	-1.40**	1.48**
17	ICMA 89111 × ICMR 12666	-1.85	-4.73*	10.21**	1.92	-0.71	-1.67	0.70**	-0.35	-0.09
18	ICMA 89111 × ICMR 14666	1.02	11.41**	1.97	14.47**	-0.55	-3.00	2.79**	-0.16	0.18
19	ICMA 89111 × ICMR 15777	-4.34*	-5.75**	-16.41**	-7.97**	-0.93	-3.56*	0.31	-0.58*	-0.76**
20	ICMA 89111 × ICMR 15888	17.03**	0.03	18.76**	-5.30*	-12.52**	-4.30*	-0.77**	0.24	-0.47*

21	ICMA 89111 × ICMR 17479	0.17	1.95	-4.28*	-0.96	13.53**	0.36	-2.03**	-0.26	0.26
22	ICMA 89111 × ICMR 17555	2.08	-3.79	-6.66**	12.27**	-5.03*	15.42**	1.50**	-0.60*	1.37**
23	ICMA 89111 × ICMR 18196	-2.09	-0.72	-11.51**	-1.88	8.39**	2.57	-0.47*	1.34**	0.75**
24	ICMA 89111 × ICMR 19444	-12.03**	1.59	7.92**	-12.56**	-2.17	-5.83**	-2.03**	0.37	-1.25**
Range	Min.	-35.37	-8.58	-42.32	-12.56	-15.40	-11.64	-2.03	-1.82	-1.51
	Max.	22.53	11.41	32.11	15.67	23.13	17.47	2.79	1.34	1.48
Positive		12	12	13	10	9	12	12	14	13
No. of +^{ve} significant		8	4	11	6	7	5	8	5	7
Negative		12	12	11	14	15	12	12	10	11
No. of -^{ve} significant		9	3	10	6	9	9	9	5	8
S.Em.±		2.04	1.89	1.78	2.47	2.24	1.70	0.22	0.27	1.78

Table 3: Continue…

Sr. No.	Hybrids	Dry fodder yield per plant			Harvest index			Protein content		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
1	ICMA 81 × ICMR 12666	0.27	0.40	2.66	-1.25	-3.25	3.44*	-0.33**	-0.48**	-0.49**
2	ICMA 81 × ICMR 14666	-4.17**	4.12*	1.19	2.32	3.64	-1.81*	0.33**	0.00	0.30
3	ICMA 81 × ICMR 15777	-3.60*	6.95**	0.72	4.25*	3.63	3.67*	-0.06	-0.01	-0.16
4	ICMA 81 × ICMR 15888	4.34**	-9.17**	-7.72**	-1.14	1.93	-2.05	-0.06	-0.26*	0.13
5	ICMA 81 × ICMR 17479	5.51**	-2.44	-0.27	-1.28	-0.47	-0.54	0.16**	0.14	0.37*
6	ICMA 81 × ICMR 17555	-7.85**	-6.52**	-4.16**	-3.16	-6.80*	-4.60*	0.16*	0.39**	-0.01
7	ICMA 81 × ICMR 18196	3.60*	-7.16**	-5.12**	4.23*	-4.23	-0.75	-0.03	0.34*	0.17
8	ICMA 81 × ICMR 19444	1.90	13.82**	12.71**	-3.95*	5.54*	2.65	-0.16**	-0.10	-0.31
9	ICMA 843 × ICMR 12666	-1.14	-0.56	-3.99**	0.62	4.92	0.44	0.00	0.11	-0.17
10	ICMA 843 × ICMR 14666	-0.83	-3.78*	4.17**	-8.25**	-4.21	-2.33	-0.24**	-0.37**	-0.18
11	ICMA 843 × ICMR 15777	7.23**	-2.80	-1.35	0.64	-8.03**	2.22	-0.03	0.00	-0.01
12	ICMA 843 × ICMR 15888	1.51	15.00**	11.69**	-0.81	5.76*	1.80	0.31**	0.52**	-0.35
13	ICMA 843 × ICMR 17479	-4.16**	-4.50*	0.15	1.19	-3.58	-0.24	0.04	-0.32*	-0.20
14	ICMA 843 × ICMR 17555	-4.45**	10.84**	-1.04	4.01*	6.20*	-3.86*	-0.15*	0.00	0.22
15	ICMA 843 × ICMR 18196	-6.39**	-0.93	1.17	0.06	3.44	1.65	-0.14*	-0.04	0.22
16	ICMA 843 × ICMR 19444	8.23**	-13.26**	-10.81**	2.52	-4.50**	0.33	0.21**	0.11	0.47**
17	ICMA 89111 × ICMR 12666	0.87	0.16	1.33	0.63	-1.67	-3.88*	0.34**	0.37**	0.67**
18	ICMA 89111 × ICMR 14666	4.99**	-0.34	-5.36**	5.93**	0.57	4.15*	-0.08	0.37**	-0.12
19	ICMA 89111 × ICMR 15777	-3.63*	-4.15*	0.63	-4.89*	4.40*	-5.88**	0.09	0.01	0.17
20	ICMA 89111 × ICMR 15888	-5.85**	-5.84**	-3.97**	1.95	-7.70**	0.25	-0.25**	-0.25	0.22
21	ICMA 89111 × ICMR 17479	-1.35	6.94**	0.12	0.09	4.05	0.79	-0.21**	0.19	-0.17
22	ICMA 89111 × ICMR 17555	12.30**	-4.32*	5.20**	-0.85	0.61	8.46**	0.00	-0.39**	-0.21
23	ICMA 89111 × ICMR 18196	2.79	8.09**	3.95**	-4.29*	0.79	-0.90	0.17**	-0.29*	-0.39*
24	ICMA 89111 × ICMR 19444	-10.13**	-0.56	-1.90	1.43	-1.04	-2.98	-0.04	-0.01	-0.17
Range	Min.	-10.13	-13.26	-10.81	-8.25	-8.03	-5.88	-0.33	-0.48	-0.49
	Max.	12.30	15.00	12.71	5.93	6.20	8.46	0.34	0.52	0.67
Positive		12	9	13	14	13	12	11	13	10
No. of +^{ve} significant		7	7	5	4	3	3	7	5	3
Negative		12	15	11	10	11	12	13	11	14
No. of -^{ve} significant		9	9	7	4	3	4	7	6	2
S.Em.±		1.46	1.85	1.39	1.95	2.54	1.76	0.06	0.13	0.18

Table 3: Continue…

Sr. No.	Hybrids	Iron content			Zinc content		
		Source A_1	Source A_4	Source A_5	Source A_1	Source A_4	Source A_5
1	ICMA 81 × ICMR 12666	-2.70	-5.40**	-6.00**	-0.84	0.37	7.53**
2	ICMA 81 × ICMR 14666	-28.71**	-23.96**	-24.56**	1.85*	6.37**	-3.33**
3	ICMA 81 × ICMR 15777	30.75**	30.60**	30.33**	1.28	5.15**	-1.17
4	ICMA 81 × ICMR 15888	45.97**	34.71**	42.33**	-8.02**	-8.94**	-9.27**
5	ICMA 81 × ICMR 17479	-31.15**	-23.07**	-27.89**	-0.76	1.33	-2.74**
6	ICMA 81 × ICMR 17555	-14.42**	-11.96**	-9.78**	1.11	-1.99*	3.20**
7	ICMA 81 × ICMR 18196	-24.70**	-27.85**	-24.33**	2.53**	-1.06	1.73
8	ICMA 81 × ICMR 19444	24.96**	26.93**	19.89**	2.84**	-1.24	4.07**
9	ICMA 843 × ICMR 12666	-16.30**	-13.94**	-14.38**	4.17**	1.66	-3.76**
10	ICMA 843 × ICMR 14666	17.39**	15.50**	15.40**	9.36**	5.42**	6.85**
11	ICMA 843 × ICMR 15777	-17.49**	-14.94**	-14.71**	-4.20**	-3.67**	2.84**

12	**ICMA 843 × ICMR 15888**	-32.96**	-27.17**	-29.38**	1.33	0.35	6.50**
13	**ICMA 843 × ICMR 17479**	24.28**	15.39**	20.74**	-0.85	-0.92	-1.70
14	**ICMA 843 × ICMR 17555**	-5.85**	-3.83*	-7.82**	-3.38**	-2.08*	-1.82
15	**ICMA 843 × ICMR 18196**	35.54**	35.61**	33.63**	-4.06**	-2.81**	-5.66**
16	**ICMA 843 × ICMR 19444**	-4.61*	-6.61**	-3.49*	-2.38**	2.05*	-3.25**
17	**ICMA 89111 × ICMR 12666**	18.99**	19.35**	20.38**	-3.34**	-2.03*	-3.76**
18	**ICMA 89111 × ICMR 14666**	11.32**	8.46**	9.15**	-11.22**	-11.80**	-3.52**
19	**ICMA 89111 × ICMR 15777**	-13.26**	-15.65**	-15.63**	2.92**	-1.49	-1.66
20	**ICMA 89111 × ICMR 15888**	-13.01**	-7.54**	-12.96**	6.68**	8.59**	2.77**
21	**ICMA 89111 × ICMR 17479**	6.87**	7.68**	7.15	1.61*	-0.41	4.44**
22	**ICMA 89111 × ICMR 17555**	20.27**	15.79**	17.60	2.27**	4.07**	-1.38
23	**ICMA 89111 × ICMR 18196**	-10.84**	-7.76**	-9.29	1.53*	3.87**	3.94**
24	**ICMA 89111 × ICMR 19444**	-20.35**	-20.32**	-16.40	-0.46	-0.81	-0.82
Range	**Min.**	-32.96	-27.85	-29.38	-11.22	-11.80	-9.27
	Max.	45.97	35.61	42.33	9.36	8.59	7.53
Positive		10	10	10	13	11	10
No. of +^{ve} significant		10	10	8	10	7	9
Negative		14	14	14	11	13	14
No. of -^{ve} significant		13	14	12	7	7	8
S.Em.±		2.00	1.62	1.56	0.73	0.95	0.96

* and** indicate significant at 5 per cent and 1 per cent levels of significance, respectively

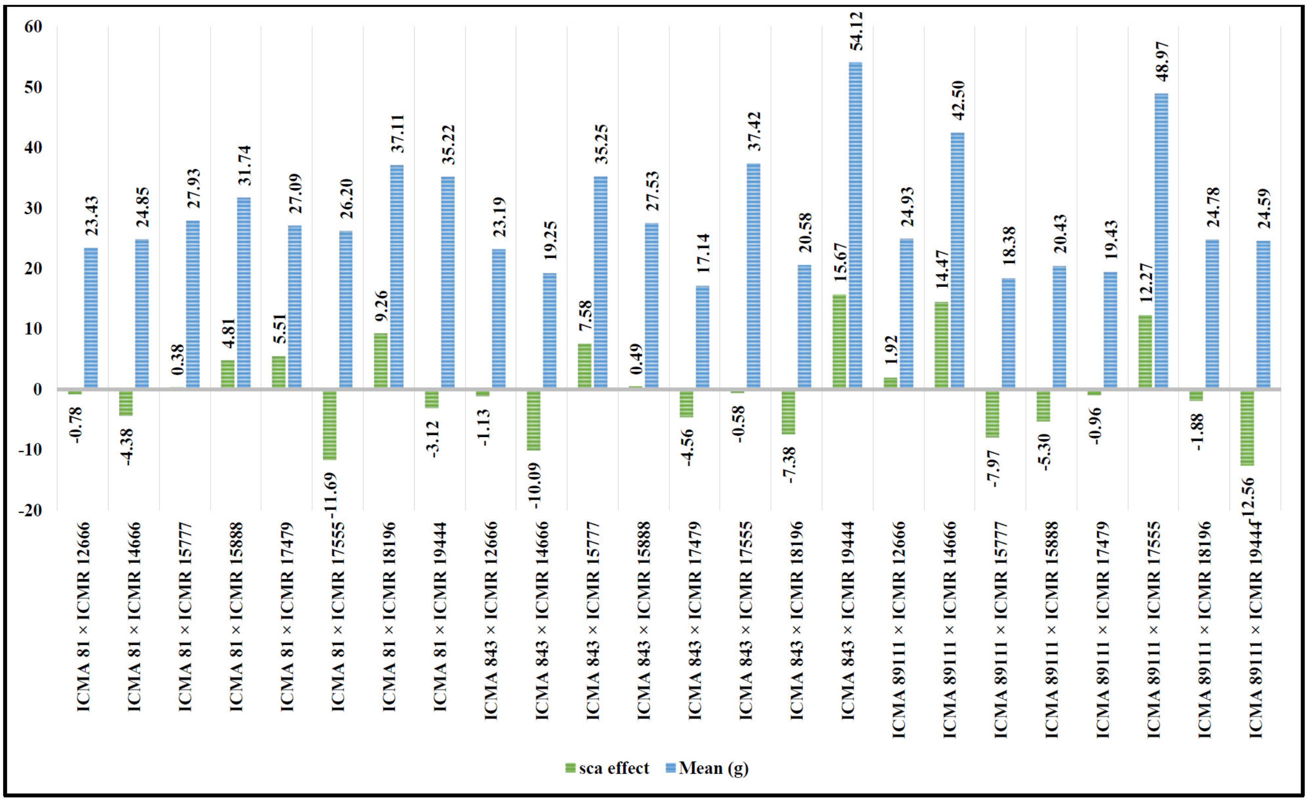

Fig. 1: Graphical representation of *sca* effects and *per se* performance of hybrids for grain yield per plant in cytoplasmic male sterile source A_1

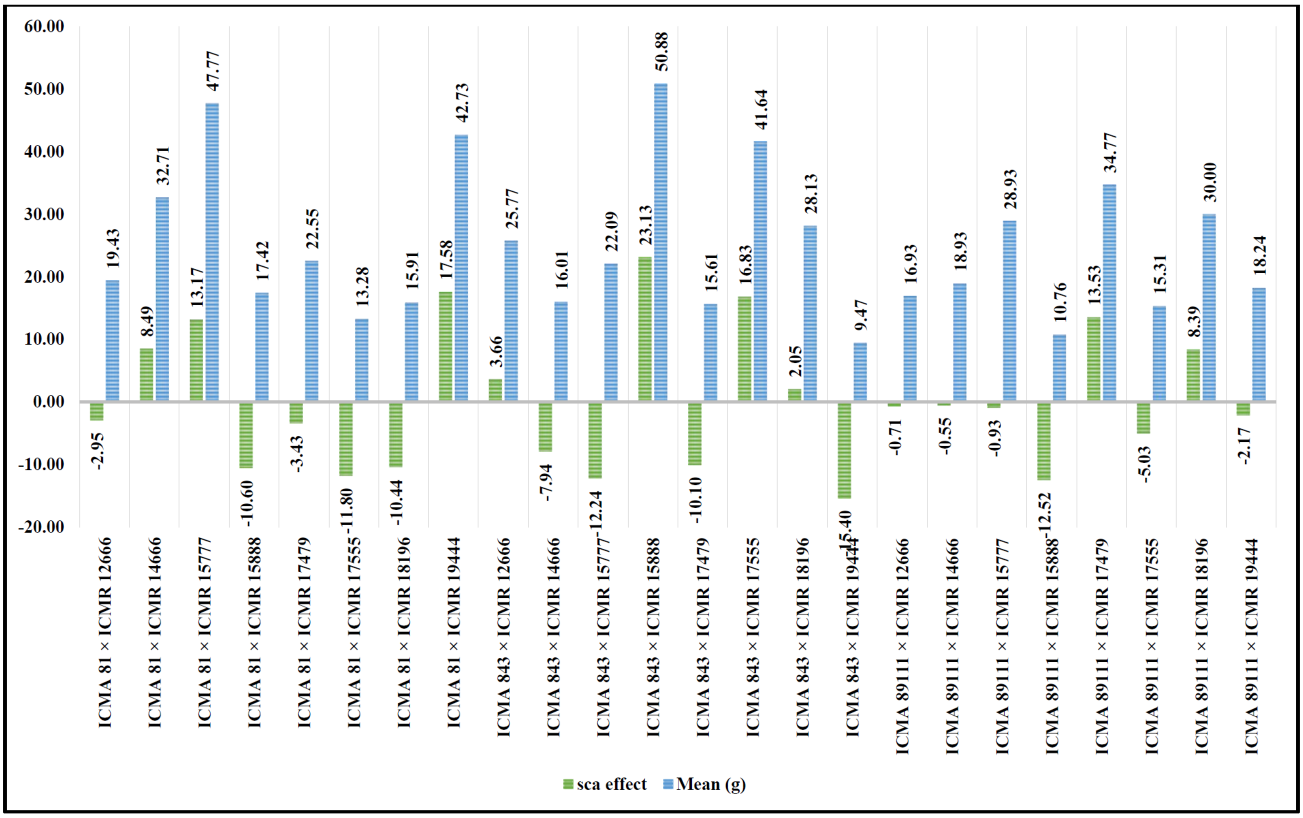

Fig. 2: Graphical representation of *sca* effects and *per se* performance of hybrids for grain yield per plant in cytoplasmic male sterile source A_4

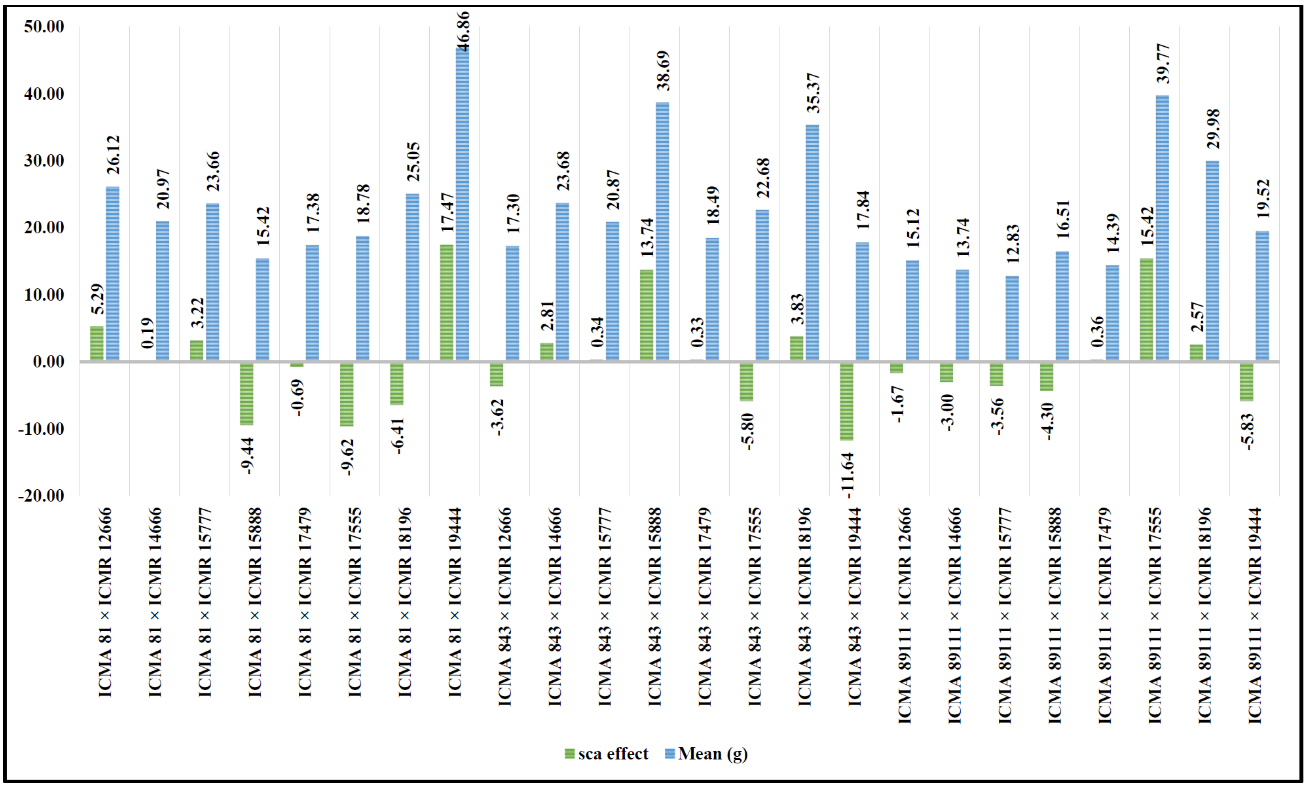

Fig. 3: Graphical representation of *sca* effects and *per se* performance of hybrids for grain yield per plant in cytoplasmic male sterile source A_5

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