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Research Article

Combining ability analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.] for yield and yield contributing traits

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Abstract
In the present study, a set of six female (lines) and seven male (testers) parents of pearl millet were crossed in Line × Tester mating fashion. The newly synthesized hybrids were evaluated for yield performance during *Summer*, 2020. The high magnitude of SCA variance indicates the predominance of non-additive gene action for all the characters. Hence, the heterosis breeding method is suggested to exploit this kind of gene action. The estimates of *gca* effects for yield and its component characters were high in the line ICMB 04111 and the tester PT 6029. Considering the *per se* performance, *gca* of parents, *sca* effect and standard heterosis over hybrid CO 9 for yield and yield related characters, the hybrid combination ICMB 04111 × PT 6029 was identified as superior followed by ICMB 04111 × PT 6317, ICMB 15666 × PT 7043 and ICMB 99222 × PT 6029. Hence, these hybrids could be further evaluated and exploited commercially.

Keywords: Pearl millet, Line × Tester, combining ability and heterosis.

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] originated in Senegal region of West Africa (Brunken *et al.,* 1977). In India, it is called as Cumbu, Sajjalu, Bajri and Bajra. It is well adapted to the arid regions, nutrient depleted soil, high temperature and drought prone regions. It is the richest source of energy (361kcal/100g) than other cereals like wheat, rice, maize and sorghum (Gopalan and Deosthale, 2003). It has non-glutinous starch, high protein content (14 per cent) (Sade, 2009), low glycemic index (55) among the cereal crops (Mani *et al.,*1993). It is also rich source of Fe (>80 ppm) and Zn (>60 ppm) (Rai *et al.,* 2012). Considering the nutritional profile of the pearl millet grains, the consumption is increasing among the diabetic patients. So, increasing the production through crop improvement becomes the need of the hour. In this crop, the yield contributing characters are controlled by non-additive gene action which can exploited by heterosis breeding. So, there is a need for identifying potential parents for heterosis breeding to improve the yield related traits in pearl millet. Hence, the study was aimed to identify potential parents and hybrids through combining ability analysis.

MATERIALS AND METHODS

In the present study, a set of six lines *viz.,* ICMB 98222, ICMB 99111, ICMB 99222, ICMB 04111, ICMB 06111 and ICMB 15666 and seven testers *viz.,* PT 6029, PT 5721, PT 5748, PT 5456, PT 6317, PT 6475 and PT 7043 were collected from the Department of Millets, Tamil Nadu Agricultural University, Coimbatore. They were crossed in Line × Tester mating fashion and 42 hybrids were developed during *kharif*, 2019. The newly developed hybrids were evaluated during *Summer* 2020. In this experiment, all the 42 hybrids along with their 13 parents were raised in Randomized Completely Block Design (RCBD) with two replications. The hybrid CO 9 was used as a check for comparison. Observations on nine quantitative traits were recorded from five randomly selected plants from each replication. The Analysis of Variance (ANOVA) for line × tester was done as per Kempthorne (1957). The gene action controlling the traits were identified through analyzing the variances of general combining ability (GCA) and specific combining ability (SCA). The effects of general combining ability (*gca*) and specific combining ability (*sca*) were calculated and their significance were tested. The standard heterosis of the hybrids over the commercial hybrid CO 9 were calculated for all the traits (Meredith and Bridge, 1972). All the analysis was carried out using the INDOSTAT statistical software. The potential hybrids were identified based on the *per se* performance, *sca* and standard heterosis of the hybrids.

RESULTS AND DISCUSSION

Analysis of variance for combining ability: The ANOVA for combining ability revealed that the lines showed significant variation for all the characters except leaf length (**Table 1**). The significant difference indicates that the lines contributed towards the combining ability and the diverse nature of hybrids. The variances of plant height and panicle girth were significant in testers. The contribution of testers for these two traits is significant for the combining ability. The combining ability variance of interaction revealed the significant variation for the traits, days to 50 per cent flowering, number of productive tillers per plant, leaf length, leaf breadth, panicle girth and single plant yield. These results were found in consistence with the reports of Karvar *et al.* (2017), Saini *et al.* (2018) and Choudhary *et al.* (2023) for all the traits studied in pearl millet. It indicates the scope for expression of good amount of heterosis for these characters.

Gene action based on GCA and SCA variances: The combining ability analysis provides the nature and magnitude of genetic variance of the quantitative characters which helps to select the suitable breeding program for improving those characters. The additive component of gene action is explained by general combining ability variance, whereas the non-additive gene action is explained by specific combining ability variance. The ratio of variances of GCA and SCA give the information about the predominant gene action controlling the character. Hence, the combining ability analysis help to utilize the parental materials in a proper way in the crop improvement. The ratios of estimates of GCA / SCA variances were lesser than the unity for all the studied characters (**Table 1**). It indicated the preponderance of non-additive gene action for all the characters. The earlier workers Patel *et al.* (2018), Kumawat *et al.* (2019) and Suryawanshi *et al.* (2021) also reported the non-additive gene action for the characters *viz*., number of productive tillers per plant, panicle length, panicle girth, 1000 grain weight and single plant yield in pearl millet. This nature of gene action and pollination behavior of crop maintains the heterozygous condition in a population. Hence, these characters could be effectively improved by heterosis breeding to exploit this non-additive gene action.

Identification of good general combiners (parents) for heterosis breeding: In heterosis breeding, selection of parents plays a crucial role in the success of the plant breeders. The mere selection of parents based on the *per se* performance will not be sufficient for hybrid breeding program. There is a need for studying the genetic potential of the parents to produce elite progenies. The significant *gca* effects and *per se* performance for all the characters of parents were compared in the **Table 2**.

The estimates of *gca* effects revealed that the line ICMB 04111 was the good combiner as it has significant positive (S^+) *gca* effects for plant height (25.76), leaf length (3.39), leaf breadth (0.06), panicle length (8.91) and 1000 grain

Table 1. Analysis of variance for combining ability for quantitative traits in pearl millet

Traits	Mean sum of squares				GCA / SCA
	Line	Tester	Line x Tester	Error	
DFF	147.53 **	15.25	7.87 **	0.42	0.129
PH	3008.00 **	749.10 **	191.98	162.69	0.649
NPT	0.64 *	0.28	0.24 *	0.13	0.026
LL	67.30	30.17	37.17 **	2.80	0.004
LB	0.84 **	0.27	0.20 **	0.03	0.029
PL	337.31 **	2.50	8.08	6.07	0.790
PG	11.79 **	4.08 *	1.31 **	0.08	0.072
TGW	8.62 **	2.25	1.81	1.32	0.122
SPY	2966.50 **	613.79	505.88 **	12.75	0.034

* Significant at 5 % probability level; ** Significant at 1 % probability level; DFF - Days to 50 per cent flowering; PH - Plant height; NPT - Number of productive tillers per plant; LL - Leaf length; LB - Leaf breadth; PL - Panicle length; PG - Panicle girth; TGW - 1000 grain weight; SPY - Single plant yield.

Table 2. Comparison of mean performance and *gca* effects of lines and testers for nine quantitative characters

Traits	Lines				Testers			
	Lines with significant gca	*gca value*	*Mean*	*gca & mean*	*Testers with significant gca*	*gca value*	*Mean*	*gca & mean*
DFF	ICMB 98222	-2.44 **	42 **	√	PT 5721	-1.79 **	40 **	√
	ICMB 99111	-3.08 **	41 **	√	PT 6317	-0.56 *	43	×
	ICMB 99222	-1.22 **	49	×				
PH (cm)	ICMB 04111	25.76 **	141.00	×	PT 5456	11.77 **	187.50	×
	ICMB 15666	4.71 *	93.38	×				
NPT	ICMB 99222	0.18 **	3	×	-	-	-	-
	ICMB 15666	0.22 **	3	×				
LL (cm)	ICMB 99222	1.37 **	55.25 **	√	PT 5456	1.90 **	54.38	×
	ICMB 04111	3.39 **	44.00	×	PT 7043	2.29 **	58.8	×
LB (cm)	ICMB 99222	0.18 **	4.93 *	√	PT 6029	0.10 *	4.25	×
	ICMB 04111	0.06 *	4.45	×	PT 6475	0.11 *	4.35	×
	ICMB 15666	0.26 **	5.33	×	PT 7043	0.17 **	4.30	×
PL (cm)	ICMB 04111	8.91 **	36.25 **	√	-	-	-	-
PG (cm)	ICMB 99111	0.55 **	11.38 **	√	PT 6029	0.25 **	12.07 **	√
	ICMB 99222	1.10 **	12.90 **	√	PT 6317	0.48 **	10.69 **	√
	ICMB 15666	0.32 **	10.75	×	PT 7043	0.90 **	9.09	×
TGW (g)	ICMB 04111	0.75 **	10.28	×	-	-	-	-
	ICMB 15666	1.06 **	10.32	×				
SPY (g)	ICMB 99222	7.25 **	76.35**	√	PT 6029	9.96 **	93.04 **	√
	ICMB 04111	23.66 **	56.73	×	PT 5456	4.27 **	83.66 *	√
	ICMB 15666	2.32 **	57.54	×	PT 7043	4.39 **	62.53	×

* Significant at 5 % probability level; ** Significant at 1 % probability level; DFF - Days to 50 per cent flowering; PH - Plant height; NPT - Number of productive tillers per plant; LL - Leaf length; LB - Leaf breadth; PL - Panicle length; PG - Panicle girth; TGW - 1000 grain weight; SPY - Single plant yield.

weight (0.75) along with single plant yield (23.66). The parent ICMB 15666 also showed S^+ *gca* for single plant yield (2.32) and also in most of the contributing characters *viz.,* plant height (4.71), number of productive tillers per plant (0.22), leaf breadth (0.26), panicle girth (0.32) and 1000 grain weight (1.06). Along with single plant yield, the line ICMB 99222 was found to have significant negative (S^-) *gca* for days to 50 per cent flowering (-1.22) and S^+ *gca* for the characters *viz.,* number of productive tillers per plant (0.18), leaf length (1.37), leaf breadth (0.18) and panicle girth (1.10). There is no line found with S^+ *gca* effect for all the characters which revealed that these lines could be utilized in the hybrid development for improvement of specific characters only. Considering significant *gca* for yield and yield contributing characters, the lines ICMB 04111, ICMB 99222 and ICMB 15666 were found to be superior.

Among the testers PT 7043 had a S^+ *gca* for leaf length (2.29), leaf breadth (0.17), panicle girth (0.90) and single plant yield (4.39). The tester PT 5456 had a good estimate of *gca* effect for single plant yield (4.27) and its related characters plant height (11.77) and leaf length (1.90). The parent PT 6029 showed S^+ *gca* for single plant yield (9.96), panicle girth (0.90) and leaf breadth (0.10). The testers PT 5721 and PT 6317 showed S^- *gca* effects (-1.79 and -0.56, respectively) for the negative character days to 50 per cent flowering. As in the case of lines, there is no tester found with S^+ *gca* effect for all the characters studied and these testers are suggested for utilizing in hybrid breeding programme to improve the specific characters. For the improvement of yield with component characters, PT 6029, PT 7043 and PT 5456 were identified as good general combiners among the testers. Hence, the above testers could be used for the development of hybrids. This kind of *gca* effects in yield component traits were also reported by Khandagale *et al.* (2014) for PT 408, PT 4108 and PT 4563 pearl millet parents and Choudhary *et al.* (2023) in pearl millet parents RIB 17 S/109 and RIB 16300.

Considering *per se* performance along with the *gca* effects, ICMB 99222, PT 6029 and PT 5456 were found to be elite parents for single plant yield (76.35, 93.04 and 83.66 g, respectively). Contrastingly, the parents ICMB 04111, ICMB 15666 and PT 7043 were showed S^+ *gca* estimates for single plant yield but non-significant mean performance (56.73, 57.54 and 62.53 g). The same trend was also found in the other yield contributing traits. It indicates that the good parents for heterosis breeding need not to have a good phenotypic expression as they have prepotency to produce elite progeny through desirable gene flow from them. Hence, it was decided that the lines ICMB 99222, ICMB 04111 and ICMB 15666 and the testers PT 6029, PT 7043 and PT 5456 were good general combiners for the improvement of yield.

Relationship between gca of parents and sca of hybrids: In the selection of parents for hybrid development, both *gca* of parents and *sca* of the hybrids are considered (Fasahat *et al.,* 2016). But all possible combinations of parents with significant positive (S^+), significant negative (S^-) and non-significant (NS) *gca* produced hybrids with S^+ *sca* for most of the characters (**Table 3**).

The S^+ *sca* for single plant yield was observed in the hybrids *viz.*, ICMB 98222 × PT 5721, ICMB 98222 × PT 5456, ICMB 98222 × PT 6317, ICMB 99111 × PT 5721, ICMB 99111 × PT 5748, ICMB 99111 × PT 6475, ICMB 99222 × PT 6029, ICMB 04111 × PT 6029, ICMB 04111 × PT 6317, ICMB 06111 × PT 6029, ICMB 15666 × PT 5748 and ICMB 15666 × PT 7043. Of these, ICMB 99222 × PT 6029, ICMB 04111 × PT 6029 and ICMB 15666 × PT 7043 hybrids had S^+ *gca* in both the parents. This S^+ *sca* resulted from cross between (S^+ × S^+) *gca* parents is due to the additive × additive gene interaction. The S^+ *sca* hybrids *viz.*, ICMB 98222 × PT 5456, ICMB 98222 × PT 6317, ICMB 04111 × PT 6317, ICMB 06111 × PT 6029 and ICMB 15666 × PT 5748 had one parent with S^+ *gca* and another is S^- or NS *gca*. This effect is due to the additive effect of S^+ *gca* parent and epistatic effect of S^- or NS *gca* parent which makes the favorable gene combination. The hybrid with (S^- × S^-) *gca* parental combination showed S^+ *sca* in the hybrids *viz.,* ICMB 98222 × PT 5721, ICMB 99111 × PT 5721, ICMB 99111 × PT 5748 and ICMB 99111 × PT 6475 is due to the dominance x dominance gene interaction and over dominance gene action which is non-fixable. These kinds of hybrids should not be considered because the hybrid vigour is due to pseudo allelic interaction. These parental combinations in pearl millet hybrids were also reported by Pethani *et al.* (2004) and Solanki *et al.* (2017), Madane *et al.* (2022) and Choudhary *et al.* (2023).

Identification of superior hybrids based on sca effects, per se performance and heterosis over hybrid CO 9 : The specific combining ability is the deviation of performance of the hybrid combination from the predicted performance of their parents in general combining ability (Sprague and Tautum, 1942). The combination of *sca* effects and *per se* performance should be considered for the selection of hybrids for heterosis breeding (Fasahat *et al.,* 2016). The comparison between *per se* performance and *sca* effect of hybrids along with heterosis over hybrid CO 9 were given in the **Table 4**.

The hybrids with S+ *sca* effects, the *per se* performance for single plant yield *viz.,* ICMB 04111 × PT 6317 (153.50 g), ICMB 04111 × PT 6029 (149.48 g), ICMB 15666 × PT 7043 (135.80 g), ICMB 98222 × PT 5456 (104.5 g) and ICMB 99222 × PT 6029 (129.03 g) were found to be superior. Along with single plant yield, ICMB 04111 × PT 6029 had significantly high mean performance and S^+ *sca* effects for plant height (235.13 cm), leaf length (66.75 cm) and 1000 grain weight (15.83 g). The hybrid combinations ICMB 15666 × PT 7043 and ICMB 99222×PT 6029 showed significantly high mean for independent characters *viz.,* number of productive tillers per plant (4 and 5) and leaf length (64.70 cm and 64.33 cm) in addition to single plant yield. The hybrid ICMB 04111 × PT 6317 performed well in *per se* and S^+ *sca* effect for single plant yield and number of productive tillers per plant (4). The pearl millet hybrids with high *per se* performance and S^+ *sca* effects for yield

Table 3. Analyzing the parental *gca* combinations of the hybrids with significant *sca*

Traits	Parental *gca* combinations			
	S^+ x S^+	**S^+ x S^-**	**S^- x S^+**	**S^- x S^-**
DFF	ICMB 98222 × PT 6317	ICMB 99222 × PT 5456	ICMB 04111 × PT 5721	ICMB 15666 × PT 5456
PH	-	-	-	-
NPT	-	ICMB 04111 × PT 6317	-	-
LL	ICMB 99222 × PT 7043	-	ICMB 98222 × PT 7043	ICMB 98222 × PT 6317
LB	ICMB 99222 × PT 6475, ICMB 99222 × PT 7043	ICMB 99222 × PT 5456	ICMB 06111 × PT 6029	ICMB 06111 × PT 6317
PL	-	-	-	-
PG	ICMB 99111 × PT 6317, ICMB 99222 × PT 6317, ICMB 15666 × PT 6317	ICMB 99222 × PT 5721, ICMB 15666 × PT 5456	ICMB 04111 × PT 6029	ICMB 04111 × PT 5748, ICMB 04111 × PT 5456
TGW	-	-	-	-
SPY	ICMB 99222 × PT 6029, ICMB 04111 × PT 6029, ICMB 15666 × PT 7043	ICMB 15666 × PT 5748	ICMB 98222 × PT 5456, ICMB 06111 × PT 6029	ICMB 98222 × PT 5721, ICMB 99111 × PT 5721, ICMB 99111 × PT 5748, ICMB 99111 × PT 6475

S^+ Significant positive; S^- Significant negative; DFF - Days to 50 per cent flowering; PH - Plant height; NPT - Number of productive tillers per plant; LL - Leaf length; LB - Leaf breadth; PL - Panicle length; PG - Panicle girth; TGW - 1000 grain weight; SPY - Single plant yield.

Table 4. Comparison of mean performance, *sca* effects and standard heterosis of hybrids for nine quantitative characters

Traits	Hybrids with significant *sca*	*sca* values	*per se*	Heterosis over CO 9 hybrid (%)	Selection based on *sca*, mean and heterosis
DFF (-ve)	ICMB 98222 × PT 6029	-2.47 **	39 **	-2.53	×
	ICMB 98222 × PT 6317	-2.39 **	38 **	-3.80 *	√
	ICMB 99222 × PT 5748	-3.44 **	39 **	-2.53	×
	ICMB 99222 × PT 5456	-1.11 *	42 *	5.06 **	×
	ICMB 04111 × PT 5721	-4.91 **	43	7.59 **	×
	ICMB 06111 × PT 5748	-1.15 *	42	6.33 **	×
	ICMB 06111 × PT 7043	-2.23 **	43	8.86 **	×
	ICMB 15666 × PT 5456	-2.18 **	43	7.59 **	×
	ICMB 15666 × PT 6475	-1.43 **	43	7.59 **	×
PH (cm)	ICMB 04111 × PT 6029	22.13 *	235.13 **	30.08 **	√
NPT	ICMB 99222 × PT 6029	0.73 **	5 **	50.00 **	√
	ICMB 04111 × PT 6317	0.64 *	4 *	41.67 **	√
	ICMB 15666 × PT 7043	0.63 *	4 *	41.67 **	√
LL (cm)	ICMB 98222 × PT 6317	5.72 **	62.86	0.91	×
	ICMB 98222 × PT 7043	4.92 **	65.90 **	5.78	×
	ICMB 99111 × PT 5721	7.80 **	65.28 **	4.78	×
	ICMB 99222 × PT 6029	2.95 *	64.33 **	3.25	×
	ICMB 99222 × PT 7043	3.23 *	66.50 **	6.74 *	√
	ICMB 04111 × PT 6029	3.35 **	66.75 **	7.14 *	√
	ICMB 06111 × PT 6029	5.78 **	62.90	0.96	×
	ICMB 15666 × PT 5748	5.50 **	63.75 *	2.33	×
	ICMB 15666 × PT 6475	5.28 **	64.52 **	3.57	×
	ICMB 15666 × PT 7043	2.58 *	64.70 **	3.85	×
LB (cm)	ICMB 99111 × PT 5721	0.43 *	5.17	3.50	×
	ICMB 99222 × PT 5456	0.26 *	5.40	8.00 *	×
	ICMB 99222 × PT 6475	0.33 *	5.80 **	16.00 **	√
	ICMB 99222 × PT 7043	0.52 **	6.05 **	21.00 **	√
	ICMB 06111 × PT 6029	0.26 *	5.48	9.50 *	×
	ICMB 06111 × PT 6317	0.38 **	5.30	6.00	×
	ICMB 15666 × PT 5748	0.51 **	5.95 **	19.00 **	√
PL (cm)	ICMB 06111 × PT 5456	4.00 *	33.25	20.91 *	×
PG (cm)	ICMB 98222 × PT 7043	1.30 **	13.17 **	9.98 **	√
	ICMB 99111 × PT 6317	0.72 **	12.75 **	6.47 **	√
	ICMB 99222 × PT 5721	1.03 **	12.60 **	5.22 *	√
	ICMB 99222 × PT 6317	0.68 **	13.26 **	10.77 **	√
	ICMB 99222 × PT 6475	0.44 *	12.54 **	4.72 *	√
	ICMB 04111 × PT 6029	0.62 **	10.32	-13.86 **	×
	ICMB 04111 × PT 5748	0.57 **	9.57	-20.04 **	×
	ICMB 04111 × PT 5456	0.43 *	9.19	-23.26 **	×
	ICMB 04111 × PT 6475	0.62 **	10.07	-15.95 **	×
	ICMB 06111 × PT 6475	0.90 **	11.47	-4.26	×
	ICMB 15666 × PT 5456	0.42 *	11.05	-7.72 **	×
	ICMB 15666 × PT 6317	1.18 **	12.97 **	8.35 **	√
TGW (g)	ICMB 04111 × PT 6029	1.77 *	15.83 *	19.84 *	√
SPY (g)	ICMB 98222 × PT 5721	5.79 *	82.93	-14.49 **	×
	ICMB 98222 × PT 5456	11.26 **	104.50 **	7.75 *	√
	ICMB 98222 × PT 6317	6.81 *	96.51	-0.48	×
	ICMB 99111 × PT 5721	23.27 **	88.38	-8.87 *	×
	ICMB 99111 × PT 5748	5.62 *	78.05	-19.52 **	×
	ICMB 99111 × PT 6475	14.74 **	88.69	-8.55 *	×
	ICMB 99222 × PT 6029	18.14 **	129.03 **	33.04 **	√
	ICMB 04111 × PT 6029	22.17 **	149.48 **	54.13 **	√
	ICMB 04111 × PT 6317	35.43 **	153.50 **	58.27 **	√
	ICMB 06111 × PT 6029	8.69 **	100.51	3.64	×
	ICMB 15666 × PT 5748	6.52 *	98.00	1.05	×
	ICMB 15666 × PT 7043	35.40 **	135.80 **	40.02 **	√

*Significant at 5 % probability level; ** Significant at 1 % probability level; DFF - Days to 50 per cent flowering; PH - Plant height; NPT - Number of productive tillers per plant; LL - Leaf length; LB - Leaf breadth; PL - Panicle length; PG - Panicle girth; TGW - 1000 grain weight; SPY - Single plant yield.

and related characters were also found in the reports of Singh and Sharma (2014), Khandagale *et al.* (2014) and Madane *et al.* (2022) and Choudhary *et al.* (2023). Thus, the hybrid combinations ICMB 04111 × PT 6029 followed by ICMB 15666 × PT 7043, ICMB 99222 × PT 6029 and ICMB 04111 × PT 6317 were selected as superior hybrids on the basis *per se* performance and *sca* effects in single plant yield and its contributing characters.

Analyzing the standard heterosis (over CO 9 hybrid) of the hybrids having S^+ *sca*, five hybrids *viz.,* ICMB 98222 × PT 5456 (7.75 %) ICMB 99222 × PT 6029 (33.04 %) ICMB 04111 × PT 6029 (54.13 %) ICMB 04111 × PT 6317 (58.27 %) and ICMB 15666 × PT 7043 (40.02 %) were found with S^+ heterosis for single plant yield. Along with single plant yield, ICMB 04111 × PT 6029 identified as superior as it showed S^+ heterosis for three contributing characters *viz.,* plant height (30.08 %), leaf length (7.14 %) and 1000 grain weight (19.84 %). The hybrids ICMB 99222 × PT 6029, ICMB 04111×PT 6317 and ICMB 15666 × PT 7043 were observed with S^+ heterosis for number of productive tillers per plant (50.00, 41.67 and 41.67 %, respectively) along with single plant yield. The non-additive gene action and the heterotic vigour are the reason for the elite performance of yield, *sca* and heterosis.

Taking on to consideration all the criteria of selection of hybrids, ICMB 04111 × PT 6029 followed by ICMB 04111 × PT 6317, ICMB 15666 × PT 7043 and ICMB 99222 × PT 6029 were considered as potential hybrids for heterosis breeding program as they excelled in the *sca* effects, *per se* performance, standard heterosis and good parental *gca* combinations.

The lines ICMB 99222, ICMB 04111 and ICMB 15666 and the testers PT 6029, PT 7043 and PT 5456 are suggested for hybridization and selection program. The hybrids *viz.,* ICMB 04111 × PT 6029, ICMB 04111 × PT 6317, ICMB 15666 × PT 7043 and ICMB 99222 × PT 6029 are identified as a superior hybrid as they are elite in heterotic potential with good parental status. Since, the hybrids *viz.,* ICMB 04111 × PT 6029 and ICMB 99222 × PT 6029 had a good restorer (PT 6029) of CGMS lines, and will be utilized for developing CGMS based hybrids. Hence, the above hybrids could be evaluated in multi-location yield trials and exploited commercially.

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