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Research Article

Nature of gene action for kernel yield and its component traits in maize (*Zea mays* L.)

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Abstract
Towards understanding the nature of gene action for kernel yield and its components traits, a set of 45 F_1 hybrids generated by adopting diallel mating design (Method IV and Model I) involving 10 inbred lines were tested across three seasons for their performance and combining ability. Combining ability analysis revealed that the mean sum of squares due to general and specific combining ability were significant indicating the contribution of both additive and non-additive gene action in controlling days to 50% flowering, days to 50% silking, anthesis-silking interval, days to maturity, plant height, SPAD chlorophyll meter reading, specific leaf area, cob length, cob girth, number of kernel rows per cob, number of kernels per row, 100 kernel weight, harvest index and kernel yield. Estimates of components of variances (σ^2GCA and σ^2SCA) and ratio of σ^2GCA/σ^2SCA indicated the predominance of non-additive gene action for all the characters studied. Among the inbred lines, BML 2, DFTY, Heypool and PDM 1474 were found to be the best general combiners across seasons for kernel yield and most of yield components as well as developmental characters. DFTY, Heypool, PDM 1452 and PAM 1474 were identified as good general combiners for earliness. Among the top 20 best performing hybrids, BML 15 × PDM 1452, BML 15 × PDM 1474 and BML 7 × DFTY were rated as promising hybrids based on their superior performance and *sca* effects for kernel yield and most of the yield components. These hybrids could be recommended for commercial cultivation after extensive testing in multilocation trials.

Key words: Maize, Combing ability analysis, Gene action, Yield components

INTRODUCTION

Maize is a versatile staple cereal crop with wider genetic variability which can be successfully cultivated in tropical, sub-tropical and temperate agro-climatic conditions. In India, maize is the third most important cereal crop after wheat and rice. It is cultivated in an area of 9.2 million hectares with a production of 21.80 million tones and productivity of 2965 kg per ha primarily during *kharif* and *rabi* season (DES, 2020). In Andhra Pradesh, it is grown in an area of 2.77 lakh hectare with a production of 17.77 lakh metric tonnes. The productivity of maize in the state is 6403 kg per ha (DES, 2018). Maize is cultivated round the year under different seasons. Cultivation of high yielding and stable hybrids suitable for all the seasons

would be a better proposition rather than growing specific hybrids in different seasons. Nature and magnitude of gene action controlling the yield and its component traits are important in understanding the genetic potential of a population. Further, knowledge on the genetic architecture of characters is essential in choosing an appropriate breeding procedure in a given population.

The use of inbred lines in generating superior hybrids has become more effective with the increased use of recurrent selection. Combining ability analysis provides information on the identification of potential parents which can be used for the development of hybrids and synthetics. The

diallel cross analysis provides the estimates of genetic parameters pertaining to combining ability and dominance relationship of parents using the first filial generation (F$_1$'s). Assessment of the stability of a genotype over different seasons is useful for recommending hybrids suitable for commercial seed programme. The present study was carried out to identify suitable inbred lines for hybridization programme, select promising hybrid combinations and estimate the nature and magnitude of gene action for kernel yield and components traits so as to adopt an appropriate breeding methodology in maize.

MATERIALS AND METHODS
Ten maize inbred lines were crossed in a diallel fashion excluding reciprocals during *rabi*, 2015-16 and *kharif*, 2016 by adopting staggered sowings in order to achieve synchrony in flowering and to generate F$_1$ hybrids. Simultaneously the parental lines were selfed to get the parental seeds. Forty-five F$_1$ hybrids and their parents were tested in a randomized block design with three replications during *rabi*, 2016-17, *summer*, 2016-17 and *kharif*, 2017 at Agricultural Research Station, Perumallapalli , Chittoor, Andhra Pradesh. Each genotype was planted in a row of 5 m length with a spacing of 75 cm between rows and 25 cm between plants in the row. A fertilizer dose of 100 kg / ha N, 80 kg/ ha P$_2$O$_5$, 60 kg/ ha K$_2$O kg/ ha during *kharif*, 2017 and 120 kg/ ha N, 80 kg/ ha P$_2$O$_5$, 60 kg/ ha K$_2$O kg/ ha during *rabi*, 2016-17 and *summer*, 2016-17 was applied. All the recommended agronomic management practices and plant protection measures were followed in raising a good crop. Observations were recorded on five randomly selected plants from row for plant height (cm), SPAD chlorophyll meter readings, specific leaf area (cm^2 g^{-1}), cob length (cm), cob girth (cm), number of kernel rows per cob, number of kernels per row, 100 kernel weight (g), harvest index (%) and kernel yield per plant (g). Days to 50% tasseling, days to 50% silking and days to maturity were recorded on a whole plot basis. Specific leaf area (cm^2 g^{-1}) was determined as the ratio of leaf area to leaf weight, while harvest index (%) as the ratio of kernel yield to total dry matter (kernel yield + biomass). The chlorophyll content of the third leaf was measured with a SPAD-502 Chlorophyll Meter (Minolta Co Ltd, Osaka, Japan). Pooled analyses of variance over three seasons was also carried out after testing for the homogeneity of error variances by using Bartlett`s test of homogeneity (Bartlett, 1937) as quoted by Panse and Sukhatme (1985). General combining ability (GCA) and specific combining ability (SCA) estimates were determined adopting diallel cross analysis Model I and Method IV of Griffing's approach (1956) and Singh and Chaudhary (1985).

RESULTS AND DISCUSSION
Analysis of variance for kernel yield and the its contributing characters performed on season-wise data indicated that mean sum of squares due to genotypes (F$_1$'s) were highly significant for all the characters *viz*., days to 50% flowering, days to 50% silking, anthesis-silking interval,

days to maturity, plant height, SCMR, specific leaf area, cob length, cob girth, number of kernel rows per cob, number of kernels per row, 100 kernel weight, harvest index, kernel yield per plant indicating the existence of sufficient variability among the genotypes. The presence of variability among the hybrids for characters of interest helps in the selection of best hybrid combinations. Similar results were reported by Azad *et al*. (2014) in maize.

Pooled analysis of variance for combining ability over three seasons is presented in **Table 1**. The variance components due to GCA, SCA and seasons showed the highly significant differences for all the characters. Mean sum of squares due to GCA × Seasons were significant for days to 50% tasseling, days to 50% silking, days to maturity, plant height , SCMR and ear girth, while they were non-significant for the characters *viz*., anthesis-silking interval, specific leaf area, specific leaf weight, ear length, number of kernel rows per ear, number of kernels per row, 100 kernel weight, harvest index and kernel yield plant. The interaction of SCA × Seasons exhibited non-significant differences for all characters except days to 50% tasseling, days to 50% silking, days to maturity, plant height, ear girth and kernel yield per plant. Significant mean sum squares due to seasons, GCA × Seasons and SCA × Seasons for yield and yield components indicate that both additive and non-additive genetic variances are greatly influenced by environments (Seasons).

Significant mean sum of squares in pooled analysis due to GCA were recorded for days to 50% flowering, days to 50% silking, anthesis-silking interval, days to maturity, plant height, SCMR, specific leaf area, cob length, cob girth, number of kernel rows per cob, number of kernels per row, 100 kernel weight, harvest index and kernel yield per plant. As a rule, GCA is the result of additive gene effects, while the SCA is the result of dominance and non-allelic interactions (Sprague and Tatum, 1942). In the present study , it was observed that both additive and non-additive gene actions are involved in governing these characters. Similarly, importance of both additive and non-additive gene actions for yield and yield related characters in maize was reported in maize by Joshi *et al*. (1998), Dubey *et al*. 2001, Akbar *et al*. (2008), Haddadi *et al*. (2012) and Kumari *et al*. (2017).

Estimates of components of genetic variances *viz*., σ^{2}GCA, σ^{2}SCA and ratio of σ^{2}GCA/σ^{2}SCA are presented in **Table 1**. The greater magnitude of σ^{2}SCA than σ^{2}GCA and the ratio of σ^{2}GCA/σ^{2}SCA less than one were recorded for all the characters indicating the predominance of non-additive gene action. Based on results of genetic variance components, it is evident that non additive types of genetic actions is predominant for days to 50% flowering, days to 50% silking, anthesis-silking interval, days to maturity, plant height, SCMR, specific leaf area, cob length, cob girth, number of kernel rows per cob, number of kernels per row, 100 kernel weight, harvest index, kernel

Table 1. Analysis of variance for kernel yield and its contributing characters (pooled analysis)

S.No.	Characters	GCA (D.F=9)	SCA (D.F=35)	σ² GCA	σ² SCA	σ²GCA/σ²SCA
1.	Days to 50% tasseling	10.56**	2.83**	1.23	2.31	0.53
2.	Days to 50% silking	13.53**	4.10**	1.59	3.32	0.48
3.	Anthesis-silking interval	0.60*	0.32*	0.04	0.05	0.84
4.	Days to maturity	14.94**	2.92**	1.77	2.13	0.83
5.	Plant height	377.45**	158.94**	40.48	105.34	0.38
6.	SPAD chlorophyll meter readings (SCMR)	13.19**	3.34**	1.54	2.45	0.63
7.	Specific leaf area	33.75**	10.39*	3.44	4.15	0.83
8.	Cob length	4.64**	2.97**	0.51	2.41	0.09
9.	Cob girth	2.39**	0.79**	0.28	0.68	0.42
10.	Number of kernel rows per cob	2.51**	0.62**	0.28	0.34	0.83
11.	Number of kernels per row	35.92**	9.23**	4.13	6.37	0.65
12.	100 kernel weight	12.45**	4.40**	1.46	3.64	0.40
13.	Harvest index	1.27**	0.46**	0.13	0.26	0.52
14.	Kernel yield per plant	1222.91**	263.59**	148.03	224.89	0.66

*Significant at 5% level,**Significant at 1% level:
GCA – general combining ability; SCA – specific combining ability; DF – degrees of freedom

yield per plant. Similar results were also reported by Premalatha, (2006), Akbar *et al.* (2008), Kanagarasu *et al.* (2010), Kapoor *et al.* (2014), Purushottam and Shantakumar (2017) and Varalakshmi and Wali, (2017) in maize.

Per se performance and estimates of *gca* effects in pooled analysis over seasons pertaining to parental lines and their respective standard errors for 14 characters studied are presented in **Table 2**. Significant differences were recorded among parental lines for their general combining ability effects. However, none of the inbred lines recorded significant *gca* effects for all the characters studied. Significant negative *gca* effects across seasons for days to 50% tasseling, silking and maturity were recorded by four inbred lines *viz.*, DFTY, Heypool, PDM 1452 and PDM 1474 . All these four inbred lines also recorded low *per se* performance for these characters. Negative *gca* effects are desirable for these characters as they are associated with earliness. Significant negative *gca* effects in the desirable direction indicates that these four parental lines are the best general combiners for days to 50% tasseling, silking and maturity. Similar results were reported in maize by Kumari *et al.* (2008), Matin *et al.* (2016) and Darshan and Marker, (2019). However, BML 2 and PDM 1428 registered positive and significant *gca* effects and higher mean values for days to 50% tasseling, silking and maturity indicating that they are late in maturity. Similarly, negative *gca* effects are desirable for anthesis-silking interval for getting synchrony in flowering. However, none the inbred lines tested in the present study recorded significant negative *gca* effects for

anthesis-silking interval. One inbred line BML 15 recorded a significant and positive *gca* effect for anthesis-silking interval. Both positive and negative significant *gca* effects were recorded for plant height. In the present study, BML 7, BML 15, DFTY , Heypool and PDM 1474 recorded significant negative *gca* effects for plant height. Negative *gca* effects are desirable to select the inbred lines for use as a source lines in breeding for dwarf plant types suitable for stress conditions. Positive significant *gca* effects were recorded by BML 6, PDM 1416 and PDM 1428 for plant height besides high mean performance and thus they are found to be good general combiners for plant height.

The value of an inbred line in the commercial production of hybrid maize depends on characteristics (yield, adaptability, disease resistance and tolerance to environmental factors) and behavior of the line in hybrid combinations and therefore *per se* performance and its combining abilities should be considered. Parental lines *viz.*, DFTY, Heypool and PDM 1452 exhibited significant positive *gca* effects for SCMR, cob length, cob girth, number of kernel rows per cob number of kernels per row, 100 kernel weight, harvest index and kernel yield per plant, days to 50% tasseling and maturity across the seasons in addition to high *per se* performance for these characters. Based on the above results, the inbred lines *viz.*, DFTY, Heypool and PDM 1474 could be adjudged as good general combiners. BML 2 recorded significant *gca* effects and mean performance in desirable direction for specific leaf area , cob girth and kernel yield per plant, however significant *gca* effects were recorded in undesirable direction for days to 50% tasseling, days to

Table 2. General combining ability (gca) effects of inbred lines (pooled analysis)

S. No.	Inbred line	Days to 50% tasseling		Days to 50% silking		Anthesis-silking interval		Days to maturity		Plant height (cm)		SPAD chlorophyll meter readings (SCMR)		Specific leaf area (cm² g⁻¹)	
		Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects
1	BML 2	66.67	0.40**	70.11	0.63**	3.44	0.19	106.27	0.39*	201.43	0.72	41.53	-0.21	78.63	-0.97*
2	BML 6	66.78	0.39**	69.44	0.26	2.67	-0.12	106.18	0.33*	186.64	5.43**	43.09	-0.17	79.68	-0.55
3	BML 7	67.44	0.46**	70.89	0.42*	3.44	-0.03	106.78	0.22	180.63	-3.31*	40.33	-0.76**	79.73	-0.48
4	BML 15	65.56	0.19	69.22	0.46*	3.67	0.30*	105.33	0.69**	173.32	-5.16**	43.59	-0.21	78.25	0.62
5	DFTY	64.78	-0.91**	67.33	-1.02**	2.56	-0.13	104.34	-0.94**	177.18	-4.19**	46.68	1.26**	82.12	1.60**
6	Heypool	65.00	-0.30*	67.67	-0.48*	2.67	-0.16	104.44	-0.79**	180.25	-2.81*	47.03	0.90**	83.18	1.13**
7	PDM 1416	68.00	-0.03	71.89	-0.03	3.89	-0.02	105.04	0.52**	172.98	5.12**	43.42	-0.73**	78.51	-1.26*
8	PDM 1428	66.56	1.21**	70.00	1.31**	3.44	0.13	106.02	1.24**	165.88	3.84**	36.56	-0.55**	78.13	-1.62**
9	PDM 1452	65.56	-0.73**	68.89	-0.78**	3.33	-0.06	106.72	-0.66**	178.89	2.13	43.86	-0.40**	80.52	-0.10
10	PDM 1474	64.67	-0.67**	67.89	-0.77**	3.22	-0.09	104.56	-1.00**	176.64	-2.78*	45.84	0.89**	81.25	1.63**
	Grand Mean	66.10		69.33		3.23		105.57		179.38		43.19		80.00	
	SE(gi)		0.14		0.17		0.11		0.16		1.42		0.21		0.48

Table 2. contd….

S. No	Inbred line	Cob length (cm)		Cob girth (cm)		Number of kernel rows cob⁻¹		Number of kernels row⁻¹		100 kernel weight (g)		Harvest index (%)		Kernel yield plant⁻¹ (g)	
		Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects	Mean	*gca* effects
1	BML 2	12.54	-0.06	9.57	0.13*	12.14	0.05	20.22	0.02	19.66	0.05	33.82	-0.33*	65.52	5.70**
2	BML 6	12.44	-0.14	10.31	-0.15*	12.58	-0.10	21.33	-0.22	19.59	-0.46**	33.37	-0.02	68.05	1.53
3	BML 7	12.73	-0.20	10.42	-0.20**	12.73	-0.24*	22.78	-0.20	20.32	-0.24	33.75	-0.25**	68.92	-5.32**
4	BML 15	12.86	-0.24	10.06	-0.04**	12.47	-0.11	20.67	-0.23	20.33	-0.43*	33.08	-0.15	68.86	-6.98**
5	DFTY	13.97	0.62**	11.44	0.33**	13.34	0.35**	24.67	1.70**	24.99	0.96**	35.09	0.30**	76.84	6.16**
6	Heypool	14.12	0.52**	11.43	0.39**	13.54	0.32**	25.00	1.04**	25.98	0.80**	35.03	0.19*	78.22	5.29**
7	PDM 1416	12.41	-0.51**	10.25	-0.33**	12.55	-0.43**	21.89	-1.45**	19.96	-0.98**	34.08	-0.10	63.28	-11.05**
8	PDM 1428	12.49	-0.58**	10.12	-0.53**	12.22	-0.49**	20.78	-2.09**	19.10	-0.75**	34.44	-0.11	63.69	-6.68**
9	PDM 1452	13.34	0.02	10.37	0.04	12.93	-0.01	23.11	-0.22	21.43	0.02	34.50	0.18*	71.31	0.69
10	PDM 1474	13.21	0.58**	10.79	0.36**	13.25	0.65**	23.33	1.66**	22.47	1.04**	34.68	0.29**	70.53	10.64**
	Grand Mean	13.01		10.48		12.78		22.38		21.38		34.18		69.52	
	SE(gi)		0.14		0.06		0.1		0.33		0.17		0.08		1.38

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

50% silking and days to maturity. Three inbred lines *viz.*, BML 7, PDM 1416 and PDM 1428 are considered as poor general combiners based on negative *gca* effects and low mean performance for yield and its contributing characters.

The *sca* effects estimated in pooled analysis for the top 20 hybrids along with *per se* performance are presented in **Table 3**. Among the top 20 hybrids DFTY × PDM 1474 recorded higher kernel yield per plant (151.10 g) followed by BML 2 × Heypool (146.11 g), Heypool × PDM 1474 (141.94 g), BML 2 × BML 6 (141.73 g), BML 15 × PDM 1474 (140.40 g), BM 7 × DFTY (140.33 g) and BML 15 × PDM 1452 (140.14 g). Though the hybrid DFTY × PDM 1474 registered higher yield, it recorded a low 100 kernel weight and low mean values for yield components. The next best hybrids BML 2 × Heypool, BML 2 × BML 6 and Heypool × PDM 1474 recorded average mean values for yield attributes coupled with long duration for flowering. The hybrids *viz.*, BML 7 × DFTY, BML 15 × PDM 1452 and

BML 15 × PDM 1474 and recorded higher mean values for most of the yield components.

Significant and negative *sca* effects by BML 7 × DFTY and BML 15 × PDM 1454 for days to 50% tasseling, days to 50% silking and days to maturity across seasons indicated that they are the best specific combiners for earliness. These two hybrids also registered low mean values for the characters. Three hybrids *viz.*, BML 15 × PDM 1452, BML 15 × PDM 1474 and Heypool × PDM 1474 exhibited significant negative *sca* effects for days to 50% tasseling and days to 50% silking, whereas BML 6 × PDM 1474 and BML 2 × PDM 1428 for days to 50% tasseling and days to maturity and BML 6 × PDM 1452 for days to silking and days to maturity recorded significant negative *sca* effects. Significant positive *sca* effects were recorded by BML 2 × PDM 1474, BML 15 × Heypool, DFTY × PDM 1428 and PDM 1452 × PDM 1474 for plant height. None of the hybrids recorded significant *sca* effects in a desirable direction (negative effects) for specific leaf area.

Table 3. Mean performance and specific combining ability (*sca*) effects of top 20 F$_1$ hybrids (pooled analysis)

S. No.	Hybrids	Days to 50% tasseling		Days to 50% silking		Anthesis-silking interval		Days to maturity		Plant height (cm)		SPAD chlorophyll meter readings (SCMR)		Specific leaf area (cm² g⁻¹)	
		Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects
1	BML 2 × BML 6	63.11	-0.04	66.22	-0.26	3.11	-0.21	102.82	0.21	196.00	2.75	50.42	-0.54	83.48	-0.02
2	BML 2 × BML 7	63.11	-0.11	66.44	-0.19	3.37	-0.04	102.92	0.42	187.29	2.80	51.46	1.08	83.96	0.39
3	BML 2 × Heypool	64.00	1.54**	68.00	2.26**	4.00	0.72*	100.05	-1.43**	178.36	-7.04	52.28	0.24	87.07	1.88
4	BML 2 × PDM 1428	63.22	-0.75*	66.78	-0.75	3.63	0.05	102.33	-1.18**	181.77	-9.88**	50.69	0.11	82.34	-0.09
5	BML 2 × PDM 1474	61.78	-0.30	64.78	-0.66	3.04	-0.31	101.28	0.01	194.53	8.90*	52.57	0.53	86.98	1.29
6	BML 6 × PDM 1452	61.56	-0.45	64.00	-1.07*	2.44	-0.62*	100.33	-1.22**	201.31	6.65	49.52	-1.26*	84.4	0.03
7	BML 6 × PDM 1474	61.22	-0.84*	64.44	-0.64	3.26	0.23	100.11	-1.09*	196.44	6.10	53.62	1.54**	87.4	1.29
8	BML 7 × DFTY	60.67	-1.23**	63.56	-1.43**	2.89	-0.19	99.33	-1.82**	166.59	-12.97**	53.57	1.70**	89.39	3.23*
9	BML 15 × Heypool	62.89	0.63	66.33	0.76	3.56	0.17	101.78	-0.01	189.78	10.26**	51.16	-0.89	85.57	-1.21
10	BML 15 × PDM 1452	59.56	-2.26**	62.67	-2.59**	3.22	-0.27	101.13	-0.78	169.76	-14.28**	53.41	2.67**	89.41	3.86**
11	BML 15 × PDM 1474	60.89	-0.98*	64.11	-1.16*	3.30	-0.15	100.22	-1.34**	166.73	-13.00**	53.41	1.37*	90.7	3.40**
12	DFTY × Heypool	60.89	-0.25	63.56	-0.52	2.63	-0.32	99.89	-0.25	179.67	-0.81	53.7	0.17	86.76	-1.00
13	DFTY × PDM 1428	62.89	0.23	66.22	0.34	3.37	0.12	102.22	0.04	197.11	10.38**	51.96	-0.10	84.81	-0.20
14	DFTY × PDM 1452	60.44	-0.26	63.67	-0.11	3.15	0.09	99.94	-0.33	185.58	0.56	52.69	0.46	85.91	-0.62
15	DFTY × PDM 1474	62.33	1.56**	65.44	1.65**	3.15	0.12	99.77	-0.15	182.78	2.07	52.93	-0.58	87.93	-0.34
16	Heypool × PDM 1452	61.44	0.12	64.56	0.23	3.15	0.12	101.78	1.35**	192.93	6.11	52.27	0.41	85.75	-0.30
17	Heypool × PDM 1474	60.00	-1.37**	63.11	-1.22**	3.07	0.09	100.13	0.05	182.42	-0.08	52.46	-0.69	85.94	-1.85
18	PDM 1416 × PDM 1474	61.11	-0.52	64.22	-0.55	3.15	0.02	101.22	-0.16	185.73	-4.29	50.26	-1.25*	83.66	-1.74
19	PDM 1428 × PDM 1474	63.56	0.66	66.33	0.20	2.74	-0.53	103.22	1.10*	183.11	-5.63	50.47	-1.22*	84.28	-0.76
20	PDM 1452 × PDM 1474	62.22	1.27**	65.56	1.52**	3.30	0.20	100	-0.20	195.96	8.92*	52.8	0.95	85.88	-0.68
	Grand Mean	**61.84**		**65.00**		**3.18**		**101.02**		**185.69**		**52.08**		**86.08**	
	SE (S$_{ij}$)		0.36		0.45		0.0		0.45		3.73		0.56		1.27

Table 3. contd…

S. No.	Hybrids	Cob length (cm)		Cob girth (cm)		Number of kernel rows cob⁻¹		Number of kernels row⁻¹		100 kernel weight (g)		Harvest index (%)		Kernel yield plant⁻¹ (g)		GCA status of inbred lines
		Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects	Mean	*sca* effects	
1	BML 2 × BML 6	17.25	-0.25	14.11	-0.24	14.07	-0.21	37.22	-0.21	32.43	-0.27	37.76	0.47**	141.73	7.43*	G×P
2	BML 2 × BML 7	17.52	0.07	15.08	0.77**	14.26	0.10	38.67	1.21	34.07	1.13*	36.76	-0.29	136.84	9.40**	G×P
3	BML 2 × Heypool	18.44	0.26	15.01	0.10	15.22	0.50	38.22	-0.47	34.13	0.15	37.07	-0.42	146.11	8.05*	G×G
4	BML 2 × PDM 1428	17.04	-0.01	14.4	0.42*	13.97	0.06	37.56	1.99*	32.71	0.28	37.56	0.36	133.50	7.42*	G×P
5	BML 2 × PDM 1474	18.99	0.75*	15.14	0.26	15.52	0.47	38.67	-0.65	34.61	0.38	37.88	0.27	130.38	-13.01**	G×G
6	BML 6 × PDM 1452	17.01	-0.59	13.95	-0.31*	13.89	-0.34	36.56	-0.62	31.8	-0.88*	37.34	-0.46*	137.11	7.82	P×P
7	BML 6 × PDM 1474	19.18	1.02**	15.28	0.68**	15.44	0.55*	40.33	1.26	35.16	1.45**	38.1	0.17	135.49	-3.74*	P×G
8	BML 7 × DFTY	19.12	0.99*	15.32	0.80**	15.21	0.76**	41.31	2.17*	35.2	1.35**	38.41	0.71**	140.33	12.42**	P×G
9	BML 15 × Heypool	17.5	-0.49	14.51	-0.21	14.61	0.06	38	-0.43	33.33	-0.15	37.73	0.05	135.04	9.67**	P×G
10	BML 15 × PDM 1452	18.73	1.23**	15.3	0.92**	14.99	0.76**	40.33	3.16**	35.26	2.54**	38.51	0.83**	140.14	19.37**	P×P
11	BML 15 × PDM 1474	19.13	1.06**	15.45	0.75**	15.58	0.70*	40.89	1.83*	35.17	1.43**	38.39	0.59**	140.40	9.68**	P×G
12	DFTY × Heypool	19.19	0.33	15.28	0.17	15.23	0.22	40.44	0.06	35	0.10	37.99	-0.15	137.67	-0.84	G×G
13	DFTY × PDM 1428	17.61	-0.13	14.01	-0.16	14.53	0.32	37.67	0.43	33.98	0.64	37.72	-0.12	134.10	7.56*	G×P
14	DFTY × PDM 1452	19.06	0.69	15.43	0.67**	15.24	0.55*	40.33	1.22	34.74	0.61	38.23	0.09	141.29	7.36*	G×P
15	DFTY × PDM 1474	18.25	-0.67	14.22	-0.85**	14.26	-1.09**	39.67	-1.33	32.67	-2.47**	38.14	-0.10	151.10	7.23*	G×G
16	Heypool × PDM 1452	18.15	-0.11	14.61	-0.20	14.49	-0.16	38.11	-0.33	34.47	0.50	37.84	-0.17	132.47	-0.58	G×P
17	Heypool × PDM 1474	18.17	-0.65	15.24	0.10	15.29	-0.02	40.78	0.44	35.04	0.06	38.3	0.17	141.94	-1.05	G×G
18	PDM 1416 × PDM 1474	17.18	-0.60	13.86	-0.54**	14.12	-0.44	37.56	-0.29	32.51	-0.68	37.24	-0.58**	134.95	8.31*	P×G
19	PDM 1428 × PDM 1474	17.1	-0.60	13.74	-0.46**	14.34	-0.16	36.22	-0.97	33.54	0.12	37.37	-0.46*	137.93	6.92*	P×G
20	PDM 1452 × PDM 1474	18.4	0.07	15.39	0.61**	15.54	0.55*	39.89	0.81	35.2	0.99*	38.14	0.01	133.28	-5.11	P×G
	Grand Mean	**18.15**		**14.77**		**14.79**		**38.92**		**34.05**		**37.82**		**138.09**		
	SE (S$_{ij}$)		0.38		0.17		0.27		0.86		0.44		0.22		3.20	

*Significant at 5% level,**Significant at 1% level   G-good;P-Poor

Of the top 20 performing hybrids, 14 hybrids showed significant positive *sca* effects for kernel yield, while two hybrids *viz*., BML 2 × PDM 1474 and BML 6 × PDM 1474 showed negative significant *sca* effects and the remaining four hybrids *viz*., DFTY × Heypool, Heypool × PDM 1452, Heypool × PDM 1474 and PDM 1452 × PDM1474 recorded non-significant *sca* effects for kernel yield per plant. Among the 14 hybrids exhibiting significant positive *sca* effects and high *per se* performance for kernel yield, the hybrids BML 2 × Heypool and DFTY × PDM 1474 involved good × good general combiners, BML 2 × BML 6, BML 2 × BML 7, BML 2 × PDM 1428, DFTY × PDM 1428 and DFTY × PDM 1452 involved good × poor general combiners, BML 7 × DFTY, BML 15 × Heypool, BML 15 × PDM 1474, PDM 1416 × PDM 1474 and PDM 1428 × PDM 1474 involved poor × good general combiners and BML 6 × PDM 1452 and BML 15 × PDM 1452 involved poor × poor general combiners. Two hybrids with   significant negative *sca* effects and high *per se* performance *viz*.,

BML 2 × PDM 1474 and BML 6 × PDM 1474 involved good × good and poor × good combiners, respectively. Four hybrids *viz*., DFTY × Heypool, Heypool × PDM 1452, Heypool × PDM 1474 and PDM 1452 × PDM 1474 with non- significant *sca* effects and high *per se* performance involved good × good, good × poor, good × good and poor × good combinations.

The superior hybrids *viz*., DFTY × PDM 1474, BML 2 × Heypool and Heypool × PDM 1474 which showed either significant positive *sca* or non-significant *sca* effects and involving good × good combinations may be handled through population improvement programme to accumulate favorable alleles leading to the isolation of improved inbred lines. On the other hand, high yielding hybrids *viz*., BML 2 × BML 6 and DFTY × PDM 1452 with positive and significant *sca* effects involving good × poor general combiners may be handled though heterosis breeding towards the development of superior hybrids or

inbred lines. Among the top 20 best performing hybrids BML 15 × PDM 1452 recorded significant *sca* effects for days to 50% tasseling, days to 50% silking, SCMR, cob length, cob girth, number of kernel rows per cob, number of kernels per row, 100 kernel weight, harvest index and kernel yield per plant, while BML 15 × PDM 1474 and BML 7 × DFTY recorded for days to 50% tasseling, days to 50% silking, days to maturity, SCMR, cob length, cob girth, number of kernel rows per cob, number of kernels per row, 100 kernel weight, harvest index and kernel yield per plant in addition to high *per se* performance for kernel yield and its contributing characters. These three hybrids may be recommended for immediate commercial exploitation of heterosis after multi-location testing.

Combining ability analysis for yield and its contributing characters indicated that both additive and non-additive gene actions are controlling all the characters studied with the predominance of non-additive gene actions. Of the ten inbred lines BML2, DFTY, Heypool and PMD 1474 are found as the good general combiners for kernel yield of which, the latter three inbred lines *viz*., DFTY, Heypool and PMD 1474 are the best general combiners due to their significant *gca* effects and high *per se* performance for yield and most of the yield contributing characters. However, the inbred lines *viz*., BML 7, PDM 1416 and PDM 1428 are the poor general combiners. Four inbred lines DFTY, Heypool, PDM 1452 and PMD 1474 are considered as good general combiners for days to 50% flowering, days to 50% silking and days to maturity. Among the top 20 single cross hybrids, BML 15 × PDM 1452, BML 15 × PDM 1474 and BML 7 × DFTY were considered as outstanding hybrids since they registered high *per se* performance and desirable significant *sca* effects for yield and most of the yield contributing characters revealing the potential of these hybrids for immediate commercial exploitation after extensive testing under different environments and locations.

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