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Combining Ability Analysis for Seed Yield and Attributing Traits in Linseed (*Linum usitatissimum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A complete set of 79 entries comprising of twelve parents, their 66 F1s and one check RLC-92 were evaluated during rabi 2020-21 at two locations *i.e*., ARS, Dahod, and BTRS, Anand, under two dates of sowing *i.e*., 2nd fortnight of October and 1st fortnight of November. The present study aimed to investigate the combining ability analysis over environments for seed yield and attributing traits in linseed (*Linum usitatissimum* L.). Among the all four environments, E_1 had higher mean value for seed yield per plant and all other important yield contributing traits by sowing in second

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fortnight at Dahod conditions best for linseed cultivation. Combining ability analysis revealed importance of both additive and non-additive variances with prime role of non-additive genetic variance for seed yield per plant and its related traits in all environments as well as pooled over environments suggesting heterosis breeding would be more useful for development of superior hybrids if sterility system available. Among the parents; Shekhar, GS 384, KB 9610 and K 29 were good general combiners for seed yield per plant and test weight and capsules per plant. The parent *viz*., IPl 10, H 45, GS 384 and RLC 133 were good general combiners for earliness. The cross Indira × ILS 264, Gaurav × H 45 and RLC 133 × Shekhar showed higher sca effects for seed yield and test weight. Most of the crosses with high *per se* performance involved at least one good general combining parent such as Shekhar, GS 384, KB 9610 and K 29 through out for all studied characters.

Keywords: Seed yield; attributing traits; linseed; Linum usitatissimum; environments.

1. INTRODUCTION

India is among the largest vegetable oil economy in the world accounting for about 14% of the world oilseed area and 8% oilseed production [1], India is the 4th largest oilseeds producer in the world. It has 20.8% of the total area under cultivation globally, accounting for 10% of global production [2]. Oilseed crops are grown for edible oils, non-edible oils. Although, oil compositions such as fatty acids, saturated fat and unsaturated fat in both non-edible and edible oil oils are almost similar, the edible oil contains valuable nutrient and antioxidants. Conversely, non-edible oil is not suitable for human consumption because it contains toxic substances in the oil as cyanogenetic glycoside, linamarin. Non-edible oil crops are considered as an alternative feedstock for biodiesel production. Non-edible oilseeds are castor and linseed.

Linseed (*Linum usitatissimum* L.) commonly known as flax is a self-pollinated crop belongs to the genus *Linum* of the family Linaceae and order *Geranial* having 14 genera and more than 200 species. Crop is predominantly self-pollinated but out crossing (less than 2 per cent) occasionally results from insect activity [3]. It has been cultivated for several thousand years mainly for its seed oil and its high-quality stem fibre. *Linum usitatissimum* L. is the only species of the family Linaceae [4] with non-dehiscent or semi-dehiscent capsules suitable for modern cultivation.

Linseed stands fourth among oilseeds after groundnut, mustard and sesame. India ranked first in the world for linseed cultivation and occupies around 27% of the world acreage of 4.2 million hectares. Linseed growing countries include India, U.S.A, Canada, Argentina, Uruguay and Russia. In south west Asia and Canada, it is primarily cultivated for oil, whereas, in Russia, Egypt and northwestern European countries, it is mainly cultivated for the production of high-quality fibre for making linen fabrics and several other products. In India, linseed is cultivated on about 2.94 lakh hectares with an annual production of 1.54 lakh tones and a productivity of 525 kg/ha [5]. In India, presently linseed is under cultivation in 17 states, among which Madhya Pradesh, Uttar Pradesh, Bihar, Chhattisgarh and Jharkhand cultivates about 85% of the total area. Under normal sown condition and an optimum inputs linseed can yield 16-18 q/ha and from dual purpose varieties about 10-12 quintals of fiber can be obtained in addition to the yield (14-16 q/ha). But it is cultivated with low input and, biotic and abiotic stress as resulting invariably in poor seed yield.

2. MATERIALS AND METHODS

A complete set of 79 entries comprising of twelve parents, their 66 F_1s and one check RLC-92 were evaluated during *rab*i 2020-21at two locations *i.e*., ARS, Dahod, and BTRS, Anand, under two dates of sowing *i.e*., 2nd fortnight of October and 1st fortnight of November. Trial was conducted in a randomized block design with three replications. Each entry was planted in a single row of meter 1.5 meter. Row to row and plant to plant distance was 30 cm and 10 cm, respectively. The field was ploughed until fine tilth of soil was obtained and recommended agronomical practices and plant protection measures were adopted as and when required to raise a good crop of linseed under irrigated condition.

Five competitive plants were randomly selected from the single rows of each entry in each replication and observations were recorded on these plants for all characters except days to

50% flowering and days to maturity. These characters were recorded per plot basis.

The combining ability analysis was carried out according to method II; model 1 (fixed effect) by Griffing [6]. In this model, experimental material was considered as population about which inferences was to be drawn and combining ability effects of parents could be compared when parents themselves are used as testers to identify good combiners. The GCA and SCA effects of ijk[th] observations were calculated by following formula:

Sum of square for GCA:

$$S_g = \frac{1}{P+2}\left[\sum_{i=1}^{P}(X_{i.}+X_{ii})^2 - \frac{4}{P}X^2_{..}\right]$$

Sum of squares for SCA:

$$S_S = \sum_{i\leq}\sum_{j} X^2_{ij} - \frac{1}{P+2}\sum_{i}(X_{i.}+X_{ii})^2 + \frac{2}{(P+1)(P+2)}X^2_{..}$$

Where,

P = Number of parents,
S_g = Sum of squares due to GCA
S_g = Sum of squares due to GCA
S_s = Sum of squares due to SCA
X_{ij} = Value of cross between i[th] and j[th] parents
$X_{i.}$ = Total of i[th] (row) array in diallel table (Summed over j)
X. = Grand total of 'P' parents and P (P-1)/2 progenies of diallel table,
X_{ii} = Parental value of the i[th] parent
$X_{i\bullet} + X_{ii}$ = Total of i[th] array + mean value of parent i
$X_{\bullet j} + X_{jj}$ = Total of j[th] array + mean value of parent j

The estimation of standard error of GCA and SCA effects were obtained by following formula:

$S.E._{\cdot g_i} = \left[\frac{p-1}{p(p+2)}\sigma_e^2\right]^{\frac{1}{2}}$ (for testing individual GCA effect)

$S.E._{\cdot s_{ij}} = \left[\frac{p^2+p+2}{(p+1)(p+2)}\sigma_e^2\right]^{\frac{1}{2}}$ (for testing individual SCA effect)

$S.E._{\cdot(g_i-g_j)} = \left[\frac{2}{(p+2)}\sigma_e^2\right]^{\frac{1}{2}}$ (for testing differences between two GCA effects)

$S.E._{\cdot(s_{ij}-s_{ik})} = \left[\frac{2(p+1)}{(p+2)}\sigma_e^2\right]^{\frac{1}{2}}$ (for testing difference between SCA of the same array)

$S.E._{\cdot(s_{ij}-s_{kl})} = \left[\frac{2p}{(p+2)}\sigma_e^2\right]^{\frac{1}{2}}$ (for testing SCA of any two crosses)

Where,

p = Number of parents,
σ_e^2 = Error mean square (M_e)

The GCA and SCA effects were subjected to 't' test for testing of significance.

$$t\,(GCA) = {}^{g_i - 0}\Big/_{S.E._{\cdot g_i}}$$

$$t\,(SCA) = {}^{s_{ij} - 0}\Big/_{S.E._{\cdot s_{ij}}}$$

The test of significance of GCA and SCA for individual environment were carried out by comparing the calculated 't' values with the tabulated 't' values at 5 per cent (1.96) and 1 per cent (2.58) levels of significance.

Table 1. List of parents used in crossing program

S. N.	Parents	Source
1	INDIRA	I.G.K.V, Raipur
2	GAURAV	CSAUAT Kanpur
3	DIPIKA	I.G.K.V, Raipur
4	SHEKHAR	CSAUAT Kanpur
5	KB 96 10	I.G.K.V, Raipur
6	ILS 264	PAU, Ludhiana
7	RLC 133	I.G.K.V, Raipur
8	K 29	AICORPO, Palampur
9	IPI 10	I.G.K.V, Raipur
10	GS 384	RRS, Gurdaspur
11	H 45	I.G.K.V, Raipur
12	KARTIKA	I.G.K.V, Raipur

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

The analysis of variance for combining ability using half-diallel mating design in respect of twelve parents and sixty-six crosses for all the ten characters in individual environment is presented in Table 2 and pooled over environments (pooled basis) is presented in Table 3.

The analysis of variance in each environment (Griffings, 1956a method II, model I) revealed

that mean squares due to general combining ability (GCA) were significant for all the characters in all the four environments. Likewise, mean squares due to specific combining ability (SCA) were significant for all the characters in all the four environments except for number of primary branches per plant and number of secondary branches per plant in E_4. Significant mean squares due GCA and SCA for the concern characters suggested difference among parents for GCA and among hybrids for SCA. Characters with significant mean squares due to GCA of parents and SCA of hybrids are indication that importance of both additive as well as non-additive effects for their inheritance. However, the magnitude of variance due to specific combining ability was higher in comparison to general combining ability for all the trait at individual location except for days to 50 % flowering, days to maturity, plant height in E1 and E2, number of primary branches per plant in E1 and E3, number of secondary branches per plant in E4, number of capsules per plant in E2 and number of seeds per capsules in E_1 and E_3, indicating preponderance of non-additive genetic variance in comparison to its counterpart additive genetic variance. This is also confirmed by $\sigma^2_{gca} / \sigma^2_{sca}$ ratio and σ^2 D value. For characters mentioned above had higher magnitude of GCA variance and more than 1 value for $\sigma^2_{gca} / \sigma^2_{sca}$, indicates the importance of additive genetic variance. Similar results were observed by Srivastava et al. [7], Singh et al. [8], Mishra et al. [9], Nirala et al. [10], Shekhar et al. [11] and Mahawar et al. [12].

In pooled analysis over environments mean squares due to environments, GCA and SCA were significant for all the characters in varied environments, differences among parents for GCA and differences among crosses for SCA. Similarly, mean squares due to GCA × E and SCA × E were significant for all the characters except for GCA × E in number of secondary branches per plant indicates both σ^2 gca and σ^2 sca were influenced by environments and also importance of experimentation over environments. σ^2_{sca} variance was higher than their respective σ^2_{gca} variance for all the characters except number of primary branches per plant, number of capsules per plant, number of seeds per capsules and seed yield per plant indicated that both additive and non-additive genetic variance with preponderance of non-additive genetic variance for inheritance of these traits.

Moreover, SCA × E interaction component was higher than their respective GCA × E interaction component for the characters days to maturity, plant height and number of secondary branches per plant. Analysis of variance for GCA source was highly significant and favoring high values for all the ten characters studied during the experimental programme at all the four individual locations as well as pooled over locations. It means that parents have variation in their combining ability and hence can be classified into good, average and poor on the basis of their GCA effects. SCA source was also highly significant at all locations as well as pooled over locations for most of the traits suggesting hybrids are somewhere different from parents involved in any specific cross and hence, there might be a chance of isolating good hybrid. All the characters found to be significant for GCA as well SCA at all four locations as well as pooled over locations (as seen above) showing that both additive and non-additive gene action were at play for different characters and both effects are variable to environments. The ratio of $\sigma^2_{gca} / \sigma^2_{sca}$ was more than one for all the trait over environment except number of primary branches per plant, number of capsules per plant, number of seeds per capsules and seed yield per plant, suggesting greater influence of non-additive genetic variance in comparison to its counterpart additive genetic variance.

Similar findings in accordance to the above result have also been reported by Singh et al. [8], Mohammadi et al. [13], Nirala et al. [10], Shekhar et al. [11] and Mahawar et al. [12].

3.2 General and Specific Combining Ability Effects

The estimate of general combining ability (GCA) effects of the parents and specific combining ability (SCA) effects of crosses for different characters for individual and pooled over environments are presented in Table 4a to 12b. The salient features of the results of general combining ability effects and specific combining ability (SCA) effects for different characters are given below:

3.2.1 Days to 50% flowering

Earliness is desirable, hence, parents and crosses with significant and negative GCA and SCA effects were considered as good general combiner and good specific combiner, respectively. Out of twelve parent *viz.*, RLC 133,

KB 9610, K 29, H 45 and ILS 264 were identified as good general combiners in all environments (Table 4a). RLC 133 in [E_1: -2.60, E_2: -3.15, E_3: -3.15, E_4: -3.47 and PEVs: -3.09] followed by KB 9610 [E_1: -1.89, E_2: -2.44, E_3: -2.98, E_4: -2.47 and PEVs: -2.44] exhibited significant and negative GCA effect in each environment and PEVs. The parent Shekhar [E_1: 3.11, E_2: 3.09, E_3: 2.85, E_4: 1.46 and PEVs: 2.63] was identified as poor general combiner as it exhibited significant and positive GCA effect across and over the environments. Pparents *viz*., Indira, Gaurav and Dipika also recorded significant and positive GCA effects in all environments as well as pooled basis indicating poor general combiners for days to 50 **%** flowering.

Table 2. Analysis of variance for combining ability of individual environment for different characters

S.N.	Characters	Env.	Sources			σ^2_{gca}	σ^2_{sca}	$\sigma^2_{gca}/\sigma^2_{sca}$	σ^2_A	σ^2_D
			GCA	SCA	Error					
		df	11	66	154					
1	**Days to 50% flowering**	E_1	46.99**	2.75**	0.82	3.29	1.93	1.70	6.60	1.93
		E_2	59.84**	3.59**	0.46	4.24	3.13	1.35	8.48	3.13
		E_3	66.07**	8.32**	0.36	4.69	7.95	0.58	9.38	7.95
		E_4	52.33**	6.59**	0.43	3.70	6.16	0.60	7.41	6.16
2	**Days to maturity**	E_1	55.95**	3.05**	0.63	3.95	2.41	1.63	7.90	2.41
		E_2	65.71**	3.88**	0.41	4.66	3.46	1.34	9.32	3.46
		E_3	72.83**	9.58**	0.40	5.17	9.18	0.56	10.34	9.18
		E_4	55.45**	8.79**	0.37	3.93	8.42	0.46	7.86	8.42
3	**Plant height**	E_1	27.94**	2.77**	1.02	1.92	1.75	1.09	3.48	1.75
		E_2	44.67**	1.91**	0.71	3.13	1.20	2.60	6.27	1.20
		E_3	22.21**	7.52**	0.43	1.55	7.09	0.21	3.11	7.09
		E_4	24.01**	4.95**	1.08	1.63	3.87	0.42	3.27	3.87
4	**Number of primary branches**	E_1	0.57**	0.06**	0.00	0.04	0.05	0.77	0.08	0.05
		E_2	1.03**	0.06**	0.01	0.04	-0.00	-53.96	0.09	-0.00
		E_3	1.28**	0.07**	0.01	0.09	0.06	1.44	0.18	0.06
		E_4	0.13**	0.05	0.04	0.03	0.01	0.36	0.00	0.01
5	**Number of secondary branches**	E_1	6.27**	2.41**	0.93	0.38	1.47	0.25	0.76	1.47
		E_2	9.71**	1.81**	0.81	0.63	1.00	0.63	1.27	1.00
		E_3	3.46**	1.68**	0.35	0.22	1.32	0.16	0.44	1.32
		E_4	7.51**	1.23	1.13	0.45	0.09	4.71	0.91	0.09
6	**Number of capsules per plant**	E_1	61.83**	6.40**	1.79	4.28	4.61	0.92	8.57	4.61
		E_2	94.54**	4.34**	0.68	6.70	3.65	1.83	13.40	3.65
		E_3	67.05**	6.51**	1.00	4.71	5.50	0.85	9.43	5.50
		E_4	80.57**	7.67**	0.62	5.71	7.05	0.80	11.42	7.05
7	**Number of Seeds per capsules**	E_1	0.53**	0.04**	0.01	0.04	0.03	1.12	0.07	0.03
		E_2	0.45**	0.04**	0.01	0.03	0.03	0.96	0.06	0.03
		E_3	0.43**	0.03**	0.01	0.02	0.02	1.16	0.05	0.02
		E_4	0.70**	0.06**	0.01	0.04	0.05	0.98	0.09	0.05
8	**Test weight**	E_1	3.58**	0.27**	0.00	0.25	0.26	0.97	0.51	0.26
		E_2	3.39**	0.30**	0.01	0.24	0.28	0.85	0.48	0.28
		E_3	3.29**	0.27**	0.02	0.23	0.25	0.90	0.46	0.25
		E_4	2.72**	0.33**	0.01	0.19	0.32	0.59	0.38	0.32
9	**Seed Yield per Plant**	E_1	1.54**	0.16**	0.01	0.08	0.20	0.41	0.16	0.20
		E_2	1.35**	0.12**	0.01	1.02	3.89	0.26	2.04	3.89
		E_3	1.25**	0.09**	0.01	0.19	1.81	0.11	0.39	1.81
		E_4	0.81**	0.10**	0.01	0.32	2.23	0.14	0.64	2.23
10	**Oil content**	E_1	7.72**	1.63**	0.25	0.53	1.37	0.38	1.06	1.37
		E_2	6.95**	1.46**	0.27	0.47	1.18	0.40	0.95	1.18
		E_3	6.13**	1.24**	0.23	0.42	1.00	0.41	0.84	1.00
		E_4	5.69**	1.73**	0.27	0.38	1.45	0.26	0.77	1.45

**, ** Significant at 5 and 1 percent levels, respectively*

Table 3. Analysis of variance for combining ability over the environments for different characters

S. N.	Characters	Sources										
		GCA	SCA	ENV. (E)	GCA × E	SCA × E	Pooled error	σ^2_{gca}	σ^2_{sca}	$\sigma^2_{gca}/\sigma^2_{sca}$	σ^2_A	σ^2_D
	Df	11	66	3	33	198	616					
1	Days to 50 % flowering	218.34**	16.85**	696.96**	2.29**	1.47**	0.52	3.89	4.08	0.95	7.77	4.08
2	Days to maturity	245.04**	18.52**	933.46**	1.63**	2.26**	0.45	4.37	4.52	0.97	8.73	4.51
3	Plant height	110.85**	8.70**	171.59**	2.66**	2.82**	0.81	1.97	1.97	1.00	3.93	1.97
4	Number of primary branches per plant	2.01**	0.09**	14.59**	0.20**	0.04**	0.02	0.04	0.02	2.03	0.07	0.01
5	Number of secondary branches per plant	23.83**	2.96**	63.89**	1.04	1.39**	0.81	0.41	0.54	0.76	0.82	0.53
6	Number of capsules per plant	293.94**	16.18**	965.54**	3.35**	2.91**	1.02	5.23	3.79	1.38	10.46	3.79
7	Number of seeds per capsules	2.00**	0.10**	8.01**	0.03**	0.02**	0.01	0.04	0.02	1.48	0.07	0.02
8	Test weight	12.78**	1.06**	5.12**	0.06**	0.04**	0.01	0.23	0.26	0.87	0.45	0.26
9	Seed yield per plant	3.99**	0.21**	26.84**	0.20**	0.11**	0.01	0.07	0.05	1.44	0.14	0.04
10	Oil content	25.09**	4.73**	60.00**	0.47*	0.44**	0.26	0.44	1.12	0.40	0.88	1.11

**, ** Significant at 5 and 1 percent levels, respectively*

Out of 66 crosses, 4, 15, 21, 21 and 20 crosses exhibited significant and negative (desirable) SCA effects in E_1, E_2, E_3, E_4 and PEVs, respectively, hence all these crosses were classified as good specific combiners for early flowering (Table 4b). The highest significant and negative SCA effect was observed -2.78 (Gaurav × IPI 10) in E_1, -5.45 (Indira × GS 384 in E_2, -5.21 (Indira × GS 384) and -4.00 (RLC 133 × K 29) in E_3, -4.90 (Indira × GS 384) in E_4 and -4.30 (Indira × GS 384) in PEVs for days to 50 per cent flowering. Whereas, cross IPI 10 × GS 384 [E_2: 4.12, E_3: 7.26 E_4: 5.45 and PEVs: 5.24] and Dipika x H 45 [4.25] in E_1 showed significant and positive SCA effect, hence, it was considered as poor specific combiner. Similar results were also reported by Mohammadi et al. [13], Mishra et al. [9], Nirala et al. [10], Shekhar et al. [11] and Mahawar et al. [12].

3.2.2 Day to maturity

Early maturity is desirable in linseed crop. There were five common parents exhibited significant and negative (desirable) GCA effects. The parent IPI 10 [E_1: -3.01, E_2: -3.21, E_3: -3.54, E_4: -3.51 and PEVs: -3.32] showed maximum significant negative GCA effect followed by H 45, GS 384, RLC 133 and KB 9610 (Table 5a). Hence, they were registered as good general combiners. Further comparison across the environments indicated that the parents ILS 264, Gaurav, Shekhar, K 29, Indira and Kartika recorded significant and positive GCA effects and was considered as poor general combiners.

Out of significant crosses, a more number of crosses depicted positive SCA effects in all environments. Total 10 crosses in E_1, 18 crosses in E_2, 19 crosses in E_3, 22 crosses in E_4 and 23 crosses in PEVs exhibited significant and negative estimates of SCA effect. The highest significant and negative SCA effect was observed -4.29 (Gaurav × RLC 133) in E_1, -3.85 (Gaurav × GS 384) in E_2, -6.25 (Gaurav × GS 384) in E_3, -6.78 (K 29 × H 45) in E_4 and -4.41 (K 29 × H 45) in PEVs for days to maturity (Table 5b). The findings are corroborated with the results of Srivastava et al. [7], Ratnaparkhi et al. [14] Singh et al. [8], Shekhar et al. [11] and Mahawar et al. [12].

3.2.3 Plant height

The parents GS 384, Kartika, KB 9610 in each E_1, E_2, E_3, E_4 and PEVs had significant and negative GCA effect and considered as desired GCA effects hence good general combiners (Table 6a). Similarly, line IPI 10 showed highest negative GCA effect among parents [E_1: -1.99, E_2: -1.98, E_3: -1.49, E_4: -2.27 and PEVs: -1.94] whereas, line Indra and Gaurav in both locations and both sowing dates had significant and positive GCA effects suggesting poor general combiners. The lines Dipika in E_4, RLC 133 in E_1, E_3 and PEVs and K 29 in E_3 depicted significant and positive GCA effect as they considered as poor general combiner in respective environment. The parents, Shekhar and ILS 264 depicted the significant and negative estimate of GCA effect in E_3 (-0.47) and E_2 (-0.68), respectively considered as good general combiners. Only H 45 recorded non-significant GCA effect in all environment and PEVs suggesting average general combiners.

Out of 66 crosses, 8, 5, 29, 13 and 21 crosses exhibited significant and negative SCA effects in E_1, E_2, E_3, E_4 and PEVs, respectively for plant height. Cconsequently, these hybrids were good specific combiner for plant height. The cross -4.08 (Indira × IPI 10) in E_1; -2.61 (KB 9610 × K 29) in E_2; -4.56 (Gaurav × K 29) in E_3; -3.65 (Dipika × RLC 133) in E_4 and -2.61 (Dipika × ILS 264) in PEVs (-2.61) had the highest estimate of SCA effect. Likewise, highest, significant and positive SCA effect was observed 3.90 (K 29 × GS 384) in E_1, 2.75 (RLC 133 × IPI 10) in E_2, 6.08 (KB 9610 × ILS 264 and H 45 × Kartika) in E_3, 5.54 (ILS 264 × RLC 133 in E_4 and 3.58 (H 45 × Kartika) in PEVs and were considered as poor specific combiners (Table 6b). The results were in correspondence to the findings of Khan et al. [15], Kumar et al. [16], Ratnaparkhi et al. [14], Singh et al. [8], Mohammadi et al. [13], Mishra et al. [9] and Mahawar et al. [12].

3.2.4 Number of primary branches per plant

Total three parents *viz.,* Gaurav, Shekhar and H 45 in all environment and in PEVs and IPI 10 in E_1, E_2, E_3 and PEVs exhibited positive GCA effects, therefore they were good general combiners (Table 7a). On contrary to above performance, RLC 133, K 29 and ILS 264 recorded significant and negative GCA effect in all environment with PEVs, indicating poor general combiner for number of primary branches per plant.

Among the hybrids, 22, 21, 17, 10 and 14 F_1s exhibited significant and positive SCA effects in E_1, E_2, E_3, E_4 and in PEVs, respectively for primary branches per plant (Table 7b). The highest significant and positive SCA effect was observed 0.56 (Indira × Dipika) in E_1, 0.58

(Gaurav × K 29) in E_2, 0.85 (Gaurav × K 29 in E_3, 0.31 (K 29 × H 45) in E_4 and 0.53 (Gaurav × K 29) in PEVs suggesting good specific combiners. These results are inconformity to the findings of Bhateria et al. [17], Singh et al. [8], Mishra et al. [9], Prasad et al. [18], Nirala et al. [10] and Mahawar et al. [12].

3.2.5 Number of secondary branches per plant

GCA effects were significant and positive for Gaurav in E_1 (1.17), E_2 (1.93), E_3 (1.09), (1.31) in E_4 and PEVs (1.37); Shekhar E_1 (1.01), E_2 (0.55), E_3 (0.61), (0.78) in E_4 and PEVs (0.73) and IPI 10 in E_1 (0.80), E_2 (0.97), E_3 (0.0.39), (1.14) in E_4 and PEVs (0.82) (Table 8a). Hence, they were registered as good general combiners. Parent *viz*., RLC 133 and KB 9610 recorded significant and negative GCA effects in all environments and pooled over environments, indicating poor general combiners for number of secondary branches per plant. Moreover, parents Indira in (E_3 and E_4), Dipika (E_3), ILS 264 (E_3), K 29 (E_1 and E_2) and Kartika (E_3) had negative and significant SCA effects so they were poor combiners for respective environments.

Most of hybrids depicted non-significant SCA effects, however, out of 66 crosses, 9, 8, 11, 2 and 11 crosses in E_1, E_2, E_3, E_4 and PEVs exhibited significant and positive (desirable) SCA effects for secondary branches per plant (Table 8b). The highest, significant and positive SCA effect was observed 3.19 (GS 384 × H 45) in E_1, 3.64 (Shekhar × KB 9610) in E_2, 2.60 (K 29 × IPI 10) in E_3, 2.86 (Gaurav × K 29) in E_4 and 1.94 (Gaurav × Shekhar) in PEVs. The results were corroborative to the reports of Srivastava et al. [7], Mishra et al. [9], Prasad et al. [18], Shekhar et al. [11] and Mahawar et al. [12].

3.2.6 Number of capsules per plant

Three parents *i.e.,* IPI 10, GS 384 and Shekhar exhibited significant and positive GCA effects in all four environments as well as on PEVs (Table 9a). The parents possessing significant and positive GCA effects were IPI 10 (4.20), GS 384 (2.93) and Shekhar (2.91) in E_1; IPI 10 (5.30), GS 384 (3.18) and Shekhar (3.83) in E_2; IPI 10 (4.39), GS 384 (2.79), Shekhar (3.11) and KB 9610 (0.50) in E_3; IPI 10 (5.04), GS 384 (3.36) and Shekhar (2.72) in E_4 and IPI 10 (4.73), GS 384 (3.06), Shekhar (3.14) and KB 9610 (0.54) in PEVs. This indicated that these parents were good general combiners for number of capsules per plant. While, all other Parents recorded significant and negative GCA effects, indicating poor general combiners.

Out of 66 crosses, very few F_1s noted *i.e.,* seven crosses in E_1, 16 in E_2, 13 in E_3, 20 in E_4 and 22 in PEVs exhibited significant and positive (desirable) SCA effects (Table 9b). The highest significant and positive SCA effect was observed 7.37 (RLC 133 × Kartika) in E_1, 4.11 (RLC 133 × IPI 10) in E_2, 6.51 (ILS 264 × GS 384) in E_3, 6.69 (KB 9610 × K 29) in E_4 and 4.93 (RLC 133 × IPI 10) in PEVs for number of capsules per plant indicating good specific combiners for this trait. Similar findings to the one recorded in present condition have also been reported by Mohammadi et al. [13], Mishra et al. [9], Prasad et al. [18], Shekhar et al. [11] and Mahawar et al. [12].

3.2.7 Number of seeds per capsules

Out of twelve parents, seven parents recorded positive GCA effects in pooled over environments. Parent Kartika (0.31 in E_1, 0.26 in E_2, 0.31 in E_3, 0.38 in E_4 and 0.31 in PEVs) noted the highest GCA effects in all environments and PEVs. Other parents having significant and positive GCA effect were, ILS 264 [E_1: 0.23, E_2: 0.17, E_3: 0.16, E_4: 0.22 and PEVs: 0.19]; Gaurav [E_1: 0.15, E_2: 0.15, E_3: 0.16, E_4: 0.15 and PEVs: 0.15], H 45 [E_1: 0.13, E_2: 0.06, E_3: 0.13, E_4: 0.21 and PEVs: 0.13]; Dipika [E_1: 0.06, E_2: 0.14 and PEVs: 0.03]; Shekhar [E_1: 0.04, E_2: 0.06, E_4: 0.06 and PEVs: 0.05] and GS 384 [E_4: 0.05]. Hence, they were registered as good general combiners for seeds per capsules. Among the remaining parents, GCA effects were significant and negative for RLC 133, Indira, KB 9610 and K 29. Hence, they were registered as poor general combiners for seeds per capsules (Table 10a).

Among the F_1s, 16, 17, 18, 22 and 23 crosses exhibited significant and positive SCA effects in E_1, E_2, E_3, E_4 and PEVs, respectively (Table 10b). The maximum significant and positive SCA effect was observed by Dipika × RLC 133 (0.42) in E_1, Gaurav × KB 9610 (0.43) in E_2, Gaurav × KB 9610 (0.35) in E_3, Indira × IPI 10 (0.50) in E_4 and Dipika × RLC 133 and Shekhar × RLC 133 (0.31) in PEVs for number of seeds per capsules. Similar finding to the one found for above trait have also been reported by Khan et al. [15], Srivastava et al. [7], Ratnaparkhi et al. [14], Bhateria et al. [17], Mishra et al. [9] and Mahawar et al. [12].

Table 4a. General combining ability effects for days to 50 % flowering under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	2.11**	2.42**	2.57**	2.89**	2.50**
2	Gaurav	2.44**	2.56**	2.57**	2.34**	2.48**
3	Dipika	1.28**	1.54**	2.28**	1.77**	1.72**
4	Shekhar	3.11**	3.09**	2.85**	1.46**	2.63**
5	KB 9610	-1.89**	-2.44**	-2.98**	-2.47**	-2.44**
6	ILS 264	-0.56*	-0.15	-0.81**	-0.59**	-0.53**
7	RLC 133	-2.60**	-3.15**	-3.15**	-3.47**	-3.09**
8	K 29	-1.46**	-1.82**	-1.58**	-0.83**	-1.42**
9	IPI 10	-0.98**	-0.82**	-0.58**	-0.47**	-0.71**
10	GS 384	-0.13	0.30	-0.08	0.13	0.06
11	H 45	-1.18**	-1.65**	-1.67**	-1.47**	-1.49**
12	Kartika	-0.15	0.11	0.57**	0.70**	0.31**
SE (g_i) ±		0.23	0.17	0.15	0.17	0.09
Min.		-2.60	-3.15	-3.15	-3.47	-3.09
Max.		3.11	3.09	2.85	2.89	2.63
No. of Significant parents		10	9	11	11	11
No. of Significant +ve parents		4	4	5	5	5
No. of Significant -ve parents		6	5	6	6	6

Table 4b. Specific combining ability effects for days to 50 % flowering under different environments

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	1.13	0.29	0.14	-1.12	0.11
2	Indira x Dipika	0.29	1.31	1.43 *	1.12	1.04
3	Indira x Shekhar	2.46**	3.10 **	2.52 **	3.10 **	2.80**
4	Indira x KB 9610	-0.54	0.62	-0.64	-0.64	-0.30
5	Indira x ILS 264	-1.21	-0.66	-0.14	0.81	-0.30
6	Indira x RLC 133	-0.82	0.67	0.52	-0.31	0.02
7	Indira x K29	-0.3	-0.33	1.62 **	1.38 *	0.59
8	Indira x IPI 10	-0.44	-1.00	-2.05 **	-1.31 *	-1.20*
9	Indira x GS 384	-1.63	-5.45 **	-5.21 **	-4.90 **	-4.30**
10	Indira x H 45	1.08	0.84	3.05 **	1.69 **	1.67**
11	Indira x Kartika	2.39 **	1.08	2.48 **	1.52 *	1.87**
12	Gaurav x Dipika	0.63	0.17	-1.57 **	0.67	-0.03
13	Gaurav x Shekhar	-1.87 *	-1.04	-3.81 **	-3.36 **	-2.52**
14	Gaurav x KB 9610	-1.54	-2.52 **	-2.64 **	-2.76 **	-2.37**
15	Gaurav x ILS 264	-1.87*	-1.47 *	-3.14 **	-2.31 **	-2.20**
16	Gaurav x RLC 133	0.84	2.19 **	2.19 **	4.24 **	2.37**
17	Gaurav x K 29	-1.3	-1.14	0.95	1.60 **	0.03
18	Gaurav x IPI 10	-2.78 **	-2.14 **	-2.05 **	-3.76 **	-2.68**
19	Gaurav x GS 384	0.03	0.74	2.45 **	2.64 **	1.47**
20	Gaurav x H 45	-2.59 **	-1.97 **	-3.29 **	-3.76 **	-2.90**
21	Gaurav x Kartika	1.06	1.93 **	1.81 **	1.07	1.47**
22	Dipika x Shekhar	-1.04	0.31	-2.52 **	-1.79 **	-1.26**
23	Dipika x KB 9610	-2.04 *	-1.50 **	-3.02 **	-2.19 **	-2.19**
24	Dipika x ILS 264	1.29	1.22	3.14 **	4.93 **	2.65**
25	Dipika x RLC 133	-0.32	-0.45	3.81 **	-0.86	0.55
26	Dipika x K 29	-0.13	-0.12	1.90 **	0.83	0.62
27	Dipika x IPI 10	1.06	0.88	0.90	1.81 **	1.16
28	Dipika x GS 384	-1.13	-1.90 **	-2.26 **	-2.79 **	-2.02**
29	Dipika x H 45	4.25 **	3.72 **	4.33 **	3.81 **	4.03**
30	Dipika x Kartika	0.22	-2.04 **	-2.24 **	-2.69 **	-1.69**

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
31	Shekhar x KB 9610	0.46	0.62	-0.26	-0.88	-0.02
32	Shekhar x ILS 264	-1.54	-3.33 **	-4.76 **	-4.76 **	-3.60**
33	Shekhar x RLC 133	-1.16	-2.33 **	0.24	-1.21 *	-1.12**
34	Shekhar x K 29	-0.30	0.00	0.33	1.81 **	0.46
35	Shekhar x IPI 10	1.56	0.34	1.67 **	2.45 **	1.51**
36	Shekhar x GS 384	1.03	-0.12	2.83 **	0.52	1.07
37	Shekhar x H 45	-0.59	-0.83	-1.24 *	-2.88 **	-1.39**
38	Shekhar x Kartika	0.06	0.41	3.19 **	2.62 **	1.57**
39	KB 9610 x ILS 264	0.46	-0.81	2.07 **	-0.83	0.22
40	KB 9610 x RLC 133	1.51	2.19 **	0.40	0.38	1.12
41	KB 9610 x K 29	-1.63	-1.47 *	-2.83 **	0.07	-1.47**
42	KB 9610 x IPI 10	0.22	-0.47	-3.83 **	-2.29 **	-1.59**
43	KB 9610 x GS 384	0.03	1.74 **	0.00	0.45	0.56
44	KB 9610 x H 45	1.08	1.69 **	4.26 **	4.05 **	2.77**
45	KB 9610 x Kartika	1.06	0.93	3.36 **	4.55 **	2.48**
46	ILS 264 x RLC 133	0.51	2.58 **	1.57 **	1.83 **	1.62**
47	ILS 264 x K 29	-1.30	0.58	-2.33 **	-1.81 **	-1.22**
48	ILS 264 x IPI 10	-0.44	0.58	-2.00 **	-0.17	-0.51
49	ILS 264 x GS 384	-0.63	0.46	0.50	0.90	0.31
50	ILS 264 x H 45	-0.92	-1.59 *	-0.90	-0.83	-1.06
51	ILS 264 x Kartika	2.72 **	2.65 **	3.52 **	1.00	2.47**
52	RLC 133 x K 29	-0.25	-1.42 *	-4.00 **	-1.93 **	-1.90*
53	RLC 133 x IPI 10	0.60	-1.42 *	0.67	0.05	-0.26
54	RLC 133 x GS 384	-1.25	-0.88	1.50 **	-0.55	-0.30
55	RLC 133 x H 45	-0.87	-1.92 **	-2.57 **	-1.95 **	-1.83**
56	RLC 133 x Kartika	0.10	1.65 **	-0.14	0.88	0.62
57	K 29 x IPI 10	0.46	-0.76	1.10 *	1.07	0.47
58	K 29 x GS 384	1.60	1.12	0.93	1.81 **	1.37
59	K 29 x H 45	2.32 **	3.74 **	4.86 **	4.40 **	3.83**
60	K 29 x Kartika	-1.04	-0.69	-2.05 **	-2.76 **	-1.64**
61	IPI 10 x GS 384	4.13 **	4.12 **	7.26 **	5.45 **	5.24**
62	IPI 10 x H 45	-0.82	0.41	2.86 **	1.71 **	1.04
63	IPI 10 x Kartika	-0.85	0.98	-0.71	-1.79 **	-0.59
64	GS 384 x H 45	-1.35	-0.04	0.36	0.45	-0.15
65	GS 384 x Kartika	1.29	2.19 **	1.45 **	2.29 **	1.81**
66	H 45 x Kartika	1.01	0.15	-2.95 **	-2.12 **	-0.98
Min.		-2.78	-5.45	-5.21	-4.90	-4.30
Max.		4.25	4.12	7.26	5.45	5.24
SE (S_{ij}) ±		0.84	0.63	0.56	0.61	0.34
No. of significant crosses		10	28	48	42	37
No. of +ve significant crosses		6	13	27	21	17
No. of -ve significant crosses		4	15	21	21	20

**, ** Significant at 5 and 1 percent levels, respectively*

Table 5a. General combining ability effects for days to maturity under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	0.80**	0.93**	0.41*	0.75**	0.72**
2	Gaurav	2.14**	3.17**	2.98**	1.94**	2.56**
3	Dipika	-0.72**	-1.19**	-0.21	-0.46**	-0.65**
4	Shekhar	2.21**	1.95**	2.53**	2.40**	2.27**
5	KB 9610	-0.65**	-0.71**	-0.71**	-1.08**	-0.79**
6	ILS 264	3.21**	3.33**	3.41**	3.11**	3.26**
7	RLC 133	-1.39**	-1.95**	-1.83**	-1.37**	-1.63**
8	K 29	1.06**	1.21**	1.17**	0.92**	1.09**
9	IPI 10	-3.01**	-3.21**	-3.54**	-3.51**	-3.32**

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
10	GS 384	-2.08**	-1.86**	-2.54**	-2.29**	-2.19**
11	H 45	-2.37**	-2.14**	-2.33**	-1.22**	-2.01**
12	Kartika	0.80**	0.48**	0.67**	0.80**	0.69**
SE (g_i) ±		0.20	0.16	0.16	0.16	0.09
Min.		-3.01	-3.21	-3.54	-3.51	-3.32
Max.		3.21	3.33	3.41	3.11	3.26
No. of Significant parents		12	12	11	12	12
No. of Significant +ve parents		6	6	6	6	6
No. of Significant -ve parents		6	6	5	6	6

**, ** Significant at 5 and 1 percent levels, respectively*

Table 5b. Specific combining ability effects for days to maturity under different environments

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	-2.15**	-1.63**	-1.87**	-3.45**	-2.28**
2	Indira x Dipika	-1.29	-1.94**	-3.35**	-3.71**	-2.57**
3	Indira x Shekhar	2.78**	1.91**	5.25**	4.43**	3.59**
4	Indira x KB 9610	1.30	0.25	0.15	0.91	0.65*
5	Indira x ILS 264	1.11	0.20	-3.63**	-2.28**	-1.15**
6	Indira x RLC 133	-0.29	-1.52*	-2.06**	-2.14**	-1.50**
7	Indira x K29	1.26	1.99**	1.60**	0.91	1.44**
8	Indira x IPI 10	0.66	-0.25	0.99	1.00	0.60
9	Indira x GS 384	0.40	2.39**	2.65**	2.12**	1.89**
10	Indira x H 45	1.02	1.34*	3.44**	3.72**	2.38**
11	Indira x Kartika	0.85	2.06**	4.10**	3.69**	2.68**
12	Gaurav x Dipika	0.37	0.49	1.08	1.43*	0.84**
13	Gaurav x Shekhar	2.45**	3.34**	4.01**	3.24**	3.26**
14	Gaurav x KB 9610	-1.36	0.01	-3.42**	-3.95**	-2.18**
15	Gaurav x ILS 264	1.45*	2.96**	3.80**	3.53**	2.93**
16	Gaurav x RLC 133	-4.29**	-3.75**	-1.63**	-1.67**	-2.84**
17	Gaurav x K 29	0.26	2.08**	3.03**	4.38**	2.44**
18	Gaurav x IPI 10	-1.01	-0.82	0.41	1.15*	-0.07
19	Gaurav x GS 384	-1.60*	-3.85**	-6.25**	-3.07**	-3.69**
20	Gaurav x H 45	0.35	-0.56	-0.80	-2.14**	-0.79*
21	Gaurav x Kartika	0.52	0.82	0.53	-2.83**	-0.24
22	Dipika x Shekhar	2.30**	4.03**	3.87**	1.98**	3.04**
23	Dipika x KB 9610	-0.51	-0.97	0.77*	0.45	-0.06
24	Dipika x ILS 264	1.97**	0.32	-1.02	-0.07	0.30
25	Dipika x RLC 133	-0.10	0.60	-3.78**	-1.26*	-1.13**
26	Dipika x K 29	-1.22	-2.56**	0.56	0.45	-0.69*
27	Dipika x IPI 10	1.85*	2.20**	3.27**	3.22**	2.63**
28	Dipika x GS 384	1.59*	2.84**	0.60	-0.67	1.09**
29	Dipika x H 45	-1.79*	-0.21	2.06**	2.60**	0.66*
30	Dipika x Kartika	-0.96	-0.49	1.39*	1.24*	0.29
31	Shekhar x KB 9610	-0.44	1.22*	0.70**	2.93**	1.10**
32	Shekhar x ILS 264	-0.63	-1.82**	0.58	-0.59	-0.62*
33	Shekhar x RLC 133	-2.03**	-2.54**	-0.52	0.55	-1.13**
34	Shekhar x K 29	-1.82*	-2.71**	-0.52	-2.07**	-1.78**
35	Shekhar x IPI 10	-2.41**	-0.94	-4.80**	-2.64**	-2.70**
36	Shekhar x GS 384	-2.01**	-2.30**	0.20	0.48	-0.91**
37	Shekhar x H 45	-1.06	0.65	-3.68**	-3.93**	-2.00**
38	Shekhar x Kartika	2.11**	2.03**	1.99**	0.72	1.71**
39	KB 9610 x ILS 264	-1.44	-0.49	4.15**	4.22**	1.61**
40	KB 9610 x RLC 133	1.49*	1.13	3.72**	2.69**	2.26**
41	KB 9610 x K 29	0.37	-1.37*	-5.28**	-2.59**	-2.22**

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
42	KB 9610 x IPI 10	0.45	0.39	3.44**	2.17**	1.61**
43	KB 9610 x GS 384	1.18	1.03	3.10**	-0.05	1.32**
44	KB 9610 x H 45	1.47*	0.65	-1.44*	1.55**	0.56
45	KB 9610 x Kartika	0.64	1.70**	2.89**	2.86**	2.02**
46	ILS 264 x RLC 133	1.97**	3.08**	2.60**	2.50**	2.54**
47	ILS 264 x K 29	2.52**	1.91**	1.60**	1.22*	1.81**
48	ILS 264 x IPI 10	-1.75*	-2.66**	-5.35**	-4.36**	-3.53**
49	ILS 264 x GS 384	-2.67**	-1.02	0.32	-0.24	-0.90
50	ILS 264 x H 45	-2.39**	-2.06**	-2.90**	-2.31**	-2.41**
51	ILS 264 x Kartika	-0.89	-1.35*	-0.90	-0.33	-0.87
52	RLC 133 x K 29	1.78*	2.20**	1.18*	2.03**	1.80**
53	RLC 133 x IPI 10	2.52**	1.30*	-1.44*	-2.55**	-0.04
54	RLC 133 x GS 384	1.92**	1.27*	5.56**	5.91**	3.66**
55	RLC 133 x H 45	2.54**	2.56**	4.34**	2.50**	2.99**
56	RLC 133 x Kartika	-1.29	-1.73**	-3.66**	-4.52**	-2.80**
57	K 29 x IPI 10	1.06	1.46*	3.56**	3.17**	2.31**
58	K 29 x GS 384	0.80	2.10**	-1.44**	-2.05**	-0.15
59	K 29 x H 45	-2.58**	-3.61**	-4.66**	-6.78**	-4.41**
60	K 29 x Kartika	-0.41	-1.56**	-1.32*	-0.14	-0.86**
61	IPI 10 x GS 384	0.87	-0.13	-0.73	-1.62**	-0.40
62	IPI 10 x H 45	-0.51	-0.52	0.06	-0.69	-0.41
63	IPI 10 x Kartika	-0.01	0.20	-4.61**	-4.05**	-2.12**
64	GS 384 x H 45	2.23**	2.13**	1.72**	3.76**	2.46**
65	GS 384 x Kartika	1.40	-0.82	1.06	3.07**	1.18**
66	H 45 x Kartika	-0.32	-1.87**	0.84	2.34**	0.25
Min.		-4.29	-3.85	-6.25	-6.78	-4.41
Max.		2.78	4.03	5.56	5.91	3.66
SE (S_{ij}) ±		0.74	0.59	0.58	0.56	0.31
Number of significant crosses		27	39	46	50	52
No. of +ve significant crosses		17	21	27	28	29
No. of -ve significant crosses		10	18	19	22	23

Table 6a. General combining ability effects for plant height under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	1.41**	2.23**	1.70**	1.89**	1.81**
2	Gaurav	3.13**	4.42**	2.75**	2.32**	3.15**
3	Dipika	-0.49	0.18	0.22	0.58*	0.12
4	Shekhar	0.41	0.30	-0.47**	0.04	0.07
5	KB 9610	-0.73**	-1.01**	-1.04**	-1.13**	-0.98**
6	ILS 264	0.03	-0.68**	-0.16	0.06	-0.19
7	RLC 133	0.70**	0.28	0.39*	0.11	0.37**
8	K 29	0.39	-0.34	0.37*	0.13	0.14
9	IPI 10	-1.99**	-1.98**	-1.49**	-2.27**	-1.94**
10	GS 384	-1.94**	-1.82**	-1.73**	-1.75**	-1.81**
11	H 45	0.01	-0.41	-0.21	-0.06	-0.17
12	Kartika	-0.92**	-1.18**	-0.33*	0.08	-0.58**
SE (g_i) ±		0.26	0.22	0.17	0.27	0.12
Min.		-1.99	-1.98	-1.73	-2.27	-1.94
Max.		3.13	4.42	2.75	2.32	3.15
No. of Significant parents		7	7	9	6	7
No. of Significant +ve parents		3	2	4	3	3
No. of Significant -ve parents		4	5	5	3	4

**, ** Significant at 5 and 1 percent levels, respectively*

Table 6b. Specific combining ability effects for plant height under different environments

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	1.47	-0.61	2.10**	0.49	0.86*
2	Indira x Dipika	-0.58	1.30	1.96**	1.90*	1.14**
3	Indira x Shekhar	1.52	-0.49	-1.68**	-3.22**	-0.97*
4	Indira x KB 9610	0.33	0.15	1.89**	1.61	0.99*
5	Indira x ILS 264	-1.77	-0.51	-4.33**	-0.58	-1.80**
6	Indira x RLC 133	0.90	2.54**	-2.54**	0.37	0.32
7	Indira x K29	-3.46**	-1.85*	0.48	-0.99	-1.45**
8	Indira x IPI 10	-4.08**	-0.87	-1.33*	-3.25**	-2.38**
9	Indira x GS 384	0.21	1.96*	0.25	1.90*	1.08**
10	Indira x H 45	0.26	-1.78*	-0.61	0.54	-0.40
11	Indira x Kartika	1.52	0.32	2.84**	2.06*	1.69**
12	Gaurav x Dipika	1.71	0.77	1.58**	1.47	1.38**
13	Gaurav x Shekhar	-1.20	-1.01	0.27	0.68	-0.32
14	Gaurav x KB 9610	-2.39*	-1.04	4.17**	0.85	0.40
15	Gaurav x ILS 264	1.85*	1.30	-1.04	-2.34*	-0.06
16	Gaurav x RLC 133	1.52	2.68**	-1.59**	-2.06*	0.14
17	Gaurav x K 29	0.49	2.30**	-4.56**	-3.08**	-1.21**
18	Gaurav x IPI 10	-0.13	-1.39	-3.37**	-1.68	-1.64**
19	Gaurav x GS 384	-1.84*	-0.56	0.20	-1.87	-1.02
20	Gaurav x H 45	0.54	-0.63	-1.99**	0.44	-0.41
21	Gaurav x Kartika	-0.20	-0.20	-0.54	1.63	0.17
22	Dipika x Shekhar	0.09	-0.44	4.13**	4.09**	1.96**
23	Dipika x KB 9610	-0.44	-0.13	-1.97**	-3.08**	-1.40**
24	Dipika x ILS 264	-2.86**	-0.47	-4.52**	-2.60**	-2.61**
25	Dipika x RLC 133	0.47	-0.42	-2.06**	-3.65**	-1.42**
26	Dipika x K 29	1.11	1.87*	-3.71**	-1.34	-0.52
27	Dipika x IPI 10	-0.51	-1.49	-1.52*	-1.27	-1.20**
28	Dipika x GS 384	0.11	-0.99	-1.61**	-2.46*	-1.24**
29	Dipika x H 45	0.16	1.27	3.20**	2.52**	1.79**
30	Dipika x Kartika	0.76	1.37	4.98**	2.04*	2.29**
31	Shekhar x KB 9610	-1.34	0.75	-0.28	-0.53	-0.35
32	Shekhar x ILS 264	-0.10	0.75	2.51**	0.94	1.02*
33	Shekhar x RLC 133	-0.77	-1.54*	-0.37	2.23*	-0.11
34	Shekhar x K 29	0.54	1.08	0.65	1.54	0.95*
35	Shekhar x IPI 10	1.59	0.73	0.51	0.28	0.77
36	Shekhar x GS 384	1.87*	1.23	-0.26	0.09	0.73
37	Shekhar x H 45	-1.08	-0.85	-1.45*	-2.27*	-1.41**
38	Shekhar x Kartika	-2.82**	0.25	-2.99**	-1.08	-1.66**
39	KB 9610 x ILS 264	2.37*	1.06	6.08**	4.44**	3.49**
40	KB 9610 x RLC 133	-0.63	-0.89	-2.47**	-0.94	-1.23**
41	KB 9610 x K 29	-1.32	-2.61**	-2.45**	0.37	-1.50**
42	KB 9610 x IPI 10	2.40*	1.04	1.41*	1.78	1.66**
43	KB 9610 x GS 384	1.68	-0.47	-0.35	-0.08	0.20
44	KB 9610 x H 45	-0.94	1.46	-0.87	-0.10	-0.11
45	KB 9610 x Kartika	1.33	-0.11	-2.42**	-3.58**	-1.20**
46	ILS 264 x RLC 133	0.95	-0.23	5.65**	5.54**	2.98**
47	ILS 264 x K 29	-0.75	-2.28**	3.01**	0.52	0.13
48	ILS 264 x IPI 10	-0.36	-0.97	-2.47**	-2.41*	-1.55**
49	ILS 264 x GS 384	-2.08*	-1.47	-1.56**	-1.60	-1.68**
50	ILS 264 x H 45	2.97**	1.80*	-2.42**	-1.63	0.18
51	ILS 264 x Kartika	1.90*	1.56*	-2.64**	-1.44	-0.15
52	RLC 133 x K 29	-0.08	1.11	-0.54	-0.87	-0.09
53	RLC 133 x IPI 10	0.30	2.75**	-0.02	-0.46	0.64
54	RLC 133 x GS 384	0.59	0.58	3.56**	3.35**	2.02**

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
55	RLC 133 x H 45	0.97	-0.49	5.03**	3.66**	2.29**
56	RLC 133 x Kartika	-0.77	-1.06	-0.85	-2.15*	-1.21**
57	K 29 x IPI 10	1.95*	1.37	0.67	-0.15	0.96*
58	K 29 x GS 384	3.90**	2.54**	-1.76**	-1.01	0.92*
59	K 29 x H 45	-2.39**	-0.87	0.06	-0.37	-0.89*
60	K 29 x Kartika	-1.13	0.56	3.17**	1.16	0.94*
61	IPI 10 x GS 384	1.61	0.51	3.44**	2.40*	1.99**
62	IPI 10 x H 45	-1.01	-0.56	-0.76	-1.30	-0.90*
63	IPI 10 x Kartika	-1.08	-1.13	0.36	1.56	-0.07
64	GS 384 x H 45	-0.06	0.27	0.48	-1.49	-0.20
65	GS 384 x Kartika	-1.13	-0.97	-1.06	1.04	-0.53
66	H 45 x Kartika	2.59**	1.96**	6.08**	3.68**	3.58**
Min.		-4.08	-2.61	-4.56	-3.65	-2.61
Max.		3.90	2.75	6.08	5.54	3.58
SE (S_{ij}) ±		0.93	0.78	0.60	0.96	0.42
No. of significant crosses		16	15	43	26	42
No. of +ve significant crosses		8	10	17	13	21
No. of -ve significant crosses		8	5	29	13	21

**, ** Significant at 5 and 1 percent levels, respectively*

Table 7a. General combining ability effects for number of primary branches per plant under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	-0.32**	-0.43**	-0.49**	0.03	-0.30**
2	Gaurav	0.27**	0.33**	0.37**	0.19**	0.29**
3	Dipika	-0.06**	-0.15**	-0.20**	0.03	-0.09**
4	Shekhar	0.21**	0.31**	0.38**	0.05*	0.24**
5	KB 9610	-0.09**	-0.03	-0.03	0.01	-0.03**
6	ILS 264	-0.09**	-0.10*	-0.13**	-0.15**	-0.12**
7	RLC 133	-0.12**	-0.25**	-0.25**	-0.05*	-0.17**
8	K 29	-0.06**	-0.09*	-0.12**	-0.17**	-0.11**
9	IPI 10	0.37**	0.46**	0.47**	0.04	0.33**
10	GS 384	-0.08**	0.001	-0.02	-0.04	-0.03**
11	H 45	0.14**	0.22**	0.26**	0.07**	0.17**
12	Kartika	-0.16**	-0.25**	-0.25**	-0.02	-0.17**
SE (g_i) ±		0.02	0.02	0.03	0.03	0.02
Min.		-0.32	-0.43	-0.49	-0.17	-0.30
Max.		0.37	0.46	0.47	0.19	0.33
No. of Significant parents		12	10	10	6	12
No. of Significant +ve parents		4	4	4	3	4
No. of Significant -ve parents		8	6	6	3	8

**, ** Significant at 5 and 1 percent levels, respectively*

Table 7b. Specific combining ability effects for number of primary branches per plant under different environments

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	0.33**	-0.15	-0.31**	-0.04	-0.04
2	Indira x Dipika	0.56**	-0.40**	-0.38**	0.05	-0.04
3	Indira x Shekhar	-0.65**	0.01	0.22*	0.16	-0.07
4	Indira x KB 9610	-0.01	0.40**	0.32**	0.07	0.20**
5	Indira x ILS 264	-0.01	0.18**	0.26**	0.17	0.15*
6	Indira x RLC 133	0.38**	-0.04	-0.29**	-0.01	0.01
7	Indira x K29	-0.34*	-0.30**	-0.28**	-0.06	-0.24**
8	Indira x IPI 10	0.13*	0.39**	0.26**	-0.26**	0.13*

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
9	Indira x GS 384	0.18**	0.51**	0.75**	0.15	0.40**
10	Indira x H 45	-0.07	-0.01	-0.07	-0.12	-0.07
11	Indira x Kartika	0.06	0.13	-0.06	-0.07	0.02
12	Gaurav x Dipika	-0.16**	0.21**	-0.01	-0.14	-0.03
13	Gaurav x Shekhar	-0.07	-0.05	-0.35**	0.17*	-0.07
14	Gaurav x KB 9610	-0.40**	-0.25**	-0.24**	0.05	-0.21**
15	Gaurav x ILS 264	-0.13*	-0.25**	-0.30**	-0.02	-0.18**
16	Gaurav x RLC 133	0.33**	0.21**	0.25**	0.14	0.23**
17	Gaurav x K 29	0.44**	0.58**	0.85**	0.26**	0.53**
18	Gaurav x IPI 10	0.11*	-0.04	0.01	-0.19*	-0.03
19	Gaurav x GS 384	0.12*	0.32**	0.35**	-0.21*	0.15*
20	Gaurav x H 45	-0.19**	0.17*	0.27**	-0.01	0.06
21	Gaurav x Kartika	0.07	-0.06	0.04	-0.19*	-0.03
22	Dipika x Shekhar	0.12*	-0.07	0.05	0.10	0.05
23	Dipika x KB 9610	0.10	0.06	0.39**	-0.13	0.10
24	Dipika x ILS 264	0.06	0.23**	0.16	-0.03	0.11
25	Dipika x RLC 133	-0.05	-0.05	-0.19*	-0.07	-0.09
26	Dipika x K 29	-0.01	-0.20**	-0.35**	0.08	-0.12*
27	Dipika x IPI 10	-0.27**	-0.12	-0.17	-0.09	-0.16**
28	Dipika x GS 384	-0.02	0.20*	0.22*	-0.18*	0.05
29	Dipika x H 45	-0.10	0.15	0.01	0.28**	0.08
30	Dipika x Kartika	0.06	0.22**	0.21*	0.03	0.13*
31	Shekhar x KB 9610	0.43**	0.50**	0.31**	-0.08	0.29**
32	Shekhar x ILS 264	0.12*	0.11	0.09	0.01	0.08
33	Shekhar x RLC 133	0.35**	0.03	0.10	0.14	0.15*
34	Shekhar x K 29	-0.07	-0.20**	-0.06	0.26**	-0.02
35	Shekhar x IPI 10	0.19**	0.02	0.25**	-0.15	0.08
36	Shekhar x GS 384	-0.32**	-0.35**	-0.23*	-0.01	-0.23**
37	Shekhar x H 45	0.13*	0.09	-0.04	-0.35**	-0.04
38	Shekhar x Kartika	-0.07	0.03	-0.10	0.14	0.001
39	KB 9610 x ILS 264	0.16**	0.34**	0.26**	0.16	0.23**
40	KB 9610 x RLC 133	-0.08	0.01	0.08	-0.05	-0.02
41	KB 9610 x K 29	0.06	0.04	-0.02	0.20*	0.07
42	KB 9610 x IPI 10	-0.30**	-0.15	-0.34**	0.16	-0.16**
43	KB 9610 x GS 384	-0.02	-0.22**	-0.49**	-0.06	-0.20**
44	KB 9610 x H 45	-0.13*	-0.14	-0.04	-0.03	-0.09
45	KB 9610 x Kartika	0.06	0.03	0.07	-0.08	0.02
46	ILS 264 x RLC 133	-0.08	0.07	0.05	0.05	0.02
47	ILS 264 x K 29	0.03	-0.16*	0.06	-1.24**	-0.33**
48	ILS 264 x IPI 10	-0.01	-0.17*	-0.20*	0.26**	-0.03
49	ILS 264 x GS 384	0.01	-0.35**	-0.42**	0.00	-0.19**
50	ILS 264 x H 45	-0.20**	-0.07	-0.06	0.06	-0.07
51	ILS 264 x Kartika	0.13*	0.17*	-0.021	0.15	0.11
52	RLC 133 x K 29	-0.05	-0.04	0.07	-0.01	-0.01
53	RLC 133 x IPI 10	0.02	-0.02	0.02	-0.02	0.001
54	RLC 133 x GS 384	0.17**	0.27**	0.10	0.26**	0.20**
55	RLC 133 x H 45	0.02	0.22**	0.12	0.02	0.10
56	RLC 133 x Kartika	0.05	0.02	-0.17	-0.26**	-0.09
57	K 29 x IPI 10	-0.10	-0.05	-0.18*	-0.23**	-0.14*
58	K 29 x GS 384	0.05	0.18*	0.18*	0.11	0.13*
59	K 29 x H 45	0.10	0.16*	-0.14	0.31**	0.11
60	K 29 x Kartika	0.10	0.03	-0.23*	0.03	-0.02
61	IPI 10 x GS 384	0.11	0.20*	-0.02	-0.06	0.06
62	IPI 10 x H 45	0.17**	0.08	-0.03	0.23**	0.11
63	IPI 10 x Kartika	-0.17**	-0.29**	-0.12	-0.05	-0.16**
64	GS 384 x H 45	-0.12*	-0.43**	-0.41**	-0.09	-0.26**

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
65	GS 384 x Kartika	0.11*	0.04	0.17	-0.03	0.07
66	H 45 x Kartika	0.53**	0.29**	0.49**	0.29**	0.40**
Min.		-0.65	-0.43	-0.49	-1.24	-0.33
Max.		0.56	0.58	0.85	0.31	0.53
SE (S_{ij}) ±		0.05	0.08	0.09	0.09	0.06
No. of significant crosses		34	34	34	19	27
No. of +ve significant crosses		22	21	17	10	14
No. of -ve significant crosses		12	13	17	09	13

**, ** Significant at 5 and 1 percent levels, respectively*

Table 8a. General combining ability effects for number of secondary branches per plant under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	0.20	-0.22	-0.37*	-0.98**	-0.34**
2	Gaurav	1.17**	1.93**	1.09**	1.31**	1.37**
3	Dipika	-0.61	-0.29	-0.38*	-0.41	-0.42**
4	Shekhar	1.01**	0.55*	0.61**	0.78**	0.73**
5	KB 9610	-0.70**	-0.93**	-0.31*	-0.58*	-0.63**
6	ILS 264	-0.10	-0.18	-0.36*	-0.18	-0.20
7	RLC 133	-0.73**	-1.01**	-0.38*	-0.73**	-0.71**
8	K 29	-0.58*	-0.65**	-0.06	-0.29	-0.39**
9	IPI 10	0.80**	0.97**	0.39**	1.14**	0.82**
10	GS 384	-0.31	-0.07	-0.21	-0.19	-0.19
11	H 45	0.03	0.25	0.39*	0.34	0.25*
12	Kartika	-0.16	-0.34	-0.41**	-0.21	-0.28*
SE (g_i) ±		0.25	0.23	0.15	0.27	0.11
Min.		-0.73	-1.01	-0.41	-0.98	-0.71
Max.		1.17	1.93	1.09	1.31	1.37
No. of Significant parents		6	6	10	6	10
No. of Significant +ve parents		3	3	4	3	4
No. of Significant -ve parents		3	3	6	3	6

**, ** Significant at 5 and 1 percent levels, respectively*

Table 8b. Specific combining ability effects for number of secondary branches per plant under different environments

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	1.24	0.48	0.58	1.05	0.84*
2	Indira x Dipika	-1.54	-0.27	0.41	0.23	-0.29
3	Indira x Shekhar	1.67	-1.87*	0.86	-1.66	-0.25
4	Indira x KB 9610	-0.29	-1.93*	1.61*	-0.84	-0.36
5	Indira x ILS 264	1.41	0.89	-1.08*	1.29	0.63
6	Indira x RLC 133	1.98*	-0.25	1.34*	0.72	0.95*
7	Indira x K29	0.83	-1.68*	-1.25*	-1.69	-0.95*
8	Indira x IPI 10	1.55	2.37**	1.67*	0.38	1.49**
9	Indira x GS 384	-2.21*	0.61	-0.97	0.34	-0.56
10	Indira x H 45	0.42	0.23	0.17	-1.26	-0.11
11	Indira x Kartika	-1.03	1.35	-0.93	-0.40	-0.25
12	Gaurav x Dipika	0.55	-1.09	0.29	0.18	-0.01
13	Gaurav x Shekhar	2.23*	2.04*	2.37**	1.12	1.94**
14	Gaurav x KB 9610	-1.12	-0.38	0.19	0.85	-0.12
15	Gaurav x ILS 264	1.41	1.36	0.41	0.08	0.81
16	Gaurav x RLC 133	-1.96*	1.27	-2.21**	-0.50	-0.85
17	Gaurav x K 29	-0.04	2.30**	-0.73	2.86**	1.10**
18	Gaurav x IPI 10	-2.62**	-0.58	-1.35*	-1.50	-1.51**

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
19	Gaurav x GS 384	-0.65	0.09	-2.65**	0.02	-0.80
20	Gaurav x H 45	-0.29	-2.89**	0.79	-1.84	-1.06*
21	Gaurav x Kartika	-0.17	-0.30	0.52	0.42	0.12
22	Dipika x Shekhar	0.65	-0.63	-1.40*	-0.49	-0.47
23	Dipika x KB 9610	-0.51	-0.76	-0.04	-1.27	-0.65
24	Dipika x ILS 264	-0.28	0.85	-0.56	1.46	0.37
25	Dipika x RLC 133	1.99*	-0.51	0.59	-0.52	0.39
26	Dipika x K 29	-1.53	0.16	-0.43	-1.59	-0.85
27	Dipika x IPI 10	0.36	0.04	-1.75*	0.12	-0.31
28	Dipika x GS 384	-0.80	-1.96*	-0.02	-1.30	-1.02*
29	Dipika x H 45	0.76	1.86*	-0.08	1.91	1.11**
30	Dipika x Kartika	0.22	1.55	-0.81	-0.34	0.16
31	Shekhar x KB 9610	2.44**	3.64**	0.57	1.01	1.91**
32	Shekhar x ILS 264	-2.60**	0.68	-0.72	-1.66	-1.07*
33	Shekhar x RLC 133	0.43	-1.62*	-1.10*	-0.71	-0.75
34	Shekhar x K 29	0.35	-0.78	0.88	0.09	0.13
35	Shekhar x IPI 10	0.48	0.94	0.80	1.09	0.83
36	Shekhar x GS 384	-0.19	-1.89*	-0.14	-0.82	-0.76
37	Shekhar x H 45	-3.06**	1.63*	0.00	0.09	-0.34
38	Shekhar x Kartika	0.93	-0.58	0.17	2.11*	0.66
39	KB 9610 x ILS 264	-0.15	-0.48	1.84*	0.76	0.49
40	KB 9610 x RLC 133	0.34	-0.11	-0.94	1.18	0.12
41	KB 9610 x K 29	-1.37	0.36	-0.43	-0.76	-0.55
42	KB 9610 x IPI 10	0.68	0.71	0.92	0.62	0.73
43	KB 9610 x GS 384	2.25*	0.42	-1.32*	1.44	0.70
44	KB 9610 x H 45	-0.45	-0.60	0.95	1.11	0.25
45	KB 9610 x Kartika	-1.26	1.43	-0.58	-0.67	-0.27
46	ILS 264 x RLC 133	-0.03	1.21	1.31*	-1.15	0.33
47	ILS 264 x K 29	0.96	-0.39	-0.98	0.71	0.07
48	ILS 264 x IPI 10	-3.59**	-0.58	-1.77*	0.38	-1.39**
49	ILS 264 x GS 384	0.02	-0.37	1.83*	0.40	0.47
50	ILS 264 x H 45	0.72	-1.79*	0.86	-1.02	-0.31
51	ILS 264 x Kartika	1.30	0.60	-0.96	-0.97	-0.01
52	RLC 133 x K 29	1.49	0.41	-0.46	0.96	0.60
53	RLC 133 x IPI 10	-1.75	0.73	-0.01	-0.13	-0.29
54	RLC 133 x GS 384	-1.89*	2.30**	1.02	-0.54	0.22
55	RLC 133 x H 45	-0.59	0.42	-0.28	1.23	0.20
56	RLC 133 x Kartika	1.83*	-1.73*	2.02*	-0.35	0.45
57	K 29 x IPI 10	2.63**	0.53	2.60**	-0.20	1.39**
58	K 29 x GS 384	-0.40	-1.37	-1.84*	-0.48	-1.02*
59	K 29 x H 45	-1.34	0.25	-0.50	0.69	-0.22
60	K 29 x Kartika	-1.98*	-0.93	0.30	-0.49	-0.77
61	IPI 10 x GS 384	0.69	-0.82	0.18	-0.84	-0.20
62	IPI 10 x H 45	-1.45	-0.30	-2.39**	-0.04	-1.04*
63	IPI 10 x Kartika	1.31	0.62	0.82	1.52	1.07*
64	GS 384 x H 45	3.19**	2.40**	1.38*	-0.85	1.53**
65	GS 384 x Kartika	-1.06	1.10	-1.15*	1.47	0.09
66	H 45 x Kartika	2.78**	-0.05	2.08*	0.58	1.35**
Min.		-3.59	-2.89	-2.65	-1.84	-1.51
Max.		3.19	3.64	2.60	2.86	1.94
SE (S_{ij}) ±		0.90	0.84	0.55	0.99	0.42
Number of significant crosses		17	17	24	02	19
No. of +ve significant crosses		9	8	11	02	11
No. of -ve significant crosses		8	9	13	-	08

**, ** Significant at 5 and 1 percent levels, respectively*

Table 9a. General combining ability effects for number of capsules per plant under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	-0.62	-1.91**	-1.19**	-1.59**	-1.33**
2	Gaurav	-1.07**	-1.11**	-1.51**	-1.68**	-1.34**
3	Dipika	-1.39**	-1.16**	-1.55**	-1.44**	-1.38**
4	Shekhar	2.91**	3.83**	3.11**	2.72**	3.14**
5	KB 9610	-0.49	0.13	0.50*	0.54**	0.17
6	ILS 264	-1.53**	-1.65**	-0.99**	-1.21**	-1.34**
7	RLC 133	-0.93*	-1.96**	-2.14**	-2.03**	-1.77**
8	K 29	-2.26**	-2.22**	-0.80**	-0.74**	-1.51**
9	IPI 10	4.20**	5.30**	4.39**	5.04**	4.73**
10	GS 384	2.93**	3.18**	2.79**	3.36**	3.06**
11	H 45	-0.47	-0.55**	-1.22**	-0.78**	-0.75**
12	Kartika	-1.30**	-1.87**	-1.40**	-2.19**	-1.69**
SE (g_i) ±		0.34	0.21	0.26	0.20	0.13
Min.		-2.26	-2.22	-2.14	-2.19	-1.77
Max.		4.20	5.30	4.39	5.04	4.73
No. of Significant parents		9	11	12	12	11
No. of Significant +ve parents		3	3	4	4	3
No. of Significant -ve parents		6	8	8	8	8

**, ** Significant at 5 and 1 percent levels, respectively*

Table 9b. Estimates of specific combining ability effects for number of capsules per plant

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	1.90	-1.24	4.54**	3.46**	2.17**
2	Indira x Dipika	0.75	-0.59	1.38	2.25**	0.95*
3	Indira x Shekhar	0.45	0.29	1.42	-0.30	0.47
4	Indira x KB 9610	-1.09	-0.61	-0.87	2.47**	-0.02
5	Indira x ILS 264	1.02	1.37	-1.61	-1.28	-0.13
6	Indira x RLC 133	6.12**	2.75**	-1.05	-0.70	1.78**
7	Indira x K29	4.15**	3.37**	2.21*	1.79*	2.88**
8	Indira x IPI 10	1.99	3.56**	0.52	-0.50	1.39**
9	Indira x GS 384	0.69	-0.76	-0.18	0.58	0.08
10	Indira x H 45	-4.31**	-2.37**	0.69	-1.58*	-1.89**
11	Indira x Kartika	-2.48	-1.42	-2.56**	-1.33	-1.95**
12	Gaurav x Dipika	1.27	0.91	-1.16	1.50*	0.63
13	Gaurav x Shekhar	3.87**	3.66**	2.28*	3.12**	3.23**
14	Gaurav x KB 9610	-3.14*	-1.37	-3.68**	-4.87**	-3.27**
15	Gaurav x ILS 264	-1.60	-0.90	-0.73	-0.23	-0.86
16	Gaurav x RLC 133	-2.12	1.08	-2.97**	-0.91	-1.23**
17	Gaurav x K 29	1.87	1.34	0.06	-0.26	0.75
18	Gaurav x IPI 10	0.08	0.26	-1.10	-2.57**	-0.83
19	Gaurav x GS 384	1.01	-0.49	1.37	1.40	0.83
20	Gaurav x H 45	3.18*	1.14	2.27*	0.51	1.77**
21	Gaurav x Kartika	-0.76	0.26	0.19	-1.24	-0.39
22	Dipika x Shekhar	2.02	2.71**	2.55**	1.67*	2.24**
23	Dipika x KB 9610	1.05	2.34**	0.56	-1.45*	0.62
24	Dipika x ILS 264	-0.55	-0.35	-0.35	-0.74	-0.50
25	Dipika x RLC 133	-0.54	-0.31	-1.66	-1.29	-0.95*
26	Dipika x K 29	-0.44	-0.98	6.23**	5.00**	2.45**
27	Dipika x IPI 10	0.70	-1.40	-1.19	0.65	-0.31
28	Dipika x GS 384	1.93	3.06**	-2.32*	-1.34	0.33
29	Dipika x H 45	-0.34	0.58	-0.36	-3.00**	-0.78
30	Dipika x Kartika	-0.87	-0.57	0.57	3.18**	0.58

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
31	Shekhar x KB 9610	0.62	-0.71	-0.23	-0.13	-0.11
32	Shekhar x ILS 264	2.43	0.80	-0.31	1.21	1.03*
33	Shekhar x RLC 133	-1.27	-2.56**	0.85	-0.97	-0.99*
34	Shekhar x K 29	0.43	1.53*	-2.73**	-4.29**	-1.26**
35	Shekhar x IPI 10	-0.97	-1.28	-0.95	-1.14	-1.08*
36	Shekhar x GS 384	-0.46	-0.03	1.95*	1.47*	0.73
37	Shekhar x H 45	-1.93	-1.74*	-1.71	-0.89	-1.57**
38	Shekhar x Kartika	-0.87	0.81	0.64	2.20**	0.70
39	KB 9610 x ILS 264	2.05	1.46	2.53**	4.06**	2.53**
40	KB 9610 x RLC 133	-0.64	-0.82	-1.34	-1.16	-0.99*
41	KB 9610 x K 29	-1.15	0.27	0.18	6.69**	1.50**
42	KB 9610 x IPI 10	-1.37	-0.81	0.99	3.98**	0.70
43	KB 9610 x GS 384	-0.01	0.04	5.19**	-0.68	1.14*
44	KB 9610 x H 45	3.03	1.46	0.93	-0.08	1.34**
45	KB 9610 x Kartika	0.96	2.18**	-0.82	-4.39**	-0.52
46	ILS 264 x RLC 133	-1.60	-1.75*	-3.89**	-4.08**	-2.83**
47	ILS 264 x K 29	0.63	0.98	1.87	-1.06	0.60
48	ILS 264 x IPI 10	0.03	-0.27	-0.09	-0.35	-0.17
49	ILS 264 x GS 384	3.80**	3.82**	6.51**	5.06**	4.80**
50	ILS 264 x H 45	-0.63	-0.33	0.42	0.63	0.02
51	ILS 264 x Kartika	0.03	0.82	-0.73	1.65*	0.44
52	RLC 133 x K 29	-1.93	-1.51*	0.20	-2.51**	-1.44**
53	RLC 133 x IPI 10	3.64*	4.11**	6.01**	5.97**	4.93**
54	RLC 133 x GS 384	0.81	3.23**	0.14	2.35**	1.63**
55	RLC 133 x H 45	2.47	2.12**	0.18	-0.45	1.08*
56	RLC 133 x Kartika	7.37**	0.54	5.93**	3.31**	4.29**
57	K 29 x IPI 10	2.24	2.23**	0.80	-0.61	1.16*
58	K 29 x GS 384	1.30	0.05	-3.07**	-0.77	-0.62
59	K 29 x H 45	0.60	0.18	4.30**	6.21**	2.82**
60	K 29 x Kartika	0.30	0.39	0.09	0.92	0.43
61	IPI 10 x GS 384	-0.72	-0.73	1.11	0.78	0.11
62	IPI 10 x H 45	0.81	1.66*	-2.32*	0.16	0.08
63	IPI 10 x Kartika	-0.43	1.05	0.01	0.87	0.37
64	GS 384 x H 45	-0.39	-0.42	-2.72**	-0.44	-0.99*
65	GS 384 x Kartika	-0.92	-1.97**	-1.20	-4.49**	-2.14**
66	H 45 x Kartika	1.84	2.49**	-1.03	0.45	0.94*
Min.		-4.31	-2.56	-3.89	-4.87	-3.27
Max.		7.37	4.11	6.51	6.69	4.93
SE (S_{ij}) ±		1.25	0.77	0.93	0.73	0.47
No. of significant crosses		09	22	22	30	36
No. of +ve significant crosses		07	16	13	20	22
No. of -ve significant crosses		02	06	09	10	14

**, ** Significant at 5 and 1 percent levels, respectively*

Table 10a. General combining ability effects for number of seeds per capsules under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	-0.23**	-0.09**	-0.17**	-0.27**	-0.19**
2	Gaurav	0.15**	0.15**	0.16**	0.15**	0.15**
3	Dipika	0.06**	0.14**	0.003	-0.08**	0.03**
4	Shekhar	0.04*	0.06**	0.04	0.06**	0.05**
5	KB 9610	-0.25**	-0.28**	-0.19**	-0.28**	-0.25**
6	ILS 264	0.23**	0.17**	0.16**	0.22**	0.19**
7	RLC 133	-0.15**	-0.13**	-0.13**	-0.12**	-0.13**
8	K 29	-0.29**	-0.32**	-0.29**	-0.33**	-0.31**

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
9	IPI 10	-0.01	-0.03	-0.05*	0.01	-0.02
10	GS 384	0.01	0.03	0.04	0.05**	0.03*
11	H 45	0.13**	0.06**	0.13**	0.21**	0.13**
12	Kartika	0.31**	0.26**	0.31**	0.38**	0.31**
SE (g_i) ±		0.02	0.02	0.02	0.02	0.01
Min.		-0.29	-0.32	-0.29	-0.33	-0.31
Max.		0.31	0.26	0.31	0.38	0.31
No. of Significant parents		10	10	9	11	11
No. of Significant +ve parents		6	6	4	6	7
No. of Significant -ve parents		4	4	5	5	4

**, ** Significant at 5 and 1 percent levels, respectively*

Table 10b. Specific combining ability effects for number of seeds per capsules under different environments

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	0.27**	0.10	0.06	-0.45**	-0.004
2	Indira x Dipika	0.07	-0.16*	-0.15	-0.58**	-0.21**
3	Indira x Shekhar	0.22**	0.22**	0.21*	0.25**	0.23**
4	Indira x KB 9610	-0.25**	-0.07	-0.06	0.15**	-0.06
5	Indira x ILS 264	-0.001	0.19*	0.32**	0.22**	0.18**
6	Indira x RLC 133	0.21**	0.04	0.001	-0.10	0.04
7	Indira x K29	-0.16*	-0.13	0.001	0.21**	-0.02
8	Indira x IPI 10	-0.10	-0.12	0.20**	0.50**	0.12**
9	Indira x GS 384	-0.35**	-0.21**	-0.35**	-0.17*	-0.27**
10	Indira x H 45	-0.07	0.09	-0.05	-0.37**	-0.10**
11	Indira x Kartika	0.05	0.16*	0.18*	0.06	0.11**
12	Gaurav x Dipika	0.18**	0.24**	0.29**	0.30**	0.25**
13	Gaurav x Shekhar	-0.66**	-0.68**	-0.15	-0.30**	-0.45**
14	Gaurav x KB 9610	0.13	0.43**	0.35**	0.10	0.25**
15	Gaurav x ILS 264	-0.06	-0.12	-0.11	0.10	-0.05
16	Gaurav x RLC 133	0.02	-0.13	-0.39**	-0.35**	-0.21**
17	Gaurav x K 29	0.09	0.001	0.28**	0.12	0.12**
18	Gaurav x IPI 10	-0.02	0.04	-0.16	0.12	-0.01
19	Gaurav x GS 384	0.03	0.09	0.05	-0.12	0.01
20	Gaurav x H 45	0.11	0.16*	0.12	0.28**	0.17**
21	Gaurav x Kartika	0.001	-0.14	-0.05	-0.13*	-0.08*
22	Dipika x Shekhar	-0.17*	-0.18*	-0.12	-0.17*	-0.16**
23	Dipika x KB 9610	0.02	0.20*	0.04	-0.03	0.06
24	Dipika x ILS 264	-0.07	0.09	0.02	0.17*	0.05
25	Dipika x RLC 133	0.42**	0.31**	0.21*	0.31**	0.31**
26	Dipika x K 29	-0.05	0.11	-0.03	0.02	0.01
27	Dipika x IPI 10	-0.49**	-0.32**	-0.20*	-0.42**	-0.36**
28	Dipika x GS 384	0.06	0.12	-0.02	0.21**	0.09*
29	Dipika x H 45	0.17*	-0.01	0.25**	0.21**	0.16**
30	Dipika x Kartika	-0.14*	0.13	-0.19*	-0.36**	-0.14**
31	Shekhar x KB 9610	0.14*	0.05	0.001	-0.14*	0.01
32	Shekhar x ILS 264	-0.24**	0.001	-0.42**	-0.17*	-0.21**
33	Shekhar x RLC 133	0.21**	0.29**	0.30**	0.44**	0.31**
34	Shekhar x K 29	-0.03	0.02	0.001	-0.12	-0.03
35	Shekhar x IPI 10	0.10	0.13	-0.04	-0.09	0.02
36	Shekhar x GS 384	0.11	0.24**	0.17*	-0.09	0.11**
37	Shekhar x H 45	0.26**	0.17*	-0.13	0.21**	0.13**
38	Shekhar x Kartika	0.15*	-0.06	0.24**	0.13*	0.12**
39	KB 9610 x ILS 264	0.05	-0.16*	-0.19*	-0.33**	-0.16**
40	KB 9610 x RLC 133	-0.14*	-0.06	-0.11	-0.25**	-0.14**

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
41	KB 9610 x K 29	-0.10	-0.07	-0.14	-0.18**	-0.12**
42	KB 9610 x IPI 10	0.29**	0.04	0.22*	0.32**	0.22**
43	KB 9610 x GS 384	-0.06	-0.22**	0.10	-0.06	-0.06
44	KB 9610 x H 45	0.15*	-0.12	0.27**	0.18**	0.12**
45	KB 9610 x Kartika	0.04	0.19*	-0.20*	0.17*	0.05
46	ILS 264 x RLC 133	0.31**	0.29**	0.18*	0.35**	0.28**
47	ILS 264 x K 29	0.18**	0.19*	0.04	0.12	0.13**
48	ILS 264 x IPI 10	0.17*	0.06	0.20*	0.02	0.11**
49	ILS 264 x GS 384	-0.08	-0.17*	-0.12	0.04	-0.08*
50	ILS 264 x H 45	-0.27**	-0.03	-0.28**	-0.29**	-0.22**
51	ILS 264 x Kartika	0.09	0.07	0.11	0.04	0.08*
52	RLC 133 x K 29	-0.04	0.11	0.10	0.07	0.06
53	RLC 133 x IPI 10	0.08	-0.08	0.05	-0.11	-0.01
54	RLC 133 x GS 384	-0.10	-0.24**	0.17*	0.29**	0.03
55	RLC 133 x H 45	-0.29**	0.20*	-0.26**	-0.34**	-0.17**
56	RLC 133 x Kartika	-0.20**	-0.10	-0.10	-0.08	-0.12**
57	K 29 x IPI 10	-0.38**	-0.32**	-0.28**	-0.20**	-0.29**
58	K 29 x GS 384	0.27**	0.22**	0.001	-0.30**	0.05
59	K 29 x H 45	0.05	-0.11	-0.10	-0.07	-0.06
60	K 29 x Kartika	0.04	0.23**	0.06	0.13*	0.11**
61	IPI 10 x GS 384	0.13	0.20*	0.20*	0.03	0.14**
62	IPI 10 x H 45	0.07	0.10	0.001	-0.01	0.04
63	IPI 10 x Kartika	0.13	0.10	-0.14	0.12	0.05
64	GS 384 x H 45	-0.01	-0.26**	0.01	0.09	-0.04
65	GS 384 x Kartika	-0.13	0.01	0.04	0.05	-0.01
66	H 45 x Kartika	-0.04	-0.02	0.14	0.18**	0.07
Min.		-0.66	-0.68	-0.42	-0.58	-0.45
Max.		0.42	0.43	0.35	0.50	0.31
SE (S_{ij}) ±		0.07	0.08	0.09	0.07	0.04
No. of significant crosses		28	28	28	40	41
No. of +ve significant crosses		16	17	18	22	23
No. of -ve significant crosses		12	11	10	18	18

**, ** Significant at 5 and 1 percent levels, respectively*

3.2.8 Test weight

Four parents *viz*., KB 9610, K 29, Shekhar and GS 384 in all environments and PEVs exhibiting significant and positive GCA effects (Table 11a). Among the parents, GCA effect was significant and positive for KB 9610 [E_1: 0.79, E_2: 0.74, E_3: 0.75, E_4: 0.63 in and PEVs: 0.73]; K 29 [E_1: 0.72, E_2: 0.66, E_3: 0.65, E_4: 0.66 in and PEVs: 0.67]; Shekhar [E_1: 0.62, E_2: 0.57, E_3: 0.58, E_4: 0.49 in and PEVs: 0.56]; and GS 384 [E_1: 0.44, E_2: 0.49, E_3: 0.53, E_4: 0.46 in and PEVs: 0.48]. Hence, they were registered as good general combiners for test weight. All other parents *viz*., Dipika, ILS 264, Kartika, H 45, Indira, RLC 133 and IPI 10 recorded significant and negative GCA effects indicating poor general combiners for test weight.

Total 24 crosses in E_1, 28 crosses in E_2, 21 crosses in E_3, 25 crosses in E_4 and 28 in PEVs exhibited significant and positive (desirable) SCA effects. Cross Indira × ILS 264 noted highest, significant and positive SCA effect in E_1 (1.84), E_2 (1.88), E_3 (1.61), E_4 (1.67) and PEVs (1.75) and cross Dipika × RLC 133 in E_4 (1.71) for test weight (Table 11b). Similar finding in accordance to the above result has also been reported by Khan et al. [15], Srivastava et al. [7], Singh et al. [8], Mohammadi et al. [13], Mishra et al. [9], Prasad et al. [18] and Mahawar et al. [12].

3.2.9 Seed yield per plant

Among twelve parents, significant and positive GCA effects depicted by Shekhar (0.63), GS 384 (0.51) and K 29 (0.09) in E_1; Shekhar (0.59), GS 384 (0.48) and K 29 (0.06) in E_2; Shekhar (0.52), GS 384 (0.46) and K 29 (0.13) in E_3; Shekhar (0.40), GS 384 (0.42) and K 29 (0.10) in E_4 and Shekhar (0.53), GS 384 (0.47) and K 29 (0.09) in PEVs. Hence, they were noted as good general combiners for seed yield per plant. Further, comparison across the environments indicated that the parents Indira and RLC 133 recorded significant and negative GCA effects, indicating poor general combiners. Further, it was observed

that parent IPI 10 in E_4 (0.04) was good general combiners in particular environments opposite to that parent Gaurav in E_4 (-0.07) and PEVs (-0.03) was a poor specific combiner in particular environments (Table 12a). Depicts the GCA effects of parents in pooled over environments.

Table 11a. General combining ability effects for test weight under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	-0.45**	-0.41**	-0.32**	-0.39**	-0.39**
2	Gaurav	-0.05**	0.08**	-0.04	-0.08**	-0.02
3	Dipika	-0.04**	-0.07*	-0.19**	0.07**	-0.06**
4	Shekhar	0.62**	0.57**	0.58**	0.49**	0.56**
5	KB 9610	0.79**	0.74**	0.75**	0.63**	0.73**
6	ILS 264	-0.23**	-0.26**	-0.21**	-0.31**	-0.25**
7	RLC 133	-0.52**	-0.47**	-0.54**	-0.31**	-0.46**
8	K 29	0.72**	0.66**	0.65**	0.66**	0.67**
9	IPI 10	-0.56**	-0.59**	-0.49**	-0.52**	-0.54**
10	GS 384	0.44**	0.49**	0.53**	0.46**	0.48**
11	H 45	-0.41**	-0.42**	-0.37**	-0.31**	-0.38**
12	Kartika	-0.30**	-0.34**	-0.34**	-0.39**	-0.34**
SE (g_i) ±		0.02	0.03	0.03	0.02	0.01
Min.		-0.56	-0.59	-0.54	-0.52	-0.54
Max.		0.79	0.74	0.75	0.66	0.73
No. of Significant parents		12	12	11	12	11
No. of Significant +ve parents		4	5	4	5	4
No. of Significant -ve parents		8	7	7	7	7

**, ** Significant at 5 and 1 percent levels, respectively*

Table 11b. Specific combining ability effects for test weight under different environments

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	-0.48**	-0.59**	-0.44**	-0.66**	-0.54**
2	Indira x Dipika	0.28**	0.23*	0.46**	-0.10	0.21**
3	Indira x Shekhar	-0.95**	-0.82**	-1.02**	-1.02**	-0.95**
4	Indira x KB 9610	0.35**	0.31**	0.05	0.21**	0.23**
5	Indira x ILS 264	1.84**	1.88**	1.61**	1.67**	1.75**
6	Indira x RLC 133	-0.11	-0.21*	0.07	0.07	-0.04
7	Indira x K29	0.69**	0.56**	0.58**	0.51**	0.58**
8	Indira x IPI 10	-0.17**	-0.36**	-0.21	-0.18*	-0.23**
9	Indira x GS 384	-0.17**	0.84**	0.87**	0.81**	0.59**
10	Indira x H 45	-0.15*	-0.42**	-0.47**	-0.63**	-0.42**
11	Indira x Kartika	-0.70**	-0.84**	-0.86**	-0.58**	-0.74**
12	Gaurav x Dipika	-0.09	-0.20	-0.42**	-0.56**	-0.32**
13	Gaurav x Shekhar	-0.12*	-0.04	0.001	-0.07	-0.06
14	Gaurav x KB 9610	-0.22**	-0.31**	-0.30**	-0.25**	-0.27**
15	Gaurav x ILS 264	0.07	0.09	0.16	0.15	0.12**
16	Gaurav x RLC 133	-0.21**	0.30**	-0.14	-0.11	-0.04
17	Gaurav x K 29	-0.15*	-0.43**	-0.44**	-0.55**	-0.39**
18	Gaurav x IPI 10	-0.34**	0.29**	-0.29*	-0.17*	-0.13**
19	Gaurav x GS 384	0.26**	0.25*	0.22	0.19*	0.23**
20	Gaurav x H 45	0.68**	0.62**	0.58**	0.65**	0.63**
21	Gaurav x Kartika	0.23**	0.27*	0.16	0.13	0.20**
22	Dipika x Shekhar	-0.06	-0.09	-0.31**	-0.22**	-0.17**
23	Dipika x KB 9610	0.08	-0.06	-0.11	-0.19*	-0.07
24	Dipika x ILS 264	-0.34**	-0.46**	-0.31**	-0.33**	-0.36**
25	Dipika x RLC 133	0.11	0.12	0.29*	1.71**	0.56**
26	Dipika x K 29	0.05	0.22*	0.09	0.14	0.12**
27	Dipika x IPI 10	0.59**	0.37**	0.27*	0.52**	0.44**

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
28	Dipika x GS 384	-0.28**	-0.10	-0.25*	-0.55**	-0.30**
29	Dipika x H 45	-0.23**	-0.09	-0.26*	-0.39**	-0.24**
30	Dipika x Kartika	0.29**	0.36**	0.42**	0.49**	0.39**
31	Shekhar x KB 9610	-0.39**	-0.44**	-0.15	-0.07	-0.26**
32	Shekhar x ILS 264	0.33**	0.30**	0.35**	0.49**	0.37**
33	Shekhar x RLC 133	0.65**	0.51**	0.84**	0.39**	0.60**
34	Shekhar x K 29	-0.18**	-0.22*	-0.29*	0.23**	-0.12**
35	Shekhar x IPI 10	0.33**	0.23*	0.19	0.21**	0.24**
36	Shekhar x GS 384	-0.54**	-0.55**	-0.43**	-0.27**	-0.45**
37	Shekhar x H 45	0.92**	0.86**	0.87**	0.86**	0.88**
38	Shekhar x Kartika	0.50**	0.51**	0.24*	0.27**	0.38**
39	KB 9610 x ILS 264	0.30**	0.43**	0.25*	0.25**	0.31**
40	KB 9610 x RLC 133	0.89**	0.94**	0.91**	0.82**	0.89**
41	KB 9610 x K 29	-0.05	0.001	-0.19	-0.21**	-0.11*
42	KB 9610 x IPI 10	0.46**	0.46**	0.39**	0.53**	0.46**
43	KB 9610 x GS 384	-0.57**	-0.78**	-0.40**	-0.61**	-0.59**
44	KB 9610 x H 45	-0.19**	0.09	0.10	-0.15	-0.04
45	KB 9610 x Kartika	0.10	-0.09	0.08	0.23**	0.08
46	ILS 264 x RLC 133	-0.03	0.04	0.01	0.02	0.01
47	ILS 264 x K 29	-0.66**	-0.79**	-0.56**	-0.48**	-0.62**
48	ILS 264 x IPI 10	-0.19**	-0.14	-0.05	0.10	-0.07
49	ILS 264 x GS 384	0.11	-0.05	-0.10	-0.08	-0.03
50	ILS 264 x H 45	-0.37**	-0.34**	-0.31**	-0.22**	-0.31**
51	ILS 264 x Kartika	-0.32**	0.01	-0.20	-0.14	-0.16**
52	RLC 133 x K 29	-0.28**	-0.18	-0.06	-0.11	-0.16**
53	RLC 133 x IPI 10	-0.20**	-0.23*	-0.28*	-0.30**	-0.25**
54	RLC 133 x GS 384	-0.40**	-0.44**	-0.80**	-0.88**	-0.63**
55	RLC 133 x H 45	-0.25**	-0.20	-0.17	-0.22**	-0.21**
56	RLC 133 x Kartika	0.50**	0.52**	0.47**	0.37**	0.46**
57	K 29 x IPI 10	0.87**	0.74**	0.82**	0.90**	0.83**
58	K 29 x GS 384	-0.04	-0.04	-0.10	-0.04	-0.05
59	K 29 x H 45	0.09	0.07	0.06	0.02	0.06
60	K 29 x Kartika	-0.13*	0.09	-0.06	-0.30**	-0.10*
61	IPI 10 x GS 384	0.38**	0.45**	0.21	-0.13	0.23**
62	IPI 10 x H 45	0.20**	0.22*	0.21	0.20**	0.21**
63	IPI 10 x Kartika	0.05	-0.06	0.52**	-0.42**	0.02
64	GS 384 x H 45	0.79**	0.68**	0.82**	0.92**	0.80**
65	GS 384 x Kartika	0.38**	0.27*	0.30**	0.20**	0.29**
66	H 45 x Kartika	0.60**	0.78**	0.59**	0.86**	0.71**
Min.		-0.95	-0.84	-1.02	-1.02	-0.95
Max.		1.84	1.88	1.61	1.71	1.75
SE (S_{ij}) ±		0.06	0.11	0.12	0.08	0.05
No. of significant crosses		52	45	40	49	54
No. of +ve significant crosses		24	28	21	25	28
No. of -ve significant crosses		28	17	19	24	26

**, ** Significant at 5 and 1 percent levels, respectively*

Table 12a. General combining ability effects for seed yield per plant under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	-0.43**	-0.39*	-0.30**	-0.35**	-0.37**
2	Gaurav	-0.03	0.01	-0.04	-0.07**	-0.03**
3	Dipika	-0.09**	-0.07**	-0.19**	-0.09**	-0.11**
4	Shekhar	0.63**	0.59**	0.52**	0.40**	0.53**
5	KB 9610	0.28**	0.26**	0.31**	0.18**	0.26**
6	ILS 264	-0.13**	-0.14**	-0.10**	-0.12**	-0.12**

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
7	RLC 133	-0.45**	-0.41**	-0.44**	-0.29*	-0.40**
8	K 29	0.09**	0.06**	0.13**	0.10**	0.09**
9	IPI 10	-0.07**	-0.04*	-0.03	0.04**	-0.03**
10	GS 384	0.51**	0.48**	0.46**	0.42**	0.47**
11	H 45	-0.20**	-0.21**	-0.20**	-0.08**	-0.17**
12	Kartika	-0.11**	-0.14**	-0.13**	-0.15**	-0.13**
SE (g_i) ±		0.03	0.02	0.03	0.02	0.01
Min.		-0.45	-0.41	-0.44	-0.35	-0.40
Max.		0.63	0.59	0.52	0.42	0.53
No. of Significant parents		11	11	10	12	12
No. of Significant +ve parents		4	4	4	5	4
No. of Significant -ve parents		7	7	6	8	8

**, ** Significant at 5 and 1 percent levels, respectively*

Table 12b. Specific combining ability effects for seed yield per plant under different environments

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	-0.02	-0.18**	0.06	-0.25**	-0.10*
2	Indira x Dipika	0.26*	0.12	0.25**	-0.13*	0.12**
3	Indira x Shekhar	-0.47**	-0.40**	-0.38**	-0.40**	-0.41**
4	Indira x KB 9610	-0.03	0.03	-0.07	0.27**	0.05
5	Indira x ILS 264	1.17**	1.12**	0.83**	0.69**	0.95**
6	Indira x RLC 133	0.43**	0.23**	0.001	-0.02	0.16**
7	Indira x K29	0.61**	0.50**	0.42**	0.39**	0.48**
8	Indira x IPI 10	-0.03	-0.04	0.001	0.06	-0.01
9	Indira x GS 384	-0.28**	0.01	0.23*	0.28**	0.06
10	Indira x H 45	-0.40**	-0.34**	-0.20*	-0.46**	-0.35**
11	Indira x Kartika	-0.54**	-0.47**	-0.49**	-0.28**	-0.45**
12	Gaurav x Dipika	0.13	0.09	-0.17	-0.05	0.001
13	Gaurav x Shekhar	-0.18	-0.15*	0.07	0.02	-0.06
14	Gaurav x KB 9610	-0.29**	-0.15*	-0.24*	-0.35**	-0.26**
15	Gaurav x ILS 264	-0.11	-0.09	-0.01	0.08	-0.03
16	Gaurav x RLC 133	-0.26*	-0.03	-0.38**	-0.21**	-0.22**
17	Gaurav x K 29	0.12	-0.01	-0.07	-0.19**	-0.04
18	Gaurav x IPI 10	-0.20*	0.02	-0.28**	-0.17**	-0.16**
19	Gaurav x GS 384	0.27**	0.20**	0.24*	0.12*	0.21**
20	Gaurav x H 45	0.71**	0.56**	0.48**	0.40**	0.54**
21	Gaurav x Kartika	0.08	0.08	0.06	-0.07	0.04
22	Dipika x Shekhar	0.02	0.03	-0.07	-0.07	-0.03
23	Dipika x KB 9610	0.14	0.19**	0.001	-0.18**	0.04
24	Dipika x ILS 264	-0.28**	-0.25**	-0.16	-0.12*	-0.20**
25	Dipika x RLC 133	0.24*	0.19**	0.12	0.74**	0.32**
26	Dipika x K 29	-0.03	0.04	0.43**	0.37**	0.20**
27	Dipika x IPI 10	0.16	0.07	-0.01	0.13*	0.09*
28	Dipika x GS 384	-0.01	0.11	-0.29**	-0.24**	-0.11**
29	Dipika x H 45	-0.09	-0.06	-0.05	-0.27**	-0.12**
30	Dipika x Kartika	0.04	0.11	0.16	0.26**	0.14**
31	Shekhar x KB 9610	-0.08	-0.16*	-0.08	-0.10	-0.11**
32	Shekhar x ILS 264	0.26*	0.23**	-0.05	0.23**	0.17**
33	Shekhar x RLC 133	0.39**	0.28**	0.60**	0.28**	0.39**
34	Shekhar x K 29	-0.09	-0.04	-0.32**	-0.23**	-0.17**
35	Shekhar x IPI 10	0.23*	0.17**	0.04	0.01	0.11**
36	Shekhar x GS 384	-0.29**	-0.21**	0.02	-0.05	-0.13**
37	Shekhar x H 45	0.56**	0.47**	0.26**	0.42**	0.43**
38	Shekhar x Kartika	0.34**	0.31**	0.29**	0.32**	0.32**

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
39	KB 9610 x ILS 264	0.38**	0.30**	0.21*	0.22**	0.28**
40	KB 9610 x RLC 133	0.37**	0.35**	0.27**	0.15*	0.28**
41	KB 9610 x K 29	-0.21*	-0.11	-0.16	0.22**	-0.07
42	KB 9610 x IPI 10	0.41**	0.32**	0.42**	0.67**	0.46**
43	KB 9610 x GS 384	-0.39**	-0.44**	0.22*	-0.33**	-0.23**
44	KB 9610 x H 45	0.20*	0.14*	0.24*	0.001	0.14**
45	KB 9610 x Kartika	0.17	0.18**	-0.10	-0.09	0.04
46	ILS 264 x RLC 133	0.01	0.02	-0.15	-0.10	-0.06
47	ILS 264 x K 29	-0.23*	-0.23**	-0.12	-0.20**	-0.20**
48	ILS 264 x IPI 10	-0.03	-0.05	0.06	0.03	0.001
49	ILS 264 x GS 384	0.31**	0.21**	0.30**	0.28**	0.28**
50	ILS 264 x H 45	-0.41**	-0.30**	-0.24*	-0.18**	-0.28**
51	ILS 264 x Kartika	-0.17	-0.04	-0.11	0.03	-0.07
52	RLC 133 x K 29	-0.29**	-0.19**	0.03	-0.16**	-0.15**
53	RLC 133 x IPI 10	0.12	0.08	0.16	0.11	0.12**
54	RLC 133 x GS 384	-0.29**	-0.22**	-0.37**	-0.18**	-0.26**
55	RLC 133 x H 45	-0.15	-0.02	-0.17	-0.23**	-0.14**
56	RLC 133 x Kartika	0.71**	0.45**	0.52**	0.31**	0.50**
57	K 29 x IPI 10	0.51**	0.45**	0.36**	0.31**	0.41**
58	K 29 x GS 384	0.25*	0.17**	-0.25**	-0.20**	-0.01
59	K 29 x H 45	0.13	0.07	0.26**	0.35**	0.20**
60	K 29 x Kartika	-0.02	0.09	0.03	0.001	0.02
61	IPI 10 x GS 384	0.28**	0.30**	0.30**	0.001	0.22**
62	IPI 10 x H 45	0.20*	0.22**	-0.03	0.08	0.12**
63	IPI 10 x Kartika	0.07	0.06	0.24*	-0.12*	0.06
64	GS 384 x H 45	0.44**	0.30**	0.23*	0.43**	0.35**
65	GS 384 x Kartika	0.09	0.04	0.10	-0.17**	0.02
66	H 45 x Kartika	0.46**	0.49**	0.28**	0.46**	0.42**
Min.		-0.54	-0.47	-0.49	-0.46	-0.45
Max.		1.17	1.12	0.83	0.74	0.95
SE (S_{ij}) ±		0.10	0.07	0.10	0.06	0.04
No. of significant crosses		39	39	34	47	46
No. of +ve significant crosses		24	25	23	24	28
No. of -ve significant crosses		15	14	11	23	19

**, ** Significant at 5 and 1 percent levels, respectively*

Out of 66 crosses, 24, 25, 23, 24 and 28 crosses exhibited significant and positive (desirable) SCA effects in E_1, E_2, E_3, E_4 and in PEVs, respectively for seed yield per plant. The highest significant and positive SCA effect was observed by Indira × ILS 264 1.17 E_1, 1.12 in E_2, 0.83 in E_3 and 0.95 in PEVs and 0.74 in E_4 by Dipika × RLC 133 for seed yield per plant (Table 12b). The SCA effects of hybrids in pooled over environments The derived results were in conformity with Mishra et al. [9], Prasad et al. [18], Nirala et al. [10], Shekhar et al. [11] and Mahawar et al. [12].

3.2.10 Oil content

For oil content, among the parents, Kartika (1.26), (1.12), (0.92), (1.06) and (1.09) had maximum significant and positive GCA in E_1, E_2, E_3, E_4 and PEVs, respectively, other parents with significant and positive GCA effects were ILS 264, Dipika, RLC 133 and Indira [19-25]. Hence, they were registered as good general combiners for oil content (Table 13a). Remaining parents, had significant and negative GCA effects GS 384, IPI 10, KB 9610 and K 29 in all environments [26-32]. Hence, they were registered as poor general combiners for total oil content [33-40].

Out of 66 crosses, 16, 13, 13, 14 and 23 crosses exhibited significant and positive SCA effects in E_1, E_2, E_3, E_4 and in PEVs, respectively (Table 13b). The high significant and positive SCA effect was observed 2.09 (Shekhar × GS 384) in E_1, 2.00 (Shekhar × GS 384) in E_2, 2.04 (Shekhar × GS 384) in E_3, 2.59 (KB 9610 × ILS 264) in E_4 and 1.90 (Shekhar × GS 384) in PEVs for oil content [41-46]. Similar finding in accordance to the above result has also been reported by Kumar et al. [16], Srivastava et al. [7], Ratnaparkhi et al. [14], Shekhar et al. [11] and Mahawar et al. [12].

Table 13a. General combining ability effects for oil content under different environments

S.N.	Parents	E_1	E_2	E_3	E_4	Pooled
1	Indira	0.39**	0.36**	0.67**	0.55**	0.49**
2	Gaurav	-0.11	0.14	0.03	-0.35**	-0.07
3	Dipika	0.52**	0.59**	0.43**	0.64**	0.54**
4	Shekhar	-0.34**	-0.40**	-0.15	-0.02	-0.22**
5	KB 9610	-0.78**	-0.55**	-0.67**	-0.53**	-0.63**
6	ILS 264	1.13**	0.98**	0.59**	0.63**	0.83**
7	RLC 133	0.46**	0.32*	0.63**	0.45**	0.47**
8	K 29	-0.35**	-0.57**	-0.41**	-0.56**	-0.47**
9	IPI 10	-0.74**	-0.46**	-0.95**	-0.40**	-0.64**
10	GS 384	-1.00**	-1.26**	-1.02**	-0.91**	-1.05**
11	H 45	-0.43**	-0.28*	-0.08	-0.56**	-0.34**
12	Kartika	1.26**	1.12**	0.92**	1.06**	1.09**
SE (g_i) ±		0.13	0.13	0.12	0.13	0.06
Min.		-1.00	-1.26	-1.02	-0.91	-1.05
Max.		1.26	1.12	0.92	1.06	1.09
No. of Significant parents		11	11	9	11	11
No. of Significant +ve parents		5	5	5	5	5
No. of Significant -ve parents		6	6	4	6	6

**, ** Significant at 5 and 1 percent levels, respectively*

Table 13b. Specific combining ability effects for oil content under different environments

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
1	Indira x Gaurav	1.03*	1.12*	1.17**	0.20	0.88**
2	Indira x Dipika	1.10	0.16	0.05	-0.16	0.29
3	Indira x Shekhar	0.39	0.02	0.22	-0.03	0.15
4	Indira x KB 9610	0.17	0.37	0.41*	-0.95*	0.00
5	Indira x ILS 264	0.69	1.24**	0.49	0.62	0.76**
6	Indira x RLC 133	-0.04	0.52	0.31	1.16*	0.49*
7	Indira x K29	-0.62	-0.29	0.32	-1.26**	-0.46*
8	Indira x IPI 10	-1.07*	-2.42**	-0.67	-1.15*	-1.33**
9	Indira x GS 384	-1.57**	-1.95**	-2.18**	-1.24**	-1.73**
10	Indira x H 45	-1.84**	-2.02**	-2.45**	-0.86	-1.79**
11	Indira x Kartika	-0.78	0.06	-0.22	-0.88	-0.46*
12	Gaurav x Dipika	-0.60	-0.64	-0.19	0.38	-0.26
13	Gaurav x Shekhar	-0.83	-0.91	0.25	0.50	-0.25
14	Gaurav x KB 9610	0.79	1.03*	1.44**	1.38**	1.16**
15	Gaurav x ILS 264	0.24	-0.01	-0.08	0.02	0.04
16	Gaurav x RLC 133	-0.59	0.91	0.28	0.83	0.36
17	Gaurav x K 29	-0.55	-0.15	0.02	-0.02	-0.18
18	Gaurav x IPI 10	-1.97**	-2.05**	-0.87	-1.49**	-1.59**
19	Gaurav x GS 384	1.39**	0.45	-0.11	0.30	0.51
20	Gaurav x H 45	0.21	1.20*	0.39	1.18*	0.74**
21	Gaurav x Kartika	0.52	0.13	0.08	-1.81**	-0.27
22	Dipika x Shekhar	1.74**	0.73	1.59**	0.57	1.16**
23	Dipika x KB 9610	0.53	0.60	0.61	0.49	0.56*
24	Dipika x ILS 264	0.48	0.88	0.92*	0.33	0.65**
25	Dipika x RLC 133	-2.48**	-2.06**	-2.29**	-1.53**	-2.09**
26	Dipika x K 29	-2.36**	-3.18**	-1.91**	-2.02**	-2.37**
27	Dipika x IPI 10	1.15*	0.35	0.80	1.22*	0.88**
28	Dipika x GS 384	0.47	0.93	1.40**	1.47**	1.07**
29	Dipika x H 45	-2.66*	-1.65**	-1.44**	-1.85**	-1.90**
30	Dipika x Kartika	-0.75	0.43	-0.58	-0.21	-0.28
31	Shekhar x KB 9610	-1.22**	-0.88	-1.48**	-1.26**	-1.21**

S.N.	Crosses	E_1	E_2	E_3	E_4	Pooled
32	Shekhar x ILS 264	-0.51	-0.44	-0.37	-0.99*	-0.58*
33	Shekhar x RLC 133	1.88**	1.16*	1.46**	-0.84	0.91**
34	Shekhar x K 29	-1.23**	-1.03*	-0.83	-1.13*	-1.06**
35	Shekhar x IPI 10	-0.56	-0.70	-1.16**	-1.23*	-0.91**
36	Shekhar x GS 384	2.09**	2.00**	2.04**	1.46**	1.90**
37	Shekhar x H 45	-0.11	1.04*	-0.90*	-0.99*	-0.24
38	Shekhar x Kartika	-0.09	-0.03	0.86	0.55	0.32
39	KB 9610 x ILS 264	1.51**	1.04*	1.09**	2.59**	1.56**
40	KB 9610 x RLC 133	-0.47	-0.29	0.31	-0.29	-0.19
41	KB 9610 x K 29	-1.00*	-0.38	0.06	-1.25**	-0.64**
42	KB 9610 x IPI 10	1.27**	1.25**	0.96*	-0.01	0.87**
43	KB 9610 x GS 384	-1.98**	-1.85**	-1.64**	-0.79	-1.57**
44	KB 9610 x H 45	-1.52**	-1.51**	-1.78**	-1.35**	-1.54**
45	KB 9610 x Kartika	-0.95*	-1.01*	-0.92*	-1.00*	-0.97**
46	ILS 264 x RLC 133	1.11*	0.74	0.62	1.31**	0.95**
47	ILS 264 x K 29	-0.87	-1.17*	0.80	1.13*	-0.03
48	ILS 264 x IPI 10	-0.56	-0.74	-1.23**	-1.14*	-0.92**
49	ILS 264 x GS 384	-0.12	-0.30	0.04	-0.69	-0.27
50	ILS 264 x H 45	0.25	-0.57	-0.07	-0.64	-0.26
51	ILS 264 x Kartika	-0.59	-0.67	-0.67	-2.20**	-1.03**
52	RLC 133 x K 29	1.86**	1.67**	1.42**	1.27**	1.56**
53	RLC 133 x IPI 10	-0.81	0.08	-0.77	-1.53**	-0.76**
54	RLC 133 x GS 384	-2.04**	-1.20*	-1.67**	-1.51**	-1.61**
55	RLC 133 x H 45	0.75	0.81	-0.75	-0.46	0.09
56	RLC 133 x Kartika	-1.06*	-0.54	0.32	0.28	-0.25
57	K 29 x IPI 10	-0.37	0.49	-0.22	-2.51**	-0.65**
58	K 29 x GS 384	-0.53	-0.57	-1.16**	-1.16*	-0.86**
59	K 29 x H 45	1.01*	-0.54	0.001	0.79	0.31
60	K 29 x Kartika	1.05*	0.78	-0.37	0.93	0.60*
61	IPI 10 x GS 384	0.73	0.43	0.08	0.74	0.49*
62	IPI 10 x H 45	-1.08*	1.64**	1.64**	1.82**	1.01**
63	IPI 10 x Kartika	1.29**	0.42	0.94*	2.10**	1.19**
64	GS 384 x H 45	1.27**	1.86**	1.57**	1.94**	1.66**
65	GS 384 x Kartika	0.95*	0.70	0.83	0.45	0.73**
66	H 45 x Kartika	2.00**	1.02*	0.40	1.19**	1.15**
Min.		-2.66	-3.18	-2.45	-2.51	-2.37
Max.		2.09	2.00	2.04	2.59	1.90
SE (S_{ij}) ±		0.46	0.48	0.45	0.49	0.24
No. of significant crosses		32	26	27	37	46
No. of +ve significant crosses		16	13	13	14	23
No. of -ve significant crosses		16	13	14	23	23

**, ** Significant at 5 and 1 percent levels, respectively*

4. CONCLUSIONS

The results of GCA effect of parents for different characters for pooled over the environments shows that for the character seed yield per plant, parents Shekhar, GS 384, KB 9610 and K 29 were good general combiners and they were also good general combiners for test weight and capsules per plant and number of seeds per capsules. Among the parents, RLC 133, KB 9610, K 29, H 45 and IPI 10 were good general combiners early flowering and maturity. Genotype IPI 10 was good general combiners for early flowering, maturity, plant height, number of primary branches, secondary branches per plant and number of capsules per plant but poor combiners for test weight, seed yield per plant and oil content. Genotypes Shekhar and GS 384 were good general combiners for seed yield per plant and its contributing traits viz., number of capsules per plant, number of seeds per capsules and test weight. Indira is poor combiners of all traits except oil content. Therefore, above superior parents will be used for improvement of seed yield and component traits.

Among the 66 F1s, top three crosses were Indira × ILS 264, Gaurav × H 45 and RLC 133 × Kartika on pooled basis for seed yield per plant. These crosses had both the poor general combiners parents which indicated that there is no relationship between sca effects of hybrids and gca effects of their parents, and non-additive variance resulting from dominance and pseudo dominance (d × d) might having prepondend. These crosses were also noted significant sca effects for yield contributing traits like test weight, seeds per capsules, capsules per plant etc. Crosses IPI 10 × GS 384, Gaurav × Shekhar shows desirable SCA effects for early flowering. Cross Indira × ILS 264 was good specific combiner for large number of characters across the environments. None the hybrids showed a desirable sca effects for all the traits. The cross Indira × GS 384 was good specific combiner for days to 50 % flowering, primary branches per plant and test weight. Another cross Dipika × RLC 133 was good combiner for seed yield, seeds per capsules.

From the above findings, Shekhar × H 45, Shekhar × GS 384, KB 9610 × H 45, Indira × ILS 264, Gaurav × H 45 and RLC 133 × Shekhar showed high mean value, heterosis, sca effect and stability. These aforesaid hybrids should be tested in multilocation trials in the future breeding program and advanced the segregating material for identification of desirable segregants for development of agronomically sound varieties for seed yield with better quality.

In addition to its traditional industrial uses in the production of linoleum and paints and varnishes, linseed has the potential to become a platform crop for even more powerful drying gents, antioxidants, and high performance fibers. linseed oil has the potential to be part of a growing specialty oils market that could drive a substantial increase in production of the crop. To compete for the potentially large modified oils markets, however, linseed must overcome major challenges. Although the crop is amenable to genetic transformation, it has yet to benefit, like other oilseeds crops have, from enhanced agronomic traits such as herbicide-resistance, enhanced yield from hybrid breeding and increased breeding efficiency from the routine use of marker-assisted breeding for trait development.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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