

Combining ability analysis over environments for seed yield and its attributing traits in linseed (*Linum usitatissimum* L.)

ABSTARCT

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 its attributing traits in linseed (*Linum usitatissimum* L.). Among the all four environments, E₁ had higher mean value for seed yield per plant and all other important yield contributing traits indicating sowing in second 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 parents *viz.*, parents IPI 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.

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 (Hedge 1999). 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 (NFSM oilseed 2021-22 Annual Report). 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. 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 (Dilman, 1928). 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 (Getinet and Nigussie, 1997) 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 (Anonymous, 2020). 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.

MATERIALS AND METHODS

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. 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) of Griffing (1956). 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:

$$\text{Sum of square for GCA: } S_g = \frac{1}{P+2} \left[\sum_{i=1}^P (X_{i.} + X_{.ii})^2 - \frac{4}{P} X^2 \right]$$

$$\text{Sum of squares for SCA: } S_s = \sum_{i \leq j} \sum_j X^2_{ij} - \frac{1}{P+2} \sum_i (X_{i.} + X_{.ii})^2 + \frac{2}{(P+1)(P+2)} X^2$$

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

$X_{i.} + X_{.ii}$ = Total of i^{th} array + mean value of parent i

$X_{.j} + X_{.jj}$ = 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:

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

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

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

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

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

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.

$$t(GCA) = \frac{g_i - 0}{S.E.g_i} \quad t(SCA) = \frac{s_{ij} - 0}{S.E.s_{ij}}$$

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 programme

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

Result and discussion

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 E₄. 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 variance due 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 E₁ and E₃, 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 $\sigma^2 D$ 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.* (2004), Singh *et al.* (2009), Mishra *et al.* (2013), Nirala *et al.* (2018), Shekhar *et al.* (2019) and Mahawar *et al.* (2021).

In pooled analysis over environments mean squares due to environments, GCA and SCA were significant for all the characters revealed varied environments, differences among parents for GCA and differences among crosses for SCA. Similarly, mean squares due to GCA \times E and SCA \times E were significant for all the characters except for GCA \times 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 \times E interaction component was higher than their respective GCA \times 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 finding in accordance to the above result has also been reported by Singh *et al.* (2009), Mohammadi *et al.* (2010), Nirala *et al.* (2018), Shekhar *et al.* (2019) and Mahawar *et al.* (2021).

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

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					
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}	$\frac{\sigma^2_{gca}}{\sigma^2_{sca}}$	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

ESTIMATION OF 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 3a to Table 12b. The salient features of the results of general combining ability effects and specific combining ability (SCA) effects for different characters are given below:

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 parents *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. Parents *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 per cent flowering.

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 \times IPI 10) in E_1 , -5.45 (Indira \times GS 384) in E_2 , -5.21 (Indira \times GS 384) and -4.00 (RLC 133 \times K 29) in E_3 , -4.90 (Indira \times GS 384) in E_4 and -4.30 (Indira \times GS 384) in PEVs for days to 50 per cent flowering. Whereas, cross IPI 10 \times GS 384 [E_2 : 4.12, E_3 : 7.26 E_4 : 5.45 and PEVs: 5.24] and Dipika \times 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.* (2010), Mishra *et al.* (2013), Nirala *et al.* (2018), Shekhar *et al.* (2019) and Mahawar *et al.* (2021).

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 \times RLC 133) in E_1 , -3.85 (Gaurav \times GS 384) in E_2 , -6.25 (Gaurav \times GS 384) in E_3 , -6.78 (K 29 \times H 45) in E_4 and -4.41 (K 29 \times H 45) in PEVs for days to maturity (Table 5b). Similar finding in accordance to the above result has also been reported by Srivastava *et al.* (2004), Ratnaparkhi *et al.* (2005) Singh *et al.* (2009), Shekhar *et al.* (2019) and Mahawar *et al.* (2021).

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. Consequently, these hybrids

were good specific combiner for plant height. The cross -4.08 (Indira × IPI 10) in E₁; -2.61 (KB 9610 × K 29) in E₂; -4.56 (Gaurav × K 29) in E₃; -3.65 (Dipika × RLC 133) in E₄ 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 E₁, 2.75 (RLC 133 × IPI 10) in E₂, 6.08 (KB 9610 × ILS 264 & H 45 × Kartika) in E₃, 5.54 (ILS 264 × RLC 133 in E₄ 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 with Khan *et al.* (1999), Kumar *et al.* (2000), Ratnaparkhi *et al.* (2005), Singh *et al.* (2009), Mohammadi *et al.* (2010), Mishra *et al.* (2013) and Mahawar *et al.* (2021).

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 E₁, E₂, E₃ 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 F₁s exhibited significant and positive SCA effects in E₁, E₂, E₃, E₄ 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 E₁, 0.58 (Gaurav × K 29) in E₂, 0.85 (Gaurav × K 29) in E₃, 0.31 (K 29 × H 45) in E₄ and 0.53 (Gaurav × K 29) in PEVs suggesting good specific combiners. These results are similar to the findings of Bhatia *et al.* (2006), Singh *et al.* (2009), Mishra *et al.* (2013), Prasad *et al.* (2018), Nirala *et al.* (2018) and Mahawar *et al.* (2021).

Number of secondary branches per plant

GCA effects was significant and positive for Gaurav in E₁ (1.17), E₂ (1.93), E₃ (1.09), (1.31) in E₄ and PEVs (1.37); Shekhar E₁ (1.01), E₂ (0.55), E₃ (0.61), (0.78) in E₄ and PEVs (0.73) and IPI 10 in E₁ (0.80), E₂ (0.97), E₃ (0.039), (1.14) in E₄ and PEVs (0.82) (Table 8a). Hence, they were registered as good general combiners. Parents *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 (E₃ and E₄), Dipika (E₃), ILS 264 (E₃), K 29 (E₁ and E₂) and Kartika

(E₃) 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 E₁, E₂, E₃, E₄ 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 E₁, 3.64 (Shekhar × KB 9610) in E₂, 2.60 (K 29 × IPI 10) in E₃, 2.86 (Gaurav × K 29) in E₄ and 1.94 (Gaurav × Shekhar) in PEVs. The results were corroborative to the reports of Srivastava *et al.* (2004), Mishra *et al.* (2013), Prasad *et al.* (2018), Shekhar *et al.* (2019) and Mahawar *et al.* (2021).

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 E₁; IPI 10 (5.30), GS 384 (3.18) and Shekhar (3.83) in E₂; IPI 10 (4.39), GS 384 (2.79), Shekhar (3.11) and KB 9610 (0.50) in E₃; IPI 10 (5.04), GS 384 (3.36) and Shekhar (2.72) in E₄ 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 F₁s noted *i.e.*, seven crosses in E₁, 16 in E₂, 13 in E₃, 20 in E₄ 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 E₁, 4.11 (RLC 133 × IPI 10) in E₂, 6.51 (ILS 264 × GS 384) in E₃, 6.69 (KB 9610 × K 29) in E₄ and 4.93 (RLC 133 × IPI 10) in PEVs for number of capsules per plant indicating good specific combiners for this trait. Similar finding to the one reported in present condition have also been reported by Mohammadi *et al.* (2010), Mishra *et al.* (2013), Prasad *et al.* (2018), Shekhar *et al.* (2019) and Mahawar *et al.* (2021).

Number of seeds per capsules

Out of twelve parents, seven parents recorded positive GCA effects in pooled over environments. Parent Kartika (0.31 in E₁, 0.26 in E₂, 0.31 in E₃, 0.38 in E₄ 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 [E₁: 0.23, E₂: 0.17, E₃: 0.16, E₄: 0.22 and PEVs: 0.19]; Gaurav [E₁: 0.15, E₂: 0.15, E₃: 0.16, E₄: 0.15 and PEVs: 0.15], H 45 [E₁: 0.13, E₂: 0.06, E₃: 0.13, E₄: 0.21 and PEVs: 0.13]; Dipika [E₁: 0.06, E₂: 0.14 and PEVs: 0.03]; Shekhar [E₁: 0.04, E₂: 0.06, E₄: 0.06 and PEVs: 0.05] and GS 384 [E₄: 0.05]. Hence, they were registered as good general combiners for seeds per capsules. Among the remaining parents, GCA effects was 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 F₁s, 16, 17, 18, 22 and 23 crosses exhibited significant and positive SCA effects in E₁, E₂, E₃, E₄ and PEVs, respectively (Table 10b). The maximum significant and positive SCA effect was observed by Dipika × RLC 133 (0.42) in E₁, Gaurav × KB 9610 (0.43) in E₂, Gaurav × KB 9610 (0.35) in E₃, Indira × IPI 10 (0.50) in E₄ 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.* (1999), Srivastava *et al.* (2004), Ratnaparkhi *et al.* (2005), Bhateria *et al.* (2006), Mishra *et al.* (2013) and Mahawar *et al.* (2021).

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 [E₁: 0.79, E₂: 0.74, E₃: 0.75, E₄: 0.63 in and PEVs: 0.73]; K 29 [E₁: 0.72, E₂: 0.66, E₃: 0.65, E₄: 0.66 in and PEVs: 0.67]; Shekhar [E₁: 0.62, E₂: 0.57, E₃: 0.58, E₄: 0.49 in and PEVs: 0.56]; and GS 384 [E₁: 0.44, E₂: 0.49, E₃: 0.53, E₄: 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 E₁, 28 crosses in E₂, 21 crosses in E₃, 25 crosses in E₄ and 28 in PEVs exhibited significant and positive (desirable) SCA effects. Cross Indira × ILS 264 noted highest, significant and positive SCA effect in E₁ (1.84), E₂ (1.88), E₃ (1.61), E₄ (1.67) and PEVs (1.75) and cross Dipika × RLC 133 in E₄ (1.71) for test weight (Table 11b). Similar finding in accordance to the above result has also been reported by Khan *et al.* (1999), Srivastava *et al.*

(2004), Singh *et al.* (2009), Mohammadi *et al.* (2010), Mishra *et al.* (2013), Prasad *et al.* (2014) and Mahawar *et al.* (2021).

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 E₁; Shekhar (0.59), GS 384 (0.48) and K 29 (0.06) in E₂; Shekhar (0.52), GS 384 (0.46) and K 29 (0.13) in E₃; Shekhar (0.40), GS 384 (0.42) and K 29 (0.10) in E₄ 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 E₄ (0.04) was good general combiners in particular environments opposite to that parent Gaurav in E₄ (-0.07) and PEVs (-0.03) was a poor specific combiner in particular environments (Table 12a). Figure 4.4 depicts the GCA effects of parents in pooled over environments.

Out of 66 crosses, 24, 25, 23, 24 and 28 crosses exhibited significant and positive (desirable) SCA effects in E₁, E₂, E₃, E₄ and in PEVs, respectively for seed yield per plant. The highest significant and positive SCA effect was observed by Indira × ILS 264 1.17 E₁, 1.12 in E₂, 0.83 in E₃ and 0.95 in PEVs and 0.74 in E₄ by Dipika × RLC 133 for seed yield per plant (Table 12b). Figure 4.5 shows the SCA effects of hybrids in pooled over environments The derived results were in conformity with Mishra *et al.* (2013), Prasad *et al.* (2014), Nirala *et al.* (2018), Shekhar *et al.* (2019) and Mahawar *et al.* (2021).

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 E₁, E₂, E₃, E₄ and PEVs, respectively, other parents with significant and positive GCA effects were ILS 264, Dipika, RLC 133 and Indira. 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. Hence, they were registered as poor general combiners for total oil content.

Out of 66 crosses, 16, 13, 13, 14 and 23 crosses exhibited significant and positive SCA effects in E₁, E₂, E₃, E₄ and in PEVs, respectively (Table 13b). The high significant and positive

SCA effect was observed 2.09 (Shekhar × GS 384) in E₁, 2.00 (Shekhar × GS 384) in E₂, 2.04 (Shekhar × GS 384) in E₃, 2.59 (KB 9610 × ILS 264) in E₄ and 1.90 (Shekhar × GS 384) in PEVs for oil content. Similar finding in accordance to the above result has also been reported by Kumar *et al.* (2000), Srivastava *et al.* (2004), Ratnaparkhi *et al.* (2005), Shekhar *et al.* (2019) and Mahawar *et al.* (2021).

CONCLUSIONS

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 (Table 4.5.2.12). 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.

Table 4a Estimates of general combining ability effects for days to 50 % flowering

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 Estimates of specific combining ability effects for days to 50 % flowering

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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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**
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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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 Estimates of general combining ability effects for days to maturity

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**
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 Estimates of specific combining ability effects for days to maturity

S.N.	Crosses	E₁	E₂	E₃	E₄	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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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**
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

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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 Estimates of general combining ability effects for plant height

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 Estimates of specific combining ability effects for plant height

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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
54	RLC 133 x GS 384	0.59	0.58	3.56**	3.35**	2.02**
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 Estimates of general combining ability effects for number of primary branches per plant

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 Estimates of specific combining ability effects for number of primary branches per plant

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*
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*

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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**
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. Estimates of general combining ability effects for number of secondary branches per plant

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 Estimates of specific combining ability effects for number of secondary branches per plant

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**
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*

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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 Estimates of general combining ability effects for number of capsules per plant

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

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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
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

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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 Estimates of general combining ability effects for number of seeds per capsules

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**
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 Estimates of specific combining ability effects for number of seeds per capsules

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

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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**
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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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

Table 11a Estimates of general combining ability effects for test weight

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 Estimates of specific combining ability effects for test weight

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**
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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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 Estimates of general combining ability effects for seed yield per plant

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**
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 Estimates of specific combining ability effects for seed yield per plant

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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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**
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

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
	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

Table 13a Estimates of general combining ability effects for oil content

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 13 Estimates of specific combining ability effects for oil content

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**
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**

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
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

S.N.	Crosses	E ₁	E ₂	E ₃	E ₄	Pooled
	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**

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