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

Abstract

A complete set of 79 entries comprising of twelve parents, their 66 F_1s 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 Heterosis analysis over environments for seed yield and its 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 indicating sowing in second fortnight at Dahod conditions best for linseed cultivation. The hybrids *viz.*, Indira × ILS 264, RLC 133 × Kartika, H 45 × Kartika, IPI 10 × H 45 and IPI 10 × Kartika depicted higher better parent heterosis (HB) and Shekhar × GS 384 and Shekhar × H 45 noted significant standard heterosis for seed yield per plant and other traits. Parental lines, Shekhar, GS 384, H 45, KB 961, IPI 10 and Kartika yielded superior heterotic crosses for seed yield and its component characters. The heterotic effect for seed yield per plant was found to be associated with heterosis for its related traits in the majority of the crosses. High standard heterosis and heterobeltiosis for seed yield per plant and its component characters suggested ample scope of exploiting heterosis commercially. The magnitude of heterosis provides information on the extent of genetic diversity in parents of a cross and helps in choosing the parents for superior F_1's, and to exploit hybrid vigour.

Keywords: *Linum usitatissimum, hybrids, Heterosis analysis, biodiesel production*

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 and 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 F_1s and one check RLC-92 (Table 1) 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 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 phenomenon of heterosis has provided the most important genetic tools for improving yield of crop plants. Identification of specific parental combination capable of producing the highest level of heterotic effects in F_1 has immense value for commercial exploitation of heterosis. The magnitude of heterosis provides information on the extent of genetic diversity in parents of a cross and helps in choosing the parents for superior F_1's, and to exploit hybrid vigour.

According to modern concept, heterosis is expression of joint effect of favorable genes, interaction between alleles, non-allelic interaction and mitochondrial genes brought together from the parents. The heterobeltiosis expressed as per cent superiority of cross over better parent value, whereas economic heterosis as check variety for character under reference, decides whether an experimental hybrid is worth exploiting or not. In general, the magnitude of heterosis for different characters varied in degree and direction with cross to cross.

Estimation of Heterosis

Heterosis was estimated in terms of two parameters *i.e.*,

Heterobeltiosis (HB)

Heterosis expressed as per cent deviation towards better parent in respect to desirable direction was worked out as per Fonseca and Patterson (1968).

$$\text{Heterobeltiosis (\%)} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

Where, $\overline{F_1}$ = Mean performance of F_1 hybrid

$\overline{BP}$ = Mean performance of better parent in desired direction

Standard Heterosis (SH)

Heterosis expressed as per cent increase or decrease in hybrid (F_1) over standard check (SC) values in the desirable direction was worked out as per Meredith and Bridge (1972).

$$SH\ (\%) = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$$

Where, $\overline{F_1}$ = Mean performance of F_1 hybrid

$\overline{SC}$ = Mean performance of standard check

Test of significance

The test of significance for standard heterosis and heterobeltiosis was carried out following "t" test as under.

$$t = \frac{\overline{F}_1 - \overline{SC}}{SE(\overline{F}_1 - \overline{SC})} \text{ for standard heterosis}$$

$$t = \frac{\overline{F}_1 - \overline{BP}}{SE(\overline{F}_1 - \overline{BP})} \text{ for heterobeltiosis}$$

Where,

$SE\left(\overline{F}_1 - \overline{SC}\right) = \left[\frac{2\ MSe}{r}\right]^{0.5}$ for individual environment

$SE\ S = \left[\frac{2\ MSe}{r}\right]^{0.5}$ for individual environment and

MSe = Error mean square

r = Number of replications

e = Number of environments

The calculated values were compared with the value of 1.96 (5% level) and 2.58 (1% level) for 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

Days to 50% Flowering

In linseed, earliness in flowering is desirable trait. The perusal of data revealed that out of 66 crosses, significant 32 hybrids in E_1; 39 hybrids in E_2; 33 hybrids in E_3 and 34 hybrids in E_4, had significant negative heterosis (Table 2). The range of heterobeltiosis for flowering was -16.67 % (Gaurav × H 45) to 8.39 % (IPI 10 × GS 384) in E_1; -15.87 % (Gaurav × KB 9610 & Shekhar × RLC 133) to 7.27 % (IPI 10 × GS 384) in E_2; -18.63 % (Gaurav × KB 9610) to 17.47

% (IPI 10 × GS 384) in E_3 and -15.94 % (Gaurav × KB 9610) to 13.14 % (IPI 10 × GS 384) in E_4. The highest magnitude of heterobeltiosis in desirable direction *i.e.*, early flowering was estimated by the cross Gaurav × H 45 (-16.67 %) in E_1, cross Gaurav × KB 9610 & Shekhar × RLC 133 (-15.87) in E_2, by Gaurav × KB 9610 (-18.63 %) in E_3 and E_4 (-15.94 %). Likewise, highest magnitude of heterobeltiosis for late flowering was estimated by cross IPI 10 × GS 384 in all four environments *i.e.*, 8.39 %, 7.27 %, 17.47 % and 13.14 % in E_1, E_2, E_3 and E_4, respectively.

The negative and significance economic heterosis over standard check (RLC 92) were noted by 15, 42, 26 and 36 hybrids in E_1, E_2, E_3 and E_4, respectively, in desirable (negative) direction. The range of standard heterosis was -9.43 % (KB 9610 × K 29) to 14.47 % (Indira × Shekhar) in E_1, -16.09 % (RLC133 × H 45) to 10.34 % (Indira × Shekhar) in E_2, -16.29 (RLC 133 × K 29) % to 11.8 % (Indira × Shekhar) in E_3 and -14.29 (RLC 133 × H 45) % to 8.47 % (Indira × Shekhar) in E_4. These results are in confirmation with by Sharma *et al*. (2005), Ahmad *et al.* (2018), Chaure *et al*. (2018), Yadav *et al*. (2018) and Mahto *et al*. (2020).

Days to Maturity

Out of 66 crosses, negative and desirable heterobeltiosis was observed in 27 hybrids in E_1; 35 hybrids in E_2; 29 hybrids in E_3 and 27 hybrids in E_4. Also, positive and significant heterobeltiosis was observed in 5, 11, 17 and 16. E_1, E_2, E_3, and E_4, respectively (Table 3).

The minimum and maximum heterobeltiosis for days to maturity was noted by Gaurav × RLC 133 (-8.99 %) and RLC 133 × GS 384 (3.23 %) in E_1; ILS 264 × IPI 10 (-8.15 %) and Dipika × GS 384 (4.05 %) in E_2; ILS 264 × IPI 10 (-10.38 %) and RLC 133 × GS 384 (6.42 %) in E_3 and ILS 264 × IPI 10 (-8.4 %) and RLC 133 × GS 384 (6.21 %) in E_4 respectively.

Majority of crosses exhibited undesired standard heterosis. Total four, nine, sixteen and seven hybrids manifested significant and negative standard heterosis in E_1, E_2, E_3 and E_4 respectively while, significant and positive standard heterosis manifested by 25, 24, 28 and 40 hybrids in E_1, E_2, E_3 and E_4 respectively. A cross Gaurav × ILS 264 depicted significant highest positive SH 7.81 %, 9.34 %, 9.65 % and 9.57 % in E_1, E_2, E_3 and E_4, respectively. Hybrid IPI 10 × H 45 have been found significant least negative standard heterosis in E_1 (-4.06 %) and E_2 (-4.52 %), IPI 10 × Kartika in E_3 (-5.85 %) in E_3 and RLC 133 × IPI 10 & IPI 10 × GS 384 in E_4 (-4.35 %). Similar results were also reported by Sharma *et al*. (2005), Reddy *et al*. (2013), Pali and Mehta (2014), Ahmad *et al.* (2018) and Yadav *et al*. (2018)

Plant Height

Most of the crosses depicted significant and negative better parent heterosis in all environments among significant F_1s. Out of 66 crosses, significant heterobeltiosis for 19 hybrids in E_1; 18 hybrids in E_2; 42 hybrids in E_3 and 29 hybrids in E_4. Out of which 18 hybrids exhibited significant and negative better parent heterosis in E_1, 14 hybrids in E_2, 33 hybrids in E_3 and 24 hybrids in E_4 (Table 4). The range of better parent heterosis for plant height at different environment was from -14.51 % (Indira × IPI 10) to 6.82 % (ILS 264 × H 45) in E_1, -10.71 % (Gaurav × IPI 10) to 5.42 % (RLC 133 × K 29 & RLC 133 × IPI 10) in E_2, -15.08 % (Gaurav × IPI 10) to 17.07 % (H 45 × Kartika) in E_3 and -13.11 % (Gaurav × IPI 10) to 9.55 % (RLC 133 × H 45 & H 45 × Kartika) in E_4.

Similarly, only two hybrids recorded significant and desired (negative) heterosis over check in E_1 with range of -11.29 (Indira × IPI 10) % to 5.91 % (Indira × Gaurav); 30 hybrids in E_2 with range of -10.67 % (IPI 10 x Kartika) to 8.99 % (Gaurav × RLC 133); 28 hybrids in E_3 with range of -8.47 % (Dipika × ILS 264) to 10.17 % (Indira × Gaurav) and 25 hybrids in E_4 with range of -9.57 % (ILS 264 × IPI 10 & KB 9610 × Kartika) to 6.91 % (ILS 264 × RLC 133). These findings are in conformity with Reddy *et al*. (2013), Pali and Mehta (2014), Ram and Ahmad (2016), Chaure *et al*. (2018), Yadav *et al.* (2018) and Mahto *et al*. (2020).

Number of Primary Branches per Plant

For primary branches per plant, eight F_1s each in E_1 and E_2 and five F_1s in E_3 and zero in E_4 exhibited significant and positive HB. The better parent heterosis varied from -18.23 % (Indira × Shekhar) to 14.19 % (Indira × RLC 133) in E_1, -15.61 % (IPI 10 × Kartika) to 8.33 % (KB 9610 × ILS 264) in E_2, -16.34 % (IPI 10× Kartika) to 10.56 % (Gaurav × K 29) in E_3 and -31.88 % (ILS 264 × K29) to 8.09 % (K 29 × H 45) in E_4 (Table 5).

The highest and lowest economic heterosis for primary branches per plant was 25.16 % (Shekhar × IPI 10) and -4.52 % (Indira × Shekhar); 24.38 % (Shekhar × KB 9610 & Shekhar × IPI 10) and -8.75 % (Indira × Dipika); 30.07 % (Gaurav × K 29 & Shekhar × IPI 10) and -12.42 % (Indira × Dipika) and 11.68 (Gaurav × Shekhar) and -31.39 (ILS 264 × K 29) in E_1, E_2, E_3 and E_4, respectively. Total 61 crosses in E_1, 52 crosses in E_2 and 41 crosses in E_3 were positive and significant. The results are in agreement with findings of Sharma *et al*. (2005), Reddy *et al*. (2013), Singh *et al.* (2014), Yadav *et al*. (2018) and Mahto *et al*. (2020).

Number of Secondary Branches per Plant

The positive heterosis for number of secondary branches per plant is desirable and very

few crosses depicted desirable HB. Out of 66 crosses 11, 5, 32 and 1 crosses showed significant heterobeltiosis, among them, 3, 3, 6 and none of the crosses were found positive in E_1, E_2, E_3 and E_4, respectively (Table 6). Indira × RLC 133 (14.89 %) and GS 384 × H 45 (13.55 %) in E_1; Indira × IPI 10 (13.80 %) and Shekhar × KB 9610 (13.37) in E_2 and Indira × KB 9610 (15.66 %) in E_3 were the top significant heterobeltiotic hybrids. The heterosis over better parent varied from -21.62 % (ILS 264 × IPI 10) to 14.89 % (Indira × RLC 133); -14.11 % (Gaurav × H 45) to 13.80 % (Indira × IPI 10), -20.74 % (Gaurav × GS 384) to 15.66 % (Indira × KB 9610) and -15.46 % (Indira × Shekhar) to 12.34 % (Gaurav × K 29) in E_1, E_2, E_3, and E_4, respectively.

The magnitude of standard heterosis for this trait ranged from -4.93 % (RLC 133 × GS 384) to 31.20 % (Gaurav × Shekhar); -3.97 % (RLC 133 × Kartika & Indira × KB 9610) to 35.41 % (Gaurav × Shekhar); 0.93 % (K 29 × GS 384) to 35.25 % to (Gaurav × Shekhar); and -5.86 % (Indira × K 29) to 31.68 % (Gaurav × K 29) in E_1, E_2, E_3 and E_4, respectively. The results were in correspondence to the findings of Pali and Mehta (2014), Singh *et al.* (2014) and Yadav *et al*. (2018).

Number of Capsules per Plant

Relative number of capsules per plant over better parent heterosis in E_1, E_2, E_3 and E_4 varied from -5.69 % (Gaurav × KB 9610) to 17.95 % (Indira × RLC 133), -9.72 % (Shekhar × RLC 133) to 9.34 % (Indira × K 29), -9.16 % (IPI 10 × H 45) to 16.91 (Dipika × K 29) and -13.62 % (GS 384 × Kartika) to 18.39 % (Dipika × K 29), respectively (Table 7). Total 8, 16, 10 and 17 crosses showed positive and significant heterobeltiosis in E_1, E_2, E_3 and E_4, respectively. Hybrids, Indira × RLC 133 (17.95 %) and RLC 133 × Kartika (16.65 %) in E_1; Indira × K 29 (9.34 %) and Indira × RLC 133 (8.69 %) in E_2; Dipika × K 29 (16.91 %) in E_3 and Dipika × K 29 (18.39 %) in E_4 were noted the best significant heterobeltiotic hybrids for average number of capsules per plant.

Many hybrids noted desired economic heterosis. Total 39, 34, 35 and 44 crosses showed positive and significant standard heterosis. The minimum and maximum standard heterosis noted -2.01 % (Indira × H 45) and 18.63 % (RLC 133 × IPI 10); -5.64 % (RLC 133 × K 29) and 17.03 % (Shekhar × IPI 10); -7.2 % (ILS 264 × RLC 133) and 20.46 % (KB 9610 × GS 384) and -5.85 % (ILS 264 × RLC 133) and 27.81 % (KB 9610 × IPI 10) in E_1, E_2, E_3 and E_4, respectively. IPI

10 × GS 384 have been found to be best performing hybrids in all environment due to high magnitude of economic heterosis at all locations. These results are similar to the findings of Ratnaparkhi *et al*. (2005), Singh *et al*. (2014), Ram and Ahmad (2016), Ahmad *et al*. (2018), Chaure *et al*. (2018) and Mahto *et al*. (2020).

Number of Seeds per Capsules

Number of seeds per capsules is one of the main yields contributing character who's positive heterosis is desirable for yield improvement in linseed. The highest and lowest heterobeltiosis over better parent observed 2.86 % (Indira × RLC 133) and -8.3 % (Gaurav × Shekhar) in E_1, 3.41 % (Dipika × RLC 133) and -8.46 % (Gaurav × Shekhar) in E_2, 3.21 % (Gaurav × Dipika) and -7.78 % (Shekhar × ILS 264 & KB 9610 × ILS 264) in E_3 and 4.66 % (Indira × IPI 10) and -12.2 % (Indira × Gaurav) in E_4 (Table 8). In case of better parent heterosis estimate of the best hybrids were namely, Indira × RLC 133 (2.86 %) and Shekhar × H 45 (2.66 %) in E_1; Dipika × RLC 133 (3.41 %) and Dipika × Kartika (3.33 %) in E_2; Gaurav × Dipika (3.21 %) in E_3 and Indira × IPI 10 (4.66 %) and Shekhar × RLC 133 (2.87 %) in E_4 which registered significant heterosis over better parent in desirable direction.

Majority of F_1s were poor performer than RC 92. The least performing hybrids for standard heterosis were -13.6 % (Indira × KB 9610); -12.27 % (KB 960 × K 29 & K 29 × IPI 10); -12.45 (KB 9610 × K 29) and -14.86 % (Indira × Dipika) in E_1, E_2, E_3 and E_4, respectively. The best performing hybrids were H 45 × Kartika (5.62 %), Gaurav × H 45 (4.02 %), ILS 264 × Kartika (4.02) and Shekhar × Kartika (3.21 %) in E_4. Similar finding in accordance to the above result has also been reported by Pali and Mehta (2014), Ram and Ahmad (2016), Ahmad *et al.* (2018) and Mahto *et al*. (2020).

Test Weight

Total 8, 38 in E_1, 7, 36 in E_2, 6, 37 in E_3 and 12, 45 in E_4 F_1s exhibit HB and SH, respectively, which indicate majority of hybrids are better than check variety but poorer than their bolder parents. The range heterobeltiosis for test weight varied from -20.38 % (Indira × Shekhar) to 29.77 % (Indira × ILS 264) in E_1, -19.38 % (Indira × Shekhar) to 33.33 % (Indira × ILS 264) in E_2, -21.72 % (Indira × Shekhar) to 30.85 % (Indira × ILS 264) in E_3 and -22.58 % (RLC 133 × GS 384) to 28.57 % (Indira × ILS 264) in E_4 (Table 9).

The crosses Indira × Kartika and KB 9610 × K 29 exhibited minimum and maximum standard heterosis in E_1, E_2 and E_3 (-15.77 % to 23.42 %, -17.81 % to 23.29 % and -17.24 % to 23.15 %, respectively) and in E_4 Indira × Kartika (-11.28 %) and Dipika × RLC 133 (32.21 %). Top hybrids for test weight were KB 9610 × K 29 (23.42 %) and Indira × ILS 264, Shekhar × K 29 & KB 9610 × RLC 133 (19.37 %) in E_1; KB 9610 × K 29 (23.29 %) and Indira × ILS 264 & KB 9610 × RLC 133 (20.55 %) in E_2; KB 9610 × K 29 (23.15 %) and Shekhar × KB 9610 (22.66 %) in E_3 and Dipika × RLC 133 (32.21 %) and Shekhar × K 29 (30.77 %) in E_4 were the top most significant and desirable standard heterotic hybrids for test weight. Similar results were also reported by Singh *et al*. (2014), Ram and Ahmad (2016), Ahmad *et al.* (2018), Chaure *et al*. (2018) and Mahto *et al*. (2020).

Seed Yield Per Plant

In general, equal magnitude of HB observed in both the directions. Seed yield is the most economic important trait for improvement in linseed and plant breeders attempt to evolve varieties/hybrids in regard with high seed yield per plant. Positive heterosis is highly desirable for this character. The heterosis over better parent for seed yield per plant ranged from -21.46 % (Indira × Shekhar) to 33.22 % (Indira × ILS 264); -21.29 % (Indira × Shekhar) to 38.78 % (Indira × ILS 264); -24.55 % (Gaurav × RLC 133) to 28.8 % (Indira × ILS 264) and -25.98 % (Indira × Gaurav) to 39.51 % (Indira × ILS 264) in E_1, E_2, E_3 and E_4, respectively (Table 10). Total 16, 22, 13 and 20 hybrids manifested significant and positive heterobeltiosis in E_1, E_2, E_3 and E_4, respectively. Indira × ILS 264 [(33.22) in E_1, Indira × ILS 264 (38.78) in E_2, (28.8 %) in E_3 and (39.51 %) in E_4] were the top most significant and positive heterobeltiotic hybrids for seed yield per plant. Table 10 represents the heterobeltiosis (HB) of hybrids in pooled over environments.

The magnitude of standard heterosis for seed yield per plant is the important criteria for selection of better performing hybris in compare to the check variety. Range of standard heterosis varied from -19.46 % (Indira × Kartika) to 27.36 % (Shekhar × H 45); -21.18 % (Indira × Kartika) to 25.27 % (Shekhar × H 45); -21.65 % (Indira × Kartika) to 34.36 % (Shekhar × GS 384) and -17.96 % (Indira × H 45) to 47.84 % (KB 9610 × IPI 10) in E1, E2, E3, and E4, respectively. Total 32, 33, 29 and 47 hybrids manifested significant and positive standard heterosis in E1, E2, E3 and E4, respectively. Crosses Shekhar × H 45 (27.36) in E1, and in E2 (25.27 %), Shekhar × GS 384 (34.36 %), in E3 and KB 9610 × IPI 10 (47.84 %) in E4 were the top most significant and desirable standard heterotic hybrids for seed yield per plant. Based on heterosis estimate Shekhar × H 45, KB 9610 × IPI 10 and Shekhar × GS 384 were found to be

best suited heterotic hybrid over location for hybrid vigour improvement pertaining to seed yield per plant. Table 3 represents the standard heterobeltiosis (SH) of hybrids in pooled over environments. The results were corroborative to the reports Singh *et al*. (2014), Ram and Ahmad (2016), Chaure *et al*. (2018), Yadav *et al*. (2018) and Mahto *et al*. (2020).

4.4.10 Oil Content

Oil content is an important qualitative trait, high oil content is considered as a desirable quality character for superior linseed variety. Positive and significant value of oil content is desirable. Heterobeltiosis were reported in between -12.85 % (Dipika × H 45) to 5.92 % (Shekhar × GS 384) in E1; -14.48 % (Dipika × K 29) to 4.26 % (Shekhar × GS 384) in E2; -12.83 % (Indira × GS 384) to 5.51 % (Shekhar × GS 384) in E3 and -12.97 % (K 29 × IPI 10) to 5.57 % (GS 384 × H 45) in E4 (Table 11). Hybrids namely Shekhar × GS 384 (5.92 %) in E1; Shekhar × GS 384 (4.26 %), Gaurav × RLC 133 (4.18 %) and Shekhar × H 45 (4.11 %) in E2; Shekhar × GS 384 (5.51 %) in E3 and GS 384 × H 45 (5.57 %) in E4 were the best heterobeltiotic hybrids for oil content.

Range of standard heterosis reported in between -12.58 % (KB 9610 × GS 384) to 3.97 % (H 45 × Kartika) in E1, -10.87 % (KB 9610 × GS 384) to 4.88 % (Indira × ILS 264) in E2, -13.24 % (KB 9610 × GS 384) to 0.17 % (Dipika × ILS 264 & Shekahr × RLC 133) in E3 and -11.27 % (K 29 × IPI 10) to 5.32 % (IPI 10 × Kartika) in E4. The promising hybrids were H 45 × Kartika (3.97 %) and ILS 264 × RLC 133 (3.63 %) in E1; Indira × ILS 264 (4.88 %) and Dipika × ILS 264 (4.53 %) in E2; IPI 10 × Kartika (5.32 %) and KB 9610 × ILS 264 (5.15 %) in E3 and ILS 264 × RLC 133 (4.35 %) in E4 exhibited significant and positive standard heterosis. The derived results were in conformity with Ratnaparkhi *et al*. (2005), Sharma *et al*. (2005), Pali and Mehta (2014) and Ram and Ahmad (2016).

CONCLUSIONS

The perusal of results of heterotic effects over better parent (HB) and standard check hybrid (SH) for various characters revealed that the estimates and magnitude of various heterotic effects varied with cross combinations and characters. Inconsistent performance of most of the crosses across the environments for various characters suggested that parental genes and their combinations responded differently to environmental variation, which is the general feature of quantitative inheritance.

The results revealed that crosses Indira × ILS 264, RLC 133 × Kartika, H 45 × Kartika, IPI 10 × H 45 and IPI 10 × Kartika depicted higher better parent heterosis (HB) for seed yield per plant in most of the environments. These crosses also depicted desired heterosis for test

weight, number of secondary branches and capsules per plant also indicating these are major yield contributing traits.

For standard heterosis, crosses Shekhar × GS 384, Shekhar × H 45 had higher estimates against standard check (RLC 92) in all environment along with pooled data. This superiority was due to high SH for primary, secondary branches per plant, capsules per plant and test weight. There are some other crosses also which show good SH in two or three environments only. In general, the crosses, which had higher estimates of HB and SH for seed yield also had significant and positive heterotic effects for yield contributing characters like capsules per plant, seeds per capsules and test weight. Therefore, heterotic effects for seed yield per plant could be outcome of direct effects of the above stated component characters and could be outcome of indirect effects of other yield contributing characters.

The crosses Indira × ILS 264, RLC 133 × Kartika, H 45 × Kartika, IPI 10 × H 45 and IPI 10 × Kartika depicted higher better parent heterosis (HB) for seed yield per plant, test weight, number of secondary branches and capsules per plant in most of the environments as well as pooled over environments. The maximum value of standard heterosis for seed yield per plant, secondary branches per plant, capsules per plant and test weight was observed for Shekhar × GS 384 and Shekhar × H 45 in all the environments as well as pooled analysis. Hybrids viz., RLC 133 × K 29, RLC133 × H 45 and RLC 133 × H 45 were the earliest for flowering and maturity. F1s Dipika × RLC 133, Shekhar × K 29 and Shekhar × KB 9610 were highest and significant for test weight. Among the parental genotypes, Shekhar, GS 384, H 45, KB 961, IPI 10 and Kartika yielded superior heterotic crosses for seed yield and its component characters. The heterotic effects of seed yield and its component characters were greatly influenced by environments. Therefore, as a breeding strategy, the promising hybrids should be evaluated over array of environments. High heterosis crosses showed a negative heterosis for oil content. While comparing the per se performance and standard heterosis, rank of top hybrids were same but it changed with heterobeltiosis indicating per se performance used for SH but not for HB.

The crosses Indira × ILS 264, RLC 133 × Kartika, H 45 × Kartika, IPI 10 × H 45 and IPI 10 × Kartika depicted higher better parent heterosis (HB) for seed yield per plant, test weight, number of secondary branches and capsules per plant in most of the environments as well as pooled over environments.

The maximum value of standard heterosis for seed yield per plant was observed for Shekhar × GS 384 and Shekhar × H 45 in all environments and PEVs. The high heterotic response in these hybrids due to substantial heterosis for secondary branches per plant, number of capsules per plant and test weight. Parental lines, Shekhar, GS 384, H 45, KB 961, IPI 10 and Kartika yielded superior heterotic crosses for seed yield and its component characters.

Table 2 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for days to 50 % flowering

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
1	**Indira x Gaurav**	-5.38*	10.69**	-3.7*	4.6**	-6.37**	7.3**	-5.8**	3.17*
2	**Indira x Dipika**	1.19	6.92**	1.11	4.6**	4.86**	8.99**	1.01	5.82**
3	**Indira x Shekhar**	1.68	**14.47****	1.59	**10.34****	2.05	**11.8****	3.54*	**8.47****
4	**Indira x KB 9610**	-5.95*	-0.63	-6.67**	-3.45*	-7.03**	-3.37*	-8.08**	-3.70*
5	**Indira x ILS 264**	-4.76*	0.63	-5.00**	-1.72	-2.70	1.12	-3.03*	1.59
6	**Indira x RLC 133**	-7.74**	-2.52	-7.78**	-4.6**	-5.41**	-1.69	-9.09**	-4.76**
7	**Indira x K29**	-4.76*	0.63	-7.22**	-4.02*	-1.08	2.81	-2.53	2.12
8	**Indira x IPI 10**	-4.17	1.26	-6.67**	-3.45*	-5.41**	-1.69	-6.06**	-1.59
9	**Indira x GS 384**	-4.76*	0.63	-12.22**	-9.2**	-9.73**	-6.18**	-10.61**	-6.35**
10	**Indira x H 45**	-1.79	3.77	-5**	-1.72	1.08	5.06**	-3.03*	1.59
11	**Indira x Kartika**	2.38	8.18**	-1.67	1.72	3.78**	7.87**	0.00	4.76**
12	**Gaurav x Dipika**	-7.53**	8.18**	-5.29**	2.87	-9.31**	3.93**	-4.83**	4.23**
13	**Gaurav x Shekhar**	-8.6**	6.92**	-4.76**	3.45*	-11.76**	1.12	-11.11**	-2.65
14	**Gaurav x KB 9610**	-16.13**	-1.89	**-15.87****	-8.62**	**-18.63****	-6.74**	**-15.94****	-7.94**
15	**Gaurav x ILS 264**	-14.52**	0.00	-10.58**	-2.87	-16.18**	-3.93**	-12.56**	-4.23**
16	**Gaurav x RLC 133**	-13.44**	1.26	-9.52**	-1.72	-11.76**	1.12	-7.25**	1.59
17	**Gaurav x K 29**	-15.05**	-0.63	-12.7**	-5.17**	-11.27**	1.69	-7.25**	1.59
18	**Gaurav x IPI 10**	**-16.67****	-2.52	-12.7**	-5.17**	-14.22**	-1.69	-14.49**	-6.35**
19	**Gaurav x GS 384**	-10.75**	4.4	-6.35**	1.72	-6.86**	6.74**	-4.35**	4.76**
20	**Gaurav x H 45**	**-16.67****	-2.52	-13.76**	-6.32**	-17.65**	-5.62**	-15.94**	-7.94**
21	**Gaurav x Kartika**	-9.14**	6.29*	-4.76**	3.45*	-6.86**	6.74**	-5.8**	3.17*
22	**Dipika x Shekhar**	-5.59*	6.29*	-4.23**	4.02*	-6.15**	2.81	-5.56**	-1.06
23	**Dipika x KB 9610**	-6.79**	-5.03*	-8.09**	-8.62**	-10.38**	-7.87**	-7.94**	-7.94**
24	**Dipika x ILS 264**	1.85	3.77	0.58	0.00	3.28*	6.18**	6.35**	6.35**
25	**Dipika x RLC 133**	-4.94*	-3.14	-7.51**	-8.05**	0.55	3.37*	-7.41**	-7.41**
26	**Dipika x K 29**	-2.47	-0.63	-4.62**	-5.17**	0.00	2.81	-0.53	-0.53
27	**Dipika x IPI 10**	0.62	2.52	-1.16	-1.72	0.00	2.81	1.59	1.59

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
28	**Dipika x GS 384**	-1.85	0.00	-4.05*	-4.6**	-4.37**	-1.69	-4.76**	-4.76**
29	**Dipika x H 45**	6.17*	8.18**	2.31	1.72	3.83**	6.74**	3.17*	3.17*
30	**Dipika x Kartika**	0.62	2.52	-4.62**	-5.17**	-3.28*	-0.56	-3.70*	-3.70*
31	**Shekhar x KB 9610**	-8.38**	3.14	-10.05**	-2.3	-10.77**	-2.25	-10.61**	-6.35**
32	**Shekhar x ILS 264**	-9.5**	1.89	-12.7**	-5.17**	-14.36**	-6.18**	-13.64**	-9.52**
33	**Shekhar x RLC 133**	-12.29**	-1.26	**-15.87****	-8.62**	-10.26**	-1.69	-12.63**	-8.47**
34	**Shekhar x K 29**	-8.94**	2.52	-10.05**	-2.3	-7.69**	1.12	-4.04**	0.53
35	**Shekhar x IPI 10**	-5.03*	6.92**	-7.94**	0.00	-4.10**	5.06**	-2.53	2.12
36	**Shekhar x GS 384**	-4.47*	7.55**	-6.88**	1.15	-1.54	7.87**	-4.55**	0.00
37	**Shekhar x H 45**	-8.94**	2.52	-11.11**	-3.45*	-10.26**	-1.69	-12.12**	-7.94**
38	**Shekhar x Kartika**	-6.15**	5.66*	-6.35**	1.72	0.00	9.55**	-0.51	4.23**
39	**KB 9610 x ILS 264**	-4.38	-3.77	-5.45**	-10.34**	-2.300	-4.49**	-5.52**	-9.52**
40	**KB 9610 x RLC 133**	0.67	-5.66*	4.00*	-10.34**	-2.47	-11.24**	-1.19	-12.17**
41	**KB 9610 x K 29**	-5.88*	**-9.43****	-4.49*	-14.37**	-7.27**	-14.04**	2.98	-8.47**
42	**KB 9610 x IPI 10**	1.34	-5.03*	-2.52	-10.92**	-7.83**	-14.04**	-4.57**	-11.64**
43	**KB 9610 x GS 384**	-1.29	-3.77	0.00	-5.17**	2.47	-6.74**	1.72	-6.35**
44	**KB 9610 x H 45**	2.68	-3.77	6.00**	-8.62**	7.41**	-2.25	8.93**	-3.17*
45	**KB 9610 x Kartika**	4.70	-1.89	5.88**	-6.9**	6.59**	0.00	6.11**	1.06
46	**ILS 264 x RLC 133**	-5.63*	-5.03*	-0.61	-5.75**	-3.45*	-5.62**	-2.76	-6.88**
47	**ILS 264 x K 29**	-6.88**	-6.29*	-1.82	-6.9**	-7.47**	-9.55**	-4.42**	-8.47**
48	**ILS 264 x IPI 10**	-4.38	-3.77	0.00	-5.17**	-5.17**	-7.3**	-1.10	-5.29**
49	**ILS 264 x GS 384**	-3.13	-2.52	1.82	-3.45*	0.00	-2.25	1.66	-2.65
50	**ILS 264 x H 45**	-5.63*	-5.03*	-5.45**	-10.34**	-5.17**	-7.3**	-3.87*	-7.94**
51	**ILS 264 x Kartika**	3.13	3.77	5.45**	0.00	6.32**	3.93**	2.76	-1.59
52	**RLC 133 x K 29**	-4.58	-8.18**	-5.77**	-15.52**	-9.7**	**-16.29****	-2.38	-13.23**
53	**RLC 133 x IPI 10**	0.67	-5.66*	-5.66**	-13.79**	0.00	-6.74**	-2.29	-9.52**
54	**RLC 133 x GS 384**	-5.16*	-7.55**	-6.06**	-10.92**	6.25**	-4.49**	-1.72	-9.52**
55	**RLC 133 x H 45**	-2.03	-8.81**	-2.67	**-16.09****	0.66	-14.04**	-2.99	**-14.29****
56	**RLC 133 x Kartika**	3.42	-5.03*	5.88**	-6.9**	0.00	-6.18**	-1.67	-6.35**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
57	**K 29 x IPI 10**	0.00	-3.77	-1.89	-10.34**	3.61*	-3.37*	4.00*	-3.70*
58	**K 29 x GS 384**	2.58	0.00	0.00	-5.17**	4.85**	-2.81	6.90**	-1.59
59	**K 29 x H 45**	3.27	-0.63	7.05**	-4.02*	9.09**	1.12	12.5**	0.00
60	**K 29 x Kartika**	-1.31	-5.03*	1.92	-8.62**	-0.60	-6.74**	-3.33*	-7.94**
61	**IPI 10 x GS 384**	**8.39****	5.66*	**7.27****	1.72	**17.47****	9.55**	**13.14****	4.76**
62	**IPI 10 x H 45**	0.67	-5.66*	0.63	-8.05**	6.63**	-0.56	4.00*	-3.7*
63	**IPI 10 x Kartika**	2.68	-3.77	5.03**	-4.02*	3.59*	-2.81	-1.11	-5.82**
64	**GS 384 x H 45**	-2.58	-5.03*	-1.82	-6.90**	6.87**	-3.93**	3.45*	-4.76**
65	**GS 384 x Kartika**	4.52	1.89	5.45**	0.00	8.38**	1.69	6.67**	1.59
66	**H 45 x Kartika**	6.76*	-0.63	5.88**	-6.90**	-2.40	-8.43**	-3.33*	-7.94**
Min.		**-16.67**	**-9.43**	**-15.87**	**-16.09**	**-18.63**	**-16.29**	**-15.94**	**-14.29**
Max.		**8.39**	**14.47**	**7.27**	**10.34**	**17.47**	**11.8**	**13.14**	**8.47**
SE (±)		**1.27**		**0.95**		**0.85**		**0.92**	
No. of significant crosses		**35**	**28**	**48**	**48**	**48**	**41**	**46**	**47**
No. of Significant +ve crosses		**3**	**13**	**9**	**6**	**15**	**15**	**12**	**11**
No. of Significant -ve crosses		**32**	**15**	**39**	**42**	**33**	**26**	**34**	**36**

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

Table 3 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for days to maturity

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
1	**Indira x Gaurav**	-5.22**	2.19*	-3.66**	3.01**	-4.12**	2.05**	-5.15**	1.45
2	**Indira x Dipika**	0.00	0.31	-1.50	-1.20	-0.30	-2.05**	-2.01**	-0.87
3	**Indira x Shekhar**	0.88	6.87**	2.05*	5.12**	5.73**	7.89**	4.46**	8.70**
4	**Indira x KB 9610**	2.49*	2.81**	0.90	1.20	2.38**	0.58	1.43	2.61**
5	**Indira x ILS 264**	-1.45	6.25**	-2.25**	4.82**	-5.74**	0.88	-3.25**	3.48**
6	**Indira x RLC 133**	0.31	0.62	-1.80*	-1.51	-0.60	-2.34**	-1.43	-0.29
7	**Indira x K29**	1.83	4.37**	1.46	4.52**	0.00	3.51**	0.00	4.35**
8	**Indira x IPI 10**	-0.31	0.00	-1.80*	-1.51	0.60	-1.17	-0.57	0.58
9	**Indira x GS 384**	0.31	0.62	1.80*	2.11*	2.98**	1.17	1.43	2.61**
10	**Indira x H 45**	0.62	0.94	0.60	0.90	3.87**	2.05**	3.72**	4.93**
11	**Indira x Kartika**	1.53	3.75**	1.77*	3.92**	4.35**	5.26**	3.95**	6.67**
12	**Gaurav x Dipika**	-4.35**	3.13**	-3.66**	3.01**	-2.20**	4.09**	-2.17**	4.64**
13	**Gaurav x Shekhar**	0.00	7.81**	1.41	8.43**	2.47**	9.06**	1.63*	8.70**
14	**Gaurav x KB 9610**	-5.80**	1.56	-3.66**	3.01**	-6.32**	-0.29	-7.05**	-0.58
15	**Gaurav x ILS 264**	0.00	**7.81****	1.97*	**9.34****	2.46**	**9.65****	2.44**	**9.57****
16	**Gaurav x RLC 133**	**-8.99****	-1.88	-7.89**	-1.51	-5.77**	0.29	-5.42**	1.16
17	**Gaurav x K 29**	-2.90**	4.69**	-0.28	6.63**	0.55	7.02**	1.36	8.41**
18	**Gaurav x IPI 10**	-7.54**	-0.31	-6.48**	0.00	-5.49**	0.58	-4.88**	1.74*
19	**Gaurav x GS 384**	-7.25**	0.00	-7.89**	-1.51	-10.16**	-4.39**	-7.32**	-0.87
20	**Gaurav x H 45**	-5.80**	1.56	-5.35**	1.20	-5.49**	0.58	-5.69**	0.87
21	**Gaurav x Kartika**	-2.90**	4.69**	-1.97*	4.82**	-1.92**	4.39**	-4.61**	2.03**
22	**Dipika x Shekhar**	-0.88	5.00**	2.05*	5.12**	4.01**	6.14**	1.39	5.51**
23	**Dipika x KB 9610**	0.63	-0.31	0.31	-1.81*	2.69**	0.58	2.35**	1.16
24	**Dipika x ILS 264**	-2.03*	5.63**	-3.93**	3.01**	-4.10**	2.63**	-2.44**	4.35**
25	**Dipika x RLC 133**	0.32	-0.63	1.87*	-1.51	-2.39**	-4.39**	0.59	-0.58
26	**Dipika x K 29**	-1.83	0.62	-4.39**	-1.51	-1.41	2.05**	-1.39	2.90**
27	**Dipika x IPI 10**	0.63	-0.31	2.18*	-1.20	2.39**	0.29	2.64**	1.45

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
28	**Dipika x GS 384**	1.26	0.31	**4.05****	0.60	0.90	-1.17	0.29	-0.87
29	**Dipika x H 45**	-2.21*	-3.13**	0.00	-2.41**	2.39**	0.29	3.20**	2.90**
30	**Dipika x Kartika**	-1.53	0.62	-2.36**	-0.30	1.45	2.34**	0.85	3.48**
31	**Shekhar x KB 9610**	-3.24**	2.50*	0.00	3.01**	0.86	2.92**	1.67*	5.8**
32	**Shekhar x ILS 264**	-1.74	5.94**	-3.09**	3.92**	-0.55	6.43**	-0.54	6.38**
33	**Shekhar x RLC 133**	-5.31**	0.31	-4.39**	-1.51	-1.15	0.88	-0.56	3.48**
34	**Shekhar x K 29**	-2.95**	2.81**	-1.75*	1.20	0.00	3.51**	-1.11	3.19**
35	**Shekhar x IPI 10**	-7.08**	-1.56	-4.09**	-1.20	-6.3**	-4.39**	-5.01**	-1.16
36	**Shekhar x GS 384**	-5.90**	-0.31	-4.09**	-1.20	-1.15	0.88	-1.39	2.61**
37	**Shekhar x H 45**	-5.31**	0.31	-1.75*	1.20	-4.3**	-2.34**	-4.18**	-0.29
38	**Shekhar x Kartika**	0.29	6.25**	1.75*	4.82**	3.15**	5.26**	1.39	5.51**
39	**KB 9610 x ILS 264**	-4.93**	2.50*	-4.21**	2.71**	-0.27	6.73**	0.54	7.54**
40	**KB 9610 x RLC 133**	2.22*	0.94	1.54	-0.60	6.42**	1.75*	4.44**	2.32**
41	**KB 9610 x K 29**	-0.30	2.19*	-2.92**	0.00	-6.78**	-3.51**	-4.44**	-0.29
42	**KB 9610 x IPI 10**	-0.32	-1.56	-0.31	-2.41**	3.32**	0.00	1.77*	0.00
43	**KB 9610 x GS 384**	1.27	0.00	1.54	-0.60	5.20**	0.58	3.95**	-0.87
44	**KB 9610 x H 45**	1.27	0.00	0.92	-1.20	-0.30	-3.22**	1.74*	1.45
45	**KB 9610 x Kartika**	0.00	2.19*	0.00	2.11*	2.32**	3.22**	1.69*	4.35**
46	**ILS 264 x RLC 133**	-2.61**	5.00**	-2.25**	4.82**	-2.46**	4.39**	-1.08	5.8**
47	**ILS 264 x K 29**	0.00	7.81**	-0.56	6.63**	-0.82	6.14**	-0.27	6.67**
48	**ILS 264 x IPI 10**	-7.25**	0.00	**-8.15****	-1.51	**-10.38****	-4.09**	**-8.40****	-2.03**
49	**ILS 264 x GS 384**	-7.25**	0.00	-5.62**	1.20	-4.92**	1.75*	-4.07**	2.61**
50	**ILS 264 x H 45**	-7.25**	0.00	-6.74**	0.00	-7.38**	-0.88	-4.88**	1.74*
51	**ILS 264 x Kartika**	-3.19**	4.37**	-3.93**	3.01**	-3.28**	3.51**	-1.63*	5.22**
52	**RLC 133 x K 29**	0.30	2.81**	-0.88	2.11*	-2.26**	1.17	-0.83	3.48**
53	**RLC 133 x IPI 10**	2.90**	-0.31	1.25	-2.71**	-2.11**	-5.26**	-2.65**	**-4.35****
54	**RLC 133 x GS 384**	**3.23****	0.00	2.51**	-1.51	**6.42****	1.75*	**6.21****	4.06**
55	**RLC 133 x H 45**	2.88**	0.31	1.85*	-0.60	3.92**	0.88	2.33**	2.03**
56	**RLC 133 x Kartika**	-2.45*	-0.31	-4.13**	-2.11*	-4.35**	-3.51**	-4.8**	-2.32**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
57	**K 29 x IPI 10**	-1.83	0.62	-2.63**	0.30	-1.69*	1.75*	-1.67*	2.61**
58	**K 29 x GS 384**	-1.22	1.25	-0.88	2.11*	-5.08**	-1.75*	-5.00**	-0.87
59	**K 29 x H 45**	-4.57**	-2.19*	-6.14**	-3.31**	-7.63**	-4.39**	-8.06**	-4.06**
60	**K 29 x Kartika**	0.3	2.81**	-2.05*	0.90	-2.26**	1.17	-0.83	3.48**
61	**IPI 10 x GS 384**	1.96	-2.50*	0.31	-3.92**	-2.11**	-5.26**	-2.65**	**-4.35****
62	**IPI 10 x H 45**	-1.60	**-4.06****	-2.16*	**-4.52****	-1.51	-4.39**	-2.33**	-2.61**
63	**IPI 10 x Kartika**	-2.75**	-0.63	-3.54**	-1.51	-6.67**	**-5.85****	-6.21**	-3.77**
64	**GS 384 x H 45**	1.92	-0.63	1.54	-0.90	0.90	-2.05**	2.62**	2.32**
65	**GS 384 x Kartika**	-0.61	1.56	-3.24**	-1.20	-0.87	0.00	0.85	3.48**
66	**H 45 x Kartika**	-2.45*	-0.31	-4.42**	-2.41**	-0.87	0.00	1.13	3.77**
	Min.	**-8.99**	**-4.06**	**-8.15**	**-4.52**	**-10.38**	**-5.85**	**-8.4**	**-4.35**
	Max.	**3.23**	**7.81**	**4.05**	**9.34**	**6.42**	**9.65**	**6.21**	**9.57**
	SE (±)	**1.12**		**0.90**		**0.89**		**0.86**	
No. of significant crosses		**32**	**29**	**46**	**33**	**46**	**44**	**43**	**47**
No. of Significant +ve crosses		**5**	**25**	**11**	**24**	**17**	**28**	**16**	**40**
No. of Significant -ve crosses		**27**	**4**	**35**	**9**	**29**	**16**	**27**	**7**

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

Table 4 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for plant height

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
1	**Indira x Gaurav**	1.03	**5.91***	-3.06	6.74**	-2.01	**10.17****	-3.88	5.32*
2	**Indira x Dipika**	-6.74**	-3.23	-1.08	2.81	0.00	5.65**	1.55	4.79*
3	**Indira x Shekhar**	-2.07	1.61	-3.78	0.00	-6.95**	-1.69	-7.22**	-4.26
4	**Indira x KB 9610**	-5.70*	-2.15	-4.86*	-1.12	-2.14	3.39*	-1.55	1.60
5	**Indira x ILS 264**	-7.77**	-4.3	-5.41**	-1.69	-10.7**	-5.65**	-3.09	0.00
6	**Indira x RLC 133**	-2.59	1.08	1.08	5.06*	-6.95**	-1.69	-1.55	1.60
7	**Indira x K29**	-9.84**	-6.45**	-7.03**	-3.37	-2.14	3.39*	-3.61	-0.53
8	**Indira x IPI 10**	**-14.51****	**-11.29****	-8.11**	-4.49*	-8.02**	-2.82	-10.82**	-7.98**
9	**Indira x GS 384**	-7.77**	-4.3	-3.24	0.56	-5.88**	-0.56	-2.06	1.06
10	**Indira x H 45**	-4.66*	-1.08	-7.03**	-3.37	-4.81**	0.56	-1.55	1.60
11	**Indira x Kartika**	-4.15	-0.54	-4.86*	-1.12	0.53	6.21**	1.03	4.26
12	**Gaurav x Dipika**	-1.54	3.23	-4.08*	5.62**	-5.03**	6.78**	-4.37*	4.79*
13	**Gaurav x Shekhar**	-4.62*	0.00	-6.63**	2.81	-8.04**	3.39*	-6.31**	2.66
14	**Gaurav x KB 9610**	-8.21**	-3.76	-8.67**	0.56	-3.02*	9.04**	-7.77**	1.06
15	**Gaurav x ILS 264**	-0.51	4.3	-4.59*	5.06*	-9.55**	1.69	-10.68**	-2.13
16	**Gaurav x RLC 133**	0.00	4.84*	-1.02	**8.99****	-9.55**	1.69	-10.19**	-1.6
17	**Gaurav x K 29**	-2.05	2.69	-2.55	7.3**	-14.07**	-3.39*	-11.65**	-3.19
18	**Gaurav x IPI 10**	-6.67**	-2.15	**-10.71****	-1.69	**-15.08****	-4.52**	**-13.11****	-4.79*
19	**Gaurav x GS 384**	-9.23**	-4.84*	-9.18**	0.00	-10.05**	1.13	-12.62**	-4.26
20	**Gaurav x H 45**	-2.56	2.15	-7.14**	2.25	-11.06**	0.00	-6.8**	2.13
21	**Gaurav x Kartika**	-5.13*	-0.54	-7.65**	1.69	-9.05**	2.26	-4.85*	4.26
22	**Dipika x Shekhar**	-2.72	-3.76	-0.58	-3.37	6.25**	5.65**	3.66	5.32*
23	**Dipika x KB 9610**	-1.14	-6.45**	0.00	-5.06*	-5.11**	-5.65**	-9.42**	-7.98**
24	**Dipika x ILS 264**	-3.98	-9.14**	0.00	-5.06*	-8.47**	**-8.47****	-6.81**	-5.32*
25	**Dipika x RLC 133**	1.69	-2.69	1.78	-3.37	-2.84	-3.39*	-8.38**	-6.91**
26	**Dipika x K 29**	-0.55	-2.15	4.73*	-0.56	-10.27**	-6.21**	-4.71*	-3.19
27	**Dipika x IPI 10**	-3.41	-8.6**	-4.14	-8.99**	-5.11**	-5.65**	-8.38**	-6.91**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
28	**Dipika x GS 384**	-2.27	-7.53**	-2.96	-7.87**	-5.68**	-6.21**	-9.42**	-7.98**
29	**Dipika x H 45**	1.14	-4.3	3.55	-1.69	5.11**	4.52**	1.05	2.66
30	**Dipika x Kartika**	0.57	-4.84*	2.37	-2.81	7.95**	7.34**	0.52	2.13
31	**Shekhar x KB 9610**	-5.43*	-6.45**	-0.58	-3.37	-0.58	-3.95*	-0.56	-4.79*
32	**Shekhar x ILS 264**	-2.17	-3.23	0.00	-2.81	2.26	2.26	0.54	-0.53
33	**Shekhar x RLC 133**	-2.17	-3.23	-2.31	-5.06*	1.16	-1.69	6.11*	1.6
34	**Shekhar x K 29**	-0.54	-1.61	1.16	-1.69	-4.32**	0.00	-1.05	0.53
35	**Shekhar x IPI 10**	-2.72	-3.76	-2.31	-5.06*	0.00	-3.39*	-1.11	-5.32*
36	**Shekhar x GS 384**	-2.17	-3.23	-1.16	-3.93	-1.75	-5.08**	-0.56	-4.79*
37	**Shekhar x H 45**	-3.80	-4.84*	-2.31	-5.06*	-1.17	-4.52**	-1.67	-5.85*
38	**Shekhar x Kartika**	-8.15**	-9.14**	-1.73	-4.49*	-4.09*	-7.34**	0.56	-3.72
39	**KB 9610 x ILS 264**	4.55	-1.08	1.8	-4.49*	7.34**	7.34**	4.30	3.19
40	**KB 9610 x RLC 133**	-0.56	-4.84*	0.00	-6.18**	-3.49*	-6.21**	0.56	-5.32*
41	**KB 9610 x K 29**	-4.92*	-6.45**	-4.19	-10.11**	-10.27**	-6.21**	-4.71*	-3.19
42	**KB 9610 x IPI 10**	2.89	-4.30	-0.60	-6.74**	0.58	-2.82	1.13	-4.79*
43	**KB 9610 x GS 384**	1.73	-5.38*	-2.99	-8.99**	0.61	-6.21**	-0.57	-6.91**
44	**KB 9610 x H 45**	-1.14	-6.45**	2.99	-3.37	2.42	-4.52**	1.12	-4.26
45	**KB 9610 x Kartika**	2.89	-4.3	-1.20	-7.3**	-0.61	-7.34**	-3.95	**-9.57****
46	**ILS 264 x RLC 133**	3.37	-1.08	1.80	-4.49*	9.04**	9.04**	8.06**	**6.91****
47	**ILS 264 x K 29**	-2.73	-4.3	-2.99	-8.99**	0.00	4.52**	-2.62	-1.06
48	**ILS 264 x IPI 10**	-2.27	-7.53**	-3.59	-9.55**	-7.91**	-7.91**	-8.6**	**-9.57****
49	**ILS 264 x GS 384**	-5.11*	-10.22**	-4.19	-10.11**	-6.78**	-6.78**	-6.45**	-7.45**
50	**ILS 264 x H 45**	**6.82****	1.08	4.19	-2.25	-5.65**	-5.65**	-3.76	-4.79*
51	**ILS 264 x Kartika**	3.41	-2.15	2.40	-3.93	-6.21**	-6.21**	-3.23	-4.26
52	**RLC 133 x K 29**	-0.55	-2.15	**5.42***	-1.69	-4.86**	-0.56	-4.71*	-3.19
53	**RLC 133 x IPI 10**	-1.12	-5.38*	**5.42***	-1.69	0.00	-2.82	-0.56	-6.38**
54	**RLC 133 x GS 384**	-0.56	-4.84*	1.81	-5.06*	5.81**	2.82	6.78**	0.53
55	**RLC 133 x H 45**	3.37	-1.08	1.8	-4.49*	11.05**	7.91**	**9.55****	3.72
56	**RLC 133 x Kartika**	-1.12	-5.38*	0.00	-6.74**	0.58	-2.26	0.56	-5.32*

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
57	**K 29 x IPI 10**	-1.64	-3.23	2.42	-5.06*	-5.95**	-1.69	-7.33**	-5.85*
58	**K 29 x GS 384**	1.64	0.00	4.85*	-2.81	-10.27**	-6.21**	-7.85**	-6.38**
59	**K 29 x H 45**	-5.46*	-6.99**	0.00	-6.18**	-4.86**	-0.56	-4.19	-2.66
60	**K 29 x Kartika**	-4.92*	-6.45**	2.42	-5.06*	0.00	4.52**	-1.57	0.00
61	**IPI 10 x GS 384**	3.61	-7.53**	1.25	-8.99**	2.92	-0.56	1.13	-4.79*
62	**IPI 10 x H 45**	-3.41	-8.6**	-2.4	-8.43**	-1.75	-5.08**	-2.81	-7.98**
63	**IPI 10 x Kartika**	-2.91	-10.22**	-1.24	**-10.67****	0.00	-3.39*	2.82	-3.19
64	**GS 384 x H 45**	-1.70	-6.99**	-0.6	-6.74**	4.27*	-3.39*	-2.25	-7.45**
65	**GS 384 x Kartika**	-2.91	-10.22**	-0.62	-10.11**	1.84	-6.21**	2.82	-3.19
66	**H 45 x Kartika**	4.55	-1.08	3.59	-2.81	**17.07****	8.47**	**9.55****	3.72
Min.		**-14.51**	**-11.29**	**-10.71**	**-10.67**	**-15.08**	**-8.47**	**-13.11**	**-9.57**
Max.		**6.82**	**5.91**	**5.42**	**8.09**	**17.07**	**10.17**	**9.55**	**6.91**
SE (±)		**1.42**		**1.19**		**0.92**		**1.46**	
No. of significant crosses		**19**	**29**	**18**	**36**	**42**	**45**	**29**	**30**
No. of Significant +ve crosses		**1**	**27**	**4**	**6**	**9**	**17**	**5**	**5**
No. of Significant -ve crosses		**18**	**2**	**14**	**30**	**33**	**28**	**24**	**25**

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

Table 5 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for number of primary branches per plant

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
1	**Indira x Gaurav**	-0.56	15.48**	-9.19**	5*	-15**	0	-5.81	6.57
2	**Indira x Dipika**	7.98**	13.55**	-10.43**	**-8.75****	**-13.55****	**-12.42****	0.00	5.11
3	**Indira x Shekhar**	**-18.23****	**-4.52****	-10.42**	7.5**	-8.65**	10.46**	4.23	8.03
4	**Indira x KB 9610**	-5.39**	1.94	5.45*	8.75**	0.00	4.58	1.41	5.11
5	**Indira x ILS 264**	-3.66*	1.94	-1.79	3.13	-3.12	1.31	0.00	3.65
6	**Indira x RLC 133**	**14.19****	9.03**	2.67	-3.75	-9.4**	-11.76**	-1.41	2.19
7	**Indira x K29**	-9.15**	-3.87*	-10.65**	-5.62*	-13.13**	-9.15**	-4.93	-1.46
8	**Indira x IPI 10**	-9.74**	13.55**	-8.29**	17.5**	-14.36**	13.07**	-9.4	-1.46
9	**Indira x GS 384**	1.23	5.81**	4.71*	11.25**	6.79**	13.07**	2.11	5.84
10	**Indira x H 45**	-7.91**	5.16**	-6.63**	5.63*	-12.78**	2.61	-1.41	2.19
11	**Indira x Kartika**	7.48**	1.94	5.30*	-0.62	-3.40	-7.19**	-2.11	1.46
12	**Gaurav x Dipika**	-4.44**	10.97**	1.08	16.88**	-5.00*	11.76**	-7.74	4.38
13	**Gaurav x Shekhar**	1.1	18.06**	0.52	20.63**	-3.78	16.34**	-1.29	**11.68**
14	**Gaurav x KB 9610**	-8.89**	5.81**	-4.32*	10.63**	-6.11**	10.46**	-4.52	8.03
15	**Gaurav x ILS 264**	-4.44**	10.97**	-5.41**	9.38**	-8.89**	7.19**	-9.03	2.92
16	**Gaurav x RLC 133**	2.78	19.35**	-0.54	15**	-1.67	15.69**	-3.87	8.76
17	**Gaurav x K 29**	5.56**	22.58**	8.11**	25**	**10.56****	**30.07****	-3.87	8.76
18	**Gaurav x IPI 10**	-1.03	24.52**	-3.41	23.75**	-5.45**	24.84**	-8.39	3.65
19	**Gaurav x GS 384**	0.00	16.13**	5.41**	21.88**	3.89	22.22**	-10.32	1.46
20	**Gaurav x H 45**	-1.67	14.19**	6.49**	23.13**	7.22**	26.14**	-4.52	8.03
21	**Gaurav x Kartika**	-2.22	13.55**	-4.86*	10**	-5.00*	11.76**	-9.68	2.19
22	**Dipika x Shekhar**	-1.10	15.48**	-7.29**	11.25**	-6.49**	13.07**	1.39	6.57
23	**Dipika x KB 9610**	1.20	9.03**	4.24	7.50**	6.88**	11.76**	-4.17	0.73
24	**Dipika x ILS 264**	2.44	8.39**	4.17	9.38**	0.63	5.23	-5.56	-0.73
25	**Dipika x RLC 133**	0.61	5.81**	-0.61	1.25	-5.16	-3.92	-4.17	0.73
26	**Dipika x K 29**	1.83	7.74**	-4.14	1.25	-8.75**	-4.58	-3.47	1.46
27	**Dipika x IPI 10**	-11.79**	10.97**	-11.71**	13.13**	-16.34**	10.46**	-6.04	2.19

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
28	**Dipika x GS 384**	1.84	7.1**	4.12	10.63**	2.47	8.50**	-6.25	-1.46
29	**Dipika x H 45**	-3.95**	9.68**	0.55	13.75**	-6.67**	9.80**	5.56	10.95
30	**Dipika x Kartika**	1.84	7.1**	4.29	6.25**	2.58	3.92	-1.39	3.65
31	**Shekhar x KB 9610**	3.31*	20.65**	3.65	**24.38****	0.54	21.57**	1.45	2.19
32	**Shekhar x ILS 264**	-1.66	14.84**	-3.65	15.63**	-4.86*	15.03**	0.00	0.73
33	**Shekhar x RLC 133**	1.66	18.71**	-7.29**	11.25**	-6.49**	13.07**	5.07	5.84
34	**Shekhar x K 29**	-4.42**	11.61**	-8.33**	10.00**	-7.03**	12.42**	5.07	5.84
35	**Shekhar x IPI 10**	-0.51	**25.16****	-2.93	**24.38****	-1.49	**30.07****	-6.71	1.46
36	**Shekhar x GS 384**	-8.84**	6.45**	-9.37**	8.75**	-8.11**	11.11**	0.71	2.92
37	**Shekhar x H 45**	2.21	19.35**	1.04	21.25**	-0.54	20.26**	-2.9	-2.19
38	**Shekhar x Kartika**	-6.08**	9.68**	-7.29**	11.25**	-9.73**	9.15**	4.29	6.57
39	**KB 9610 x ILS 264**	1.80	9.68**	**8.33****	13.75**	5.63*	10.46**	2.17	2.92
40	**KB 9610 x RLC 133**	-2.99	4.52**	1.21	4.38	0.00	4.58	0.00	0.73
41	**KB 9610 x K 29**	0.60	8.39**	2.37	8.13**	0.63	5.23	2.90	3.65
42	**KB 9610 x IPI 10**	-12.82**	9.68**	-10.24**	15**	-16.34**	10.46**	-1.34	7.30
43	**KB 9610 x GS 384**	-1.20	6.45**	-1.18	5.00*	-7.41**	-1.96	-1.43	0.73
44	**KB 9610 x H 45**	-5.08**	8.39**	-2.21	10.63**	-4.44	12.42**	2.90	3.65
45	**KB 9610 x Kartika**	-1.20	6.45**	1.82	5.00*	0.00	4.58	-1.43	0.73
46	**ILS 264 x RLC 133**	-1.22	4.52**	-0.60	4.38	-2.5	1.96	-1.45	-0.73
47	**ILS 264 x K 29**	1.83	7.74**	-2.37	3.13	0.00	4.58	**-31.88****	**-31.39****
48	**ILS 264 x IPI 10**	-8.21**	15.48**	-11.71**	13.13**	-15.84**	11.11**	-2.68	5.84
49	**ILS 264 x GS 384**	1.22	7.1**	-4.71*	1.25	-8.02**	-2.61	-3.57	-1.46
50	**ILS 264 x H 45**	-6.21**	7.1**	-2.21	10.63**	-6.67**	9.8**	1.45	2.19
51	**ILS 264 x Kartika**	1.83	7.74**	1.19	6.25**	-3.75	0.65	0.00	2.19
52	**RLC 133 x K 29**	0.00	5.81**	-2.96	2.50	-1.87	2.61	-0.74	-2.19
53	**RLC 133 x IPI 10**	-8.21**	15.48**	-11.71**	13.13**	-14.36**	13.07**	-6.04	2.19
54	**RLC 133 x GS 384**	4.94**	9.68**	3.53	10.00**	-0.62	5.23	4.29	6.57
55	**RLC 133 x H 45**	-2.82	10.97**	0.00	13.13**	-5.56*	11.11**	4.41	3.65
56	**RLC 133 x Kartika**	10.81**	5.81**	6.62**	0.63	-2.01	-4.58	-6.43	-4.38

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
57	**K 29 x IPI 10**	-9.23**	14.19**	-9.76**	15.63**	-15.35**	11.76**	-12.75*	-5.11
58	**K 29 x GS 384**	2.44	8.39**	4.71*	11.25**	3.09	9.15**	-1.43	0.73
59	**K 29 x H 45**	-0.56	13.55**	1.66	15.00**	-7.78**	8.5**	**8.09**	7.30
60	**K 29 x Kartika**	1.83	7.74**	-1.78	3.75	-7.5**	-3.27	-2.86	-0.73
61	**IPI 10 x GS 384**	-6.15**	18.06**	-4.88**	21.88**	-11.39**	16.99**	-6.71	1.46
62	**IPI 10 x H 45**	-2.05	23.23**	-3.41	23.75**	-7.43**	22.22**	1.34	10.22
63	**IPI 10 x Kartika**	-11.79**	10.97**	**-15.61****	8.12**	**-16.34****	10.46**	-6.04	2.19
64	**GS 384 x H 45**	-4.52**	9.03**	-6.63**	5.63*	-10.56**	5.23	-0.71	1.46
65	**GS 384 x Kartika**	3.09	7.74**	-0.59	5.63*	0.62	6.54*	-1.43	0.73
66	**H 45 x Kartika**	5.08**	20**	1.1	14.38**	0.56	18.3**	7.86	10.22
Min.		**-18.23**	**-4.52**	**-15.61**	**-8.75**	**-16.34**	**-12.42**	**-31.88**	**-31.39**
Max.		**14.19**	**25.16**	**8.33**	**25**	**10.56**	**30.07**	**8.09**	**11.68**
SE (±)		**0.08**		**0.30**		**0.13**		**0.15**	
No. of significant crosses		**31**	**63**	**32**	**54**	**40**	**45**	**2**	**1**
No. of Significant +ve crosses		**8**	**61**	**9**	**52**	**5**	**41**	**-**	**-**
No. of Significant -ve crosses		**23**	**2**	**23**	**2**	**35**	**4**	**2**	**1**

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

Table 6 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for number of secondary branches per plant

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
1	**Indira x Gaurav**	-1.72	22.33**	-2.19	23.32**	-7.58*	19.85**	0.63	17.95*
2	**Indira x Dipika**	-3.8	-0.16	-2.65	7.94	-6.86	10.76*	-5.65	4.03
3	**Indira x Shekhar**	11.23	23.65**	-8.51	3.97	5.09	18.74**	**-15.46***	0.18
4	**Indira x KB 9610**	4.05	5.58	-12.58*	**-3.97**	**15.66****	17.81**	-7.17	-2.75
5	**Indira x ILS 264**	5.79	16.91*	4.25	14.51*	-5.15	2.60	3.23	11.17
6	**Indira x RLC 133**	**14.89***	16.58*	-5.03	4.32	10.62*	15.96**	0.17	4.95
7	**Indira x K29**	6.58	11.66	-10.06	-1.21	-13.78**	3.34	-11.99	**-5.86**
8	**Indira x IPI 10**	0.41	22.00**	**13.8***	28.15**	3.62	22.08**	-4.77	13.37
9	**Indira x GS 384**	-10.09	-1.97	3.30	13.64*	-13.69**	4.08	-5.09	5.86
10	**Indira x H 45**	4.26	12.64	1.55	13.3*	4.61	13.73**	-11.07	0.00
11	**Indira x Kartika**	3.07	4.60	5.66	16.06*	-0.71	3.15	-2.97	1.65
12	**Gaurav x Dipika**	-7.65	14.94*	-8.90	14.85*	-8.87*	18.18**	-0.78	16.3
13	**Gaurav x Shekhar**	5.41	**31.2****	7.40	**35.41****	4.29	**35.25****	8.04	28.02**
14	**Gaurav x KB 9610**	-14.64**	6.24	-8.63	15.2*	-9.01*	18**	1.56	19.05*
15	**Gaurav x ILS 264**	-2.24	21.67**	1.64	28.15**	-8.30*	18.92**	-0.16	17.03*
16	**Gaurav x RLC 133**	-18.07**	1.97	-2.19	23.32**	-19.6**	4.27	-5.47	10.81
17	**Gaurav x K 29**	-9.89	12.15	3.56	30.57**	-11.87**	14.29**	**12.34**	**31.68****
18	**Gaurav x IPI 10**	-14.64**	6.24	-1.64	24.01**	-12.59**	13.36**	-2.92	15.57
19	**Gaurav x GS 384**	-11.21*	10.51	-3.15	22.11**	**-20.74****	2.78	-0.47	16.67*
20	**Gaurav x H 45**	-8.44	13.96*	**-14.11****	8.29	-3.43	25.23**	-6.72	9.34
21	**Gaurav x Kartika**	-8.71	13.63*	-5.89	18.65**	-8.01*	19.29**	1.25	18.68*
22	**Dipika x Shekhar**	3.10	14.61*	-3.19	10.02	-10.76**	6.12	-7.42	9.71
23	**Dipika x KB 9610**	-3.16	0.49	-8.26	1.73	-8.74*	8.53	-11.13	-2.01
24	**Dipika x ILS 264**	-5.35	4.60	2.80	13.99*	-11.39**	5.38	4.49	15.20
25	**Dipika x RLC 133**	8.54	12.64	-7.48	2.59	-6.08	11.69*	-8.14	1.28
26	**Dipika x K 29**	-8.31	-3.94	-2.65	7.94	-10.06*	7.79	-11.3	-2.20
27	**Dipika x IPI 10**	-7.7	12.15	2.76	15.72*	-13.42**	2.97	-3.38	15.02

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
28	**Dipika x GS 384**	-7.38	0.99	-9.81	0.00	-9.38*	9.28*	-10.34	0.00
29	**Dipika x H 45**	2.13	10.34	8.82	21.42**	-5.62	12.24**	7.17	20.51*
30	**Dipika x Kartika**	2.85	6.73	5.3	16.75*	-12.79**	3.71	-4.65	5.13
31	**Shekhar x KB 9610**	10.64	22.99**	13.37*	28.84**	3.94	17.44**	-1.24	17.03*
32	**Shekhar x ILS 264**	-9.01	1.15	3.34	17.44**	-2.63	10.02*	-11.75	4.58
33	**Shekhar x RLC 133**	1.62	12.97	-10.94	1.21	-4.6	7.79	-9.89	6.78
34	**Shekhar x K 29**	1.92	13.30	-5.47	7.43	0.62	20.59**	-4.17	13.55
35	**Shekhar x IPI 10**	-0.68	20.69**	9.73	24.7**	4.09	22.63**	6.62	26.92**
36	**Shekhar x GS 384**	0.74	11.99	-7.90	4.66	-5.38	14.1**	-7.88	9.16
37	**Shekhar x H 45**	-10.49	-0.49	9.57	24.53**	4.60	18.18**	-1.24	17.03*
38	**Shekhar x Kartika**	6.35	18.23**	-3.19	10.02	1.48	14.66**	5.56	25.09**
39	**KB 9610 x ILS 264**	-5.20	4.76	-1.15	3.80	10.12*	19.11**	2.55	10.44
40	**KB 9610 x RLC 133**	2.92	4.11	5.20	1.38	-1.24	3.53	7.73	9.71
41	**KB 9610 x K 29**	-7.99	-3.61	-2.39	5.7	-9.75*	8.16	-5.14	1.47
42	**KB 9610 x IPI 10**	-6.76	13.3	2.91	15.89*	0.31	18.18**	-1.85	16.85*
43	**KB 9610 x GS 384**	6.02	15.6*	-0.94	8.98	-15.08**	2.41	2.3	14.1
44	**KB 9610 x H 45**	-3.8	3.94	-5.57	5.35	8.87*	18.37**	2.44	15.2
45	**KB 9610 x Kartika**	-2.11	-0.99	12.2	12.78	1.43	5.38	2.19	2.38
46	**ILS 264 x RLC 133**	-4.75	5.25	6.74	12.09	7.03	15.77**	-7.99	-0.92
47	**ILS 264 x K 29**	0.30	10.84	-2.39	5.7	-12.54**	4.82	3.74	11.72
48	**ILS 264 x IPI 10**	**-21.62****	-4.76	0.46	13.13*	-12.6**	2.97	-1.08	17.77*
49	**ILS 264 x GS 384**	-2.67	7.55	-1.1	8.81	-0.77	19.67**	-0.82	10.62
50	**ILS 264 x H 45**	1.93	12.64	-7.59	3.11	8.19	17.63**	-6.03	5.68
51	**ILS 264 x Kartika**	3.71	14.61*	7.07	12.44	-4.80	2.97	-4.42	2.93
52	**RLC 133 x K 29**	5.33	10.34	-2.55	5.53	-10.22**	7.61	2.91	10.07
53	**RLC 133 x IPI 10**	-16.76**	1.15	2.61	15.54*	-4.41	12.62**	-6.00	11.9
54	**RLC 133 x GS 384**	-12.8*	**-4.93**	7.54	18.31**	-4.62	15.03**	-8.21	2.38
55	**RLC 133 x H 45**	-4.56	3.12	-1.24	10.19	2.22	11.13*	2.28	15.02
56	**RLC 133 x Kartika**	13.19	14.12*	-4.47	**-3.97**	13.98**	19.48**	1.44	3.3

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
57	**K 29 x IPI 10**	1.62	23.48**	3.37	16.41*	7.59	28.94**	-4.31	13.92
58	**K 29 x GS 384**	-5.42	3.12	-8.01	1.21	-16.31**	**0.93**	-5.75	5.13
59	**K 29 x H 45**	-7.29	0.16	-0.31	11.23	-6.81	11.69*	1.79	14.47
60	**K 29 x Kartika**	-8.31	-3.94	-5.74	2.07	-6.81	11.69*	-1.88	4.95
61	**IPI 10 x GS 384**	-5.14	15.27*	-0.15	12.44	-4.92	14.66**	-6.77	10.99
62	**IPI 10 x H 45**	-12.43*	6.40	3.68	16.75*	-11.97**	3.71	-0.62	18.32*
63	**IPI 10 x Kartika**	-2.03	19.05**	5.21	18.48**	-0.63	17.07**	4.00	23.81**
64	**GS 384 x H 45**	13.55*	23.81**	12.38*	25.39**	0.62	21.34**	-5.21	6.59
65	**GS 384 x Kartika**	-6.48	1.97	5.02	15.54*	-14.77**	2.78	4.27	16.3
66	**H 45 x Kartika**	13.37*	22.5**	-0.31	11.23	14.16**	24.12**	1.63	14.29
	Min.	**-21.62**	**-4.93**	**-14.11**	**-3.97**	**-20.74**	**0.93**	**-15.46**	**-5.86**
	Max.	**14.89**	**31.2**	**13.8**	**35.41**	**15.66**	**35.25**	**12.34**	**31.68**
	SE (±)	**1.36**		**1.27**		**0.83**		**1.50**	
No. of significant crosses		**11**	**22**	**5**	**32**	**32**	**42**	**1**	**16**
No. of Significant +ve crosses		**3**	**22**	**3**	**32**	**6**	**42**	**-**	**16**
No. of Significant -ve crosses		**8**	**-**	**2**	**-**	**26**	**-**	**1**	**-**

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

Table 7 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for number of capsules per plant

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
1	**Indira x Gaurav**	8.73**	7.39*	0.52	-3.24	9.74**	8.63**	6.84**	9.12**
2	**Indira x Dipika**	6.84*	4.92	2.40	-2.23	6.00*	2.91	9.89**	7.19**
3	**Indira x Shekhar**	-1.34	11.64**	-5.45**	7.59**	-1.58	11.3**	-6.17**	10.38**
4	**Indira x KB 9610**	-1.70	3.36	-1.54	-0.11	-1.43	2.56	4.81*	11.58**
5	**Indira x ILS 264**	8.11*	5.15	6.78**	0.22	0.00	-1.43	1.54	0.60
6	**Indira x RLC 133**	**17.95****	14.72**	8.69**	2.01	0.43	-2.5	-0.92	0.13
7	**Indira x K29**	12.26**	9.18**	**9.34****	2.62	8.88**	5.71*	10.37**	7.65**
8	**Indira x IPI 10**	0.24	16.4**	0.78	15.52**	-4.81*	11.96**	-5.74**	14.64**
9	**Indira x GS 384**	1.01	12.09**	-4.48*	4.75*	-1.25	7.85**	-4.05*	13.44**
10	**Indira x H 45**	-3.79	**-2.01**	-2.28	-4.19*	1.84	2.26	-3.13	0.86
11	**Indira x Kartika**	0.51	-0.34	1.43	-4.8*	-3.23	-3.87	-0.34	-1.46
12	**Gaurav x Dipika**	6.35	5.04	5.57**	1.62	-1.2	-2.2	3.32	5.52*
13	**Gaurav x Shekhar**	3.07	16.62**	0.69	14.57**	-0.74	12.25**	-0.51	17.03**
14	**Gaurav x KB 9610**	**-5.69**	-0.84	-1.49	-0.06	-6.8**	-3.03	-9.13**	-3.26
15	**Gaurav x ILS 264**	1.25	0.00	1.57	-2.23	0.60	-0.42	0.39	2.53
16	**Gaurav x RLC 133**	1.36	0.11	4.47*	0.56	-5.53*	-6.48*	-2.54	-0.47
17	**Gaurav x K 29**	5.89	4.59	4.47*	0.56	2.34	1.31	1.24	3.39
18	**Gaurav x IPI 10**	-3.18	12.42**	-2.87	11.33**	-7.74**	8.51**	-9.3**	10.31**
19	**Gaurav x GS 384**	0.81	11.86**	-2.85	6.53**	0.76	10.05**	-2.81	14.9**
20	**Gaurav x H 45**	7.8*	9.79**	5.07*	3.02	4.09	4.52	0.70	4.86*
21	**Gaurav x Kartika**	2.65	1.79	3.19	-0.67	1.14	0.48	-3.52	-1.46
22	**Dipika x Shekhar**	-0.15	12.98**	-0.79	12.9**	-0.37	12.67**	-2.55	14.64**
23	**Dipika x KB 9610**	0.48	5.65	4.57*	6.09**	0.4	4.46	-2.25	4.06
24	**Dipika x ILS 264**	3.08	1.23	3.27	-1.40	1.63	0.18	2.96	2.00
25	**Dipika x RLC 133**	4.10	2.24	2.81	-1.84	-0.25	-4.22	-1.78	-0.73
26	**Dipika x K 29**	1.99	0.17	1.17	-3.41	**16.91****	12.25**	**18.39****	14.37**
27	**Dipika x IPI 10**	-2.75	12.93**	-5.36**	8.49**	-7.94**	8.27**	-3.61*	17.23**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
28	**Dipika x GS 384**	1.71	12.87**	2.49	12.4**	-5.34*	3.39	-7.03**	9.91**
29	**Dipika x H 45**	1.48	3.36	4.04*	2.01	-0.65	-0.24	-5.56*	-1.66
30	**Dipika x Kartika**	1.92	1.06	2.51	-2.12	1.74	1.07	9.08**	7.85**
31	**Shekhar x KB 9610**	-0.89	12.14**	-3.93*	9.32**	-1.53	11.36**	-2.26	14.97**
32	**Shekhar x ILS 264**	0.25	13.43**	-4.32*	8.88**	-4.00	8.57**	-2.94	14.17**
33	**Shekhar x RLC 133**	-4.35	8.23*	**-9.72****	2.74	-4.00	8.57**	-8.03**	8.18**
34	**Shekhar x K 29**	-3.81	8.84**	-4.07*	9.16**	-7.52**	4.58	-11.48**	4.13
35	**Shekhar x IPI 10**	1.06	17.35**	2.09	**17.03****	-0.51	17.01**	0.27	21.96**
36	**Shekhar x GS 384**	2.57	16.06**	1.57	15.58**	5.52*	19.33**	4.73*	23.82**
37	**Shekhar x H 45**	-4.65	7.89*	-6.43**	6.48**	-6.58**	5.65*	-5.77**	10.84**
38	**Shekhar x Kartika**	-4.3	8.28**	-4.61**	8.54**	-3.16	9.52**	-2.94	14.17**
39	**KB 9610 x ILS 264**	1.86	7.11*	2.31	3.80	4.75	8.98**	8.5**	15.5**
40	**KB 9610 x RLC 133**	-1.49	3.58	-1.98	-0.56	-3.89	0.00	-2.81	3.46
41	**KB 9610 x K 29**	-4.42	0.50	-0.61	0.84	1.03	5.12*	14.31**	21.69**
42	**KB 9610 x IPI 10**	-4.43	10.97**	-2.63	11.61**	-1.52	15.82**	5.09**	**27.81****
43	**KB 9610 x GS 384**	0.15	11.14**	-0.15	9.49**	10.29**	**20.46****	-2.59	15.17**
44	**KB 9610 x H 45**	5.11	10.52**	4.13*	5.64**	1.6	5.71*	1.56	8.12**
45	**KB 9610 x Kartika**	0.48	5.65	3.14	4.63*	-1.72	2.26	-9.19**	-3.33
46	**ILS 264 x RLC 133**	3.11	0.22	1.37	-5.08*	-5.85*	**-7.20****	-6.85**	**-5.85****
47	**ILS 264 x K 29**	4.66	1.73	5.78**	-0.95	7.00**	5.47*	3.69	2.73
48	**ILS 264 x IPI 10**	-3.9	11.58**	-4.43*	9.55**	-5.41*	11.24**	-4.87**	15.7**
49	**ILS 264 x GS 384**	4.34	15.78**	2.90	12.84**	10.02**	20.17**	4.16*	23.15**
50	**ILS 264 x H 45**	0.77	2.63	1.65	-0.34	1.72	2.14	1.85	6.05**
51	**ILS 264 x Kartika**	3.22	2.35	5.95**	-0.61	0.42	-0.24	6.25**	5.26*
52	**RLC 133 x K 29**	5.2	-1.57	3.05	**-5.64****	5.11	0.42	-2.83	-1.80
53	**RLC 133 x IPI 10**	2.17	**18.63****	1.51	16.36**	2.07	20.05**	4.16*	26.68**
54	**RLC 133 x GS 384**	0.71	11.75**	1.53	11.33**	-2.29	6.72**	-1.80	16.1**
55	**RLC 133 x H 45**	6.87*	8.84**	5.3**	3.24	-0.77	-0.36	-1.79	2.26
56	**RLC 133 x Kartika**	16.65**	15.67**	4.88*	-1.62	10.3**	9.58**	5.79**	6.92**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
57	**K 29 x IPI 10**	-1.78	14.05**	-1.61	12.79**	-3.79	13.15**	-4.54*	16.1**
58	**K 29 x GS 384**	-0.55	10.35**	-3.72*	5.58**	-5.34*	3.39	-4.9*	12.44**
59	**K 29 x H 45**	1.59	3.47	1.54	-0.45	8.95**	9.4**	13.42**	18.1**
60	**K 29 x Kartika**	2.43	1.57	4.17*	-2.29	2.22	1.55	5.92**	4.72*
61	**IPI 10 x GS 384**	1.45	17.8**	1.95	16.86**	2.12	20.11**	4.49*	27.08**
62	**IPI 10 x H 45**	-1.25	14.66**	0.00	14.63**	**-9.16****	6.84**	-3.34	17.56**
63	**IPI 10 x Kartika**	-4.24	11.19**	-2.83	11.39**	-5.92**	10.65**	-4.49*	16.17**
64	**GS 384 x H 45**	-0.40	10.52**	-1.88	7.59**	-5.45*	3.27	-4.39*	13.04**
65	**GS 384 x Kartika**	-2.47	8.23*	-6.26**	2.79	-3.27	5.65*	**-13.62****	2.13
66	**H 45 x Kartika**	5.22	7.16*	6.09**	4.02*	-1.60	-1.19	-0.38	3.73
Max.		17.95	18.63	9.34	17.03	16.91	20.46	18.39	27.81
Min.		-5.69	-2.01	-9.72	-5.64	-9.16	-7.20	-13.62	-5.85
SE (±)		1.89	-	1.16	-	1.41	-	1.11	-
No. of significant crosses		8	39	28	38	24	37	36	45
No. of Significant +ve crosses		8	39	16	34	10	35	17	44
No. of Significant -ve crosses		-	-	12	4	14	2	19	1

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

Table 8 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for number of seeds per capsules

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
1	**Indira x Gaurav**	-0.75	-3.31**	-1.47	-3.25*	-1.61	-4.67**	**-12.2****	-10.44**
2	**Indira x Dipika**	-2.68*	-6.62**	-1.52	-6.14**	-3.31*	-8.95**	-11.67**	**-14.86****
3	**Indira x Shekhar**	0.00	-5.15**	1.89	-2.89*	0.41	-4.28**	-1.23	-3.21*
4	**Indira x KB 9610**	-4.08**	**-13.6****	-2.34	-9.75**	1.32	-10.12**	0.00	-8.43**
5	**Indira x ILS 264**	-4.81**	-5.51**	1.50	-2.17	-1.56	-1.56	-1.61	-1.61
6	**Indira x RLC 133**	**2.86***	-7.35**	0.78	-6.86**	0.43	-8.56**	-1.75	-9.64**
7	**Indira x K29**	-3.27*	-12.87**	-3.52*	-10.83**	0.88	-10.51**	0.00	-8.43**
8	**Indira x IPI 10**	-3.89**	-9.19**	-3.03*	-7.58**	1.25	-5.45**	**4.66****	-0.80
9	**Indira x GS 384**	-7.69**	-11.76**	-4.85**	-7.94**	-5.37**	-10.89**	-6.17**	-8.43**
10	**Indira x H 45**	-4.18**	-7.35**	0.38	-4.33**	-4.37**	-6.23**	-9.56**	-8.84**
11	**Indira x Kartika**	-5.43**	-4.04**	1.11	-1.44	-3.07*	-1.56	-5.04**	-1.61
12	**Gaurav x Dipika**	1.51	-1.10	2.57	0.72	**3.21***	0.00	-1.18	0.80
13	**Gaurav x Shekhar**	**-8.3****	-10.66**	**-8.46****	-10.11**	-1.61	-4.67**	-6.69**	-4.82**
14	**Gaurav x KB 9610**	-2.64*	-5.15**	0.00	-1.81	1.61	-1.56	-5.91**	-4.02**
15	**Gaurav x ILS 264**	-1.11	-1.84	-1.10	-2.89*	-2.72	-2.72	0.00	2.01
16	**Gaurav x RLC 133**	-2.64*	-5.15**	-4.41**	-6.14**	-6.43**	-9.34**	-9.45**	-7.63**
17	**Gaurav x K 29**	-3.4**	-5.88**	-5.15**	-6.86**	-0.40	-3.5*	-6.3**	-4.42**
18	**Gaurav x IPI 10**	-1.51	-4.04**	-1.47	-3.25*	-2.81	-5.84**	-2.36	-0.40
19	**Gaurav x GS 384**	-0.75	-3.31**	-0.37	-2.17	0.80	-2.33	-4.72**	-2.81*
20	**Gaurav x H 45**	1.51	-1.10	0.74	-1.08	1.59	-0.39	1.97	4.02**
21	**Gaurav x Kartika**	-1.81	-0.37	-0.37	-2.17	-1.92	-0.39	-2.33	1.20
22	**Dipika x Shekhar**	-2.3	-6.25**	0.00	-4.69**	-1.63	-6.23**	-4.1**	-6.02**
23	**Dipika x KB 9610**	-3.45**	-7.35**	0.38	-4.33**	-1.24	-7.00**	-5**	-8.43**
24	**Dipika x ILS 264**	-2.22	-2.94*	3.00*	-0.72	-3.11*	-3.11*	0.00	0.00
25	**Dipika x RLC 133**	2.30	-1.84	**3.41***	-1.44	1.65	-4.28**	1.25	-2.41
26	**Dipika x K 29**	-4.6**	-8.46**	-1.14	-5.78**	-3.31*	-8.95**	-5**	-8.43**
27	**Dipika x IPI 10**	-6.51**	-10.29**	-2.65	-7.22**	-2.48	-8.17**	-6.25**	-9.64**
28	**Dipika x GS 384**	0.00	-4.04**	1.49	-1.81	0.83	-5.06**	0.82	-1.61

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
29	**Dipika x H 45**	1.90	-1.47	1.89	-2.89*	1.19	-0.78	-0.4	0.4
30	**Dipika x Kartika**	-4.35**	-2.94*	3.33*	**0.72**	-5.36**	-3.89*	-7.75**	-4.42**
31	**Shekhar x KB 9610**	-1.16	-6.25**	-2.27	-6.86**	-2.45	-7**	-6.15**	-8.03**
32	**Shekhar x ILS 264**	-4.44**	-5.15**	1.12	-2.53	**-7.78****	-7.78**	-2.41	-2.41
33	**Shekhar x RLC 133**	0.78	-4.41**	2.27	-2.53	2.04	-2.72	2.87*	0.8
34	**Shekhar x K 29**	-3.49**	-8.46**	-3.03*	-7.58**	-3.67*	-8.17**	-6.56**	-8.43**
35	**Shekhar x IPI 10**	1.16	-4.04**	1.52	-3.25*	-1.22	-5.84**	-2.05	-4.02**
36	**Shekhar x GS 384**	0.77	-3.68**	1.87	-1.44	2.45	-2.33	-1.64	-3.61**
37	**Shekhar x H 45**	2.66*	-0.74	3.03*	-1.81	-2.78	-4.67**	1.20	2.01
38	**Shekhar x Kartika**	-1.45	0.00	0.37	-2.17	0.00	1.56	-0.39	3.21*
39	**KB 9610 x ILS 264**	-4.44**	-5.15**	-4.49**	-7.94**	**-7.78****	-7.78**	-8.43**	-8.43**
40	**KB 9610 x RLC 133**	0.00	-11.4**	1.22	-10.11**	-1.28	-10.12**	-3.93**	-11.65**
41	**KB 9610 x K 29**	-1.65	-12.5**	0.00	**-12.27****	-1.32	**-12.45****	-3.57*	-13.25**
42	**KB 9610 x IPI 10**	0.39	-5.15**	-3.41*	-7.94**	1.25	-5.45**	2.12	-3.21*
43	**KB 9610 x GS 384**	-4.62**	-8.82**	-7.09**	-10.11**	0.00	-5.84**	-4.94**	-7.23**
44	**KB 9610 x H 45**	-1.90	-5.15**	-4.17**	-8.66**	-0.79	-2.72	-3.19*	-2.41
45	**KB 9610 x Kartika**	-5.8**	-4.41**	-0.74	-3.25*	-7.66**	-6.23**	-3.88**	-0.4
46	**ILS 264 x RLC 133**	-0.37	-1.10	2.25	-1.44	-2.72	-2.72	1.61	1.61
47	**ILS 264 x K 29**	-3.33**	-4.04**	-1.12	-4.69**	-6.23**	-6.23**	-3.61**	-3.61**
48	**ILS 264 x IPI 10**	-0.37	-1.10	0.75	-2.89*	-1.56	-1.56	-0.80	-0.80
49	**ILS 264 x GS 384**	-2.96*	-3.68**	-1.49	-4.69**	-4.28**	-4.28**	0.00	0.00
50	**ILS 264 x H 45**	-3.7**	-4.41**	0.75	-2.89*	-5.06**	-5.06**	-2.79*	-2.01
51	**ILS 264 x Kartika**	0.00	**1.47**	2.96*	0.36	0.00	1.56	0.39	4.02**
52	**RLC 133 x K 29**	0.41	-10.66**	2.85	-8.66**	0.00	-8.95**	-0.44	-8.43**
53	**RLC 133 x IPI 10**	-0.78	-6.25**	-3.03*	-7.58**	0.00	-6.61**	-1.27	-6.43**
54	**RLC 133 x GS 384**	-3.85**	-8.09**	-5.6**	-8.66**	1.65	-4.28**	1.23	-1.2
55	**RLC 133 x H 45**	-5.7**	-8.82**	1.14	-3.61**	-6.35**	-8.17**	-7.57**	-6.83**
56	**RLC 133 x Kartika**	-7.25**	-5.88**	-2.22	-4.69**	-5.75**	-4.28**	-5.04**	-1.61
57	**K 29 x IPI 10**	-7.78**	-12.87**	-7.95**	**-12.27****	-6.25**	**-12.45****	-5.08**	-10.04**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
58	**K 29 x GS 384**	-1.15	-5.51**	-2.61	-5.78**	-2.48	-8.17**	-8.64**	-10.84**
59	**K 29 x H 45**	-3.42**	-6.62**	-4.55**	-9.03**	-6.35**	-8.17**	-6.77**	-6.02**
60	**K 29 x Kartika**	-6.16**	-4.78**	-0.74	-3.25*	-5.75**	-4.28**	-5.04**	-1.61
61	**IPI 10 x GS 384**	0.38	-4.04**	0.37	-2.89*	2.89	-3.11*	-0.41	-2.81*
62	**IPI 10 x H 45**	0.00	-3.31**	1.14	-3.61**	-2.38	-4.28**	-1.99	-1.2
63	**IPI 10 x Kartika**	-2.17	-0.74	1.11	-1.44	-5.36**	-3.89*	-1.16	2.41
64	**GS 384 x H 45**	-0.76	-4.04**	-3.73**	-6.86**	-1.19	-3.11*	-0.40	0.40
65	**GS 384 x Kartika**	-4.71**	-3.31**	0.74	-1.81	-2.30	-0.78	-1.55	2.01
66	**H 45 x Kartika**	-2.54*	-1.1	0.74	-1.81	0.00	**1.56**	1.94	**5.62****
Min.		**-8.3**	**-13.6**	**-8.46**	**-12.27**	**-7.78**	**-12.45**	**-12.2**	**-14.86**
Max.		**2.86**	**1.47**	**3.41**	**0.72**	**3.21**	**1.56**	**4.66**	**5.62**
SE (±)		**0.10**		**0.12**		**0.13**		**0.10**	
No. of significant crosses		**34**	**53**	**21**	**45**	**22**	**48**	**33**	**39**
No. of Significant +ve crosses		**2**	**-**	**5**	**-**	**1**	**-**	**2**	**4**
No. of Significant -ve crosses		**32**	**53**	**16**	**45**	**21**	**48**	**31**	**35**

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

Table 9 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for test weight

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
1	**Indira x Gaurav**	-13.73**	-9.46**	-12.66**	-8.68**	-15.56**	-6.4*	-21.05**	-7.69**
2	**Indira x Dipika**	0.90	0.90	0.46	0.46	3.92	4.43	-4.29*	3.08
3	**Indira x Shekhar**	**-20.38****	-6.76**	**-19.38****	-5.02*	**-21.72****	-5.91*	-19.48**	-4.62*
4	**Indira x KB 9610**	-5.64**	13.06**	-6.44**	12.79**	-8.43**	12.32**	-6.58**	16.41**
5	**Indira x ILS 264**	**29.27****	19.37**	**33.33****	20.55**	**30.85****	21.18**	**28.57****	24.62**
6	**Indira x RLC 133**	0.51	-10.81**	0.52	-10.96**	2.70	-6.40*	3.17	0.00
7	**Indira x K29**	-4.07**	16.67**	-5.62**	15.07**	-5.49**	18.72**	-5.95**	21.54**
8	**Indira x IPI 10**	-1.02	-12.16**	-3.61	-14.61**	-1.08	-9.85**	-4.23*	-7.18**
9	**Indira x GS 384**	-12.79**	1.35	2.41	16.44**	2.50	21.18**	-3.23*	23.08**
10	**Indira x H 45**	1.52	-9.91**	-2.06	-13.24**	-3.24	-11.82**	-7.94**	-10.77**
11	**Indira x Kartika**	-5.08**	**-15.77****	-7.22**	**-17.81****	-9.19**	**-17.24****	-8.47**	**-11.28****
12	**Gaurav x Dipika**	-3.43**	1.35	-3.06	1.37	-13.78**	-4.43	-13.6**	1.03
13	**Gaurav x Shekhar**	-6.15**	9.91**	-4.65*	12.33**	-5.74**	13.3**	-3.03	14.87**
14	**Gaurav x KB 9610**	-7.52**	10.81**	-7.95**	10.96**	-9.24**	11.33**	-8.23**	14.36**
15	**Gaurav x ILS 264**	-3.86**	0.90	-1.75	2.74	-6.22**	3.94	-9.21**	6.15**
16	**Gaurav x RLC 133**	-11.16**	-6.76**	-1.75	2.74	-14.67**	-5.42*	-12.72**	2.05
17	**Gaurav x K 29**	-8.89**	10.81**	-11.24**	8.22**	-14.12**	7.88**	-14.68**	10.26**
18	**Gaurav x IPI 10**	-13.3**	-9.01**	-3.49	0.91	-16.00**	-6.9**	-16.23**	-2.05
19	**Gaurav x GS 384**	-3.10**	12.61**	1.20	15.07**	-2.08	15.76**	-6.85**	18.46**
20	**Gaurav x H 45**	1.72	6.76**	3.06	7.76**	-2.67	7.88**	-2.63	13.85**
21	**Gaurav x Kartika**	-2.58*	2.25	-0.44	4.11	-8**	1.97	-10.53**	4.62*
22	**Dipika x Shekhar**	-5.38**	10.81**	-6.98**	9.59**	-11.48**	6.40*	-3.03	14.87**
23	**Dipika x KB 9610**	-4.14**	14.86**	-6.82**	12.33**	-8.84**	11.82**	-5.76**	17.44**
24	**Dipika x ILS 264**	-4.5**	-4.5**	-6.85**	-6.85**	-5.88*	-5.42*	-6.19**	1.03
25	**Dipika x RLC 133**	-2.25	-2.25	-1.83	-1.83	-1.96	-1.48	22.86**	**32.31****
26	**Dipika x K 29**	-6.67**	13.51**	-5.62**	15.07**	-9.8**	13.3**	-4.76**	23.08**
27	**Dipika x IPI 10**	3.6**	3.6**	0.00	0.00	-1.47	-0.99	2.86	10.77**
28	**Dipika x GS 384**	-9.3**	5.41**	-4.82*	8.22**	-10**	6.4*	-14.11**	9.23**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
29	**Dipika x H 45**	-5.41**	-5.41**	-4.11	-4.11	-7.35**	-6.9**	-7.14**	0.00
30	**Dipika x Kartika**	3.15*	3.15*	3.20	3.20	2.94	3.45	4.29*	12.31**
31	**Shekhar x KB 9610**	-1.88	17.57**	-3.79*	15.98**	0.00	22.66**	0.82	25.64**
32	**Shekhar x ILS 264**	-3.08**	13.51**	-4.65*	12.33**	-3.69	15.76**	1.30	20**
33	**Shekhar x RLC 133**	-2.69*	13.96**	-4.65*	12.33**	-1.64	18.23**	0.00	18.46**
34	**Shekhar x K 29**	-1.85	19.37**	-3.37	17.81**	-5.10*	19.21**	1.19	30.77**
35	**Shekhar x IPI 10**	-6.92**	9.01**	-9.3**	6.85**	-9.02**	9.36**	-5.19**	12.31**
36	**Shekhar x GS 384**	-5.38**	10.81**	-5.81**	10.96**	-4.10	15.27**	-5.65**	20**
37	**Shekhar x H 45**	1.54	18.92**	0.00	17.81**	0.82	21.18**	6.06**	25.64**
38	**Shekhar x Kartika**	-1.92	14.86**	-3.1	14.16**	-6.56**	12.32**	-2.60	15.38**
39	**KB 9610 x ILS 264**	-3.76**	15.32**	-3.41	16.44**	-4.82*	16.75**	-4.94**	18.46**
40	**KB 9610 x RLC 133**	-0.38	19.37**	0.00	20.55**	-0.80	21.67**	2.06	27.18**
41	**KB 9610 x K 29**	1.48	**23.42****	1.12	**23.29****	-1.96	**23.15****	-2.38	26.15**
42	**KB 9610 x IPI 10**	-5.64**	13.06**	-6.82**	12.33**	-6.43**	14.78**	-4.12**	19.49**
43	**KB 9610 x GS 384**	-6.02**	12.61**	-8.71**	10.05**	-3.61	18.23**	-8.06**	16.92**
44	**KB 9610 x H 45**	-11.28**	6.31**	-9.09**	9.59**	-8.43**	12.32**	-9.88**	12.31**
45	**KB 9610 x Kartika**	-6.77**	11.71**	-10.23**	8.22**	-8.43**	12.32**	-6.17**	16.92**
46	**ILS 264 x RLC 133**	0.98	-6.76**	4.55	-5.48*	1.60	-5.91*	12.64**	0.51
47	**ILS 264 x K 29**	-16.67**	1.35	-19.1**	-1.37	-17.65**	3.45	-16.67**	7.69**
48	**ILS 264 x IPI 10**	-1.95	-9.46**	0.00	-9.59**	1.60	-5.91*	10.34**	-1.54
49	**ILS 264 x GS 384**	-6.98**	8.11**	-6.43**	6.39**	-8.33**	8.37**	-12.9**	10.77**
50	**ILS 264 x H 45**	-2.44	-9.91**	-0.51	-10.05**	-0.53	-7.88**	8.62**	-3.08
51	**ILS 264 x Kartika**	0.00	-7.66**	6.06*	-4.11	1.60	-5.91*	8.62**	-3.08
52	**RLC 133 x K 29**	-15.56**	2.7*	-14.61**	4.11	-15.69**	5.91*	-12.3**	13.33**
53	**RLC 133 x IPI 10**	1.59	-13.51**	3.85	-13.7**	6.10	-14.29**	6.51**	-7.69**
54	**RLC 133 x GS 384**	-16.28**	-2.7*	-13.65**	-1.83	-21.25**	-6.9**	**-22.58****	-1.54
55	**RLC 133 x H 45**	3.17*	-12.16**	7.14*	-10.96**	10.37**	-10.84**	11.83**	-3.08
56	**RLC 133 x Kartika**	16.32**	-0.45	20.33**	0.00	19.64**	-0.99	17.24**	4.62*
57	**K 29 x IPI 10**	-3.33**	17.57**	-5.62**	15.07**	-4.71*	19.7**	-2.78	25.64**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
58	**K 29 x GS 384**	-2.22*	18.92**	-2.25	19.18**	-3.53	21.18**	-2.38	26.15**
59	**K 29 x H 45**	-10.37**	9.01**	-11.24**	8.22**	-12.16**	10.34**	-10.71**	15.38**
60	**K 29 x Kartika**	-11.48**	7.66**	-10.11**	9.59**	-13.33**	8.87**	-15.48**	9.23**
61	**IPI 10 x GS 384**	-7.75**	7.21**	-4.42*	8.68**	-7.92**	8.87**	-16.13**	6.67**
62	**IPI 10 x H 45**	18.97**	-6.76**	21.43**	-6.85**	20.5**	-4.43	16.77**	0.00
63	**IPI 10 x Kartika**	8.42**	-7.21**	10.00**	-9.59**	21.43**	0.49	0.00	-10.77**
64	**GS 384 x H 45**	-1.16	14.86**	0.40	14.16**	1.25	19.7**	-0.81	26.15**
65	**GS 384 x Kartika**	-4.65**	10.81**	-3.61	9.59**	-5.00*	12.32**	-10.48**	13.85**
66	**H 45 x Kartika**	19.47**	2.25	26.67**	4.11	25.00**	3.45	25.86**	12.31**
Min.		**-20.38**	**-15.77**	**-19.38**	**-17.81**	**-21.72**	**-17.24**	**-22.58**	**-11.28**
Max.		**29.27**	**23.42**	**33.33**	**23.29**	**30.85**	**23.15**	**28.57**	**32.31**
SE (±)		**0.09**		**0.16**		**0.17**		**0.12**	
No. of significant crosses		**48**	**57**	**37**	**50**	**41**	**54**	**50**	**52**
No. of Significant +ve crosses		**8**	**38**	**7**	**36**	**6**	**37**	**12**	**45**
No. of Significant -ve crosses		**40**	**19**	**30**	**14**	**35**	**17**	**38**	**7**

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

Table 10 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for seed yield per plant

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
1	**Indira x Gaurav**	-6.81	-5.91	-10.18**	-10.21**	-8.67*	-2.91	**-25.98****	-9.78**
2	**Indira x Dipika**	4.91	-1.11	3.14	-4.47	7.79	-2.05	-6.26	-6.00
3	**Indira x Shekhar**	**-21.46****	-1.21	**-21.91****	-1.01	-22.67**	0.27	-25.41**	1.91
4	**Indira x KB 9610**	-8.49**	0.92	-6.87**	1.29	-8.55*	3.55	-0.38	18.92**
5	**Indira x ILS 264**	**33.22****	18.68**	**38.78****	18.43**	**28.80****	17.65**	**39.51****	23.34**
6	**Indira x RLC 133**	21.94**	-5.22	15.98**	-10.34**	6.32	-16.54**	4.57	-9.47**
7	**Indira x K29**	10.61**	10.98**	10.73**	8.11**	8.31	12.32**	9.37**	19.85**
8	**Indira x IPI 10**	12.48**	-7.11*	12.34**	-7.96**	12.39*	-4.56	8.84*	5.59
9	**Indira x GS 384**	-18.67**	0.26	-12.85**	6.28*	-4.14	16.54**	-12.91**	27.88**
10	**Indira x H 45**	5.27	-18.18**	4.35	-19.33**	7.85	-15.34**	-8.81*	**-17.96****
11	**Indira x Kartika**	-6.49	**-19.46****	-2.23	**-21.18****	-6.17	**-21.65****	-5.86	-13.94**
12	**Gaurav x Dipika**	4.30	5.31	4.57	4.54	-12.13**	-6.59	-11.75**	7.56*
13	**Gaurav x Shekhar**	-8.92**	14.57**	-9.19**	15.12**	-6.51	21.22**	-6.28*	28.04**
14	**Gaurav x KB 9610**	-5.43	4.29	-2.00	6.59*	-6.13	6.29	-12.85**	6.22
15	**Gaurav x ILS 264**	-1.89	-0.94	-1.68	-1.71	-5.19	0.78	-8.86**	11.09**
16	**Gaurav x RLC 133**	-12.34**	-11.49**	-7.07**	-7.11**	**-24.55****	-19.79**	-22.97**	-6.12
17	**Gaurav x K 29**	8.01*	9.05*	5.25*	5.21*	-0.70	5.56	-10.52**	9.06*
18	**Gaurav x IPI 10**	-2.7	-1.76	3.49	3.45	-10.53*	-4.89	-11.71**	7.61*
19	**Gaurav x GS 384**	-1.13	21.9**	-0.87	20.89**	2.36	24.45**	-9.9**	32.3**
20	**Gaurav x H 45**	14.84**	15.95**	12.94**	12.9**	5.68	12.34**	1.88	24.17**
21	**Gaurav x Kartika**	2.76	3.75	2.48	2.45	-3.95	2.11	-14.4**	4.33
22	**Dipika x Shekhar**	-6.66*	17.41**	-7.17**	17.68**	-13.3**	12.42**	-9.39**	23.8**
23	**Dipika x KB 9610**	1.98	12.46**	4.12	13.24**	-4.08	8.61	-6.25*	11.91**
24	**Dipika x ILS 264**	-0.50	-6.20	-0.16	-7.52**	0.49	-8.21	2.80	3.08
25	**Dipika x RLC 133**	4.13	-1.85	4.25	-3.44	-0.63	-9.7*	27.84**	28.18**
26	**Dipika x K 29**	3.83	4.18	7.01**	4.47	11.64**	15.77**	17.68**	28.95**
27	**Dipika x IPI 10**	11.34**	4.96	10.99**	2.81	8.31	-1.58	17.44**	17.76**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
28	**Dipika x GS 384**	-7.38*	14.18**	-4.21*	16.82**	-14.04**	4.51	-19.53**	18.17**
29	**Dipika x H 45**	2.22	-3.64	3.29	-4.33	1.45	-7.81	-1.52	-1.25
30	**Dipika x Kartika**	7.35	1.19	9.56**	1.48	10.57*	0.47	15.44**	15.76**
31	**Shekhar x KB 9610**	-1.66	23.7**	-4.62*	20.91**	-2.01	27.05**	-2.75	32.87**
32	**Shekhar x ILS 264**	-2.88	22.16**	-4.79*	20.69**	-10.61**	15.9**	-2.14	33.7**
33	**Shekhar x RLC 133**	-6.27*	17.9**	-9.12**	15.2**	-3.71	24.85**	-5.45*	29.18**
34	**Shekhar x K 29**	-5.37	19.03**	-6.17**	18.94**	-11.66**	14.54**	-8.71**	24.72**
35	**Shekhar x IPI 10**	-2.43	22.73**	-3.86	21.87**	-7.07*	20.5**	-3.76	31.5**
36	**Shekhar x GS 384**	-1.45	23.97**	-1.25	25.18**	3.62	**34.36****	-2.40	43.32**
37	**Shekhar x H 45**	1.25	**27.36****	-1.18	**25.27****	-5.86	22.06**	4.03	42.13**
38	**Shekhar x Kartika**	-1.11	24.4**	-3.13	22.8**	-3.55	25.06**	-0.47	35.98**
39	**KB 9610 x ILS 264**	6.2	17.12**	4.97*	14.17**	3.67	17.39**	5.01	25.36**
40	**KB 9610 x RLC 133**	-0.55	9.67**	-0.05	8.71**	-3.45	9.33*	-2.57	16.31**
41	**KB 9610 x K 29**	-1.56	8.56*	0.05	8.82**	0.10	13.34**	11.55**	33.17**
42	**KB 9610 x IPI 10**	7.97*	19.07**	7.8**	17.25**	11.01**	25.7**	23.84**	**47.84****
43	**KB 9610 x GS 384**	-7.43*	14.13**	-8.79**	11.24**	10.33**	34.13**	-14.92**	24.93**
44	**KB 9610 x H 45**	1.07	11.46**	-0.17	8.58**	2.01	15.51**	-0.72	18.52**
45	**KB 9610 x Kartika**	2.25	12.76**	2.19	11.15**	-4.90	7.68	-5.68	12.59**
46	**ILS 264 x RLC 133**	3.77	-7.56*	5.94*	-9.59**	-7.00	-15.05**	8.72*	-3.89
47	**ILS 264 x K 29**	-1.38	-1.04	-1.65	-3.99	-1.35	2.31	-2.63	6.69
48	**ILS 264 x IPI 10**	12.17**	-0.07	14.89**	-1.96	12.86**	3.09	16.49**	13.01**
49	**ILS 264 x GS 384**	-2.18	20.59**	-3.63	17.53**	2.51	24.63**	-7.12**	36.4**
50	**ILS 264 x H 45**	-0.73	-11.56**	2.81	-12.27**	-2.22	-10.69*	12.05**	0.81
51	**ILS 264 x Kartika**	7.63	-4.11	12.21**	-4.24	4.38	-4.66	16.13**	6.16
52	**RLC 133 x K 29**	-9.9**	-9.6**	-7.75**	-9.94**	-6.54	-3.08	-7.01*	1.90
53	**RLC 133 x IPI 10**	16.49**	-3.79	15.34**	-5.51*	13.23*	-3.85	12.85**	9.48**
54	**RLC 133 x GS 384**	-18.92**	-0.05	-18.1**	-0.11	-21.78**	-4.90	-23.04**	13.01**
55	**RLC 133 x H 45**	12.94**	-12.83**	18.12**	-12.1**	4.43	-18.39**	2.72	-7.59*
56	**RLC 133 x Kartika**	25.84**	8.39*	25.35**	1.06	24.39**	3.87	20.44**	10.1**

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
57	**K 29 x IPI 10**	16.48**	16.88**	18.15**	15.35**	14.4**	18.64**	19.83**	31.3**
58	**K 29 x GS 384**	0.62	24.05**	-0.52	21.32**	-5.36	15.06**	-13.87**	26.47**
59	**K 29 x H 45**	5.11	5.46	4.19	1.72	6.85	10.8*	16.88**	28.07**
60	**K 29 x Kartika**	3.75	4.10	6.36*	3.84	2.10	5.88	2.74	12.58**
61	**IPI 10 x GS 384**	-1.67	21.22**	0.27	22.29**	4.19	26.66**	-10.31**	31.7**
62	**IPI 10 x H 45**	25.18**	3.39	25.89**	3.14	15.08**	-2.29	19.8**	16.22**
63	**IPI 10 x Kartika**	18.93**	2.44	23.09**	0.85	26.67**	7.56	9.45*	6.18
64	**GS 384 x H 45**	-1.12	21.91**	-3.12	18.15**	-1.52	19.73**	-2.49	43.19**
65	**GS 384 x Kartika**	-5.95*	15.95**	-7.12**	13.27**	-3.12	17.78**	-19.26**	18.56**
66	**H 45 x Kartika**	25.8**	8.36*	33.15**	7.35**	24.32**	3.81	34.65**	23.1**
Min.		**-21.46**	**-19.46**	**-21.91**	**-21.18**	**-24.55**	**-21.65**	**-25.98**	**-17.96**
Max.		**33.22**	**27.36**	**38.78**	**25.27**	**28.8**	**34.36**	**39.51**	**47.84**
SE (±)		**0.15**		**0.99**		**0.70**		**0.74**	
No. of significant crosses		**28**	**40**	**38**	**45**	**25**	**37**	**45**	**52**
No. of Significant +ve crosses		**16**	**32**	**22**	**33**	**13**	**29**	**20**	**47**
No. of Significant -ve crosses		**12**	**8**	**16**	**12**	**12**	**8**	**25**	**5**

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

Table 11 Estimation of heterobeltiosis (BP) and standard heterosis (SH) for oil content

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
1	**Indira x Gaurav**	-1.85	0.15	-1.72	2.44	-1.83	0.00	-7.39**	-0.98
2	**Indira x Dipika**	-1.76	1.89	-4.31*	1.17	-3.67*	-1.87	-5.81**	0.71
3	**Indira x Shekhar**	-3.99*	-2.03	-5.67**	-1.68	-4.67**	-2.89	-7.14**	-0.71
4	**Indira x KB 9610**	-5.62**	-3.70*	-5.2**	-1.19	-5.5**	-3.74*	-10.71**	-4.53*
5	**Indira x ILS 264**	0.35	2.39	0.62	**4.88****	-2.17	-0.34	-3.90*	2.75
6	**Indira x RLC 133**	-3.09	-1.12	-2.70	1.41	-2.50	-0.68	-2.99	3.73
7	**Indira x K29**	-6.51**	-4.60*	-6.81**	-2.87	-5.08**	-3.31	-11.54**	-5.41**
8	**Indira x IPI 10**	-8.56**	-6.70**	-11.72**	-7.98**	-8.92**	-7.22**	-10.87**	-4.70*
9	**Indira x GS 384**	-10.42**	-8.60**	-12.51**	-8.81**	**-12.83****	-11.21**	-12.37**	-6.3**
10	**Indira x H 45**	-9.71**	-7.87**	-10.31**	-6.52**	-11.17**	-9.51**	-10.54**	-4.35*
11	**Indira x Kartika**	-2.93	-0.95	-1.91	2.24	-3.08	-1.27	-6.56**	-0.09
12	**Gaurav x Dipika**	-7.09**	-3.63*	-6.75**	-1.40	-2.84	-4.07*	-3.27	-0.27
13	**Gaurav x Shekhar**	-3.23	-6.34**	-2.35	-4.61*	3.49	-4.41*	-3.99*	-1.69
14	**Gaurav x KB 9610**	-0.18	-3.39	2.29	-0.08	4.56*	-2.72	0.90	-0.71
15	**Gaurav x ILS 264**	-0.47	0.02	-2.08	1.14	0.35	-3.40	-2.11	-1.24
16	**Gaurav x RLC 133**	-5.21**	-3.74*	4.18*	1.80	-1.79	-2.38	-1.65	0.44
17	**Gaurav x K 29**	-5.33**	-5.69**	-4.10*	-3.11	-1.24	-5.69**	-6.35**	-4.53*
18	**Gaurav x IPI 10**	-7.24**	-10.22**	-5.43**	-7.62**	-1.84	-9.34**	-8.07**	-7.99**
19	**Gaurav x GS 384**	0.80	-2.44	-1.05	-3.34	0.09	-7.56**	1.32	-4.61*
20	**Gaurav x H 45**	-0.89	-3.98*	3.43	1.03	-3.08	-3.9*	4.81*	-1.33
21	**Gaurav x Kartika**	-0.14	1.05	-0.54	1.84	-1.20	-2.12	-9.01**	-4.97*
22	**Dipika x Shekhar**	-1.96	1.68	-4.77**	0.68	1.29	0.00	-1.89	1.15
23	**Dipika x KB 9610**	-5.97**	-2.47	-5.43**	-0.02	-2.58	-3.82*	-3.44	-0.44
24	**Dipika x ILS 264**	-1.48	2.19	-1.13	4.53*	1.46	0.17	-0.86	2.22
25	**Dipika x RLC 133**	-10.27**	-6.93**	-9.7**	-4.52*	-7.34**	-7.89**	-6.11**	-3.19
26	**Dipika x K 29**	-11.93**	-8.66**	**-14.48****	-9.59**	-8.43**	-9.59**	-9.98**	-7.19**
27	**Dipika x IPI 10**	-4.37*	-0.81	-5.81**	-0.42	-2.84	-4.07*	-1.20	1.86

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)	BP (%)	SH (%)
28	**Dipika x GS 384**	-6.64**	-3.16	-6.35**	-0.98	-1.46	-2.72	-1.89	1.15
29	**Dipika x H 45**	**-12.85****	-9.61**	-10.16**	-5.01**	-6.76**	-7.56**	-9.55**	-6.74**
30	**Dipika x Kartika**	-4.12*	-0.56	-1.87	3.75*	-1.89	-2.80	-2.38	1.95
31	**Shekhar x KB 9610**	-5.77**	-8.99**	-4.01*	-6.27**	-3.92*	-10.61**	-9.01**	-6.83**
32	**Shekhar x ILS 264**	-2.91	-2.44	-4.45*	-1.30	-0.88	-4.58**	-5.29**	-3.02
33	**Shekhar x RLC 133**	0.32	1.88	3.46	1.09	0.77	**0.17**	-5.37**	-3.11
34	**Shekhar x K 29**	-7.61**	-7.96**	-7.63**	-6.68**	-4.00*	-8.32**	-8.75**	-6.57**
35	**Shekhar x IPI 10**	-3.01	-7.26**	-3.3	-5.57**	-3.13	-10.53**	-8.58**	-6.39**
36	**Shekhar x GS 384**	**5.92****	-1.24	**4.26***	-0.78	**5.51****	-2.55	-2.95	-0.62
37	**Shekhar x H 45**	-2.31	-5.35**	4.11*	-0.73	-6.85**	-7.64**	-8.41**	-6.21**
38	**Shekhar x Kartika**	-2.20	-1.04	-2.25	0.09	0.34	-0.59	-2.12	2.22
39	**KB 9610 x ILS 264**	1.02	1.52	-1.20	2.06	1.59	-2.21	4.22*	5.15**
40	**KB 9610 x RLC 133**	-6.59**	-5.14**	-0.68	-2.95	-3.5*	-4.07*	-5.04**	-3.02
41	**KB 9610 x K 29**	-8.14**	-8.49**	-6.37**	-5.41**	-3.02	-7.39**	-10.01**	-8.25**
42	**KB 9610 x IPI 10**	-0.36	-3.78*	1.35	-1.03	0.55	-6.45**	-4.61*	-4.53*
43	**KB 9610 x GS 384**	-9.48**	**-12.58****	-8.73**	**-10.87****	-6.75**	**-13.24****	-6.49**	-7.99**
44	**KB 9610 x H 45**	-7.11**	-10.01**	-5.3**	-7.53**	-10.45**	-11.21**	-7.03**	-8.52**
45	**KB 9610 x Kartika**	-5.44**	-4.31*	-5.03**	-2.76	-5.57**	-6.45**	-7.39**	-3.28
46	**ILS 264 x RLC 133**	2.04	3.63*	0.2	3.51	0.51	-0.08	2.17	4.35*
47	**ILS 264 x K 29**	-3.87*	-3.4	-6.62**	-3.54	1.50	-2.29	-0.78	1.15
48	**ILS 264 x IPI 10**	-4.06*	-3.59*	-5.31**	-2.19	-5.29**	-8.83**	-5.28**	-4.44*
49	**ILS 264 x GS 384**	-3.59*	-3.12	-6.2**	-3.11	-2.12	-5.77**	-5.45**	-4.61*
50	**ILS 264 x H 45**	-1.24	-0.76	-4.46*	-1.31	-2.83	-3.65*	-4.4*	-3.55
51	**ILS 264 x Kartika**	0.17	1.36	-1.29	1.97	-1.71	-2.63	-7.48**	-3.37
52	**RLC 133 x K 29**	0.24	1.79	0.93	1.97	0.00	-0.59	-1.04	1.06
53	**RLC 133 x IPI 10**	-7.33**	-5.89**	0.53	-1.77	-7**	-7.56**	-7.91**	-5.94**
54	**RLC 133 x GS 384**	-11.01**	-9.63**	-4.86*	-7.04**	-9.48**	-10.02**	-9.21**	-7.28**
55	**RLC 133 x H 45**	-2.71	-1.21	2.87	0.51	-4.7**	-5.26**	-5.56**	-3.55
56	**RLC 133 x Kartika**	-2.99	-1.49	-1.72	0.64	0.60	0.00	-1.61	2.75

S.N.	Crosses	E_1		E_2		E_3		E_4	
		BP (%)	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**	**BP (%)**	**SH (%)**
57	**K 29 x IPI 10**	-6.45**	-6.82**	-3.96*	-2.98	-4.53*	-8.83**	**-12.97****	**-11.27****
58	**K 29 x GS 384**	-7.51**	-7.86**	-8.62**	-7.69**	-7.2**	-11.38**	-10.79**	-9.05**
59	**K 29 x H 45**	-2.21	-2.59	-6.08**	-5.11**	-5.22**	-6.03**	-4.79*	-2.93
60	**K 29 x Kartika**	0.59	1.78	-0.67	1.72	-3.51*	-4.41*	-2.55	1.77
61	**IPI 10 x GS 384**	-1.37	-5.68**	-2.60	-4.89**	-0.75	-9.59**	-3.63	-3.55
62	**IPI 10 x H 45**	-5.88**	-8.81**	3.07	0.66	-2.40	-3.23	0.18	0.27
63	**IPI 10 x Kartika**	0.22	1.41	-1.28	1.08	-1.54	-2.46	0.85	**5.32****
64	**GS 384 x H 45**	-0.43	-3.53*	4.02*	-0.82	-2.74	-3.57*	**5.57****	-0.80
65	**GS 384 x Kartika**	-1.27	-0.09	-2.58	-0.24	-1.97	-2.89	-4.67*	-0.44
66	**H 45 x Kartika**	2.75	**3.97***	0.63	3.04	-0.77	-1.61	-1.87	2.48
Min.		**-12.85**	**-12.58**	**-14.48**	**-10.87**	**-12.83**	**-13.24**	**-12.97**	**-11.27**
Max.		**5.92**	**3.97**	**4.26**	**4.88**	**5.51**	**0.17**	**5.57**	**5.32**
SE (±)		**0.70**		**0.73**		**0.68**		**0.73**	
No. of significant crosses		**32**	**34**	**36**	**21**	**27**	**38**	**43**	**28**
No. of Significant +ve crosses		**1**	**2**	**4**	**3**	**2**	**-**	**3**	**3**
No. of Significant -ve crosses		**31**	**32**	**32**	**18**	**25**	**38**	**40**	**25**

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

REFERENCES

Ahamad, A., Ansari, A., Paul, A., & Bhusan, S. (2018). Studies of heterosis and inbreeding depression for seed yield and its components in linseed (*Linum usitatissimum* L.). *Journal of Agricultural Science and Engineering*, 147-150.

Anonymous. (2020). Annual report on linseed. AICRP on Linseed, Kanpur.

Bhateria, S., Sood, S., & Pathania, A. (2006). Genetic analysis of quantitative traits across environments in linseed (*Linum usitatissimum* L.). *Euphytica*, 150 (1-2), 185-194.

Chaure, P. L., Dhone, P. U., Mahajan, M. M., & Misal, A. M. (2018). Studies on heterosis for yield and yield components in linseed (*Linum usitatissimum* L.). *Journal of Pharmacognosy and Phytochemistry*, 7 (1), 1331-1334.

Dabholkar, A. R. (1999). "*Elements of Bio Metrical Genetics*" (revised and enlarged edition), Concept Publishing Company, New Delhi, India, pp: 302-418.

Dillman, A. C. (1928). Daily growth and oil content of flaxseeds. *Journal of Agricultural Research*, 37, 357-377.

Dhirhi, N., Mehta, N., & Singh, S. (2018). Estimation of Heterosis for Seed Yield and Its Attributing Traits in Linseed (*Linum usitatissimum* L.). *International Journal of Current Microbiology and Applied Sciences*, 7 (11), 2332-2341.

Fonseca, S., & Patterson, F. (1968). Hybrid vigour in a seven parent diallel crosses in common winter wheat (*Triticum aestivum* L.). *Crop Science*, 8, 85-88.

Getinet, A, & Nigussie, A. (1997). High land oil crops: A three-decade research experience in Ethiopia. Research report, 30:22-27.

Hegde, D. M. (1999). Oilseed scenario in India – Past, Present and Future with Special Reference to Rapeseed-Mustard. Proc. *Winter School on Advances in Rapeseed-mustard Research Technology for Sustainable Production of Oilseeds*, 1-15.

Kang, S. J., Lee, S. H., & Park, K. S. (1998). DNA polymorphisms at alpha-Gpdh locus of Drosophila melanogaster in Korean population. *Genes & Genetics Systems*, 73 (4), 227--235.

*Kempthorne, O. (1957). An Introduction to Genetic Statistics. John Wiley and Sons. Inc., New York.

*Koelreuter, J. G. (1766). In: Principles of Plant Breeding (R. W. Allard Ed.). John Wiley and Sons, Inc., New York, pp. 214.

Kumar, M., Singh, P. K., Singh, N. P., & Kumar, M. (2000). Line × tester analysis for seed yield and its components in linseed (*Linum usitatissimum* L.). *Annals of Agricultural Research*, 21 (4): 485-489.

Mahto, C., Rahman, M. H., & Mahto, C. (2020). Heterosis for yield and yield components in linseed (*Linum usitatissimum* L.). *Journal of Research, Birsa Agricultural University*, 8 (1), 85-87.

*Meredith, W. R., & Bridge, R. R. (1972). Heterosis and gene action in cotton, *G. hirsutum* L. *Crop Science*, 12, 304-310.

Mohammadi, A. A., Saeidi, G., & Arzani, A. (2010). Genetic analysis of some agronomic traits in flax (*Linum usitatissimum* L.). *Australian Journal of Crop Science*, 4 (5), 343-352.

NFSM oilseed 2021-22 Annual Report.

Pali, V., & Mehta, N. (2014). Combining ability and heterosis for seed yield and its attributes in linseed (*Linum usitatissimum* L.). *The Bioscan*, 9 (2), 701-706.

Panse, V. G., & Sukhatme, P. V. (1967). Statistical methods for research workers. ICAR, New Delhi, 220-40.

Patial, R., Paul, S., Sharma, D., Sood, V. K., & Kumar, N. (2019). Morphological characterization and genetic diversity of linseed (*Linum usitatissimum* L.). *Journal of Oilseeds Research,* 36 (1), 8-16.

Paul. S., & Kumar, N. (2016). Selection criteria of linseed genotypes for seed yield traits through Plaisted, R. L., & Peterson, L. C. (1959). A technique of evaluating the ability of selection to yield consistency in different seasons or locations. *American Journal of Potato Research*, 36, 381-389.

Ram, A., & Ahamad, E. (2016). Heterosis and inbreeding depression for seed yield, its components and qualitative characters in linseed (*Linum usitatissimum* L.). *Journal of Crop Science and Biotechnology*, 5 (7), 23-24.

Ratnaparkhi, R. D., Dudhe, M. Y., Gawande, N. D., & Bhongle, S. A. (2005). Heterosis in relation to combining ability effects in linseed. *Annual Review of Plant Physiology,* 18 (2), 182- 186.

Reddy, M. P., Arsul, B. T., Shaik, N. R., & Maheshwari, J. J. (2013). Estimation of heterosis for some traits in linseed (*Linum usitatissimum* L.*). Journal of Agriculture and Veterinary Sciences,* 2 (5): 11-17.

Richharia, R. H. (1962). Linseed. The Indian Central Oilseeds Committee, Hyderabad, India, 155.

Schuster, A., & Friedt, W. (1998). Glucosinolate Content and Composition as Parameters of Quality of Camelina Seed. *Industrial Crops and Products*, 7 (2): 297-302.

Sharma, R., Tiwari, S. K., Singh, P., & Kant, R. (2005). Heterobeltiosis and inbreeding depression in linseed. *Agricultural Science Digest,* 25 (1), 35-37.

*Shull, G. H. (1908). The compositions of field maize. Annual report - American Breeder's Association, 4, 296-301.

Singh, R. K. and Chaudhary, B. D. (1977). *Biometrical Methods in Quantitative Genetic Analysis*, Kalyani Publishers, New Delhi, India.

Singh, P. K., Srivastava, R. L., Narain, V., & Dubey, S. D. (2009). Combining ability and heterosis for seed yield and oil content in linseed (*Linum usitatissimum* L.). *Indian Journal of Agricultural Sciences*, 79 (3), 229-232.

Singh, V. K. (2014). Estimation of heterosis for yield and its contributing attributes in linseed (*Linum usitatissimum* L.). *The Ecoscan*, 6, 81-84.

Sprague, G. F., & Tatum, L. M. (1942). General versus specific combining ability in single crosses of corn. *Agronomy Journal*, 34, 923-932.

Srivastava, R. L., Srivastava, S. K., Dubey, S. D., & Kerkhi, S. A. (2004). Heterosis and combining ability estimates in linseed under salt affected soil. *Indian Journal of Agricultural Research*, 48 (3-4), 193-197.

Vavilov, N. I. (1935). Studies on the origin of cultivated plants. *Bulletin of Applied Botany and Plant Breeding*, 16, 39-145.

Yadav, P. C., Yadav, R. K., Vishwanath, Y. P., & Kumar, S. (2018). Heterosis and Inbreeding Depression for Seed Yield and its Related Morphological Traits in Linseed (*Linum usitatisimum* L.). *International Journal of Current Microbiology and Applied Sciences*, 7 (1), 3088-3098.

Yates, F., & Cochrahm, W. G. (1938). The analysis of group of experiments.