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Studies on heterosis in ridge gourd (*Luffa acutangula* (L.) Roxb.)

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Abstract
The present investigation was carried out to estimate the magnitude of heterosis of selected parents and resultant F_1 hybrids for yield and yield components for commercial exploitation. Six ridge gourd lines *viz.,* IC-308561, IC-523876, IC-523886, IC-523882, IC-539714 and Satputia were crossed in diallel fashion excluding reciprocals during *rabi*, 2021 resulting in the development of 15 one-way F_1 hybrids. A set of twenty two entries involving fifteen F_1 hybrids along with their six parental lines and one commercial check (Arka Vikram) were evaluated by raising each entry at a spacing of 2.00 m × 0.75 m in a randomized block design with two replications at Horticulture Research Station, Venkataramannagudem during summer, 2022 for eighteen biometric characters. For average fruit weight the cross combination IC-523876 X IC-523886 showed significant standard heterosis over commercial check Arka Vikram. Significant standard heterosis over commercial check Arka Vikram with regard to fruit yield per plant and its components was exhibited by the cross combination *viz.,* IC-523886 X IC-539714 in positive direction.

Keywords: Ridge gourd, Heterosis

Introduction

Ridge gourd is one of the important cucurbitaceous vegetables grown throughout India and is known by different vernacular names around the country *viz.,* Beerakaya (Telugu), Dodka (Marathi), Turai (Hindi), Peerkankai (Tamil), Sirola (Gujarati), Heerekayi (Kannada) and Peechanga (Malayalam) *etc.,*. It is also called as angled gourd, angled loofah, Chinese okra, silky gourd and ribbed gourd (Muthaiah *et al*., 2017a) [10]. Ridge gourd (*Luffa acutangula* (L.) Roxb.) belongs to the class Magnoliopsida, order Cucurbitales, family Cucurbitaceae and genus *Luffa*.

The genus *Luffa* derived its name from the product 'loofah' which is used in bathing sponges, door mats, pillows and also for cleaning utensils. The genus includes seven species, out of which only two are important as commonly cultivated vegetables *viz*., ridge gourd (*Luffa acutangula* (L.) Roxb.) and sponge gourd (*Luffa cylindrica* L.). Ridge and sponge gourds are grown as mixed cropping in the river beds and as monocrop in the garden lands. Ridge gourd is considered to be the old world species and is native of tropical Africa and South-East Asian region including India. It is widely grown in tropical and subtropical parts of the country with the chromosome number is 2n=2x=26.

Ridge or ribbed gourd (*Luffa acutangula* Roxb.) is a popular cucurbitaceous vegetable grown as spring-summer and rainy season crop. Ridge gourd contains 0.5% protein, 3.4% carbohydrates, 37 mg carotene and 18 mg vitamin C per 100 g edible portion. It contains a gelatinous compound called luffein which is traditionally used for treatment of stomach ailment and fever. Ridge gourd provides various health benefits as it acts like blood purifier, possess laxative properties, beneficial for diabetes and it is extremely rich in dietary fibre, aiding in weight loss. Some round varieties of ridge gourd are also used for stuffing purpose.

Ridge gourd is cultivated in 5,200 hectares in Andhra Pradesh with a production of 48,221 tonnes (Anonymous, 2020) [1]. However, most of the cucurbitaceous vegetables are usually cultivated in relatively small areas for local consumption and hence the reliable statistical data on area and production is lacking. The sex forms in ridge gourd are monoecious, androecious, Gynoecious, Gynomonoecious, Andromonoecious and hermaphrodite. Anthesis occurs between 5 - 8 pm. Pollen fertility is maximum on the day of anthesis and lasts till 2 - 3 days after anthesis. Stigma is receptive 6 hours before to 84 hours after anthesis.

Heterosis is a common biological phenomenon in nature. It refers to superiority of the heterozygote produced by hybridization between two or more parents with different genetic bases. Shull (1908) [17] called this phenomenon as the stimulus of heterozygosity and hybrid vigour. Hybrids are superior to the parents in terms of yield, growth rate, viability and disease resistance. Moreover, this phenomenon results in high economic returns in agricultural production. For developing promising hybrids, the choice of parents is a matter of great concern to the plant breeder. A high yielding genotype may or may not transmit it's superiority to its progenies. Therefore, the success of breeding programme is determined by useful gene combinations in the form of high combining inbreds.

Material and Methods

An experiment was carried out at Horticulture Research Station during *rabi* and summer, 2021-2022. The experimental material consisted of 6 parents *viz.*, IC-308561, IC-523876, IC-523886, IC-523882, IC-539714 and Satputia were crossed diallel fashion excluding reciprocals during *rabi*, 2021 resulting in the development of 15 one-way F_1 hybrids. All the 15 hybrids along with their corresponding 6 parents were evaluated in a randomized block design in two replications during summer, 2022. Observations were recorded for various growth, earliness, yield and biochemical parameters to see the performance of parents and hybrids. The observations were recorded on randomly selected five plants for vine length (cm), internodal length (cm), node number at which first male flower appear, node number at which first female/hermaphrodite flower appear, days to appearance of first male flower, days to appearance first female/hermaphrodite flower appearance, fruit set percentage, days to first fruit harvest, peduncle length (cm), fruit length (cm), fruit diameter (cm), fruit weight (g), number of fruits per plant, fruit yield per plant (kg), estimated yield (t/ha), ascorbic acid content(mg 100 g^{-1}), TSS(°B) and fibre content(g 100 g^{-1}). Heterosis was calculated as percentage of F_1 performance in the favourable direction over mid parent, better parent and commercial check (Arka Vikram).

Results and Discussion

The estimates of mean sum of squares due to parents and hybrids showed significant differences for all the characters indicating the presence of sufficient variability among the parents and hybrids studied (Table 1). Variance due to Parents vs. hybrid was significant for all the characters studied except for node number at which first female/hermaphrodite flower appear and fruit yield per plant. This indicates enormous amount of variability present among the genotypes studied.

The range of mean performance and for various heterotic effects as well as the heterotic crosses identified on the basis of growth, earliness, yield and quality parameters are presented in the Table 2 to 12. In ridge gourd, earliness is a useful character for realizing the potential economic yield in a short time. The characters like days to first male flower and female flower appearance, node number at which first male and female flower appear, internodal length and days to first fruit harvest are considered as criteria for earliness and for these traits heterosis is desirable in negative direction and yield components greatly influence the yield and expression of heterosis for fruit length, fruit diameter, average fruit weight, number of fruits per plant can greatly contribute for heterosis. So for these traits positive heterosis is desirable. Total soluble solids, ascorbic acid content and fibre content are the important quality parameters of fruit and heterosis in positive direction would be desirable for these traits.

For vine length, maximum negative heterosis over the commercial check was observed in the cross IC-523882 X IC-539714 (-38.09%), the crosses IC-523886 X IC-523882 (-36.85%) and IC-523886 X Satputia (-41.68%) exhibited highest negative heterosis over mid parent and better parent respectively. (Table 3). For the trait vine length, heterosis is desirable in negative direction, if the minimum vine length with lesser internodal length accommodates more number of flowers, which ultimately produce more number of fruits even in smaller stature in a short duration of time. These results are in conformity with the findings of Devi *et al*. (2017a) [4] in snake gourd and Poshiya *et al*. (2015) [14], Chittora *et al*. (2018) [3] and Nandhini *et al*. (2018) [12] in ridge gourd. The cross IC-523876 X Satputia (-12.33%) exhibited highly significant negative heterosis over mid parent, the better parent (-14.76%) and the commercial check (-10.29%) for internodal length and similar findings were also reported by Devi *et al*. (2017) [4] in snake gourd and Sarkar *et al*. (2015) [15], Chittora *et al*. (2018) [3] and Nandhini *et al*. (2018) [12] in ridge gourd. For node number at which first male flower appear, maximum and significantly negative heterosis over mid parent was observed in the cross IC-539714 X Satputia (-225.00%) and the cross IC-308561 X IC-523882 (-37.84%) exhibited highly negatively significant heterosis over the better parent and the commercial check (-14.81%). These results are in conformity with the findings of Narasannavar *et al*. (2014) [13], Lodam *et al*. (2014) [8] and Bairwa *et al*. (2017) [2] in ridge gourd. For node number at which first female/hermaphrodite flower appear, maximum and significantly negative heterosis over mid parent, better parent and commercial check was observed in the cross IC-523882 X Satputia (-20.18%, -38.51 and -24.17) respectively. These results are in conformity with the findings of Narasannavar *et al*. (2014) [13], Lodam *et al*. (2014) [8], Bairwa *et al*. (2017) [2] and Nandhini *et al*. (2018) [12] in ridge gourd.

Negative heterosis is desirable for earliness. The maximum and significantly negative heterosis over mid parent (-5.04%) and better parent (-5.68%) was observed in the cross IC-523876 X IC-523882 and IC-523876 X Satputia exhibited maximum and significant positive heterosis over the commercial check (6.53%) for days to first male flower appearance. These results are in conformity with the findings of Laxuman *et al*. (2012) [7] in bitter gourd, Sonavane *et al*. (2013) [18] in sponge gourd and Narasannavar *et al*. (2014) [13] and Chittora *et al*. (2018) [3] in ridge gourd. For days to first female/hermaphrodite flower appearance, maximum and significant negative heterosis over mid parent (-8.13%) and better parent (-8.76%) was observed in the cross IC-308561 X IC-523882 and IC-523882 X Satputia exhibited maximum and significant negative heterosis over the commercial check (-6.66%). Negative heterosis with reference to days to female flower appearance was also reported by Laxuman *et al*. (2012) [7] in bitter gourd, Sonavane *et al*. (2013) [18] in sponge gourd and Narasannavar *et al*. (2014) [13] in ridge gourd.

For days to first fruit harvest, significant negative heterosis in the desirable direction was observed in the cross IC-308561 X IC-523882 over mid parent (-11.87%), better parent (-14.97%) and commercial check (-6.56%). For fruit set percentage, maximum and significantly negative heterosis over the mid parent was observed in the cross IC-539714 X Satputia (-15.77%) and the cross IC-523882 X Satputia was exhibited maximum and negatively significant heterosis over the better parent (-20.00%) and commercial check (-10.87%). Negative heterosis was also reported by Thangamani *et al*. (2011) in bitter gourd.

For fruit length the cross IC-523882 X Satputia showed maximum and positive significant heterosis over mid parent (60.22%), IC-523882 X IC-539714 showed maximum and positive significant heterosis over better parent (43.32%) and IC-523876 X IC-523882 showed maximum and positive significant heterosis over the commercial check (19.50%). For fruit diameter, IC-523876 X Satputia showed maximum positive heterosis of 34.95%, 7.65% and 34.95% over mid parent, better parent and commercial check respectively. These findings are in consonance with Hedau and Sirohi (2004a) [5].

Average fruit weight can contribute for yield, the cross IC-308561 X Satputia exhibited maximum heterosis of 71.81 per cent over mid parent and 26.91 per cent over better parent, which is confirmed with Shaha and Kale (2003a) [16] in ridge gourd. The cross IC-523876 X IC-523882 showed maximum and significant heterosis of 27.67 per cent over commercial check and is comparable with earlier findings by Naliyadhara *et al*. (2007) [11] in sponge gourd.

For number of fruits per plant maximum and positively significant heterosis was observed in the cross IC-523882 X IC-539714 over mid parent (24.01%), IC-523886 X Satputia over the commercial check (60.26%) and IC-523886 X IC-523882 over the better parent (12.21%). Earlier findings of significant and positive heterosis over better parent by Shaha and Kale (2003a) [16] and over the commercial check by Mole *et al*. (2001) [9] are comparable.

For fruit yield per plant the cross IC-523876 X Satputia (30.25%) exhibited positive and significant heterosis over mid parent which confirms with earlier findings by Poshiya *et al*. (2015) [14], Bairwa *et al*. (2017) [2], Muthaiah *et al*. (2017a) [10], Chittora *et al*. (2018) [3] Nandhini *et al*. (2018) [12] and Narasannavar *et al*. (2018) [13] in ridge gourd.. The maximum and significant heterosis over the better parent (16.17%) and over commercial check (10.55%) was observed in the cross IC-523886 X IC-539714 and is comparable with Jadhav *et al*. (2009) in bitter gourd. For fruit yield per hectare, the maximum and significant heterosis over mid parent was observed in the cross IC-523876 X Satputia (30.29%) and over commercial check (10.53%) and over better parent IC-523886 X IC-539714 (16.23%) exhibited positive and significant heterosis. The hybrids IC-523886 X IC-539714 and IC-523876 X Satptia could be commercially exploited after assessing their stability.

The cross combination IC-523876 X Satputia (C_9) (-12.43) expressed negative significant heterosis over the check Arka Vikram, while IC-308561 X IC-539714 (C_4) (35.38) expressed highest positive significant heterosis over the check Arka Vikram for ascorbic acid content. The cross combination IC-523876 X IC-523882 (C_7) (-52.39) expressed negative significant heterosis over the check Arka Vikram, while no cross combination expressed positive heterosis over the check Arka Vikram for fibre content. The cross combination IC-523886 X Satputia (C_{12}) (-42.28) expressed negative significant heterosis over the check Arka Vikram, while IC-523876 X IC-523882 (C_7) (14.74) expressed positive heterosis over the check Arka Vikram for total soluble solids.

Table 1: Analysis of variance for yield and biochemical characters in 6 X 6 half diallel of ridge gourd.

Source	d. f	Vine length	Internodal length	Node number at which first male flower appear	Node number at which first female/hermaphrodite flower appear	Days to appearance of first male flower	Days to appearance of first female/hermaphrodite appear	Fruit set percentage	Days to first fruit harvest
Mean Sum of Squares									
Treatments	20	9961.55**	2.49**	14.54**	3.11**	1.75**	6.28**	34.67**	11.17**
Parents	5	18272.59**	4.09**	48.61**	4.41**	0.75*	16.37**	51.59**	27.13**
Hybrids	14	7071.52**	1.82**	0.61**	2.83**	2.15**	2.29**	27.77**	6.01**
Parents Vs. Hybrids	1	8866.87**	3.92**	39.25**	0.49	1.19*	11.63**	46.73**	3.57*
Error	20	11.61	0.21	0.03	0.34	0.27	0.27	0.29	0.53

Table 1: Cont…..

Source	d.f	Peduncle length	Fruit length	Fruit diameter	Fruit weight	Number of fruits per plant	Fruit yield per plant	Estimated yield
Mean Sum of Squares								
Treatments	20	9.09**	76.28**	0.76**	6358.56**	66.20**	0.85**	38.17**
Parents	5	13.31**	65.84**	1.25**	10408.43**	157.66**	1.02**	45.52**
Hybrids	14	8.06**	82.76**	0.62**	5359.76**	36.98**	0.85**	38.03**
Parents Vs. Hybrids	1	2.45**	37.86**	0.20**	92.40*	18.06**	0.07	3.30**
Error	20	0.00	2.80	0.00	15.33	0.80	0.03	1.58

Table 1: Cont…..

Source	d.f	Ascorbic acid content	Fibre content	Total soluble solids
Mean Sum of Squares				
Treatments	20	0.52**	0.33**	0.51**
Parents	5	0.37**	0.30**	0.85**
Hybrids	14	0.50**	0.36**	0.42**
Parents Vs. Hybrid	1	1.57**	0.03**	0.03**
Error	20	0.00	0.00	0.00

* & ** indicates significant at 5% and 1% respectively

Table 2: Estimation of average heterosis, Heterobeltiosis and standard heterosis for vine length and intermodal length

Sl. No.	Pedigree/ Cross		Vine length			Internodal length		
			Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis
1	C_1	IC-308561 X IC- 523876	-27.24 **	-35.23 **	-29.08 **	-5.03	-5.90	-0.97
2	C_2	IC-308561 X IC-523886	-22.85 **	-25.64 **	-12.24 **	0.92	-13.12 **	-10.25 **
3	C_3	IC-308561 X IC-523882	0.55	-1.48	7.88 **	-1.54	-3.76	-0.58
4	C_4	IC-308561 X IC-539714	2.44 **	-10.88 **	-2.42 *	10.37 **	6.02	9.51 *
5	C_5	IC-308561 X Satputia	-13.76 **	-37.32 **	-31.37 **	3.45	1.50	4.85
6	C_6	IC-523876 X IC-523886	5.33 **	-9.19 **	7.16 **	19.22 **	1.85	7.18
7	C_7	IC-523876 X IC-523882	-29.14 **	-35.75 **	-32.49 **	-10.10 **	-12.92 **	-8.35 *
8	C_8	IC-523876 X IC-539714	9.89 **	7.03 **	-8.53 **	0.00	-4.80	0.19
9	C_9	IC-523876 X Satputia	10.80 **	-12.40 **	-25.14 **	-12.33 **	-14.76 **	-10.29 **
10	C_{10}	IC-523886 X IC-523882	-36.85 **	-40.31 **	-29.56 **	22.42 **	7.48	6.02
11	C_{11}	IC-523886 X IC-539714	-18.25 **	-31.06 **	-18.65 **	33.64 **	19.18 **	13.40 **
12	C_{12}	IC-523886 X Satputia	-17.91 **	-41.68 **	-31.18 **	15.18 **	0.78	0.19
13	C_{13}	IC-523882 X IC-539714	-33.46 **	-41.07 **	-38.09 **	5.01	3.15	1.75
14	C_{14}	IC-523882 X Satputia	12.92 **	-16.85 **	-12.64 **	-2.75	-3.13	-3.69
15	C_{15}	IC-539714 X Satputia	56.60 **	26.30 **	2.32 *	13.77 **	11.33 **	10.68 **

* & ** indicates significant at 5% and 1% respectively
C = Cross

Table 3: Estimation of average heterosis, Heterobeltiosis and standard heterosis for node number at which first male flower appear and node number at which first female/hermaphrodite flower appear.

Sl. No.	Pedigree/Cross		Node number at which first male flower appear			Node number at which first female /hermaphrodite flower appear		
			Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis
1	C_1	IC-308561 X IC- 523876	25.81 **	5.41	44.44 **	-11.76	-16.67	0.00
2	C_2	IC-308561 X IC-523886	17.74 **	-1.35	35.19 **	2.13	0.00	20.00
3	C_3	IC-308561 X IC-523882	-31.34 **	-37.84 **	-14.81 *	1.37	0.00	23.33 *
4	C_4	IC-308561 X IC-539714	-15.49 **	-18.92 **	11.11	-16.67 *	-22.62 **	8.33
5	C_5	IC-308561 X Satputia	-224.53 **	-10.81 *	22.22 **	16.07	-9.72	8.33
6	C_6	IC-523876 X IC-523886	36.00 **	36.00 **	25.93 **	8.27	4.35	20.00
7	C_7	IC-523876 X IC-523882	-9.09	-16.67 *	-7.41	-2.90	-9.46	11.67
8	C_8	IC-523876 X IC-539714	-1.69	-14.71 *	7.41	-5.41	-16.67 *	16.67
9	C_9	IC-523876 X Satputia	-210.77 **	44.00 **	33.33 **	32.69 **	7.81	15.00
10	C_{10}	IC-523886 X IC-523882	38.18 **	26.67 **	40.74 **	3.50	0.00	23.33 *
11	C_{11}	IC-523886 X IC-539714	-18.64 **	-29.41 **	-11.11	-4.58	-13.10	21.67 *
12	C_{12}	IC-523886 X Satputia	-170.77 **	-8.00	-14.81 *	21.10 *	-4.35	10.00
13	C_{13}	IC-523882 X IC-539714	6.25	0.00	25.93 **	-15.19 *	-20.24 **	11.67
14	C_{14}	IC-523882 X Satputia	-213.33 **	13.33 *	25.93 **	-20.18 *	-38.51 **	-24.17 *
15	C_{15}	IC-539714 X Satputia	-225.00 **	2.94	29.63 **	67.74 **	23.81 **	73.33 **

* & ** indicates significant at 5% and 1% respectively
C = Cross

Table 4: Estimation of average heterosis, Heterobeltiosis and standard heterosis for days to appearance of first male flower and days to appearance of first female/hermaphrodite flower

Sl. No.	Pedigree/Cross		Days to appearance of first male flower			Days to appearance of first female/hermaphrodite flower		
			Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis
1	C_1	IC-308561 X IC- 523876	-3.33 *	-4.23 *	-2.75	-1.13	-4.24 **	-0.85
2	C_2	IC-308561 X IC-523886	1.63	1.02	1.89	-0.35	-3.28 *	0.14
3	C_3	IC-308561 X IC-523882	-1.61	-3.17	-0.34	-8.13 **	-8.76 **	-5.52 **
4	C_4	IC-308561 X IC-539714	6.03 **	6.03 **	5.67 **	3.58 *	-0.96	2.55
5	C_5	IC-308561 X Satputia	3.24	1.72	1.37	8.29 **	-3.56 *	-0.14
6	C_6	IC-523876 X IC-523886	-2.38	-2.71	-1.20	3.86 **	3.63 *	0.99
7	C_7	IC-523876 X IC-523882	-5.04 **	-5.68 **	-2.92	-0.28	-2.77	-0.71
8	C_8	IC-523876 X IC-539714	0.77	-0.17	1.37	9.62 **	8.18 **	4.96 **
9	C_9	IC-523876 X Satputia	7.45 **	4.91 *	6.53 **	10.99 **	1.75	-1.27
10	C_{10}	IC-523886 X IC-523882	-3.88 *	-4.84 *	-2.06	0.07	-2.22	-0.14
11	C_{11}	IC-523886 X IC-539714	5.57 **	4.94 *	5.84 **	6.27 **	4.65 **	1.98
12	C_{12}	IC-523886 X Satputia	7.13 **	4.94 *	5.84 **	7.07 **	-2.03	-4.53 **
13	C_{13}	IC-523882 X IC-539714	-0.76	-2.34	0.52	-0.14	-3.88 *	-1.84
14	C_{14}	IC-523882 X Satputia	5.85 **	2.67	5.67 **	2.01	-8.60 **	-6.66 **
15	C_{15}	IC-539714 X Satputia	-0.96	-2.41	-2.75	13.25 **	5.10 **	-0.71

* & ** indicates significant at 5% and 1% respectively
C = Cross

Table 5: Estimation of average heterosis, Heterobeltiosis and standard heterosis for fruit set percentage and days to first fruit harvest.

Sl. No.	Pedigree/Cross		Fruit set percentage			Days to first fruit harvest		
			Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis
1	C_1	IC-308561 X IC- 523876	1.30	-0.80	0.29	-3.94 **	-7.30 **	1.86
2	C_2	IC-308561 X IC-523886	-4.37 **	-4.58 **	-3.52 **	-3.84 **	-7.50 **	1.64
3	C_3	IC-308561 X IC-523882	-0.27	-6.46 **	-5.43 **	-11.87 **	-14.97 **	-6.56 **
4	C_4	IC-308561 X IC-539714	0.00	0.00	1.10	1.13	-4.31 **	5.14 **
5	C_5	IC-308561 X Satputia	-7.42 **	-11.78 **	-1.54	5.42 **	-6.30 **	2.95
6	C_6	IC-523876 X IC-523886	-2.27 **	-4.08 **	-3.45 **	4.41 **	4.07 *	6.35 **
7	C_7	IC-523876 X IC-523882	7.84 **	3.18 **	0.00	-2.88	-2.89	-0.77
8	C_8	IC-523876 X IC-539714	-8.27 **	-10.17 **	-9.18 **	8.07 **	5.89 **	8.21 **
9	C_9	IC-523876 X Satputia	-11.27 **	-17.11 **	-7.49 **	8.69 **	-0.21	1.97
10	C_{10}	IC-523886 X IC-523882	8.19 **	1.68	2.35 **	-2.03	-2.33	-0.22
11	C_{11}	IC-523886 X IC-539714	-11.64 **	-11.84 **	-10.87 **	2.84	1.09	2.63
12	C_{12}	IC-523886 X Satputia	1.00	-3.95 **	7.20 **	5.68 **	-2.68	-1.20
13	C_{13}	IC-523882 X IC-539714	5.54 **	-1.02	0.07	2.40	0.34	2.52
14	C_{14}	IC-523882 X Satputia	-10.79 **	-20.00 **	-10.72 **	2.75	-5.65 **	-3.61 *
15	C_{15}	IC-539714 X Satputia	-15.77 **	-19.74 **	-10.43 **	7.32 **	0.41	-1.53

* & ** indicates significant at 5% and 1% respectively
C = Cross

Table 6: Estimation of average heterosis, Heterobeltiosis and standard heterosis for peduncle length and fruit length

Sl. No.	Pedigree/Cross		Peduncle length			Fruit length		
			Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis
1	C_1	IC-308561 X IC- 523876	39.90 **	14.09 **	-28.57 **	-8.56	-19.31 **	-14.38 *
2	C_2	IC-308561 X IC-523886	-25.64 **	-17.64 **	-14.29	15.62 *	13.04	-3.97
3	C_3	IC-308561 X IC-523882	-8.59 **	-11.06 **	-11.90	22.16 **	15.07 *	-6.61
4	C_4	IC-308561 X IC-539714	17.31 **	5.53 **	2.62 **	28.60 **	19.96 **	-2.64
5	C_5	IC-308561 X Satputia	-41.85 **	-9.60 **	22.62 **	6.62	-14.66 *	-30.74 **
6	C_6	IC-523876 X IC-523886	9.19 **	6.89 **	-14.29	-24.74 **	-32.24 **	-28.10 **
7	C_7	IC-523876 X IC-523882	-42.80 **	-19.42 **	-20.24 **	34.39 **	12.62 *	19.50 **
8	C_8	IC-523876 X IC-539714	-22.49 **	-14.41 **	-16.67 *	-14.90 *	-29.28 **	-24.96 **
9	C_9	IC-523876 X Satputia	-36.56 **	1.36	-17.86 *	41.94 **	3.58	9.92
10	C_{10}	IC-523886 X IC-523882	-40.31 **	-15.45 **	-11.90	-27.43 **	-33.07 **	-43.14 **
11	C_{11}	IC-523886 X IC-539714	-31.06 **	-12.94 **	-13.10	-39.08 **	-44.36 **	-52.73 **
12	C_{12}	IC-523886 X Satputia	-46.04 **	-23.02 **	-.43.12**	-20.15 *	-37.16 **	-46.61 **
13	C_{13}	IC-523882 X IC-539714	-36.56 **	-45.91	-20.24 **	44.82 **	43.32 **	2.81
14	C_{14}	IC-523882 X Satputia	-21.00 **	-10.00 **	-45.83 **	60.22 **	34.56 **	-3.47
15	C_{15}	IC-539714 X Satputia	-35.00 **	-12.00 **	23.81 **	45.83 **	23.53 **	-13.22 *

* & ** indicates significant at 5% and 1% respectively
C = Cross

Table 7: Estimation of average heterosis, Heterobeltiosis and standard heterosis for fruit diameter, fruit weight and number of fruits per plant

Sl. No.	Pedigree/Cross		Fruit diameter			Fruit weight			Number of fruits per plant		
			Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis
1	C_1	IC-308561 X IC- 523876	-9.56 **	-10.35 **	-15.07 **	-14.63 **	-21.10 **	-27.53 **	6.97 *	-5.09	13.97 **
2	C_2	IC-308561 X IC-523886	-15.88 **	-17.64 **	-18.58 **	-40.52 **	-53.11 **	-36.64 **	20.73 **	2.18	22.71 **
3	C_3	IC-308561 X IC-523882	-7.34 **	-7.49 **	-12.07 **	36.30 **	23.74 **	18.20 **	-26.04 **	-32.36 **	-18.78 **
4	C_4	IC-308561 X IC-539714	-1.09	-1.42	-6.60 **	71.81 **	26.91 **	-1.11	-35.46 **	-47.09 **	-0.66
5	C_5	IC-308561 X Satputia	19.04 **	-5.66 **	-10.63 **	-19.82 **	-23.31 **	-22.86 **	9.26 *	9.15 *	1.53
6	C_6	IC-523876 X IC-523886	-4.09 **	-6.89 **	-7.95 **	8.32 **	-5.51 **	27.67 **	-4.24	-9.22 *	-15.72 **
7	C_7	IC-523876 X IC-523882	-15.30 **	-16.18 **	-20.33 **	2.72	0.13	0.73	8.58 *	4.91	4.45
8	C_8	IC-523876 X IC-539714	-9.59 **	-10.09 **	-15.38 **	69.56 **	16.13 **	16.83 **	-35.11 **	-51.51 **	-8.95 *
9	C_9	IC-523876 X Satputia	34.95 **	7.65 **	0.21	-10.76 **	-25.05 **	1.26	18.46 **	12.21 **	4.37
10	C_{10}	IC-523886 X IC-523882	-13.78 **	-15.45 **	-16.41 **	8.97 **	6.87 **	2.08	12.47 **	8.77 *	8.30
11	C_{11}	IC-523886 X IC-539714	-10.80 **	-12.94 **	-13.93 **	-28.02 **	-49.43 **	-53.56 **	14.15 **	-14.65 **	60.26 **
12	C_{12}	IC-523886 X Satputia	-34.45 **	-48.85 **	-49.43 **	-40.18 **	-48.94 **	-31.01 **	24.01 **	13.82 **	13.32 **
13	C_{13}	IC-523882 X IC-539714	4.75 **	4.23 **	-0.93	-3.67	-38.57 **	-17.00 **	-18.45 **	-41.16 **	10.48 *
14	C_{14}	IC-523882 X Satputia	4.25 **	-17.48 **	-21.57 **	22.83 **	-14.67 **	-18.49 **	-24.47 **	-42.21 **	8.52 *
15	C_{15}	IC-539714 X Satputia	18.29 **	-6.03 **	-11.56 **	-14.63 **	-21.10 **	-27.53 **	6.97 *	-5.09	13.97 **

* & ** indicates significant at 5% and 1% respectively
C = Cross

Table 8: Estimation of average heterosis, Heterobeltiosis and standard heterosis for fruit yield per plant and estimated yield

Sl. No.	Pedigree/Cross		Fruit yield per plant			Estimated yield		
			Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis
1	C_1	IC-308561 X IC- 523876	7.46 *	7.35	0.39	7.37 *	7.25	0.35
2	C_2	IC-308561 X IC-523886	-7.68 *	-11.70 **	-17.42 **	-7.71 *	-11.73 **	-17.41 **
3	C_3	IC-308561 X IC-523882	-24.49 **	-30.84 **	-22.27 **	-24.50 **	-30.81 **	-22.27 **
4	C_4	IC-308561 X IC-539714	1.80	0.92	-3.97	1.79	0.98	-3.98
5	C_5	IC-308561 X Satputia	20.26 **	5.07	-1.74	20.16 **	4.95	-1.80
6	C_6	IC-523876 X IC-523886	-12.46 **	-16.18 **	-21.78 **	-12.43 **	-16.16 **	-21.73 **
7	C_7	IC-523876 X IC-523882	4.56	-4.31	7.55	4.59	-4.25	7.56
8	C_8	IC-523876 X IC-539714	11.66 **	10.58 *	5.23	11.68 **	10.66 *	5.23
9	C_9	IC-523876 X Satputia	30.25 **	13.90 **	6.29	30.29 **	13.90 **	6.33
10	C_{10}	IC-523886 X IC-523882	6.90 *	-5.94	5.71	6.89 *	-5.92	5.69
11	C_{11}	IC-523886 X IC-539714	22.47 **	16.17 **	10.55 **	22.46 **	16.23 **	10.53 **
12	C_{12}	IC-523886 X Satputia	-4.24	-12.93 **	-25.65 **	-4.23	-12.94 **	-25.64 **
13	C_{13}	IC-523882 X IC-539714	-24.63 **	-30.40 **	-21.78 **	-24.66 **	-30.45 **	-21.86 **
14	C_{14}	IC-523882 X Satputia	0.58	-18.43 **	-8.33 *	0.65	-18.38 **	-8.30 *
15	C_{15}	IC-539714 X Satputia	7.21	-7.02	-11.52 **	7.23	-6.99	-11.56 **

* & ** indicates significant at 5% and 1% respectively
C = Cross

Table 9: Estimation of average heterosis, Heterobeltiosis and standard heterosis for ascorbic acid content, fibre content and total soluble solids

Sl. No.	Pedigree/Cross		Ascorbic acid content			Fibre content			Total soluble solids		
			Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis	Average heterosis	Heterobeltiosis	Standard heterosis
1	C_1	IC-308561 X IC- 523876	-24.96 **	-27.29 **	-2.63 **	2.35	-5.48 **	-29.35 **	0.24	-0.47	-25.44 **
2	C_2	IC-308561 X IC-523886	-2.41 **	-11.68 **	18.27 **	11.08 **	-0.43	-20.48 **	-22.45 **	-38.10 **	-23.33 **
3	C_3	IC-308561 X IC-523882	-24.57 **	-28.60 **	-4.39 **	-21.40 **	-26.64 **	-46.42 **	-2.16	-16.58 **	-12.63 **
4	C_4	IC-308561 X IC-539714	2.83 **	1.09 *	35.38 **	-9.57 **	-25.31 **	-27.47 **	-2.53	-4.04	-29.12 **
5	C_5	IC-308561 X Satputia	9.95 **	-3.49 **	29.24 **	-11.63 **	-14.02 **	-45.56 **	10.36 **	4.99	-22.46 **
6	C_6	IC-523876 X IC-523886	0.56	-6.29 **	17.69 **	-4.42 **	-7.48 **	-26.11 **	9.09 **	-12.46 **	8.42 **
7	C_7	IC-523876 X IC-523882	-22.24 **	-24.10 **	-4.68 **	-35.57 **	-36.30 **	-52.39 **	27.73 **	9.55 **	14.74 **
8	C_8	IC-523876 X IC-539714	-3.21 **	-4.63 **	23.39 **	-38.83 **	-45.87 **	-47.44 **	-13.77 **	-15.69 **	-36.84 **
9	C_9	IC-523876 X Satputia	-22.76 **	-30.27 **	-12.43 **	26.74 **	14.16 **	-14.68 **	29.12 **	22.01 **	-8.60 **
10	C_{10}	IC-523886 X IC-523882	-4.62 **	-9.05 **	8.77 **	-3.35 *	-7.48 **	-26.11 **	-36.30 **	-41.22 **	-27.19 **
11	C_{11}	IC-523886 X IC-539714	-17.39 **	-24.07 **	-1.75 *	8.00 **	-1.58	-4.44 **	2.87	-18.84 **	0.53
12	C_{12}	IC-523886 X Satputia	-8.09 **	-11.19 **	-3.65 **	23.81 **	8.33 **	-13.48 **	-39.41 **	-53.40 **	-42.28 **
13	C_{13}	IC-523882 X IC-539714	-19.44 **	-22.49 **	0.29	-2.91 *	-14.94 **	-17.41 **	0.50	-15.41 **	-11.40 **
14	C_{14}	IC-523882 X Satputia	-15.76 **	-22.25 **	-7.02 **	6.80 **	-2.80	-29.01 **	9.93 **	-10.05 **	-5.79 *
15	C_{15}	IC-539714 X Satputia	-3.87 **	-14.35 **	10.82 **	10.00 **	-11.07 **	-13.65 **	8.63 **	4.90	-24.91 **

* & ** indicates significant at 5% and 1% respectively
C = Cross

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