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Estimation of heterosis for yield and yield attributing traits in *kharif* brinal [*Solanum melongena* L.]

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Abstract
In the present investigation, information on the magnitude of heterosis was obtained for fruit yield per plant and its related components following Line x Tester design involving thirteen (5 females and 8 males) varieties/strains of brinjal (*Solanum melongena* L.). The thirteen (5 females and 8 males) parents and their forty resultant F_1s with two standard checks (GBH 1 and NSR 1) were tested for thirteen characters in late *kharif* during 2014-15 at College farm, Navsari Agricultural University, Navsari in a randomized block design with three replications.

Significant difference existed among the parents and hybrids, indicating considerable genetic variation among these genotypes.

Highly significant positive heterosis over standard check for fruit yield and its component characters suggested that there is an ample scope of exploiting heterosis commercially and possibility of isolating desirable segregants. The maximum standard heterosis for fruit yield per plant *i.e.* 14.27 per cent and 43.11 per cent was recorded by the cross combination Punjab Barsati x GAOB 2 over both the checks *viz*., GBH 1 and NSR 1 respectively followed by Punjab Barsati x JDNB 110 (40.93 %) over check-2. Heterotic effect for fruit yield per plant was found to be associated with heterosis for its related traits in majority of the crosses.

The high yielding hybrid Punjab Barsati x GAOB 2 manifested high *per se* performance, significant standard heterosis for fruit yield and most of its important components thus, signifying its potential for commercial exploitation.

Keywords: Brinjal, heterosis, standard heterosis, yield

1. Introduction

Among vegetables, brinjal has been found a staple vegetable in our diet. It is highly productive and usually finds its place as poor man's vegetable. Its fruit is low in calories and fats, contains mostly water, some protein, fibre and carbohydrates. It is a good source of minerals and vitamins and rich in total water soluble sugars, free reducing sugars and amide proteins. It also possesses ayurvedic and medicinal value and white brinjal is said to be good for diabetic patients (Choudhary, 1976) [5].

Brinjal is an important vegetable crop of Indian origin having wide variability. It is grown in almost all parts of the country. Crop improvement involves strategies to enhance the yield potentiality and quality components. In India, it is grown throughout the country except higher altitudes. The brinjal is of much importance in the warm areas of Far East, being grown extensively in India, Bangladesh, Pakistan, China and Philippines. It is a versatile crop adapted to different agro-climatic regions and can be grown throughout the year. Brinjal has been cultivated in India for the last 4,000 years. India accounts for production of 12.60 million tones with an area of 0.67 million ha under cultivation with a productivity of 19.00 tons per ha. In Gujarat, the production of brinjal was 14.70 lakh tones from 0.74 lakh ha. Area with the productivity of 19.86 tons per ha. (NHB, 2014-15) [2]. several varieties *viz*., GBL-1, Gujarat Brinjal-6, GOB-1, JBGR-99-5, Junagarh Long, Junagarh Oblong, GJB-2, GJB-3, JBGR-1, *etc* and hybrid Arka Anand (BWBH-3), GBH-2, *etc* have been released for Gujarat state.

It is the most common, popular and principal vegetable crop also known as eggplant, Guinea squash and Aubergine. Brinjal (*Solanum melongena* L) belongs to the family *Solanaceae* having chromosome number 2n = 24. It has about 1600 species of 70 genera; among the genera *Solanum* holds 900 species. It is native crop of India and is extensively grown in all the South-East Asian countries (Choudhary, 1976) [5]. India is considered as a centre of diversity and it displays a wide range of fruit shapes and colours, ranging from oval or egg-shaped to long club-shaped; and from white, yellow, green through degrees of purple pigmentation to almost black. It is herbaceous annual with erect or semi-spreading habit. The fruit is berry, borne singly or in a cluster. So, it provides best opportunity for its genetic improvement.

Brinjal is self-compatible and highly self-pollinating crop and the extent of natural cross-pollination is about 6-7%. Although during hot and humid climate, cross-pollination from surrounding plants may occur upto 20% by insect or by wind.

Under a crop improvement programme, the breeder is often confronted with the difficulty of choosing parental lines which & when crossed that may result in a higher proportion of desirable segregants. Hence, in order to develop high yielding varieties, it would be desirable to identify better combining stocks for different traits. The evaluation of potential parental lines for combining ability is helpful in selecting the parents for hybridization. Even for producing superior hybrids, the choice of parents is an important step.

The required goals of increasing productivity in the quickest possible time can be achieved only through heterosis breeding, which is feasible in this crop (Kakizaki, 1928) [8]. There are specific genotypes suited for specific preparations apart from the large genetic variation observed with regarded to colour, shape and size of fruits. In addition, variation is also noticed for characters like vegetative growth, maturity and presence or absence of spines on leaves, stem and fruit calyx among the indigenous material. To have such kind of plant

profile, we should have some different breeding methods. One of such method is exploitation of hybrid vigour through hybridization. Bailey and Munson (1891) [3] reported artificial hybridization in brinjal for the first time. However, none of the hybrids exhibited any heterosis. Nagai and Kida (1926) [12] were probably the first to observe hybrid vigour, hoping some commercial acceptance in crosses among some Japanese varieties. Since then many public and private sectors have developed various hybrids in India, but these hybrids lacked regional preferences for colour, shape and presence or absence of spines and lacked suitability to specific product preparations. Therefore, the exploitation of hybrid vigour in brinjal has been recognized as a means of increasing yield and other economic characters. Most of the local varieties which are grown by farmers in India have not been fully utilized in any genetic improvement programme on scientific lines. The development of an effective heterosis breeding programme in brinjal needs to elucidate the genetic nature and magnitude of quantitatively inherited traits and judge the potentiality of parents in hybrid combinations. Combining ability studies like line x tester analysis (Kempthrone, 1957) [9] provide information in this direction particularly when large number of parents are to be screened for combining ability. Study of *gca* effects help in selection of superior parents and *sca* effect for superior hybrids. The information generated in the process is used to understand the magnitude of heterosis of F_1 hybrids. Exploitation of hybrids vigour is one of the possible ways for increasing production and productivity to meet the demand of population for food and raw materials. For the exploitation of heterosis, it is imperative to study the magnitude of heterosis. The expression of heterosis is greatly influenced by the magnitude of genetic differences among parents involved in the crosses.

2. Material and Method

The experimental material, consisting of 55 genotypes including 13 parents (5 females and 8 males) and their resultant 40 hybrids along with two checks (Surati ravaiya and GBH-1) was raised in a randomized block with three replications over growing season *viz*., late *kharif*during 2014-15. Each entry was accommodated in single row of 6 m. in length spaced at 90 cm apart with plant-to-plant spacing of 60 cm. recommended agronomic package and practices were followed to raise a good crop. In each entry, five plants were selected randomly from each replication and biometrical observations were recorded for days to 50% flowering, plant height (cm), primary branches per plant, number of fruits per plant, average fruit weight (g), fruit length (cm), fruit diameter (cm), days to 1st picking, fruit length: diameter ratio, fruit yield per plant (kg), total soluble sugar (%), total phenol (mg g^{-1}) and ascorbic acids (mg/100g).

3. Result and Discussion

The differences among genotypes were highly significant for all the characters. This indicated the presence of considerable amount of genetic variability among the genotypes for various traits studied.

Evaluation of heterosis

The estimates of heterosis measured as per cent increase or decrease over standard check (standard heterosis) GBH-1 (Check-1) and Surati ravaiya (Check 2) estimated for thirteen characters are presented in Table 1. While interpreting magnitude of heterosis, negative effects were considered favourable for the characters viz; days to 50% flowering, days to 1st picking and total phenol (mg/g) in order to identify good hybrids for desirable characteristics like earliness, dwarfness and total phenol imparts bitterness to the fruits.

Days to 50% flowering

The perusal of data revealed that significant negative standard heterosis over check-1 was -21.68 per cent (Pusa Kranti x JBGR 1) to 5.41 per cent (IIHR 588 x JBGR 1) and twenty two hybrids had significant negative standard heterosis. Three earliest hybrids were Pusa Kranti x JBGR 1 (-21.68%), Pusa Kranti x GJB 2 (-20.38%) and Pusa Kranti x Pant Rituraj (-19.73%), whereas, the range of standard heterosis over check-2 was -25.97 per cent (Pusa Kranti x JBGR 1) to -0.36 per cent (IIHR 588 x JBGR 1) and total thirty two hybrids had registered significant negative standard heterosis. Three earliest hybrids were Pusa Kranti x JBGR 1 (-25.97%), Pusa Kranti x GJB 2 (-24.74%) and Pusa Kranti x Pant Rituraj(-24.13%).

Plant height (cm)

The range of standard heterosis over check-1 was -8.40 per cent (IC 332576 x IIHR 635) to 24.40 per cent (Punjab Barsati x JBGR 1) and twenty four hybrids had significant positive heterosis over check-1. Three promising hybrids were Punjab Barsati x JBGR 1 (24.40%), Punjab Barsati x GJB 2 (21.30%) and IIHR 588 x Pant Rituraj (20.48%), whereas, the range of standard heterosis over check-2 was 1.01 per cent (IC 332576 x IIHR 635) to 37.18 per cent (Punjab Barsati x JBGR 1) and total thirty seven hybrids had registered significant positivestandard heterosis. The cross combinations *viz* Punjab Barsati x JBGR 1 (37.18%), Punjab Barsati x GJB 2 (33.76%) and IIHR 588 x Pant Rituraj (32.86%) were recorded as promising hybrids over check-2.

Number of primary branches per plant

The range of standard heterosis over check-1 was -2.09 per cent (Punjab Barsati x JDNB 110) to 78.37 per cent (IIHR 588 x GAOB 2) and thirty five hybrids had significant positive heterosis over check-1. Three promising hybrids were IIHR 588 x GAOB 2 (78.37%), IIHR 588 x GJB 2 (74.08%) and IIHR 588 x NSRP 1 (67.34%), whereas, the range of standard heterosis over check-2 was recorded from 5.46 per cent (Punjab Barsati x JDNB 110) to 92.11 per cent (IIHR 588 x GAOB 2) and total thirty nine hybrids had registered significant positive heterosis. The cross combinations IIHR 588 x GAOB 2 (92.11%), IIHR 588 x GJB 2 (87.48%) and IIHR 588 x NSRP 1 (80.23%) were recorded as promising hybrids over check-2.

Number of fruits per plant

The range of standard heterosis over check-1 was -33.72 per cent (GJB 3 x JBGR 1) to 40.27 per cent (Punjab Barsati x GAOB 2) and thirteen hybrids had manifested significant positive heterosis over check-1. The cross combinations *viz.*, Punjab Barsati x GAOB 2 (40.27%), IC 332576 x Pant Rituraj (27.98%) and Punjab Barsati x JDNB 110 (25.02%) were recorded as top three performing hybrids. The range of

standard heterosis over check-2 was observed from -21.82 per cent (GJB 3 x JBGR 1) to 65.46 per cent (Punjab Barsati x GAOB 2) and total twenty six hybrids had registered significant positive heterosis. The cross combinations Punjab Barsati x GAOB 2 (65.46%), IC 332576 x Pant Rituraj (50.96%) and Punjab Barsati x JDNB 110 (47.47%) were recorded as promising hybrids over check-2.

Average fruit weight (gm)

The range of standard heterosis over check-1 was -40.50 per cent (IC 332576 x IIHR 635) to 44.49 per cent (GJB 3 x NSRP 1) along with thirty two hybrids having significant positive standard heterosis. GJB 3 x NSRP 1 (44.49%), GJB 3 x JDNB 110 (29.66%) and GJB 3 x GJB 2 (16.02%) were the top three hybrids with significant positive standard heterosis. The range of standard heterosis over check-2 was -36.91 per cent (IC 332576 x IIHR 635) to 53.22 per cent (GJB 3 x NSRP 1) and total thirty hybrids had registered significant positive standard heterosis. Three promising hybrids observed were, GJB 3 x NSRP 1 (53.22%), GJB 3 x JDNB 110 (37.49%) and GJB 3 x GJB 2 (23.03%).

Fruit length (cm)

Three hybrids had significant positive heterosis over check-1 and the range of standard heterosis was -14.92 per cent (IIHR 588 x JBGR 1) to 60.22 per cent (Pusa Kranti x IIHR 635) in E_1, and three promising hybrids were Pusa Kranti x IIHR 635 (60.22%), IC 332576 x IIHR 635 (58.53%) and Pusa Kranti x Pant Rituraj (55.98%), The range of standard heterosis over check-2 was -6.86 per cent (IIHR 588 x JBGR 1) to 75.41 per cent (Pusa Kranti x IIHR 635) and total thirty five hybrids had registered significant positive heterosis. The cross combinations Pusa Kranti x IIHR 635 (75.41%), IC 332576 x IIHR 635 (73.56%) and Pusa Kranti x Pant Rituraj (70.77%) were recorded as promising hybrids over check-2.

Fruit diameter (cm)

The range of standard heterosis over check-1 was -40.37 per cent (Pusa Kranti x IIHR 635) to 27.36 per cent (GJB 3 x Pant Rituraj) along with seven hybrids having significant positive standard heterosis. GJB 3 x Pant Rituraj (27.36%), GJB 3 x NSRP 1 (26.35%) and GJB 3 x GAOB 2 (20.95%) were the top three hybrids with significant positive standard heterosis. The standard heterosis over check-2 ranged from -37.30 per cent (Pusa Kranti x IIHR 635) to 33.93 per cent (GJB 3 x Pant Rituraj) and total seven hybrids had registered significant positive standard heterosis. Three promising hybrids observed were, GJB 3 x Pant Rituraj (33.93%), GJB 3 x NSRP 1 (32.86%) and GJB 3 x GAOB 2 (27.18%).

Days to 1stpicking

The range of standard heterosis over check-1 was -24.13 per cent (Pusa Kranti x GJB 2) to 19.95 per cent (IIHR 588 x IIHR 635) and total seventeen hybrids had significant negative standard heterosis. Three earliest hybrids were Pusa Kranti x GJB 2 (-24.13%), GJB 3 x NSRP 1 (-17.03%) and Pusa Kranti x Pant Rituraj (-16.89%), whereas, the range of standard heterosis over check-2 was -25.09 per cent (Pusa Kranti x GJB 2) to 18.43 per cent (IIHR 588 x IIHR 635) and total twenty three hybrids had registered significant negative heterosis. Three promising hybrids observed Pusa Kranti x GJB 2 (-25.09%), GJB 3 x NSRP 1 (-18.08%) and Pusa Kranti x Pant Rituraj (-17.94%).

Fruit length: diameter ratio

Thirty one hybrids had significant positive heterosis over check-1 and the range of standard heterosis was -20.19 per cent (GJB 3 x NSRP 1) to 168.57 per cent (Pusa Kranti x IIHR 635) in E_1, and three promising hybrids recorded were Pusa Kranti x IIHR 635(168.57%), IC 332576 x IIHR 635 (151.78%) and Punjab Barsati x IIHR 635 (108.21%), whereas, the standard heterosis over check-2 varied from -17.00 per cent (GJB 3 x NSRP 1) to 179.31 per cent (Pusa Kranti x IIHR 635) along withthirty three hybrids exhibited significant positive standard heterosis. The cross combinations *viz*., Pusa Kranti x IIHR 635 (179.31%), IC 332576 x IIHR 635 (161.85%) and Punjab Barsati x IIHR 635 (116.54%) were recorded as promising hybrids over check-2.

Fruit yield per plant (kg)

The range of standard heterosis over check-1 was -44.23 per cent (Pusa Kranti x AB 08/5) to 14.27 per cent (Punjab Barsati x GAOB 2) along with two hybrids [Punjab Barsati x GAOB 2 (14.27%) andGJB 3 x NSRP 1 (14.16%)] having significant positive standard heterosis. In case of check-2 standard heterosis varied from-30.15 per cent (Pusa Kranti x AB 08/5) to 43.11 per cent (Punjab Barsati x GAOB 2) and total six hybrids had registered significant positive standard heterosis. Three promising hybrids observed were Punjab Barsati x GAOB 2 (43.11%), GJB 3 x NSRP 1 (42.97%) and Punjab Barsati x JDNB 110 (40.93%).

Total soluble sugar (%)

The range of standard heterosis over check-1 was -53.68 per cent (IIHR 588 x IIHR 635) to 55.79 per cent (GJB 3 x GJB 2) along with nine hybrids having significant positive standard heterosis. GJB 3 x GJB 2 (55.79%), GJB 3 x JBGR 1 (42.46%) and GJB 3 x GAOB 2 (40.00%) werethe top three hybrids with significant positive standard heterosis. The standard heterosis over check-2 varied from-50.56 per cent (IIHR 588 x IIHR 635) to 66.29 per cent (GJB 3 x GJB 2) and total thirteen hybrids had registered significant positive standard heterosis. Three promising hybrids observed were GJB 3 x GJB 2 (66.29%), GJB 3 x JBGR 1 (52.06%) and GJB 3 x GAOB 2 (49.44%).

Total phenol (mg g^{-1})

The range of standard heterosis over check-1 was -73.01 per cent (IIHR 588 x GJB 2) to 145.13 per cent (Punjab Barsati x IIHR 635) and twenty one hybrids had significant negative heterosis. Three promising hybrids were IIHR 588 x GJB 2 (-73.01%), IIHR 588 x NSRP 1 (-69.47%) and IIHR 588 x GAOB 2 (-68.14%), whereas, the range of standard heterosis over check-2 was observed from -72.15 per cent (IIHR 588 x GJB 2) to 152.97 per cent (Punjab Barsati x IIHR 635) and total twenty one hybrids had registered significant negative heterosis. The cross combination *viz*., IIHR 588 x GJB 2 (-72.15%), IIHR 588 x NSRP 1 (-68.49%) and IIHR 588 x GAOB 2 (-67.12%) were recorded as three promising hybrids over check-2.

Ascorbic acid (%)

The range of standard heterosis over check-1 was -65.44 per cent (IIHR 588 x JDNB 110) to 78.68 per cent (Punjab

Barsati x NSRP 1) along with sixteen hybrids having significant positive standard heterosis. Punjab Barsati x NSRP 1 (78.68%), Punjab Barsati x GJB 2(72.30%) and GJB 3 x NSRP 1 (71.08%) werethe top three hybrids with significant positive standard heterosis. The range of standard heterosis over check-2 ranged from-66.67 per cent (IIHR 588 x JDNB 110) to 72.34 per cent (Punjab Barsati x NSRP 1) and total sixteen hybrids had registered significant positive standard heterosis. Three promising hybrids observed were Punjab Barsati x NSRP 1 (72.34%), Punjab Barsati x GJB 2 (66.19%) and GJB 3 x NSRP 1 (65.01%).

Among the promising hybrids for fruit yield per plant most of the promising hybrids depicted significant negative standard heterosis for days to 50% flowering and day to 1st picking. Early flowering being a desirable character to escape a various biotic and abiotic stress through early maturity, thereby suggesting that high fruit yield in brinjal can be achieved along with early flowering. Negative heterosis is considered as desirable for days to 50% flowering, days to 1st picking and total phenol, while for other characters significant positive heterosis was considered as desirable.

All the promising hybrids for fruit yield per plant exhibited negative standard heterosis for days to 50% flowering over both the checks except for Punjab Barsati x GAOB 2 (only over check-1). Early flowering being a desirable character, it can be suggested that high yield in brinjal can be achieved along with early flowering as most of the promising hybrids depicted significant negative heterosis for days to 50% flowering. The results are in akin with the findings of Neelima *et al.* (2008) [14]; Chowdhury *et al.* (2010) [6]; Dharwad *et al.* (2011) [13]; Ramireddy *et al.* (2011) [17]; Reddy and Patel (2014) [18] and Deshmukh *et al.* (2015) [7].

The perusal of data revealed that all the promising nine crosses for fruit yield per plant reported positive heterosis for plant height over both the checks except IC 332576 x GAOB 2 (only over check-1). These results indicate the presence of over dominance for this trait. The present findings were in close association with the results reported by Singh *et al.* (2004) [21]; Prabhu *et al.* (2005) [15]; Shafeeq *et al.* (2005) [20]; Neelima *et al.* (2008) [14]; Suneetha *et al.* (2008) [22]; Roy *et al.* (2009) [19]; Chowdhury *et al.* (2010) [6]; Reddy and Patel (2014) [18]; Deshmukh *et al.* (2015) [7] and Ramani *et al.* (2015) [16].

Among the top nine promising hybrids for fruit yield, the hybrids that exhibited positive standard heterosis for fruit length: diameter ratio, were Punjab Barsati x JDNB 110, Punjab Barsati x GAOB 2, Punjab Barsati x GJB 2, Punjab Barsati x Pant Rituraj and IC 332576 x GAOB 2 over the check-1 (GBH-1). Whereas for heterosis over check-2 (NSR 1) the hybrids Punjab Barsati x NSRP 1, Punjab Barsati x JDNB 110, Punjab Barsati x GAOB 2, Punjab Barsati x GJB 2, Punjab Barsati x Pant Rituraj and IC 332576 x GAOB 2 were showing positive significance. The results are in harmony with the findings of Dharwad *et al.* (2011) [13].

The significant positive heterosis for total soluble sugar was reported by the promising hybrids for fruit yield viz., GJB 3 x NSRP 1 and GJB 3 x GJB 2 over the check-1 (GBH-1) and GJB 3 x NSRP 1, GJB 3 x JDNB 110 and GJB 3 x GJB 2 over check-2 (NSR 1) thus giving the importance of total soluble sugar as a quality parameter which can be obtained along with higher fruit yield. The results are in akin with the findings of Suneetha *et al.* (2006) [23]; Suneetha *et al.* (2008) [22]; Biswas *et al.* (2013) [4]; Makani *et al.* (2013) [11] and Ramani *et al.* (2015) [16].

In case of total phenol among the promising hybrids, the cross combinations viz., IC 332576 x GAOB 2, GJB 3 x NSRP 1, GJB 3 x JDNB 110 and GJB 3 x GJB 2 showed negative heterosis over both the Checks (GBH-1 and NSR 1). Total phenol imparts bitterness to the fruits hence it is undesirable character and is taken under negative direction for quality parameters. In present investigation the above mentioned hybrids were having less total phenol along with higher mean fruit yield. The results of the present investigation are in agreement with the findings of Ajjappalavara (2006) [1]; Suneetha *et al.* (2006) [23]; Suneetha *et al.* (2008) [22] and Kumar *et al.* (2012) [10].

The significant positive heterosis for ascorbic acid was reported by all the promising hybrids for fruit yield except IC 332576 x GAOB 2 over both the checks (GBH-1 and NSR 1). As ascorbic acid is an anti-browning agent its combination with the higher yield has good contribution

towards the quality parameter suitable for the market. The results are in akin with the findings of Kumar *et al.* (2012) [10].

Table 1: Estimates of heterosis over standard check (SH1 and SH2) under *kharif* for days to 50 % flowering, plant height (cm), number of primary branches per plant, number of fruits per plant, average fruit weight (g), fruit length (cm), fruit diameter (cm) and days to first picking

S. No.	Name of the crosses	Days to 50% flowering		plant height (cm)		number of primary branches per plant		number of fruits per plant		average fruit weight (g)		fruit length (cm)		fruit diameter (cm)		days to first picking	
		SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2
1.	IIHR 588 x NSRP 1	-0.41	-5.86	13.35 **	25.00 **	67.34 **	80.23 **	15.72 *	36.50 **	-19.47 **	-14.61 **	-13.20 **	-4.97	-13.01 **	-8.53	8.59 *	7.22
2.	IIHR 588 x JDNB 110	1.06	-4.47	13.01 **	24.62 **	39.09 **	49.81 **	0.63	18.70 *	-20.66 **	-15.87 **	-2.81	6.40	-21.62 **	-17.58 **	4.27	2.95
3.	IIHR 588 x GAOB 2	-6.27	-11.40 **	14.77 **	26.56 **	78.37 **	92.11 **	23.84 **	46.09 **	-23.66 **	-19.04 **	-8.92 *	-0.29	-14.19 **	-9.77 *	-4.29	-5.50
4.	IIHR 588 x GJB 2	-13.25 **	-18.00 **	19.45 **	31.72 **	74.08 **	87.48 **	13.81 *	34.25 **	-26.54 **	-22.10 **	-2.85	6.36	-23.82 **	-19.89 **	-5.20	-6.40
5.	IIHR 588 x JBGR 1	5.41	-0.36	19.40 **	31.67 **	53.04 **	64.83 **	7.27	26.53 **	-27.19 **	-22.79 **	-14.92 **	-6.86	-22.64 **	-18.65 **	13.36 **	11.93 **
6.	IIHR 588 x AB 08/5	-3.54	-8.82 *	13.08 **	24.70 **	61.38 **	73.81 **	5.03	23.89 **	-27.29 **	-22.89 **	4.69	14.61 **	-28.38 **	-24.69 **	0.11	-1.16
7.	IIHR 588 x Pant Rituraj	-8.95 *	-13.93 **	20.48 **	32.86 **	48.99 **	60.46 **	4.20	22.92 **	-25.16 **	-20.64 **	10.50 **	20.98 **	-9.80 *	-5.15	-1.38	-2.63
8.	IIHR 588 x IIHR 635	4.97	-0.77	7.25 *	18.27 **	39.57 **	50.32 **	2.97	21.47 **	-28.18 **	-23.85 **	19.12 **	30.42 **	-38.85 **	-35.70 **	19.95 **	18.43 **
9.	Punjab Barsati x NSRP 1	-10.16 *	-15.08 **	16.74 **	28.73 **	7.21 *	15.47 **	22.60 **	44.62 **	-8.25 *	-2.71	4.09	13.96 **	-6.59	-1.78	-14.14 **	-15.23 **
10.	Punjab Barsati x JDNB 110	-9.77 *	-14.71 **	8.80 **	19.98 **	-2.09	5.46	25.02 **	47.47 **	-9.76 **	-4.31	15.34 **	26.27 **	-14.53 **	-10.12 *	-11.27 **	-12.39 **
11.	Punjab Barsati x GAOB 2	-2.9	-8.21 *	18.85 **	31.06 **	36.77 **	47.30 **	40.27 **	65.46 **	-18.31 **	-13.38 **	9.52 *	19.91 **	-11.32 *	-6.75	-7.01	-8.18 *
12.	Punjab Barsati x GJB 2	-16.11 **	-20.71 **	21.30 **	33.76 **	33.49 **	43.77 **	6.80	25.98 **	-13.45 **	-8.22 *	21.78 **	33.33 **	-19.43 **	-15.28 **	-14.01 **	-15.09 **
13.	Punjab Barsati x JBGR 1	-1.68	-7.06	24.40 **	37.18 **	0.54	8.28 *	6.20	25.28 **	-16.10 **	-11.03 **	6.67	16.79 **	-17.74 **	-13.50 **	-1.30	-2.55
14.	Punjab Barsati x AB 08/5	-8.83 *	-13.82 **	9.75 **	21.02 **	17.64 **	26.70 **	10.32	30.13 **	-23.40 **	-18.77 **	25.98 **	37.93 **	-21.11 **	-17.05 **	-6.96	-8.14 *
15.	Punjab Barsati x Pant Rituraj	-1.72	-7.10	19.62 **	31.91 **	2.92	10.85 **	17.84 *	39.01 **	-23.25 **	-18.62 **	29.73 **	42.04 **	-3.21	1.78	-2.66	-3.89
16.	Punjab Barsati x IIHR 635	-9.77 *	-14.71 **	9.59 **	20.85 **	-0.42	7.25 *	-0.66	17.18 *	-25.69 **	-21.20 **	35.66 **	48.52 **	-34.80 **	-31.44 **	-11.36 **	-12.48 **
17.	IC 332576 x NSRP 1	-2.53	-7.86 *	-6.17 *	3.46	42.01 **	52.95 **	17.71 *	38.85 **	-21.79 **	-17.07 **	38.21 **	51.31 **	-11.32 *	-6.75	2.02	0.73
18.	IC 332576 x JDNB 110	-0.77	-6.20	-5.34	4.39	39.03 **	49.74 **	14.68 *	35.28 **	-27.26 **	-22.87 **	46.04 **	59.89 **	-19.43 **	-15.28 **	2.91	1.60
19.	IC 332576 x GAOB 2	-4.43	-9.66 *	0.27	10.58 **	43.74 **	54.81 **	20.05 **	41.61 **	-31.05 **	-26.88 **	39.63 **	52.87 **	-22.64 **	-18.65 **	-4.20	-5.41
20.	IC 332576 x GJB 2	-13.41 **	-18.14 **	-1.39	8.75 **	43.38 **	54.43 **	11.57	31.61 **	-29.55 **	-25.30 **	27.82 **	39.94 **	-25.84 **	-22.02 **	-9.86 *	-11.00 **
21.	IC 332576 x JBGR 1	-16.98 **	-21.53 **	-0.05	10.22 **	31.64 **	41.78 **	16.51 *	37.43 **	-30.80 **	-26.62 **	40.19 **	53.49 **	-24.16 **	-20.25 **	-9.95 *	-11.09 **
22.	IC 332576 x AB 08/5	-8.24	-13.26 **	-1.21	8.94 **	39.51 **	50.26 **	14.20 *	34.71 **	-37.41 **	-33.63 **	46.16 **	60.02 **	-27.36 **	-23.62 **	-7.03	-8.21 *
23.	IC 332576 x Pant Rituraj	-10.63 *	-15.52 **	0.12	10.40 **	34.03 **	44.35 **	27.98 **	50.96 **	-35.91 **	-32.04 **	49.08 **	63.22 **	-11.32 *	-6.75	-6.98	-8.15 *
24.	IC 332576 x IIHR 635	0.70	-4.81	-8.40 **	1.01	25.92 **	35.62 **	6.73	25.90 **	-40.50 **	-36.91 **	58.53 **	73.56 **	-36.99 **	-33.75 **	2.86	1.56
25.	Pusa Kranti x NSRP 1	-16.39 **	-20.97 **	-2.03	8.03 *	15.32 **	24.20 **	-9.56	6.68	-17.77 **	-12.81 **	33.93 **	46.63 **	-8.11	-3.37	-9.84 *	-10.98 **
26.	Pusa Kranti x JDNB 110	-14.82 **	-19.48 **	-1.92	8.16 *	13.89 **	22.66 **	-10.64	5.42	-22.52 **	-17.84 **	50.09 **	64.33 **	-14.70 **	-10.30 *	-9.83 *	-10.97 **

Significant at 5 and 1 per cent probability levels, respectively.

Table 2: *Contd…..*

Sr. No.	Name of the crosses	Days to 50% flowering		plant height (cm)		number of primary branches per plant		number of fruits per plant		average fruit weight (g)		fruit length (cm)		fruit diameter (cm)		days to first picking	
		SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2
27	Pusa Kranti x GAOB 2	-19.06 **	-23.49 **	0.30	10.60**	30.27 **	40.31 **	4.41	23.16 **	-27.59 **	-23.22 **	41.58 **	55.01**	-11.32 *	-6.75	-10.81 **	-11.94 **
28	Pusa Kranti x GJB 2	-20.38 **	-24.74 **	7.13 *	18.13**	27.18 **	36.97 **	7.14	26.38 **	-24.54 **	-19.98 **	51.29 **	65.64**	-16.22 **	-11.90 *	-24.13 **	-25.09 **
29	Pusa Kranti x JBGR 1	-21.68 **	-25.97 **	8.18 **	19.29**	15.26 **	24.13 **	-18.67 **	-4.06	-28.64 **	-24.33 **	42.22 **	55.71**	-11.32 *	-6.75	-15.16 **	-16.23 **
30	Pusa Kranti x AB 08/5	-16.32 **	-20.90 **	3.03	13.61**	11.68 **	20.28 **	-16.38 *	-1.36	-33.25 **	-29.22 **	47.96 **	61.99**	-19.43 **	-15.28 **	-9.84 *	-10.98 **
31	Pusa Kranti x Pant Rituraj	-19.73 **	-24.13 **	6.42 *	17.35**	15.97 **	24.90 **	-10.61	5.44	-32.78 **	-28.72 **	55.98 **	70.77**	-3.21	1.78	-16.89 **	-17.94 **

32	Pusa Kranti x IIHR 635	-9.65 *	-14.60 **	-3.00	6.97 *	14.78 **	23.62 **	-8.38	8.07	-35.25 **	-31.33 **	60.22 **	75.41**	-40.37 **	-37.30 **	-1.30	-2.55
33	GJB 3 x NSRP 1	-13.68 **	-18.40 **	5.61	16.46**	10.43 **	18.93 **	-20.97 **	-6.78	44.49 **	53.22 **	0.79	10.34 *	26.35 **	32.86 **	-17.03 **	-18.08 **
34	GJB 3 x JDNB 110	-7.14	-12.22 **	5.17	15.98**	7.81 *	16.11 **	-19.58 **	-5.13	29.66 **	37.49 **	9.52 *	19.91**	16.05 **	22.02 **	-7.06	-8.24 *
35	GJB 3 x GAOB 2	-13.24 **	-17.99 **	10.36**	21.70**	17.64 **	26.70 **	-22.63 **	-8.73	4.85	11.19 **	4.54	14.45**	20.95 **	27.18 **	-7.03	-8.20 *
36	GJB 3 x GJB 2	-6.40	-11.53 **	14.75**	26.54**	13.89 **	22.66 **	-20.71 **	-6.47	16.02 **	23.03 **	10.27 **	20.73**	9.63 *	15.28 **	-5.51	-6.71
37	GJB 3 x JBGR 1	-9.06 *	-14.03 **	18.17**	30.31**	8.10 *	16.43 **	-33.72 **	-21.82 **	9.96 **	16.60 **	3.26	13.05**	13.01 **	18.83 **	-7.99 *	-9.16 *
38	GJB 3 x AB 08/5	-4.78	-9.99 *	15.85**	27.76**	10.67 **	19.19 **	-17.81 *	-3.05	3.54	9.80 **	18.15 **	29.35**	11.49 **	17.23 **	-8.41 *	-9.57 *
39	GJB 3 x Pant Rituraj	-15.37 **	-20.00 **	3.55	14.18**	5.36	13.48 **	-32.35 **	-20.20 *	6.36	12.78 **	25.57 **	37.48**	27.36 **	33.93 **	-11.36 **	-12.48 **
40	GJB 3 x IIHR 635	-4.54	-9.77 *	6.87 *	17.85**	7.57 *	15.85 **	-31.60 **	-19.31 *	2.66	8.86 *	33.63 **	46.31**	-27.53 **	-23.80 **	-1.36	-2.61
Significant	**Positive**	0	0	24	37	35	39	13	26	32	30	3	35	7	7	3	2
	Negative	22	32	2	0	0	0	10	3	4	8	29	0	29	22	17	23
Maximum		5.41	-0.36	24.40	37.18	78.37	92.11	40.27	65.46	44.49	53.22	60.22	75.41	27.36	33.93	19.95	18.43
Minimum		-21.68	-25.97	-8.40	1.01	-2.09	5.46	-33.72	-21.82	-40.50	-36.91	-14.92	-6.86	-40.37	-37.3	-24.13	-25.09
S.E.±		2.39		2.39		0.18		1.98		3.63		0.32		0.09		2.70	
C.D. at 5 %		4.76		4.76		0.36		3.94		7.23		0.64		0.17		5.38	
C.D. at 1 %		6.32		6.32		0.47		5.22		9.58		0.85		0.23		7.14	

Significant at 5 and 1 per cent probability levels, respectively.

Table 3: Estimates of heterosis over standard check (SH1 and SH2) under *kharif* for fruit length: diameter ratio, fruit yield per plant (kg), total soluble sugar (%), total phenol (mg g^{-1}) and ascorbic acid (%)

S. No.	Name of the crosses	fruit length: diameter ratio		fruit yield per plant (kg)		Total soluble sugar (%)		total phenol (mg g^{-1})		Ascorbic acid (%)	
		SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2	SH1	SH2
1.	IIHR 588 x NSRP 1	-0.15	3.85	-7.19	16.23	-32.11 **	-27.53 **	-69.47 **	-68.49 **	-44.61 **	-46.57 **
2.	IIHR 588 x JDNB 110	24.11 **	29.08 **	-20.48 **	-0.41	-24.91 **	-19.85 **	-61.50 **	-60.27 **	-65.44 **	-66.67 **
3.	IIHR 588 x GAOB 2	6.21	10.46 *	-5.88	17.87 *	-20.70 **	-15.36 **	-68.14 **	-67.12 **	-62.01 **	-63.36 **
4.	IIHR 588 x GJB 2	27.37 **	32.46 **	-16.56 *	4.50	-10.88 **	-4.87	-73.01 **	-72.15 **	-50.00 **	-51.77 **
5.	IIHR 588 x JBGR 1	10.21 *	14.62 **	-22.11 **	-2.46	-18.42 **	-12.92 **	-59.73 **	-58.45 **	-40.20 **	-42.32 **
6.	IIHR 588 x AB 08/5	46.52 **	52.38 **	-23.97 **	-4.77	-36.49 **	-32.21 **	-57.52 **	-56.16 **	-45.10 **	-47.04 **
7.	IIHR 588 x Pant Rituraj	22.49 **	27.38 **	-22.22 **	-2.59	-17.89 **	-12.36 **	-66.81 **	-65.75 **	-33.82 **	-36.17 **
8.	IIHR 588 x IIHR 635	94.75 **	102.54 **	-26.25 **	-7.64	-53.68 **	-50.56 **	-46.46 **	-44.75 **	-25.25 **	-27.90 **
9.	Punjab Barsati x NSRP 1	11.46 *	15.92 **	11.98	40.25 **	-9.12 *	-3.00	115.93 **	122.83 **	78.68 **	72.34 **
10.	Punjab Barsati x JDNB 110	35.28 **	40.69 **	12.53	40.93 **	-8.95 *	-2.81	125.66 **	132.88 **	58.82 **	53.19 **
11.	Punjab Barsati x GAOB 2	23.82 **	28.77 **	14.27 *	43.11 **	-17.89 **	-12.36 **	117.70 **	124.66 **	61.52 **	55.79 **
12.	Punjab Barsati x GJB 2	51.78 **	57.85 **	-7.95	15.28	2.46	9.36 *	118.58 **	125.57 **	72.30 **	66.19 **
13.	Punjab Barsati x JBGR 1	29.81 **	35.00 **	-11.00	11.46	0.18	6.93	138.05 **	145.66 **	39.46 **	34.52 **
14.	Punjab Barsati x AB 08/5	59.54 **	65.92 **	-15.69 *	5.59	-12.63 **	-6.74	126.99 **	134.25 **	24.51 **	20.09 **
15.	Punjab Barsati x Pant Rituraj	34.62 **	40.00 **	-10.02	12.69	-3.33	3.18	116.37 **	123.29 **	44.36 **	39.24 **
16.	Punjab Barsati x IIHR 635	108.21 **	116.54 **	-26.25 **	-7.64	-20.18 **	-14.79 **	145.13 **	152.97 **	37.01 **	32.15 **
17.	IC 332576 x NSRP 1	56.21 **	62.46 **	-8.17	15.01	-21.93 **	-16.67 **	-4.42	-1.37	10.78 **	6.86 *
18.	IC 332576 x JDNB 110	81.58 **	88.85 **	-17.21 *	3.68	-22.98 **	-17.79 **	5.75	9.13 *	-9.80 **	-13.00 **
19.	IC 332576 x GAOB 2	80.77 **	88.00 **	-17.43 *	3.41	-18.60 **	-13.11 **	-2.65	0.46	-6.37 *	-9.69 **
20.	IC 332576 x GJB 2	72.71 **	79.62 **	-21.68 **	-1.91	-18.25 **	-12.73 **	0.44	3.65	4.90	1.18
21.	IC 332576 x JBGR 1	85.06 **	92.46 **	-19.83 **	0.41	-20.35 **	-14.98 **	8.85 *	12.33 **	-27.45 **	-30.02 **

22.	IC 332576 x AB 08/5	101.85	**	109.92	**	-28.54	**	-10.50		-25.09	**	-20.04	**	8.85	*	12.33	**	-43.87	**	-45.86	**
23.	IC 332576 x Pant Rituraj	68.27	**	75.00	**	-18.19	*	2.46		-25.26	**	-20.22	**	-2.21		0.91		-24.26	**	-26.95	**
24.	IC 332576 x IIHR 635	151.78	**	161.85	**	-36.93	**	-21.01	*	-27.54	**	-22.66	**	19.03	**	22.83	**	-31.37	**	-33.81	**
25.	Pusa Kranti x NSRP 1	45.86	**	51.69	**	-25.82	**	-7.09		0.35		7.12		-53.54	**	-52.05	**	-3.19		-6.62	*
26.	Pusa Kranti x JDNB 110	75.96	**	83.00	**	-30.83	**	-13.37		1.93		8.80	*	-38.05	**	-36.07	**	-24.26	**	-26.95	**

Significant at 5 and 1 per cent probability levels, respectively.

Table 4: *Contd…..*

Sr. No.	Name of the crosses	Days to 50% flowering				fruit yield per plant (kg)				Total soluble sugar (%)				total phenol (mg g^{-1})				Ascorbic acid (%)			
		SH1		SH2		SH1		SH2		SH1		SH2		SH1		SH2		SH1		SH2	
27	Pusa Kranti x GAOB 2	59.69	**	66.08	**	-24.84	**	-5.87		-0.18		6.55		-45.13	**	-43.38	**	-20.83	**	-23.64	**
28	Pusa Kranti x GJB 2	80.55	**	87.77	**	-19.39	**	0.95		10.53	**	17.98	**	-46.90	**	-45.21	**	-10.05	**	-13.24	**
29	Pusa Kranti x JBGR 1	60.65	**	67.08	**	-41.94	**	-27.29	**	5.79		12.92	**	-34.07	**	-31.96	**	-42.65	**	-44.68	**
30	Pusa Kranti x AB 08/5	83.43	**	90.77	**	-44.23	**	-30.15	**	-1.40		5.24		-37.17	**	-35.16	**	-61.27	**	-62.65	**
31	Pusa Kranti x Pant Rituraj	61.54	**	68.00	**	-39.98	**	-24.83	**	6.32		13.48	**	-47.79	**	-46.12	**	-40.20	**	-42.32	**
32	Pusa Kranti x IIHR 635	168.57	**	179.31	**	-40.74	**	-25.78	**	-8.07	*	-1.87		-25.66	**	-23.29	**	-48.28	**	-50.12	**
33	GJB 3 x NSRP 1	-20.19	**	-17.00	**	14.16	*	42.97	**	23.33	**	31.65	**	-19.47	**	-16.89	**	71.08	**	65.01	**
34	GJB 3 x JDNB 110	-5.55		-1.77		4.36		30.70	**	26.32	**	34.83	**	-5.75		-2.74		51.47	**	46.10	**
35	GJB 3 x GAOB 2	-13.61	**	-10.15	*	-19.50	**	0.82		40.00	**	49.44	**	-12.83	**	-10.05	*	53.19	**	47.75	**
36	GJB 3 x GJB 2	0.52		4.54		-8.06		15.14		55.79	**	66.29	**	-15.04	**	-12.33	**	66.18	**	60.28	**
37	GJB 3 x JBGR 1	-8.36		-4.69		-27.23	**	-8.87		42.46	**	52.06	**	-0.88		2.28		30.88	**	26.24	**
38	GJB 3 x AB 08/5	5.92		10.15	*	-15.03	*	6.41		20.35	**	28.46	**	-1.33		1.83		18.14	**	13.95	**
39	GJB 3 x Pant Rituraj	-1.41		2.54		-28.10	**	-9.96		25.44	**	33.90	**	-11.50	**	-8.68	*	37.01	**	32.15	**
40	GJB 3 x IIHR 635	84.10	**	91.46	**	-29.85	**	-12.14		14.91	**	22.66	**	7.96	*	11.42	**	30.64	**	26.00	**
Significant	Positive	31		33		2		6		9		13		11		12		16		16	
	Negative	2		2		28		5		22		17		21		21		21		22	
Maximum		168.57		179.31		14.27		43.11		55.79		66.29		145.13		152.97		78.68		72.34	
Minimum		-20.19		-17.00		-44.23		-30.15		-53.68		-50.56		-73.01		-72.15		-65.44		-66.67	
S.E.±		0.21				0.21				0.07				0.03				0.04			
C.D. at 5 %		0.42				0.42				0.14				0.06				0.07			
C.D. at 1 %		0.55				0.56				0.19				0.08				0.10			

Significant at 5 and 1 per cent probability levels, respectively.

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