Diallel Analysis in Brinjal (*Solanum melongena* L.)

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"Diallel Analysis in Brinjal (*solanum melongena* L.)"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certified that this thesis entitled **"Diallel Analysis in Brinjal (*Solanum melongena* L.)"** is a record of research work done independently by Mr. Palli Rajasekhar under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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PALLI RAJASEKHAR

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LIST OF ABBREVIATIONS

%	-	per cent
&	-	and
σ^2A	-	Additive variance
σ^2D	-	Dominant variance
ANOVA	-	Analysis of variance
a.m.	-	Anti meridian
BP	-	Better parent
CD (0.05)	-	Critical difference at 5 % level
cm	-	centimeter
d.f	-	Degrees of freedom
et al.	-	and co-workers/co-authors
Fig.	-	Figure
F_1	-	First filial generation
g	-	gram
GCA	-	General combining ability
ha	-	hectare
HB	-	Heterobeltiosis
i.e.	-	that is

kg	-	kilogram
KAU	-	Kerala Agricultural University
MP	-	Mid parent
NBPGR	-	National Bureau of Plant Genetic Resources
per se	-	mean
RH	-	Relative heterosis
SCA	-	Specific combining ability
SE	-	Standard error
S.E.D	-	Standard error difference
S.E.M	-	Standard error mean
SH	-	Standard heterosis
viz.	-	namely

Introduction

1. INTRODUCTION

Brinjal (*Solanum melongena* L.) is an important solanaceous vegetable crop widely grown in the tropics and subtropics in the world. The crop species with a somatic chromosome number 2n = 24 comprises of three botanical varieties *viz.*, var. *esculentum*, with round or egg shaped fruits, var. *serpentinum* with long slender fruits and var. *depressum* having dwarf stature. India and China are its primary centers of diversity (Kashyap *et al.,* 2003). It is being grown extensively in India, Bangladesh, Pakistan, China, Philippines, France, Italy and United States.

Brinjal is referred by various names in different parts of the country as *baigan* (Hindi), *Badanekai* (Kannada), *Vangi* (Marathi), *Katharikai* (Tamil), Vankai (Telugu) *etc.* Internationally, it is referred as Eggplant (England) or Aubergine (France). Further, in various other countries it is referred as Berenjena (Spain) and Alberenjina (Arab Countries).

Brinjal is a major vegetable crop of our country since ancient time and the human society has social and economic relationship with this crop. India ranks second after China in area and production of brinjal. Brinjal shares 8.3 percent of total vegetable production in India. The cultivated area of brinjal in India is about 7.22 lakh hectares with production of 134.43 lakh tonnes and the productivity of 18.6 tonnes per hectare. West Bengal is the leading state with area of 1.61 lakh hectares and annual production of 29.65 lakh tonnes. The productivity is 18.4 tonnes per hectare (Anon., 2013).

Though brinjal is a self-pollinated crop, cross-pollination occurs to an extent of 30 to 40 per cent (Daskalov, 1955 and Agrawal, 1980). Brinjal is highly productive and usually finds its place as the poor man's vegetable (Som and Maity, 2002). It is popular among people of all social strata and hence it is rightly called as 'vegetable of masses' (Patel and Sarnaik, 2003).

In India the average vegetable consumption is only 185 g per capita per day which is less than the required amount of 300 g (125 g leafy vegetable,100 g root and tubers and 75 g other vegetables) per day per head as per ICMR recommendation. Therefore, production of vegetable has to be increased considerably to mitigate prevailing chronic malnutrition against the ICMR recommendation of 300g per head per day (Kalloo, 2006).

Eggplant is threatened by many insect pests and diseases from the time of planting till its harvest. Among these, bacterial wilt caused by *Ralstonia solanacearum* is the most important. The incidence of this disease is increasing further by cultivation of other solanaceous crops in the same land. Most of the commercial brinjal varieties are susceptible to bacterial wilt (Madalageri *et al.*, 1983). Therefore, efforts must be put to exploit regional genetic resources without tossing consumers preferences.

Fruit and shoot borer (*Leucinodes orbonalis* Guen.) is the most serious insect pest of brinjal throughout the country. It attacks the plant in any season and stage of growth, causing dead shoot in vegetative stage and fruit boring later rendering them unmarketable. This pest may cause fruit damage as high as 100 per cent (Panda, 1999). Insecticidal control not only is uneconomical but also invites environmental pollution. Consequently, host plant resistance would be useful either as a complete control measure or as a part of the integrated pest management programme with limited dependence on pesticides. Development of hybrids resistant to major pests and diseases is an ideal choice to overcome such situation.

Many local cultivars are popular in different locations for their qualitative traits though they are poor yielders and susceptible to various pest and diseases. It is high time to develop genotypes with high yield potential. Strategies are also developed to boost vegetable production by some national institutions like NBPGR (Nalini *et al.*, 2009).

To have such a kind of plant architecture, different breeding methods can be employed. One of the methods employed is exploitation of hybrid vigour through hybridization. For the first time, Bailey and Munson (1891) reported artificial hybridization in brinjal. However, none of the hybrids exhibited any heterosis. Nagai and Kida (1926) were probably the first to observe hybrid vigour hoping some commercial acceptance in crosses among some Japanese varieties. 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.

Information concerning the extent and nature of genetic diversity within a crop species is essential. It is particularly useful for characterizing individual accessions and cultivars and as a general guide in the selection of the parents for hybridization (Furini and Wunder, 2004). Improvement in yield and quality is normally achieved by selecting genotypes with desirable character combinations existing in the nature or by hybridization. Selection of parents on the basis of divergence analysis would be more promising for a hybridization Program. More diverse the parents, greater are the chances of obtaining high heterotic F_1s and broad spectrum of variability in segregating generations (Arunachalam, 1981).

Diallel design gives better control over the experimental material and thereby provides more precise information in various parameters obtained from this design. In breeding of high yielding varieties of crop plants, the breeder often deals with problem of selecting the desirable parents. Combining ability is one of the important aspects for selecting desirable parents and cross combinations to be used in formulation of systematic breeding programme.

Hence, the present study was undertaken with the following objectives.

1. To study the *per se* performance of parents and hybrids.
2. To estimate the magnitude of heterosis for fruit yield and its component characters.
3. To estimate the general and specific combining ability effects of parents and crosses, respectively.
4. To identify the good general combiners and specific combiners for use in future breeding programme.
5. To study the nature and magnitude of gene actions.

Review of Literature

2. REVIEW OF LITERATURE

Brinjal being a crop of Indian origin has also developed some secondary variability in China (Vavilov, 1931). Brinjal has rich diversity in the form of plant and fruit morphological characteristics. During the last few decades, work on enrichment of eggplant germplasm through indigenous and exotic sources has been in progress at NBPGR. The magnitude of success to be obtained lies in the selection of the base material and its creative manipulation. The progress in plant breeding depends on the genetic information available from the parents and their combinations on the inheritance and behaviour of quantitative characters associated with yield or any economical trait of concern to the breeder. To generate such genetic information it is necessary to conceive a genetic model in relation to the material that is proposed to be utilized and to design suitable mating system that can fit into the chosen genetic model.

To enhance the place of genetic improvement in eggplant detailed investigation regarding heterosis and combining ability is essential.

Keeping in view the objectives of the present investigation relevant literature is reviewed and presented in the following headings.

2.1 HETEROSIS

In the history of the development of the scientific concepts and their applications for the benefit of agriculture, heterosis deserves a prominent position. The term *heterosis refers to the phenomenon in which* F_1 *shows increased or* decreased vigour over the parent. Shull (1908) referred to this phenomenon as the stimulus of heterozygosity. The occurrence of heterosis is common in plant species but its level of expression is highly variable. Heterosis (hybrid vigour) is the superiority of hybrid over its parents when mean of the two parents is considered, it is called heterosis over mid parent. Generally the term hybrid vigour is used to denote heterosis in the dissimilar direction and the heterosis over mid parent, better parent and standard check (ruling variety/hybrids) is designated as heterosis, heterobeltiosis and standard heterosis, respectively.

The earliest recorded instances of artificial hybridization in eggplant were evidently those carried out by Bailey and Munson in 1892. However none of the hybrids exhibited heterosis but were intermediate between the parents.

The first positive report of heterosis in the eggplant came from Munson (1892). Subsequently Halsted (1901) reported that one of his crosses had double the size of the parents and also yielded more. In the Philippines Bayla (1918) hybridized some local varieties and found that the hybrids were more vigorous, stronger and healthier than the respective parental lines.

In Japan, Nagai and Kida (1926) studied certain quantitative characteristics in the hybrids and found that heterosis was manifested in total yield and its traits. Tatesi (1927) observed higher productivity in certain crosses between Japanese brinjal varieties. Kakizaki (1928) reported the occurrence of remarkable hybrid vigour in the crosses with regard to seed weight, stem diameter and height in brinjal.

Heterosis being a complex phenomenon, no conclusive or clear-cut explanation is available to account for its manifestation. However, several theories have been put forth to explain heterosis like dominance (Davenport, 1908; Keeble and Pellew, 1910; Bruce, 1910 and Jones, 1917), over dominance (East, 1908 and Shull, 1909), epistasis (Jinks, 1955; Hayman, 1957; Bauman, 1959; Sprague *et al.*, 1962; Gamble, 1962 and Sprague and Thomas, 1967) and mitochondrial complementation (Hanson *et al.*, 1960; McDaniel, 1972 and Shrivastava, 1972).

In India the first attempt to hybridize eggplant appears to have been made by Rao in 1934, however, in the cross between two wide varieties, a high degree of partial sterility due to abortive pollen was observed. Venkataramani (1946) reported that hybrid egg plants were taller, spread more, flowered earlier than the early parent and yielded more than either parent. In the same year, Pal and Singh (1946) reported that majority of the hybrids exhibited heterosis with respect to seed germination, plant height, plant spread, number of branches, early flowering, number of fruits per plant, fruit size and fruit yield.

Hays and Foster (1976) suggested that heterosis may result from one or more genetic situations outlined below:

1. The accumulated action of favorable dominant or semi-dominant genes dispersed amongst the two parents *i.e.,* dominance.
2. Complementary interaction of additive, dominant or recessive genes at different loci *i.e., non-allelic interaction* or epistasis.

Heterosis reported for yield and its components by various workers are presented in Table 1.

Table 1. Heterosis for different traits in brinjal as reported by different authors

Type of materials studied	Range of heterosis (%) over			Authors
	Mid parent	Better parent	Standard check	
Days to first flowering				
10 F_1 hybrids	-19.60 to 2.36	-25.95 to 16.81	--	Peter and Singh (1974)
6 x 6 Diallel	--	-4.7 to 17.0	--	Vijay and Nath (1978)
72 F_1 hybrids	-13.02 to 5.61	-71.71 to 13.02	--	Dharmegowda *et al.* (1979)
5 F_1 hybrids	--	-52.06 to 9.51	--	Dhankhar *et al.* (1980)
19 F_1 hybrids	-4.3 to 1.2	-3.3 to 3.7	--	Shankaraiah and Rao (1990)
42 F_1 hybrids	-14.75 to 15.18	--	--	Patil (1991)
14 F_1 hybrids	--	-29.33 to 24.28	--	Sawant *et al.* (1991)
10 F_1 hybrids	--	-16.23 to 18.04	--	Mandal *et al.* (1994)
60 F_1 hybrids	-37.79 to 43.07	--	-49.14 to 27.43	Patil (1998)
12 F_1 hybrids	-13.4 to 5.6	-11.1 to 6.8	--	Kumar *et al.* (1999)
30 F_1 hybrids	-19.23 to 19.05	--	-13.40 to 13.04	Bulgundi (2000)
36 F_1 hybrids	--	0.00 to 16.28	--	Chadha *et al.* (2001)
4 x 4 Diallel	-0.42 to -9.51	-9.51 to 1.69	--	Das and Barua (2001)
28 F_1 hybrids	-18.00 to 11.81	--	--	Mallikarjun (2002)
27 F_1 hybrids	-10.39 to 38.99	-10.39 to 38.99	-15.35 to 27.59	Singh and Maurya (2005)
10 x 10 Diallel (Excluding reciprocals)	-17.61	-16.14	--	Bisht *et al.* (2009)
6 x 6 Diallel	--	-27.59 to 1.21	-7.83 to 32.24	Chowdhury *et al.* (2010)
8 x 8 Diallel (Excluding reciprocals)	--	--	-7.09 to 14.18	Nalini *et al.* (2011)
8 x 8 Diallel (Excluding reciprocals)	-12.59 to 14.83	-9.46 to 22.45	-9.36 to 18.22	Makani (2013)
5 x 4 Line x Tester	--	--	-29.44 to -7.22	Reddy and Patel (2014)

Days to first harvest				
12 x 12 Diallel	--	-16.49 to 0.69	--	Mishra (1977)
6 x 6 Diallel	-12.15 to 2.80	-16.80 to 10.50	--	Bhutani *et al.* (1980)
15 parents and 22 F_1 hybrids	--	1.40 to 16.62	0.29 to 4.01	Chadha and Sidhu (1982)
15 parents and 15 F_1 hybrids	--	1.49 to 4.84	--	Sidhu and Chadha (1985)
6 x 6 half diallel	--	-31.97 to -0.66	--	Verma *et al.* (1986)
21 F_1 hybrids	--	-16.49 to 15.25	-0.21 to 29.66	Chadha *et al.* (1990)
6 x 6 Diallel	-17.31 to 4.88	-12.06 to 29.43	--	Patel (1994)
55 F_1 hybrids	--	-35.64 to 20.98	--	Mankar *et al.* (1995)
7 x 5 Line x Tester	--	-4.53 to 18.14	-25.19 to 19.34	Kaur (1998)
8 x 8 Diallel (Excluding reciprocals)	--	-9.06 to 19.79	-8.75 to 16.16	Patel (2003)
10 x 10 Half diallel	--	-5.42 to 29.20 (E_1) -8.61 to 8.35 (E_2) -8.59 to 14.38 (E_3)	--	Rao (2003)
7 x 3 Line x Tester	--	-1.47 to -9.96	--	Kamal *et al.* (2006)
10 x 10 Diallel	--	-8.59 to 14.38	-2.82 to 11.96	Suneetha and Kathiria (2006)
10 x 10 Diallel	-9.78	-8.82	--	Bisht *et al.* (2009)
6 x 6 Diallel	--	-25.27 to 2.26	-18.29 to 21.40	Chowdhury *et al.* (2010)
8 x 8 Diallel (Excluding reciprocals)	-14.71 to 17.92	-12.64 to 29.37	-4.44 to 26.28	Makani (2013)
Fruit length (cm)				
21 F_1 hybrids	-28.51 to 16.90	-26.99 to 16.90	--	Lal *et al.* (1974)
12 Parents and 12 F_1 hybrids	--	-2.37 to 26.31	--	Mishra (1977)

10 F_1 hybrids	--	-30.3 to 19.0	--	Singh and Kumar (1978)
8 Parents and 20 F_1 hybrids	--	4.30 to 48.60	--	Singh *et al.* (1978a)
15 F_1 hybrids	-32.80 to 68.80	-37.93 to -5.21	4.12	Bhutani *et al.* (1980)
4 F_1 hybrids	--	1.29 to 70.00	--	Dhankhar *et al.* (1980)
11 Parents and 11 F_1 hybrids	--	-41.31 to -14.15	-32.85 to 29.82	Ram *et al.* (1981)
22 F_1 hybrids	6.92 to 70.00	33.92	--	Chadha and Sidhu (1982)
40 F_1 hybrids	--	0.52 to 13.82	--	Dahiya *et al.* (1984)
7 x 7 Diallel (Excluding reciprocals)	-2.63 to 22.94	-10.87 to 22.84	-32.78 to 9.97	Patel (1984)
15 F_1 hybrids	--	10.87 to 121.-80	--	Patil and Shinde (1984)
3 x 3 Line x Tester	36.68 to 54.97	--	6.16 to 27.17	Rajput *et al.* (1984)
15 F_1 hybrids	26.32 to 126.54	19.54 to 121.80	--	Sidhu and Chadha (1985)
12 Parents and 30 F_1 hybrids	--	5.20 to 12.10	--	Dixit and Gautam (1987)
20 F_1 hybrids	--	4.3 to 48.6	--	Singh *et al.* (1988)
9 x 9 Diallel (Excluding reciprocals)	-5.29 to 4.37	-3.39 to 4.60	--	Chadha and Hegde (1988)
18 F_1 hybrids	-25.77 to 26.18	-33.88 to 11.14	--	Prakash *et al.* (1993)
6 x 6 Diallel (Including reciprocals)	--	-56.14 to 32.55	--	Patel (1994)
66 F_1 hybrids	--	-0.74 to 31.13	--	Mankar *et al.* (1995)
10 x 10 Diallel (Excluding reciprocals)	-39.1 to 28.3	-51.90 to 19.20	-64.50 to -6.00	Ingale and Patil (1996)
7 x 5 Line x Tester	--	-19.40 to 38.04	-24.11 to 31.25	Kaur (1998)
60 F_1 hybrids	--	--	-18.84 to 28.56	Patil (1998)
12 F_1 hybrids	-18.4 to 36.1	-29.9 to 19.1	--	Kumar *et al.* (1999)
30 F_1 hybrids	-19.23 to 33.72	--	-22.27 to 23.64	Bulgundi (2000)
36 F_1 hybrids	--	-41.95 to 17.92	--	Chadha *et al.* (2001)
3 x 14 Line x Tester	-41.94 to 6.54	-59.26 to 4.59	--	Indiresh and Kulkarni (2002)
8 x 8 Diallel (Excluding reciprocals)	--	-27.40 to 2.43	-3.27 to 31.73	Patel (2003)

4 x 4 Diallel	6.64 to 28.35	-15.23 to 8.92	--	Das and Barua (2001)
28 F_1 hybrids	-11.90 to 40.69	-10.59 to 52.24	-5.85 to 47.82	Mallikarjun (2002)
28 F_1 hybrids	--	8.30	--	Harshavardhan *et al.* (2003)
28 F_1 hybrids	--	--	-37.9 to 41.4	Pratibha *et al.* (2004)
36 F_1 hybrids	16.58 to 33.95	-33.38 to 40.50	--	Singh *et al.* (2004)
24 F_1 hybrids	-24.87 to 29.82	-50.0 to 18.46	-3.45 to 112.07	Shafeeq (2005)
27 F_1 hybrids	-26.48 to 79.12	-43.33 to 39.31	-66.07 to 28.33	Singh and Maurya (2005)
10 x 10 Diallel	36.92	24.95	--	Bisht *et al.* (2009)
8 x 3 Line x Tester	--	-15.89 to 33.44	--	Shanmugapriya *et al.* (2009)
6 x 6 Diallel	--	-34.04 to 32.35	-7.85 to 93.17	Chowdhury *et al.* (2010)
8 x 6 Line x Tester	--	13.55	--	Sao and Mehta (2010)
8 x 8 Diallel (Excluding reciprocals)	-19.30 to 21.11	-19.82 to 12.11	-19.83 to 12.09	Makani (2013)
5 x 4 Line x Tester	--	--	4.66 to 84.33	Reddy and Patel (2014)
Fruit girth (cm)				
21 F_1 hybrids	--	-44.03 to -1.75	--	Lal *et al.* (1974)
15 F_1 hybrids	-18.15 to 6.66	-33.79 to 0.06	--	Bhutani *et al.* (1980)
4 F_1 hybrids	--	-32.43 to 15.57	--	Dhankhar *et al.* (1980)
11 Parents and 11 F_1 hybrids	--	-56.88 to -7.68	-39.10 to -2.57	Ram *et al.* (1981)
22 F_1 hybrids	5.26 to 199.40	38.10 to 177.37	--	Chadha and Sidhu (1982)
15 F_1 hybrids	--	0.05 to 15.44	--	Patil and Shinde (1984)
7 x 7 Diallel (Excluding reciprocals)	-19.22 to 17.42	-33.25 to 13.65	-51.30 to -7.00	Patel (1984)
15 F_1 hybrids	--	10.44 to 50.00	--	Sidhu and Chadha (1985)
12 Parents and 30 F_1 hybrids	--	9.70 to 11.20	--	Dixit and Gautam (1987)
18 F_1 hybrids	-27.79 to 32.78	-51.12 to 11.88	--	Prakash *et al.* (1993)
6 x 6 Diallel (Including reciprocals)	--	-52.03 to 17.93	--	Patel (1994)

55 F_1 hybrids	--	0.00 to 58.41	--	Mankar *et al.* (1995)
10 x 10 Diallel (Excluding reciprocals)	-21.5 to 27.2	-26.90 to 15.70	-38.70 to 0.90	Ingale and Patil (1996)
7 x 5 Line x Tester	--	-31.96 to 12.90	-17.53 to 29.22	Kaur (1998)
60 F_1 hybrids	-39.31 to 21.97	--	-43.60 to 8.49	Patil (1998)
12 F_1 hybrids	-38.8 to 48.6	-40.2 to 46.6	-43.60 to 8.49	Kumar *et al.* (1999)
30 F_1 hybrids	-13.13 to 26.02	--	-5.93 to 28.66	Bulgundi (2000)
8 x 8 Diallel (Excluding reciprocals)	--	-27.61 to 18.48	-16.69 to 41.00	Patel (2003)
4 x 4 Diallel	-19.31 to 8.07	-36.45 to 5.49	--	Das and Barua (2001)
28 F_1 hybrids	-14.97 to 23.91	-16.90 to 22.48	-13.14 to 13.58	Mallikarjun (2002)
3 x 14 Line x Tester	-30.15 to 38.16	-46.63 to 32.54	--	Indiresh and Kulkarni (2002)
28 F_1 hybrids	--	7.91	--	Harshavardhan *et al.* (2003)
22 F_1 hybrids	--	--	-1.7 to 96.8	Pratibha *et al.* (2004)
36 F_1 hybrids	-33.45 to 30.31	-40.50 to 11.07	--	Singh *et al.* (2004)
24 F_1 hybrids	-17.05 to 12.28	-24.37 to 1.98	-0.25 to 60.0	Shafeeq (2005)
27 F_1 hybrids	-23.89 to 17.68	-35.29 to 9.73	-23.89 to 17.68	Singh and Maurya (2005)
10 x 10 Diallel	--	-29.61 to 25.51	-33.69 to 10.50	Suneetha and Kathiria (2006)
10 x 10 Diallel	36.22	33.26	--	Bisht *et al.* (2009)
8 x 3 Line x Tester	--	-22.12 to -6.79	--	Shanmugapriya *et al.* (2009)
6 x 6 Diallel	--	-56.82 to 24.14	-65.33 to 22.11	Chowdhury *et al.* (2010)
8 x 6 Line x Tester	--	50.96	--	Sao and Mehta (2010)
8 x 8 Diallel (Excluding reciprocals)	-15.39 to 34.58	-32.16 to 28.83	-34.16 to 26.05	Makani (2013)
5 x 4 Line x Tester	--	--	-30.78 to 13.17	Reddy and Patel (2014)
Fruit weight (g)				
10 F_1 hybrids	-66.30 to 494.26	--	--	Peter and Singh (1974)
7 x 7 Diallel	71.11	0.00 to 63.83	--	Mital *et al.* (1976)

6 x 6 Diallel (Excluding reciprocals)	-32.00 to 75.00	-61.30 to 66.60	--	Vijay and Nath (1978)
15 F_1 hybrids	-25.71 to 11.42	-36.25 to 0.06	--	Bhutani *et al.* (1980)
11 Parents and 11 F_1 hybrids	--	-27.27 to -4.54	-27.27 to 40.00	Ram *et al.* (1981)
22 F_1 hybrids	4.79 to 135.10	0.32 to 125.0	--	Chadha and Sidhu (1982)
7 x 7 Diallel (Excluding reciprocals)	-27.09 to 38.92	-37.19 to 19.34	-62.19 to -0.36	Patel (1984)
40 F_1 hybrids	--	44.84	--	Dahiya *et al.* (1984)
15 F_1 hybrids	--	12.09 to 58.96	--	Patil and Shinde (1984)
15 F_1 hybrids	31.28 to 82.91	7.42 to 45.71	--	Sidhu and Chadha (1985)
6 x 6 Diallel (Excluding reciprocals)	--	10.94 to 16.32	--	Verma *et al.* (1986)
12 Parents and 30 F_1 hybrids	--	6.70 to 46.40	--	Dixit and Gautam (1987)
21 F_1 hybrids	--	-48.11 to 25.57	--	Chadha *et al.* (1990)
14 F_1 hybrids	--	-45.02 to 23.61	-59.65 to 63.90	Sawant *et al.* (1991)
18 F_1 hybrids	-71.44 to 32.99	-82.42 to 24.37	--	Prakash *et al.* (1993)
6 x 6 Diallel (Including reciprocals)	-14.17 to 86.80	-42.86 to 59.89	--	Patel (1994)
55 F_1 hybrids	--	0.77 to 41.36	--	Mankar *et al.* (1995)
10 x 10 Diallel (Excluding reciprocals)	-19.8 to 62.6	-36.20 to 34.40	-52.90 to 22.20	Ingale and Patil (1996)
7 x 5 Line x Tester	--	-57.80 to 15.55	-29.36 to 51.42	Kaur (1998)
60 F_1 hybrids	-26.50 to 40.77	--	-34.95 to 43.52	Patil (1998)
12 F_1 hybrids	-36.2 to 17.0	-40.5 to 2.2	-34.95 to 43.52	Kumar *et al.*, (1999)
30 F_1 hybrids	-13.47 to 60.43	--	-41.50 to 14.07	Bulgundi (2000)
4 x 4 Diallel	-17.88 to 25.29	-32.45 to 11.07	--	Das and Barua (2001)
28 F_1 hybrids	-35.39 to 75.75	--	-19.81 to 88.25	Mallikarjun (2002)
3 x 14 Line x Tester	-64.34 to 44.53	-70.86 to 0.90	--	Indiresh and Kulkarni (2002)
8 x 8 Diallel (Excluding reciprocals)	--	-62.12 to 64.32	-43.54 to 110.97	Patel (2003)
28 F_1 hybrids	--	20.69	--	Harshavardhan *et al.* (2003)

36 F_1 hybrids	-58.06 to 160.87	-61.54 to 67.44	--	Singh *et al.* (2004)
24 F_1 hybrids	-17.18 to 96.21	-20.18 to 69.22	-11.84 to 137.73	Shafeeq (2005)
7 x 3 Line x Tester	--	0.06 to 53.87	--	Kamal *et al.* (2006)
10 x 10 Diallel	59.36	46.95	--	Bisht *et al.* (2009)
8 x 3 Line x Tester	--	-27.47 to 3.53	--	Shanmugapriya *et al.* (2009)
6 x 6 Diallel	--	-49.56 to 10.09	-57.1 to 72.5	Chowdhury *et al.* (2010)
8 x 6 Line x Tester	--	83.27	--	Sao and Mehta (2010)
28 F_1 hybrids	--	--	-22.53 to 30.33	Nalini *et al.* (2011)
8 x 8 Diallel (Excluding reciprocals)	-64.71 to 46.79	-75.97 to 32.24	-58.47 to 81.73	Makani (2013)
5 x 4 Line x Tester	--	--	-36.69 to 17.53	Reddy and Patel (2014)
Fruits per cluster				
15 F_1 hybrids	--	4.92 to 48.81	--	Patil and Shinde (1984)
10 F_1 hybrids	--	-0.057 to 0.1	--	Singh and Kumar (1978)
18 F_1 hybrids	-23.81 to 87.50	-38.46 to 87.50	--	Prakash *et al.* (1993)
60 F_1 hybrids	-16.95 to 66.46	--	-57.5 to 67.61	Patil (1998)
32 F_1 hybrids	-27.24 to 52.17	-36.40 to 31.66	35.33 to 214.07	Anuroopa (2000)
30 F_1 hybrids	-52.38 to 40.00	--	-44.44 to 5.56	Bulgundi (2000)
28 F_1 hybrids	-54.20 to 108.70	-62.23 to 84.62	0.00 to 150.00	Mallikarjun (2002)
24 F_1 hybrids	-23.0 to 109	-28.57 to 91.67	0.00 to 130.00	Shafeeq (2005)
25 F_1 hybrids	-62.50 to 40.00	-62.50 to 0.00	-56.52 to 56.52	Ajjappalavara (2006)
10 x 10 Diallel (Excluding reciprocals)	107.69	82.35	--	Bisht *et al.* (2009)
48 F_1 hybrids	--	35.01 to 98.73	--	Sao and Mehta (2010)
12 F_1 hybrids	-60.00 to 26.67	-75.00 to 26.67	-60.53 to 10.53	Reddy *et al.* (2011)
28 F_1 hybrids	--	--	0.00 to 245.00	Nalini *et al.* (2011)
5 x 4 Line x Tester	--	--	0.00 to 287.50	Reddy and Patel (2014)

Fruis per plant				
21 F_1 hybrids	-63.14 to 49.25	--	--	Lal *et al.* (1974)
12 Parents and 12 F_1 hybrids	--	2.11 to 85.08	--	Mishra (1977)
8 Parents and 20 F_1 hybrids	--	10.50 to 55.40	10.10 to 54.50	Singh *et al.* (1978a)
15 x 4 Line x Tester	0.00 to 11.88	59.36 to 81.95	--	Singh *et al.* (1978b)
10 F_1 hybrids	--	53.8	--	Singh and Kumar (1978)
15 F_1 hybrids	-35.4 to 66.6	-52.3 to 36.0	--	Vijay *et al.* (1978)
72 F_1 hybrids	-65.86 to 105.21	-79.80 to 72.22	--	Dharmegowda *et al.* (1979)
15 F_1 hybrids	-47.67 to 52.09	-61.65 to 47.66	28.45	Bhutani *et al.* (1980)
4 F_1 hybrids	--	-34.67 to 78.54	--	Dhankhar *et al.* (1980)
11 Parents and 11 F_1 hybrids	--	-5.26 to 36.84	5.25 to 69.23	Ram *et al.* (1981)
15 Parents and 22 F_1 hybrids	--	1.78 to 176.62	46.07 to 86.37	Chadha and Sidhu (1982)
7 x 7 Diallel (Excluding reciprocals)	-22.43 to 64.86	-50.84 to 24.80	-56.45 to -14.97	Patel (1984)
40 F_1 hybrids	--	27.94	--	Dahiya *et al.* (1984)
15 F_1 hybrids	--	4.25 to 48.73	--	Patil and Shinde (1984)
3 x 3 Line x Tester	35.41 to 107.79	107.79	18.46 to 95.91	Rajput *et al.* (1984)
15 parents and 15 F_1 hybrids	0.00 to 27.41	0.00 to 22.87	--	Sidhu and Chadha (1985)
6 x 6 Diallel (Excluding reciprocals)	--	4.18 to 7.56	--	Verma *et al.* (1986)
12 Parents and 30 F_1 hybrids	--	3.80 to 60.1	--	Dixit and Gautam (1987)
9 x 9 Diallel (Excluding reciprocals)	10.15 to 17.50	11.28 to 18.84	--	Chadha and Hedge (1988)
20 F_1 hybrids	--	13.5 to 54.4	--	Singh *et al.* (1988)
4 Varieties along with 105 crosses	--	-46.36 to 239.81	--	Kalloo *et al.* (1989)
21 F_1 hybrids	--	-28.31 to 29.97	35.0 to 210.51	Chadha *et al.* (1990)
14 F_1 hybrids	--	-13.29 to 44.07	--	Sawant *et al.* (1991)
18 F_1 hybrids	-13.33 to 129.34	-37.24 to 118.59	--	Prakash *et al.* (1993)

6 x 6 Diallel (Including reciprocals)	--	-73.47 to 3.14	--	Patel (1994)
10 F_1 hybrids	--	69.98 to 96.49	--	Mandal *et al.* (1994)
55 F_1 hybrids	--	1.40 to 45.48	--	Mankar *et al.* (1995)
45 F_1 hybrids	-42.1 to 45.4	-63.1 to 40.6	--	Ingale and Patil (1997a)
7 x 5 Line x Tester	--	-51.49 to 93.25	-56.83 to 24.38	Kaur (1998)
60 F_1 hybrids	--	--	-47.77 to 83.20	Patil (1998)
12 F_1 hybrids	-30.72 to 81.1	-35.1 to 66.3	-	Kumar *et al.* (1999)
30 F_1 hybrids	-57.28 to 102.41	--	-46.94 to 87.07	Bulgundi (2000)
4 x 4 Diallel	4.11 to 40.29	-13.37 to 27.79	-	Das and Barua (2001)
28 F_1 hybrids	-45.16 to 37.41	-50.75 to 15.55	-41.82 to 56.53	Mallikarjun (2002)
3 x 14 Line x Tester	-45.19 to 24.82	-58.40 to 4.63	--	Indiresh and Kulkarni (2002)
8 x 8 Diallel (Excluding reciprocals)	--	-66.42 to 22.22	-50.54 to 81.70	Patel (2003)
28 F_1 hybrids	--	14.12	--	Harshavardhan *et al.* (2003)
24 F_1 hybrids	-42.18 to 22.91	-43.62 to 4.56	-26.98 to 33.95	Shafeeq (2005)
27 F_1 hybrids	-41.12 to 172.99	-223.07 to 247.00	-79.31 to 114.94	Singh and Maurya (2005)
7 x 3 Line x Tester	--	1.46 to 64.84	--	Kamal *et al.* (2006)
45 F_1 hybrids	--	-63.18 to 134.53	-77.19 to 53.03	Suneetha *et al.* (2008)
25 F_1 hybrids	--	-61.61 to 30.6	-80.17 to -30.82	Timmapur *et al.* (2008)
10 x 10 Diallel	66.08	58.83	--	Bisht *et al.* (2009)
8 x 3 Line x Tester	--	42.64 to 83.69	--	Shanmugapriya *et al.* (2009)
6 x 6 Diallel	--	-72.81 to 105.00	-60.97 to 253.65	Chowdhury *et al.* (2010)
8 x 6 Line x Tester	--	102.79	--	Sao and Mehta (2010)
28 F_1 hybrids	--	--	-30.17 to 26.42	Nalini *et al.* (2011)
8 x 8 Diallel (Excluding reciprocals)	-5.10 to 168.45	-40.10 to 190.34	-35.22 to 65.11	Makani (2013)

5 x 4 Line x Tester	--	--	-21.68 to 245.26	Reddy and Patel (2014)
Primary branches per plant				
15 F_1 hybrids	--	0 to 5.44	--	Chadha and Sidhu (1982)
22 F_1 hybrids	7.46 to 148.79	1.18 to 138.89	--	Dhankar and Singh (1983)
18 F_1 hybrids	0.0 to 55.56	-10.53 to 23.53	--	Prakash *et al.* (1993)
3 F_1 hybrids	4.97 to 14.96	-8.32 to 4.37	--	Ponnuswami *et al.* (1994)
55 F_1 hybrids	--	0.91 to 94.94	--	Mankar *et al.* (1995)
60 F_1 hybrids	-16.04 to 37.48	--	-27.88 to 20.06	Patil (1998)
12 F_1 hybrids	-17.3 to 21.4	-20.4 to 18.7	--	Kumar *et al.* (1999)
30 F_1 hybrids	-36.75 to -5.25		-9.30 to 37.46	Bulgundi (2000)
36 F_1 hybrids	--	-8.57 to 28.57	--	Chadha *et al.* (2001)
28 F_1 hybrids	-35.23 to 76.68	-35.60 to 62.31	--	Mallikarjun (2002)
36 F_1 hybrids	53.98 to 40.66	-52.75 to 50.68	--	Singh *et al.* (2004)
24 F_1 hybrids	-29.04 to 26.62	-40.68 to 22.76	-13.07 to 23.07	Shafeeq (2005)
5 F_1 hybrids	-5.88 to 31.03	-15.79 to 23.44	-18.90 to 0.11	Ajjappalavara (2006)
10 x 10 Diallel (Excluding reciprocals)	58.22	51.34	--	Bisht *et al.* (2009)
8 x 8 Diallel (Excluding reciprocals)	--	--	-28.0 to 14.2	Nalini *et al.* (2011)
5 x 4 Line x Tester	--	--	-8.87 to 23.74	Reddy and Patel (2014)
Plant height (cm)				
10 F_1 hybrids	-11.56 to 23.65	0.7 to 23.7	--	Peter and Singh (1974)
12 parents and 12 F_1 hybrids	--	-23.47 to 31.27	--	Mishra (1977)
10 F_1 hybrids	--	26.1	--	Singh and Kumar (1978)
8 parents and 20 F_1 hybrids	--	0.1 to 23.70	--	Singh *et al.* (1978a)
15 x 4 Line x Tester	--	20.69 to 38.34	--	Singh *et al.* (1978b)
72 F_1hybrids	-31.39 to 61.19	-19.17 to 28.30	--	Dharmegowda *et al.* (1979)

6 x 6 Diallel (Excluding reciprocals)	-12.00 to 30.30	-19.71 to 28.30	6.96 to 14.44	Bhutani *et al.* (1980)
4 F_1 hybrids	--	2.46 to 30.92	--	Dhankar *et al.* (1980)
11 parents and 11 F_1 hybrids	--	-3.44 to 14.94	8.18 to 20.18	Ram *et al.* (1981)
22 F_1 hybrids	3.36 to 40.96	4.79 to 14.88	--	Chadha and Sidhu (1982)
7 x 7 Diallel (Excluding reciprocals)	-14.05 to 43.17	-17.37 to 30.68	-31.66 to 26.07	Patel (1984)
15 F_1 hybrids	--	4.91 to 23.64	-	Patil and Shinde (1984)
3 x 3 Line x Tester	--	-31.38	8.96 to 29.50	Rajput *et al.* (1984)
15 parents and 15 F_1 hybrids	--	14.95 to 23.64	--	Sidhu and Chadha (1985)
6 x 6 Diallel (Excluding reciprocals)	--	-5.75 to -4.46	--	Verma *et al.* (1986)
9 x 9 Diallel (Excluding reciprocals)	--	16.50 to 25.34	--	Chadha and Hedge (1988)
7 x 7 Diallel (Excluding reciprocals)	--	-7.87 to 9.76	--	Chaudhary and Mishra (1988)
20 F_1 hybrids	--	-50.16 to 36.44	--	Singh *et al.* (1988)
21 F_1 hybrids	--	-1.40 to 44.67	20.96 to 75.04	Chadha *et al.* (1990)
5 x 5 Diallel	--	-4.1 to 13.1	--	Shankaraiah and Rao (1990)
14 F_1 hybrids	0.2 to 20.2	0.86 to 30.22	--	Sawant *et al.* (1991)
18 F_1hybrids	9.41 to 43.51	-4.30 to 43.51	--	Prakash *et al.* (1993)
6 x 6 Diallel (Including reciprocals)	-8.07 to 45.54	-19.67 to 37.24	--	Patel (1994)
55 F_1 hybrids	--	0.17 to 8.93	--	Mankar *et al.* (1995)
45 F_1 hybrids	24.1 to 45.9	-41.80 to 43.10	--	Ingale and Patil (1997a)
7 x 5 Line x Tester	--	-17.44 to 46.98	-26.96 to 25.84	Kaur (1998)
60 F_1 hybrids	--	--	-20.58 to 18.69	Patil (1998)
12 F_1 hybrids	-1.00 to 26.5	-11.90 to 24.80	--	Kumar *et al.* (1999)
30 F_1 hybrids	-11.39 to 19.46	--	-13.28 to 8.14	Bulgundi (2000)
3 x 14 Line x Tester	-72.11 to 6.64	-75.88 to 4.38	--	Indiresh and Kulkarni (2002)
8 x 8 Diallel (Excluding reciprocals)	--	-13.91 to 17.69	-9.41 to 22.88	Patel (2003)

4 x 4 Diallel	2.41 to 21.06	-7.86 to 11.62	--	Das and Barua (2001)
28 F_1 hybrids	-20.93 to 16.25	-25.55 to 10.95	-12.43 to 30.47	Mallikarjun (2002)
28 F_1 hybrids	--	-17.15	--	Harshavardhan *et al.* (2003)
36 F_1 hybrids	-59.35 to 28.65	-63.10 to 21.81	--	Singh *et al.* (2004)
24 F_1 hybrids	0.83 to 47.47	-2.70 to 45.27	-4.14 to 2.547	Shafeeq (2005)
27 F_1 hybrids	-22.66 to 56.33	-23.64 to 55.00	-14.79 to 60.17	Singh and Maurya (2005)
10 x 10 Diallel	--	-46.77 to 42.76	-42.59 to 23.38	Suneetha and Kathiria (2006)
10 x 10 Diallel	47.48	45.94	--	Bisht *et al.* (2009)
8 x 3 Line x Tester	--	-17.43 to -8.56	--	Shanmugapriya *et al.* (2009)
6 x 6 Diallel	--	2.12 to 22.36	-16.96 to 1.91	Chowdhury *et al.* (2010)
8 x 6 Line x Tester	--	22.38	--	Sao and Mehta (2010)
8 x 8 Diallel (Excluding reciprocals)	-24.11 to 42.19	-9.89 to 53.82	-19.21 to 40.53	Makani (2013)
5 x 4 Line x Tester	--	--	4.36 to 61.66	Reddy and Patel (2014)
Yield per plant (kg)				
7 x 7 Diallel	-36.92 to 112.37	--	--	Lal *et al.* (1974)
5 x5 Diallel	-66.30 to 494.26	-79.01 to 357.8	--	Peter and Singh (1974)
7 x 7 Diallel	92.5	48.64 to 90.21	--	Mital *et al.* (1976)
8 Parents and 20 F_1 hybrids	--	10.50 to 55.40	10.10 to 54.50	Singh *et al.* (1978a)
15 x 4 Line x Tester	0.00 to 9.26	59.36 to 81.95	--	Singh *et al.* (1978b)
6 x 6 Diallel (Excluding reciprocals)	-0.2 to 161.5	-12.00 to 156.90	--	Vijay and Nath (1978)
72 F_1 hybrids	-32.23 to 97.13	-42.36 to 74.03	--	Dharmegowda *et al.* (1979)
15 F_1 hybrids	-56.16 to 66.29	-59.66 to 39.36	0.25 to 12.02	Bhutani *et al.* (1980)
4 F_1 hybrids	--	-29.03 to 62.20	--	Dhankhar *et al.* (1980)
11 Parents and 11 F_1 hybrids	--	-43.69 to -16.90	-29.54 to 89.36	Ram *et al.* (1981)
15 Parents and 22 F_1 hybrids	0.00 to 172.09	6.50 to 142.19	6.50 to 83.58	Chadha and Sidhu (1982)

7 x 7 Diallel (Excluding reciprocals)	23.38 to 66.93	-23.86 to 66.91	-35.81 to -13.70	Patel (1984)
15 F_1 hybrids	--	2.04 to 60.00	--	Patil and Shinde (1984)
40 F_1 hybrids	--	83.16	--	Dahiya *et al.* (1984)
3 x 3 Line x Tester	62.90 to 126	--	32.90 to 99.19	Rajput *et al.* (1984)
15 parents and 15 F_1 hybrids	8.63 to 79.27	7.42 to 45.71	--	Sidhu and Chadha (1985)
6 x 6 Diallel (Excluding reciprocals)	--	6.70 to 12.98	--	Verma *et al.* (1986)
12 Parents and 30 F_1 hybrids	--	0.10 to 90.00	0.20 to 47.70	Dixit and Gautam (1987)
9 x 9 Diallel (Excluding reciprocals)	1.00 to 1.51	1.28 to 1.77	--	Chadha and Hedge (1988)
4 Varieties along with 105 crosses	164.56	-64.00 to 164.56	--	Kalloo *et al.* (1989)
33 F_1 hybrids	0.00 to 56.41	--	1.80 to 56.49	Singh and Kalda (1989)
21 F_1 hybrids	--	-10.74 to 42.93	-7.30 to 31.75	Chadha *et al.* (1990)
14 F_1 hybrids	--	-31.33 to 59.43	--	Sawant *et al.* (1991)
18 F_1 hybrids	-43.45 to 48.0	49.89 to 41.59	--	Prakash *et al.* (1993)
10 F_1 hybrids	--	60.25 to 136.82	--	Mandal *et al.* (1994)
6 x 6 Diallel (Including reciprocals)	-14.96 to 98.56	-35.56 to 90. 80	--	Patel (1994)
55 F_1 hybrids	--	2.29 to 89.9	--	Mankar *et al.* (1995)
10 x 10 Diallel (Excluding reciprocals)	-17.5 to 82.7	-28.20 to 72.30	-29.90 to 72.30	Ingale and Patil (1996)
7 x 5 Line x Tester	--	-14.83 to 151.50	-47.61 to 50.95	Kaur (1998)
60 F_1 hybrids	--	--	-35.78 to 78.35	Patil (1998)
12 F_1 hybrids	-30.2 to 69.4	-42.9 to 66.3	--	Kumar *et al.* (1999)
30 F_1 hybrids	-37.81 to 156.58	--	-41.62 to 59.96	Bulgundi (2000)
36 F_1 hybrids	--	-70.34 to 90.63	--	Chadha *et al.* (2001)
4 x 4 Diallel	9.19 to 63.54	-70.70 to 54.95	--	Das and Barua (2001)
3 x 14 Line x Tester	-60.25 to 28.07	-73.23 to 23.02	--	Indiresh and Kulkarni (2002)
8 x 8 Diallel (Excluding reciprocals)	--	-37.56 to 37.34	-27.39 to 52.02	Patel (2003)

28 F_1 hybrids	-50.58 to 64.42	-53.17 to 55.92	-58.94 to 59.74	Mallikarjun (2002)
28 F_1 hybrids	--	36.58	--	Harshavardhan *et al.* (2003)
36 F_1 hybrids	-72.16 to 333.75	-68.80 to 275.22	--	Singh *et al.* (2004)
24 F_1 hybrids	-37.99 to 162.89	-41.94 to 153.01	-46.17 to 75.87	Shafeeq (2005)
7 x 3 Line x Tester	--	1.00 to 83.92	--	Kamal *et al.* (2006)
10 x 10 Diallel	--	-50.54 to 114.43	-68.07 to 38.77	Suneetha and Kathiria (2006)
25 F_1 hybrids	--	-51.40 to 50.66	-49.42 to 27.74	Timmapur *et al.* (2008)
10 x 10 Diallel	132.34	99.97	--	Bisht *et al.* (2009)
6 x 6 Diallel	--	-34.62 to 74.89	-58.06 to 72.60	Chowdhury *et al.* (2010)
8 x 6 Line x Tester	--	115.84	--	Sao and Mehta (2010)
28 F_1 hybrids	--	--	-33.97 to 31.07	Nalini *et al.* (2011)
8 x 8 Diallel (Excluding reciprocals)	-36.34 to 136.39	-54.19 to 125.78	-57.38 to 50.41	Makani (2013)
5 x 4 Line x Tester	--	--	-12.69 to 103.59	Reddy and Patel (2014)

2.2 COMBINING ABILITY

A detailed knowledge on the magnitude and nature of genetic variances in breeding material is of prime importance for formulating a sound breeding programme for any crop. Combining ability is the ultimate factor in determining its usefulness for hybrids. The importance of combining ability has been well emphasized because often phenotypically promising parents don't give desired cross combinations and produce superior offspring in segregating generations whereas some combinations may give promising segregants. Allard (1960) explained that the ability of the parents to combine well depends on complex interaction among genes and cannot be adjudged by mere yield performance and adaptation of parents alone. The ability of a parent to combine well and to produce promising segregants in succeeding generation is an important criteria in selection of parents for successful hybridization programme. The concept of combining ability first proposed by Sprague and Tatum (1942) in corn is useful for selection of parents which can produce superior hybrids. The superiority of the F_1 hybrids depend on the parent material used to produce F_1 which involves the action and interaction of dissimilar gametes in the heterozygotes.

Hence information on the general combining ability (*gca*) of the parents and their gene action and specific combining ability (*sca*) of the crosses and their magnitude of heterosis is vital for the selection of parents in the breeding programmes.

The general combining ability (*gca*) is the average performance of a genotype in cross combinations involving a set of other genotypes. It is the deviation of the mean performance of all crosses involving a parent from overall mean. Specific combining ability (*sca*) is the relative performance of a specific cross combination. It is the deviation in the performance of a specific cross from the performance expected on the basis of general combining ability effects of parents involved in the cross. The *gca* variance is due to additive variance, whereas, *sca* variance is due to dominance and epistatic (additive x additive, additive x dominance and dominance x dominance) variance. In other words, the *gca* and *sca* variances act as diagnostic tools to detect the additive (linear) and non-additive (non-linear) gene action. This helps in selection of suitable parents or cross combination(s).

Earliest studies on combining ability in brinjal were reported by Odland and Noll (1948). They reported that, the hybrid combination between lower yielding parents produced more yields.

General combining ability (*gca*) is "the average performance of a line in a series of hybrid combinations and specific combining ability is "the deviation of certain crosses from the average performance of the lines". Henderson (1952) defined specific combining ability as deviation of an average value which would be expected on the basis of known general combining ability of two lines.

Regarding the combining ability of parental lines in brinjal, two aspects were worth considering. One is that in several cases the best hybrids were obtained by crossing widely different varieties (Kakizaki, 1928), while only in a few instances wide crosses resulted in partial sterility in the hybrids (Rao, 1934 and Jasmin, 1954). This should be of particular interest to workers in India, where a great number of varieties possessing considerable genetic variability exist. The other aspect is that the hybrids of high productivity may result from parents of very low productivity (Sambandam, 1962).

The choice of parental material in a breeding programme is very important, since it puts a limitation on the possibility of isolating the genotypes outside the frame work of the genetic makeup of the parents. Hence the selection of parents must be done very precisely. In order to fulfil this goal, combining ability studies become useful. As it provides information or nicking ability pertaining to gene actions of parents for various traits.

Several methods have been developed to estimate the general and specific combining ability of different genetic material *viz.,* inbred variety cross or top cross technique (Jenkins and Brunson, 1932), polycross (Tsydal *et al.*, 1942), diallel cross (Griffing, 1956), line x tester analysis (Kempthorne, 1957), partial diallel cross (Kempthorne and Curnow, 1961) and triallel cross (Rawlings and Cockerham, 1962).

It is essential to understand the types of gene action and their importance in determining the traits of interest to the breeders for increasing the efficiency of the breeding programme. The knowledge of various types of gene action and their relative magnitude in controlling the trait is important in deciding proper breeding techniques (Miller *et al.*, 1980).

The available literature pertaining to combining ability in brinjal is presented in Table 2.

Table 2. Combining ability variances and effects for different traits in brinjal as reported by different authors

Types of materials studied	Combining ability variances and gene action	Authors
	Days to first flowering	
9 x 9 Diallel (Excluding reciprocals)	Significant *GCA* and *SCA* variance	Dharmegowda (1976)
6 x 6 Diallel (Excluding reciprocals)	Significant *GCA* and *SCA* variance	Vijay *et al.* (1978)
6 x 6 Diallel (Excluding reciprocals)	Significant *GCA* and *SCA* variance	Bhutani *et al.* (1980)
9 x 9 Diallel (Excluding reciprocals)	Significant *GCA* and *SCA* variance	Chadha and Hegde (1989)
8 x 8 Diallel (Excluding reciprocals)	Significant *GCA* and *SCA* variance	Mishra and Mishra (1990)
7 x 2 Line x Tester	Significant *GCA* and *SCA* variance	Sawant *et al.* (1991)
2 x 9 Line x Tester	Significant *GCA* and *SCA* effects	Prakash *et al.* (1994)
8 x 8 Diallel (Excluding reciprocals)	Significant *GCA* and *SCA* variance	Padmanabham and Jagadish (1996)
60 F_1 hybrids	Significant *GCA* and *SCA* variance	Patil (1998)
10 x 2 Line x Tester	Presence of both additive and non-additive gene actions	Varshney *et al.* (1999)
30 F_1 hybrids	Significant *GCA* and *SCA* variance	Bulgundi (2000)
8 x 8 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Chaudhary and Pathania (2000)
10 x 10 Diallel (Excluding reciprocals)	Non-additive gene action was predominant	Baig and Patil (2002)
12 x 3 Line x Tester	Predominance of additive gene action	Singh and Singh (2004)
12 x 4 Line x Tester	Non-additive gene action was predominant	Vadodaria *et al.* (2004)
8 x 3 Line x Tester	Preponderance of non-additive gene action	Shanmugapriya *et al.* (2009)
8 x 6 Line x Tester	Important of both additive and non-additive components	Sao and Mehta (2010)
7 x 3 Line x Tester	Predominance of additive gene action	Pachiyappan *et al.* (2012)
4 x4 Diallel (Including reciprocals)	Predominance of additive gene action	Al-Hubaity and Teli (2013)

Days to first harvest		
7 x 7 Diallel	Preponderance of additive gene action	Lal *et al.* (1974)
9 x 9 Diallel	Preponderance of non-additive gene action	Dharmegowda (1976)
6 x 6 Diallel	Both additive and non-additive gene actions	Srivastava and Bajpai (1977)
6 x 6 Diallel	Both additive and non-additive gene actions	Vijay and Nath (1978)
6 x 6 Diallel	Non-additive gene action	Bhutani *et al.* (1980)
6 x 6 Diallel	Over dominance	Sidhu *et al.* (1980)
15 x 4 Line x Tester	Preponderance of non-additive gene action	Singh *et al.* (1981)
5 x 3 Line x Tester	Preponderance of non-additive gene action	Shinde and Patil (1984)
10 x 4 Line x Tester	Both additive and non-additive gene actions	Dahiya *et al.* (1985)
6 x 6 Diallel (Excluding reciprocals)	Importance of both additive and non-additive genetic variances	Verma (1986)
9 x 9 Diallel	Preponderance of additive gene action	Chadha and Hegde (1987)
12 x 12 Diallel	Preponderance of non-additive gene action	Singh and Mital (1988)
9 x 9 Diallel	Preponderance of additive gene action	Chadha and Hegde (1989)
7 x 7 Diallel	Both additive and non-additive gene actions	Patil and Shinde (1989)
18 x 3 Line x Tester	Both additive and non-additive gene actions	Randhawa *et al.* (1991)
7 x 2 Line x Tester	Preponderance of non-additive gene action	Sawant *et al.* (1991)
6 x 6 Diallel (Excluding reciprocals)	Only additive gene effect was important	Singh *et al.* (1991)
6 x 6 Diallel	Only additive gene effect was important	Ramar and Pappaiah (1993)
6 x 6 Full diallel	Only additive gene effect was important	Patel (1994)
8 x 8 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Chaudhary and Pathania (2000)
8 x 8 Half diallel	Predominance of non-additive gene action	Patel (2003)
10 x 10 Half diallel	Additive and non-additive gene effects were important	Rao (2003)

12 x 3 Line x tester	Predominance of additive gene action	Singh and Singh (2004)
12 x 4 Line x tester	Predominance of additive gene action	Vadodaria *et al.* (2004)
8 x 8 Half diallel	Additive and non-additive gene effects were important	Bendale *et al.* (2005)
10 x 10 Diallel (Excluding reciprocals)	Predominance of additive gene action	Aswani and Khandelwal (2005)
10 x 10 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene actions	Suneetha *et al.* (2008)
8 x 8 Diallel (Excluding reciprocals)	Preponderance of non-additive gene action	Sane *et al.* (2011)
Fruit length (cm)		
10 x 10 Diallel (Excluding reciprocals)	Additive variance predominant	Srivastava and Bajpai (1977)
6 x 6 Diallel (Excluding reciprocals)	Additive and non-additive gene actions	Bhutani *et al.* (1980)
15 x 4 Line x Tester	Predominance of non-additive gene effect	Singh *et al.* (1981)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patel (1984)
5 x 3 Line x Tester	Predominance of additive genetic variance	Shinde and Patil (1984)
10 x 4 Line x Tester	Additive variance present	Dahiya *et al.* (1985)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patil and Shinde (1985)
6 x 6 Diallel (Excluding reciprocals)	Additive variance present	Verma (1986)
6 x 6 Diallel (Excluding reciprocals)	Additive variance predominant	Narendrakumar and Hari Har Ram (1987a)
5 x 3 Line x Tester	Additive variance predominant	Narendrakumar and Hari Har Ram (1987b)
5 x 5 Diallel (Excluding reciprocals)	Significant of additive and non-additive genetic variances	Singh and Kumar (1978)
12 x 12 Diallel (Excluding reciprocals)	Additive variance predominant	Singh and Mital (1988)
8 x 8 Diallel (Excluding reciprocals)	Predominance of additive gene action	Mishra and Mishra (1990)

6 x 6 Diallel (Excluding reciprocals)	Only additive gene effect was important	Singh *et al.* (1991)
6 x 6 Diallel (Including reciprocals)	Predominance of non-additive gene action	Patel (1994)
7 x 7 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Patel *et al.* (1994)
7 x 5 Line x Tester	Predominance of non-additive gene action	Kaur (1998)
10 x 4 Line x Tester	Presence of both additive and non-additive gene actions	Varshney *et al.* (1999)
8 x 8 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Chaudhary and Pathania (2000)
4 x 4 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene actions	Das and Barua (2001)
10 x 10 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Rao (2003)
8 x 8 Half diallel	Both additive and non-additive gene action	Patel (2003)
12 x 3 Line x Tester	Predominance of additive gene action	Singh and Singh (2004)
10 x 10 Diallel (Excluding reciprocals)	Predominance of additive gene action	Aswani and Khandelwal (2005)
10 x 10 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene action	Bisht *et al.* (2006)
8 x 3 Line x tester	Preponderance of non-additive gene action	Shanmugapriya *et al.* (2009)
7 x 7 Diallel (Excluding reciprocals)	Preponderance of additive gene action	Rai and Asati (2011)
7 x 3 Line x Tester	Predominance of additive gene action	Pachiyappan *et al.* (2012)
4 x4 Diallel (Including reciprocals)	Predominance of additive gene action	Al-Hubaity and Teli (2013)
Fruit girth (cm)		
6 x 6 Diallel (Excluding reciprocals)	Additive and non-additive variances present	Bhutani *et al.* (1980)
15 x 4 Line x Tester	Predominance of non-additive gene effect	Singh *et al.* (1981)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patel (1984)
5 x 3 Line x Tester	Predominance of additive genetic variance	Shinde and Patil (1984)
10 x 4 Line x Tester	Additive variance predominant	Dahiya *et al.* (1985)

7 x 7 Diallel (Excluding reciprocals)	Predominance of additive variance	Patil and Shinde (1985)
6 x 6 Diallel (Excluding reciprocals	Additive variance predominant	Narendrakumar and Hari Har Ram (1987a)
5 x 3 Line x Tester	Predominance of additive genetic variance	Narendrakumar and Hari Har Ram (1987b)
9 x 9 Diallel (Excluding reciprocals)	Significant *GCA* and *SCA* variance	Chadha and Hegde (1989)
8 x 8 Diallel (Excluding reciprocals)	Predominance of additive gene action	Mishra and Mishra (1990)
6 x 6 Diallel (Excluding reciprocals)	Preponderance of additive gene effect	Singh *et al.* (1991)
6 x 6 Diallel (Including reciprocals)	Predominance of additive gene action	Patel (1994)
7 x 7 Diallel (Excluding reciprocals)	Non- additive gene effect was of greater magnitude	Patel *et al.* (1994)
8 x 8 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene actions	Padmanabham and Jagadish (1996)
60 F_1 hybrids	Significant *GCA* and *SCA* variance	Patil (1998)
7 x 5 Line x Tester	Predominance of non-additive gene action	Kaur (1998)
10 x 4 Line x Tester	Presence of both additive and non-additive gene actions	Varshney *et al.* (1999)
8 x 8 Diallel (Excluding reciprocals)	Both additive and non-additive gene action was important	Chaudhary and Pathania (2000)
4 x 4 Diallel	Presence of additive gene action	Das and Barua (2001)
10 x 10 Diallel (Excluding reciprocals)	Presence of non-additive gene action	Baig and Patil (2002)
10 x 10 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Rao (2003)
8 x 8 Half diallel	Both additive and non-additive gene action was important	Patel (2003)
12 x 3 Line x Tester	Predominance of additive gene action	Singh and Singh (2004)
10 x 10 Diallel (Excluding reciprocals)	Predominance of additive gene action	Aswani and Khandelwal (2005)

10 x 10 Diallel (Excluding reciprocals)	Predominance of additive gene effect	Bisht *et al.* (2006)
8 x 3 Line x Tester	Preponderance of non-additive gene action	Shanmugapriya *et al.* (2009)
7 x 3 Line x Tester	Predominance of additive gene action	Pachiyappan *et al.* (2012)
4 x4 Diallel (Including reciprocals)	Predominance of additive gene action	Al-Hubaity and Teli (2013)
Fruit weight (cm)		
7 x 7 Diallel	Significant additive and non-additive variances	Mital *et al.* (1976)
6 x 6 Diallel (Including reciprocals)	Significant additive and non-additive variances	Vijay *et al.* (1978)
6 x 6 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene actions	Bhutani *et al.* (1980)
15 x 4 Line x Tester	Predominance of non-additive gene effect	Singh *et al.* (1981)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patel (1984)
5 x 3 Line x Tester	Predominance of non-additive genetic variance	Shinde and Patil (1984)
7 x 7 Diallel (Excluding reciprocals)	Predominance of additive gene action	Patil and Shinde (1985)
6 x 6 Diallel (Excluding reciprocals	Additive variance predominant	Narendrakumar and Hari Har Ram (1987a)
5 x 3 Line x Tester	Additive variance predominant	Narendrakumar and Hari Har Ram (1987b)
8 x 8 Diallel (Excluding reciprocals)	Predominance of additive gene action	Mishra and Mishra (1990)
6 x 6 Diallel (Excluding reciprocals)	Additive variance present	Singh *et al.* (1991)
6 x 6 Diallel (Including reciprocals)	Predominance of additive gene action	Patel (1994)
7 x 7 Diallel (Excluding reciprocals)	Predominance of non- additive gene action	Patel *et al.* (1994)
8 x 8 Diallel (Excluding reciprocals)	Presence of both additive and non-additive gene actions	Padmanabham and Jagadish (1996)
60 F_1 hybrids	Significant *GCA* and *SCA* variance	Patil (1998)
7 x 5 Line x Tester	Presence of non-additive gene action	Kaur (1998)

Generation mean analysis (Six generations)	Predominance of additive and non-additive gene effects	Patil *et al*. (2000)
8 x 8 Diallel (Excluding reciprocals)	Additive action was important	Chaudhary and Pathania (2000)
5 x 5 Diallel	Additive x Additive	Chezhiah *et al*. (2000)
4 x 4 Diallel	Important of both additive and non-additive gene effects	Das and Barua (2001)
10 x 10 Diallel (Excluding reciprocals)	Important of both additive and non-additive gene effects	Baig and Patil (2002)
10 x 10 Diallel (Excluding reciprocals)	Predominance of non-additive gene actions	Rao (2003)
8 x 8 Half diallel	Both additive and non-additive gene action	Patel (2003)
12 x 3 Line x Tester	Predominance of additive gene action	Singh and Singh (2004)
6 x 4 Line x Tester	Significant *gca* and *sca* effects	Shafeeq (2005)
10 x 10 Diallel (Excluding reciprocals)	Predominance of additive gene action	Aswani and Khandelwal (2005)
10 x 10 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene action	Bisht *et al*. (2006)
10 x 10 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene actions	Suneetha *et al*. (2008)
8 x 3 Line x Tester	Preponderance of non-additive gene action	Shanmugapriya *et al*. (2009)
7 x 7 Diallel (Excluding reciprocals)	Preponderance of additive and non-additive gene action	Rai and Asati (2011)
7 x 3 Line x Tester	Preponderance of non-additive gene action	Pachiyappan *et al*. (2012)
4 x4 Diallel (Including reciprocals)	Predominance of additive gene action	Al-Hubaity and Teli (2013)
Fruits per cluster		
7 x 2 Line x Tester	Both additive and non-additive gene actions	Sawant *et al*. (1991)
6 x 4 Line x Tester	Preponderance of non-additive gene action	Shafeeq (2005)

10 x 10 Diallel (Excluding reciprocals)	Preponderance of additive gene action	Bisht *et al.* (2006)
5 x 4 Line x Tester	Preponderance of non-additive gene action	Ajjappalavara (2006)
8 x 8 Diallel (Excluding reciprocals)	Preponderance of non-additive gene action	Nalini (2007)
6 x 6 Line x Tester	Preponderance of non-additive gene action	Prakash (2007)
8 x 6 Line x Tester	Preponderance of non-additive gene action	Sao and Mehta (2010)
Fruits per plant		
9 x 9 Diallel (Excluding reciprocals)	Additive and non-additive variances present	Dharmegowda (1976)
10 x 10 Diallel (Excluding reciprocals)	Higher magnitude of additive variance	Srivastava and Bajpai (1977)
6 x 6 Diallel (Including reciprocals)	Additive and non-additive variances significant	Vijay *et al.* (1978)
6 x 6 Diallel (Excluding reciprocals)	Presence of additive and non-additive gene actions	Bhutani *et al.* (1980)
15 x 4 Line x Tester	Predominance of non-additive gene effect	Singh *et al.* (1981)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patel (1984)
5 x 3 Line x Tester	Predominance of non-additive genetic effect	Shinde and Patil (1984)
10 x 4 Line x Tester	Additive variance present	Dahiya *et al.* (1985)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patil and Shinde (1984)
6 x 6 Diallel (Excluding reciprocals)	Significant additive as well as non-additive variances	Verma (1986)
6 x 6 Diallel (Excluding reciprocals)	Additive variance predominant	Narendrakumar and Hari Har Ram (1987a)
5 x 3 Line x Tester	Predominance of additive genetic variance	Narendrakumar and Hari Har Ram (1987b)
5 x 5 Diallel	Significant additive and non-additive gene actions	Singh and Kumar (1978)
12 x 12 Diallel (Excluding reciprocals)	Additive variance predominant	Singh and Mital (1988)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patil and Shinde (1989)
9 x 9 Diallel (Excluding reciprocals)	Significant *SCA* variance and *GCA* variance	Chadha and Hegde (1989)
8 x 8 Diallel (Excluding reciprocals)	Predominance of additive gene action	Mishra and Mishra (1990)

7 x 2 Line x Tester	Significant *SCA* variance and *GCA* variance	Sawant *et al.* (1991)
6 x 6 Diallel (Including reciprocals)	Predominance of additive gene action	Patel (1994)
7 x 7 Diallel (Excluding reciprocals)	Additive gene effect predominant	Patel *et al.* (1994)
8 x 8 Diallel (Excluding reciprocals)	Both additive and non-additive gene actions were observed	Padmanabham and Jagadish (1996)
60 F_1 hybrids	Significant *GCA* and *SCA* variance	Patil (1998)
7 x 5 Line x Tester	Presence of non-additive gene action	Kaur (1998)
10 x 4 Line x Tester	Presence of both additive and non-additive gene actions	Varshney *et al.* (1999)
8 x 8 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Chaudhary and Pathania (2000)
5 x 5 Diallel	Additive x Additive	Chezhiah *et al.* (2000)
4 x 4 Diallel	Important of both additive and non-additive gene actions	Das and Barua (2001)
10 x 10 Diallel (Excluding reciprocals)	Important of both additive and non-additive gene effects	Baig and Patil (2002)
10 x 10 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Rao (2003)
8 x 8 Diallel	Both additive and non-additive gene actions	Patel (2003)
Six generations in six crosses	Additive as well as non-additive gene effects	Patil *et al.* (2003)
12 x 3 Line x Tester	Predominance of additive gene action	Singh and Singh (2004)
12 x 4 Line x Tester	Non-additive gene action was preponderant	Vadodaria *et al.* (2004)
6 x 4 Line x Tester	Significant *gca* and *sca* effects	Shafeeq (2005)
10 x 10 Diallel (Excluding reciprocals)	Predominance of additive gene action	Aswani and Khandelwal (2005)
8 x 3 Line x Tester	Predominance of additive gene action	Kamalakkannan *et al.* (2007)
10 x 10 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene action	Suneetha *et al.* (2008)

8 x 3 Line x Tester	Preponderance of non-additive gene action	Shanmugapriya *et al.* (2009)
8 x 6 Line x Tester	Importance of both additive as well as non-additive component	Sao and Mehta (2010)
7 x 7 Diallel (Excluding reciprocals)	Preponderance of additive and non-additive gene action	Rai and Asati (2011)
8 x 8 Diallel (Excluding reciprocals)	Preponderance of non-additive gene action	Sane *et al.* (2011)
7 x 3 Line x Tester	Preponderance of non-additive gene action	Pachiyappan *et al.* (2012)
4 x4 Diallel (Including reciprocals)	Predominance of additive gene action	Al-Hubaity and Teli (2013)
Primary branches per plant		
10 F_1 hybrids	Significant *sca* effects	Singh and Kumar (1978)
8 x 8 Diallel (Excluding reciprocals)	Significant *GCA* and *SCA* variance	Mishra and Mishra (1990)
8 x 8 Diallel (Excluding reciprocals)	Significant *gca* and *sca* effects	Mishra and Mishra (1990)
2 x Line x Tester	Significant *sca* effects	Prakash *et al.* (1994)
8 x 8 Diallel (Excluding reciprocals)	Significant *GCA* and *SCA* variance	Padmanabham and Jagadish (1996)
8 x 8 Diallel (Excluding reciprocals)	Significant *gca* and *sca* effects	Padmanabham and Jagadish (1996)
60 F_1 hybrids	Significant *GCA* and *SCA* variance	Patil (1998)
60 F_1 hybrids	Significant *gca* and *sca* effects	Patil (1998)
10 x 4 Line x Tester	Significant *GCA* variance	Varshney *et al.* (1999)
10 x 4 Line x Tester	Significant *gca* and *sca* effects	Varshney *et al.* (1999)
28 F_1 hybrids	Significant *gca* and *sca* effects	Mallikarjun (2002)
7x 7 Diallel (Excluding reciprocals)	Preponderance of additive and non-additive gene action	Rai and Asati (2011)
7 x 3 Line x Tester	Preponderance of non-additive gene action	Pachiyappan *et al.* (2012)
4 x4 Diallel (Including reciprocals)	Predominance of additive gene action	Al-Hubaity and Teli (2013)

Plant height (cm)		
9 x 9 Diallel (Excluding reciprocals)	Additive and non-additive variances present	Dharmegowda (1976)
7 x 7 Diallel (Excluding reciprocals)	Predominance of additive and non-additive gene actions	Singh *et al*. (1976)
10 x 10 Diallel (Excluding reciprocals)	Additive variance predominant	Srivastava and Bajpai (1977)
6 x 6 Diallel (Excluding reciprocals)	Additive and non-additive variances present	Bhutani *et al*. (1980)
15 x 4 Line x Tester	Predominance of non-additive gene effect	Singh *et al*. (1981)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patel (1984)
5 x 3 Line x Tester	Predominance of non-additive genetic variance	Shinde and Patil (1984)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patil and Shinde (1984)
6 x 6 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene effects	Verma (1986)
6 x 6 Diallel (Excluding reciprocals)	Predominance of additive variance	Narendrakumar and Hari Har Ram (1987a)
5 x 3 Line x Tester	Additive variance predominant	Narendrakumar and Hari Har Ram (1987b)
12 x 12 Diallel (Excluding reciprocals)	Predominance of non-additive variance	Singh and Mital (1988)
7 x 7 Diallel (Excluding reciprocals)	Predominance of additive gene action	Patil and Shinde (1989)
9 x 9 Diallel (Excluding reciprocals)	Significant *gca* and *sca* effects	Chadha and Hegde (1989)
8 x 8 Diallel (Excluding reciprocals)	Predominance of additive gene action	Mishra and Mishra (1990)
6 x 6 Diallel (Excluding reciprocals)	Additive gene action present	Singh *et al*. (1991)
7 x 2 Line x Tester	Significant *GCA* and *SCA* variance	Sawant *et al*. (1991)
6 x 6 Diallel (Including reciprocals)	Additive gene action predominant	Patel (1994)
7 x 7 Diallel (Excluding reciprocals)	Non- additive gene action predominant	Patel *et al*. (1994)
2 x 9 Line x Tester	Significant *gca* effects	Prakash *et al*. (1994)

8 x 8 Diallel (Excluding reciprocals)	Both additive and non-additive gene actions were observed	Padmanabham and Jagadish (1996)
60 F_1 hybrids	Significant *GCA* and *SCA* variance	Patil (1998)
10 x 4 Line x Tester	Presence of both additive and non-additive gene actions	Varshney *et al.*(1999)
8 x 8 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Chaudhary and Pathania (2000)
5 x 5 Diallel	Additive x Additive	Chezhiah *et al.* (2000)
4 x 4 Diallel	Important of both additive and non-additive gene actions	Das and Barua (2001)
10 x 10 Diallel (Excluding reciprocals)	Important of both additive and non-additive gene effects	Baig and Patil (2002)
8 x 8 Half diallel	Predominance of non-additive gene action	Patel (2003)
10 x 10 Half diallel	Important of both additive and non-additive gene effects	Rao (2003)
12 x 3 Line x Tester	Non-additive gene action	Singh and Singh (2004)
12 x 4 Line x Tester	Preponderance of additive gene action	Vadodaria *et al.* (2004)
6 x 4 Line x Tester	Significant *gca* effects	Shafeeq (2005)
8 x 8 Half diallel	Important of both additive and non-additive gene effects	Bendale *et al.* (2005)
10 x 10 Diallel (Excluding reciprocals)	Predominance of additive gene action	Aswani and Khandelwal (2005)
10 x 10 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene action	Bisht *et al.* (2006)
10 x 10 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene actions	Suneetha *et al.* (2008)
8 x 3 Line x Tester	Preponderance of non-additive gene action	Shanmugapriya *et al.* (2009)

8 x 6 Line x Tester	Important of both additive and non-additive components	Sao and Mehta (2010)
7 x 7 Diallel (Excluding reciprocals)	Preponderance of additive and non-additive gene action	Rai and Asati (2011)
8 x 8 Diallel (Excluding reciprocals)	Preponderance of non-additive gene action	Sane *et al.* (2011)
7 x 3 Line x Tester	Predominance of additive gene action	Pachiyappan *et al.* (2012)
4 x4 Diallel (Including reciprocals)	Predominance of additive gene action	Al-Hubaity and Teli (2013)
Yield per plant (kg)		
9 x 9 Diallel (Excluding reciprocals)	Additive and non-additive variances present	Dharmegowda (1976)
7 x 7 Diallel	Significant additive and non-additive variances	Mital *et al.* (1976)
10 x 10 Diallel (Excluding reciprocals)	Additive variance predominant	Srivastava and Bajpai (1977)
6 x 6 Diallel (Including reciprocals)	Significant additive and non-additive variances	Vijay *et al.* (1978)
6 x 6 Diallel (Excluding reciprocals)	Non-additive variance present	Bhutani *et al.* (1980)
15 x 4 Line x Tester	Predominance of non-additive variance	Singh *et al.* (1981)
8 x 8 Diallel (Excluding reciprocals)	Additive variance present	Dixit *et al.* (1982)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patel (1984)
5 x 3 Line x Tester	Both additive and non-additive genetic variances were operative	Shinde and Patil (1984)
10 x 4 Line x Tester	Additive variance present	Dahiya *et al.* (1985)
7 x 7 Diallel (Excluding reciprocals)	Predominance of additive gene action	Patil and Shinde (1984)
6 x 6 Diallel (Excluding reciprocals)	Significant additive and non-additive variances	Verma (1986)
6 x 6 Diallel (Excluding reciprocals)	Non-additive variance predominant	Narendrakumar and Hari Har Ram (1987a)
5 x 3 Line x Tester	Predominance of non-additive variance	Narendrakumar and Hari Har Ram (1987b)

6 x 6 Diallel (Excluding reciprocals)	Significant additive and non-additive gene actions	Rashid *et al*. (1988)
5 x 5 Diallel	Significant additive and non-additive gene actions	Singh and Kumar (1978)
12 x 12 Diallel (Excluding reciprocals)	Non-additive variance predominant	Singh and Mital (1988)
7 x 7 Diallel (Excluding reciprocals)	Additive variance predominant	Patil and Shinde (1989)
9 x 9 Diallel (Excluding reciprocals)	Significant *SCA* variance and *GCA* variance	Chadha and Hegde (1989)
8 x 8 Diallel (Excluding reciprocals)	Predominance of additive gene action	Mishra and Mishra (1990)
7 x 2 Line x Tester	Significant *GCA* variance and *SCA* variance	Sawant *et al*. (1991)
6 x 6 Diallel (Including reciprocals)	Predominance of additive gene action	Patel (1994)
7 x 7 Diallel (Excluding reciprocals)	Predominant of non-additive gene effect	Patel *et al*. (1994)
8 x 8 Diallel (Excluding reciprocals)	Non-additive gene effect	Padmanabham and Jagadish (1996)
10 x 10 Diallel (Excluding reciprocals)	Predominant of non-additive gene action	Ingale *et al*. (1997)
60 F_1 hybrids	Significant *SCA* variance and *GCA* variance	Patil (1998)
7 x 5 Line x Tester	Predominance of non-additive gene action	Kaur (1998)
10 x 4 Line x Tester	Presence of both additive and non-additive gene actions	Varshney *et al*. (1999)
8 x 8 Diallel (Excluding reciprocals)	Presence of non-additive gene action	Chaudhary and Malhotra (2000)
Generation mean analysis (Six generations)	Predominant of additive and non-additive gene effects	Patil *et al*. (2000)
8 x 8 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Chaudhary and Pathania (2000)
5 x 5 Diallel	Additive x Additive type of interaction	Chezhiah *et al*. (2000)
4 x 4 Diallel	Important of both additive and non-additive gene actions	Das and Barua (2001)
12 parents and 35 hybrids	Over dominance	Kaur *et al*. (2001)
10 x 10 Diallel (Excluding reciprocals)	Important of both additive and non-additive gene effects	Baig and Patil (2002)

10 x 10 Diallel (Excluding reciprocals)	Predominance of non-additive gene action	Rao (2003)
8 x 8 Half diallel	Both additive and non-additive gene actions	Patel (2003)
12 x 3 Line x Tester	Predominance of non-additive gene action	Singh and Singh (2004)
6 x 4 Line x Tester	Significant *gca* and *sca* effects	Shafeeq (2005)
8 x 8 Half diallel	Additive and non-additive	Bendale *et al*. (2005)
10 x 10 Diallel (Excluding reciprocals)	Predominance of additive gene action	Aswani and Khandelwal (2005)
10 x 10 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene action	Bisht *et al*. (2006)
8 x 3 Line x Tester	Predominance of additive gene action	Kamalakkannan *et al.* (2007)
10 x 10 Diallel (Excluding reciprocals)	Importance of both additive and non-additive gene action	Suneetha *et al*. (2008)
12 x 4 Line x Tester	Predominance of non-additive gene action	Vadodaria *et al*. (2008)
8 x 3 Line x Tester	Preponderance of non-additive gene action	Shanmugapriya *et al*. (2009)
8 x 6 Line x Tester	Importance of both additive as well as non-additive component	Sao and Mehta (2010)
7 x 7 Diallel (Excluding reciprocals)	Preponderance of additive and non-additive gene action	Rai and Asati (2011)
8 x 8 Diallel (Excluding reciprocals)	Preponderance of non-additive gene action	Sane *et al*., (2011)
7 x 3 Line x Tester	Preponderance of non-additive gene action	Pachiyappan *et al.* (2012)
4 x4 Diallel (Including reciprocals)	Predominance of additive gene action	Al-Hubaity and Teli (2013)

Materials and Methods

3. MATERIALS AND METHODS

The experiment entitled "Diallel analysis in brinjal (*Solanum melongena* L.)" was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, during the period 2013-14.

The study comprised of two experiments.

Experiment 1: Development of F_1 hybrids

Experiment 2: Evaluation of F_1 hybrids and parents

3.1 EXPERIMENT 1: DEVELOPMENT OF F_1 HYBRIDS

3.1.1 Materials

The material for the study comprised of eight parents, 28 hybrids and one standard check Neelima (KAU). The eight parents were selfed to produce the selfed seeds and these were crossed in a half diallel manner to produce 28 hybrids during kharif-rabi 2012-13. The detailed description of parental lines is given in Table 3.

Table 3. List of parents

SI. No.	Accession Number	Name of parents	Source
1	P_1	Wardha local	Wardha, Maharastra
2	P_2	Gopulapur local	Gopulapur, Andhra Pradesh
3	P_3	Palakurthi local	Palakurthi, Andhra Pradesh
4	P_4	Surya	KAU,Vellanikkara
5	P_5	NBR-38	Nagpur, Maharastra
6	P_6	Swetha	KAU,Vellanikkara
7	P_7	Vellayani local	Vellayani, Kerala
8	P_8	Selection Pooja	Bharat Seed Company, Jodhpur

Table 4. List of hybrid combinations

Sl. No.	Parents	Cross combinations
1	P_1 x P_2	Wardha local x Gopulapur local
2	P_1 x P_3	Wardha local x Palakurthi local
3	P_1 x P_4	Wardha local x Surya
4	P_1 x P_5	Wardha local x NBR-38
5	P_1 x P_6	Wardha local x Swetha
6	P_1 x P_7	Wardha local x Vellayani local
7	P_1 x P_8	Wardha local x Selection Pooja
8	P_2 x P_3	Gopulapur local x Palakurthi local
9	P_2 x P_4	Gopulapur local x Surya
10	P_2 x P_5	Gopulapur local x NBR-38
11	P_2 x P_6	Gopulapur local x Swetha
12	P_2 x P_7	Gopulapur local x Vellayani local
13	P_2 x P_8	Gopulapur local x Selection Pooja
14	P_3 x P_4	Palakurthi local x Surya
15	P_3 x P_5	Palakurthi local x NBR-38
16	P_3 x P_6	Palakurthi local x Swetha
17	P_3 x P_7	Palakurthi local x Vellayani local
18	P_3 x P_8	Palakurthi local x Selection Pooja
19	P_4 x P_5	Surya x NBR-38
20	P_4 x P_6	Surya x Swetha
21	P_4 x P_7	Surya x Vellayani local
22	P_4 x P_8	Surya x Selection Pooja
23	P_5 x P_6	NBR-38 x Swetha
24	P_5 x P_7	NBR-38 x Vellayani local
25	P_5 x P_8	NBR-38 x Selection Pooja
26	P_6 x P_7	Swetha x Vellayani local
27	P_6 x P_8	Swetha x Selection Pooja
28	P_7 x P_8	Vellayani local x Selection Pooja
29	Check	Neelima

3.1.2 Selfing and crossing technique

In brinjal anthesis occurs between 8 to 12 a.m. matured flower-buds likely to open next morning were emasculated during evening hours and bagged. On the next day morning (between 7 to 10 a.m.) emasculated buds were pollinated by the respective male parents. The pollinated buds were again bagged with paper bags and labeled. The mature crossed fruits were harvested and the seeds were collected

Plate 1. Development of F_1 hybrids

Plate 2. Evaluation of F_1 hybrids and parents (Field experiment)

separately from each cross. For maintenance of parental lines, flower buds of different parents were selfed by bagging the individual buds and properly tagged and later the seeds were collected from the mature fruits accordingly.

3.2 EXPERIMENT 2: EVALUATION OF F_1 HYBRIDS AND PARENTS

3.2.1 Materials

Eight parents, 28 hybrids and standard check Neelima from KAU were used for field experiment for analysis of heterosis and combining ability.

3.2.2 Methods

3.2.2.1 Design and Layout

The experiment was laid out in randomized block design with 36 treatments and one standard check (Neelima) in three replications. Thirty five days old seedlings having 8-10 cm height were transplanted into the main field at a spacing of 60 cm x 60 cm. The crop received timely management practices as per package of practices recommendations of Kerala Agricultural University (KAU, 2011).

3.2.2.2 Biometric Observations

Five randomly selected plants were tagged in each entry to record the observations and the average from these five plants was worked out for statistical analysis. Following are the observations recorded in this experiment.

3.2.2.2.1 Days to First Flowering

Number of days from the date of transplanting to the first flowering of observational plants was recorded and the average obtained.

3.2.2.2.2 Days to First Harvest

Number of days from the date of transplanting to the first fruit harvest of observational plants was recorded and the average obtained.

3.2.2.2.3 Fruit Length (cm)

Five fruits were selected at random from the observational plants. Fruit length was measured as the distance from peduncle attachment of the fruit to the apex using twine and scale. Average was taken and expressed in centimeters.

3.2.2.2.4 Fruit Girth (cm)

Fruit girth was taken at broadest part from the fruits used for recording the fruit length. Average was taken and expressed in centimeters.

3.2.2.2.5 Fruit Weight (g)

Weight of fruits used for recording fruit length was measured and average was found out and expressed in grams.

3.2.2.2.6 Calyx Length (cm)

The length of calyx was recorded for each fruit selected at random from the observational plants and expressed in centimeters.

3.2.2.2.7 Colour of Fruit

Dominant pigmentation on fruits of each variety was recorded.

3.2.2.2.8 Fruits per Cluster

Number of fruits at each cluster in each observational plant was recorded and average was worked out.

3.2.2.2.9 Fruits per Plant

Total number of fruits produced per plant from December (2013) – May (2014) was counted.

3.2.2.2.10 Primary Branches per Plant

Number of branches arising from the main stem was recorded from all the sample plants at the peak harvest stage and average was worked out.

3.2.2.2.11 Plant Height (cm)

Plant height was recorded from the ground level to the top-most bud leaf of the plants at the time of peak harvest and presented in centimeters.

3.2.2.2.12 Yield per Plant (kg)

Weight of all fruits harvested from selected plants was recorded, average worked out and expressed in kilograms per plant.

3.2.2.2.13 Yield per Plot (kg)

The weight of fruits harvested from each plot was recorded.

3.2.3 Statistical analysis

3.2.3.1 Analysis of Variance

Analysis of variance (ANOVA) for individual character was carried out on the basis of mean value per entry per replication as suggested by Panse and Sukhatme (1967) for Randomized Block Design (RBD). The model of analysis of variance is as given below.

ANOVA for each character

Source	**d.f.**	**Mean squares**	**Expectation of mean squares**
Replications	(r-1)	M_r	$\sigma^2 e + g\, \sigma^2 r$
Genotypes	(g-1)	M_g	$\sigma^2 e + r\, \sigma^2 g$
Parents	(p-1)	M_p	
Hybrids	(h-1)	M_h	

Parents Vs. hybrids	1	M_p Vs. M_h	
Error	(r-1) (g-1)	M_e	$\sigma^2 e$

Where,

r = number of replications

g = number of genotypes

p = number of parents

h = number of hybrids

Significance of the treatments was tested at 5 and 1 per cent level of probability.

3.2.3.2 Test of Significance

Test of significance for various components was carried out by 'F' test. The 'F' values were calculated as under.

$$\text{Genotypes} = \frac{M_g}{M_e}$$

$$\text{Parents} = \frac{M_p}{M_e}$$

$$\text{Hybrids} = \frac{M_h}{M_e}$$

$$\text{Parents vs. hybrids} = \frac{M_p \text{ vs } M_h}{M_e}$$

M_g = mean squares of genotypes

M_p = mean squares of parents

M_h = mean squares of hybrids

M_e = mean squares of error

3.2.3.3 Critical Difference of the Estimates

To test the significance of differences of the estimates, critical difference is calculated as.

$$\text{S. E. D} = \sqrt{\frac{2M_e}{r}} \text{ and S.E.M} = \sqrt{\frac{M_e}{r}}$$

C. D. = S. E. D x t

Where,

t = Table't' value for error degree of freedom at 0.01 and 0.05 levels of probability.

3.2.3.4 Co-efficient of Variation

The co-efficient of variation for each character was calculated as under,

$$C.V.\% = \frac{\sqrt{M_e}}{\overline{X}} x100$$

Where,

M_e = error mean square

$\overline{X}$ = general mean for the character

3.2.4 Heterosis

The magnitude of heterosis was estimated in relation to mid parent (MP), better parent (BP), and standard check hybrid (Neelima) as percentage increase or decrease of F_1s over the respective checks.

Estimation of heterosis was carried out following the methods suggested by Turner (1953) and Hayes *et al.* (1955).

$$\text{Mid parent value (MP)} = \frac{\overline{P_1} + \overline{P_2}}{2}$$

a) Heterosis over mid parent (MP) $= \frac{F_1 - \overline{MP}}{\overline{MP}} \text{ x } 100$ **(Relative heterosis)**

Where,

$\overline{MP}$ = Mean performance of parent P_1 and P_2

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

b) Heterosis over better parent (BP) $= \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$ **(Heterobeltiosis)**

Where,

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

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

c) Heterosis over standard check (SC) $= \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$ **(Standard heterosis)**

Where,

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

3.2.4.1 Test of Significance

Test of significance was done by comparing the mean deviation with values of critical difference (CD) obtained separately for $\overline{MP}$, $\overline{BP}$ and $\overline{SC}$ by using the following formula.

$$\text{Mean deviation for heterosis over MP} = \sqrt{\frac{3 \times mse}{2r}} \times \text{'t' value}$$

$$\text{Mean deviation for heterosis over BP \& SC} = \sqrt{\frac{2 \times mse}{r}} \times \text{'t' value}$$

Where,

r = Number of replications

t = Table value of 't' at error degree of freedom at 0.01 and 0.05 levels of probability

m.s.e = Error mean sum of squares

3.2.5 Combining ability Analysis

Combining ability analysis was performed with the data obtained for parents and hybrids according to Model-I, Method-II proposed by Griffing (1956).

This includes partitioning of variation among sources attributable to genenral combining ability (*gca*) and specific combining ability (*sca*) components. The analysis of variance for the combining ability is based on the following statistical model.

$$Y_{ijk} = \mu + g_i + g_j + s_{ij} + \varepsilon_{ij}$$

Where,

Y_{ijk} = mean value of hybrid involving i^{th} and j^{th} parent in k^{th} replication

μ = general mean

g_i = *gca* effect of i^{th} parent

g_j = *gca* effect of j^{th} parent

s_{ij} = *sca* effect for the cross between i^{th} and j^{th} parents such that $s_{ij} = s_{ji}$

ε_{ij} = uncontrolled variation associated with ijk^{th} observation

i, j = 1,2,.........p (p = number of parents)

k = 1,2,.........b (b = number of blocks)

The form of ANOVA for combining ability and expectation of mean square are given in Table 3.3.

Analysis of variance for combining ability

Source	d.f.	S.S.	M.S.	Expectation of mean squares
GCA	(p -1)	S_g	M_g	$\sigma^2e + \frac{(p+2)}{(p-1)} \sum_i g^2_i$
SCA	$\frac{p(p-1)}{2}$	S_s	M_s	$\sigma^2e + \frac{2}{p(p-1)} \sum_i \sum_j s^2_{ij}$
Error	(r-1)(g-1)	S_e	M_e	σ^2_e

Sum of squares due to various sources were calculated as follow:

$$S_g = \frac{1}{(p+2)}\left[\left(\sum_i (Xi. + Xii)^2\right) - \frac{4}{p} X^2 \ldots\right]$$

$$S_s = \sum_i \sum_j X^2_{ij} - \frac{1}{(p+2)} \sum (Xi. + Xii)^2 + \frac{2}{(p+1)(p+2)} X^2..$$

S_g = Sum of square due to general combining ability

S_s = Sum of square due to specific combining ability

p = number of parents

$X_{i.}$ = mean value of i^{th} parent

X.. = grand total of all the progenies and parental mean values

M_e = error mean square (M_e /r)

Further, the components of variance determining the additive and non-additive gene actions were computed using the following formula.

$$\sigma^2 gca = \frac{M_g - M_e}{p+2}$$

$$\sigma^2 sca = M_s - M_e$$

Where,

M_g = mean sum of square due to *gca* effect

M_s = mean sum of square due to *sca* effect

M_e = M_e / b = error mean square

3.2.5.1 Test of Significance of Combining ability

The error mean square for combining ability (M_e) was obtained by dividing error mean square (M_e) in ANOVA for each character by number of replications.

The following F ratios were used to test *gca* and *sca* variances

gca mean square : F = M_g / M_e

sca mean square : F = M_s / M_e

3.2.5.2 Estimation of General and Specific Combining ability Effects

The general and specific combining ability effects were estimated as under

$$\text{Population mean } (\mu) = \frac{2}{p(p+1)} Y..$$

$$gca \text{ effect } = (g_i) = \frac{1}{(p+2)}(\Sigma(Yi. + Yii) - \frac{2}{p} Y..)$$

$$sca \text{ effect} = (s_{ij}) = Y_{ij} - \frac{1}{(p+2)}(Y_{i.} + Y_{ii} + Y_{.j} + Y_{jj}) + \frac{2}{(p+1)(p+2)} Y..$$

Where,

p = number of parents

g_i = general combining ability effect of i^{th} parent

s_{ij} = specific combining ability effect of the

Cross involving i^{th} and j^{th} parents

$Y_{i.}$ = total of array involving i^{th} parent

$Y_{.j}$ = total of array involving j^{th} parent

Y_{ii} = parental value of the i^{th} parent

Y_{jj} = parental value of the j^{th} parent

$Y...$ = Total of all $\frac{p(p+1)}{2}$ items of the diallel table

Various standard errors required to test the significance of *gca* and *sca* effects and differences between them are calculated as

$$S.E.(g_i) = \sqrt{\frac{(p-1)}{p(p+2)} M_e}$$

$$S.E.(s_{ij}) = \sqrt{\frac{(p^2+p+2)}{(p+1)(p+2)} M_e}$$

3.2.5.3 Test of Significance

The 't' test was used to test the significance of individual *gca* and *sca* effects as under.

$$\text{To test } g_i : t = \frac{|g_i|}{S.E.(g_i)}$$

$$\text{To test } s_{ij} : t = \frac{|s_{ij}|}{S.E.(s_{ij})}$$

To test the significance of differences of two estimates, critical differences (CD) was calculated as product of the 't' for error degree of freedom and the standard error of difference of two estimates.

Results

4. RESULTS

The results of the present study entitled "Diallel analysis in brinjal (*Solanum melongena* L.)" are presented below.

1. Analysis of variance for experimental design
2. Mean performance of parents and hybrids
3. Estimation of heterosis
    a) Relative heterosis (RH)
    b) Heterobeltiosis (BH)
    c) Standard heterosis over the check Neelima (SH)
4. Combining ability analysis
    a) Analysis of variance for combining ability
    b) Estimates of combining ability (*gca* and *sca*) effects

4.1 ANALYSIS OF VARIANCE FOR EXPERIMENTAL DESIGN

The analysis of variance performed to test the difference among the parents and hybrids for all the characters are presented in Table 16. The results revealed that the mean squares due to genotypes were highly significant for all the characters. This indicated that sufficient genetic variability was present in the materials for all the characters under study. The mean squares due to genotypes were further partitioned into parents, hybrids and parents Vs. hybrids. The parents and hybrids differed significantly for all the characters. This indicated the existence of considerable genetic variability among the parents and hybrids for all the characters under study.

4.2 MEAN PERFORMANCE OF PARENTS AND HYBRIDS

The mean values of parents and hybrids for different characters are presented in Table 5. The performance of hybrids has been compared with check (Neelima) for different characters. The salient features for each character are described in ensuing paragraphs.

4.2.1 Days to First Flowering

Among parents P_3 (40.26) was the earliest for flowering and P_7 (52.13) the latest for flowering. Among hybrids earliest flowering was observed in P_1 x P_3 (44.00) and delayed flowering was observed in P_3 x P_6 (50.06).

4.2.2 Days to First Harvest

Among parents earliest harvest was recorded in P_4 (69.20) and the latest harvest was observed in P_1 (75.40). Among hybrids P_3 x P_7 (67.00) took the minimum days for harvest which was on par with P_3 x P_6 (67.60) and P_6 x P_7 (68.20).

4.2.3 Fruit Length (cm)

The longest fruits were produced by the parent P_8 (20.59 cm) and shortest fruits were recorded in P_4 (9.64 cm). Fruit length of hybrids ranged from 21.26 cm (P_7 x P_8) to 10.70 cm (P_1 x P_4). The hybrid P_7 x P_8 (21.26 cm) was on par with P_3 x P_8 (21.16 cm) for fruit length.

4.2.4 Fruit Girth (cm)

Fruit girth was maximum for the parent P_5 (18.02 cm) and the minimum for P_3 (10.06 cm). The hybrids with maximum and minimum fruit girth were observed in P_5 x P_8 (20.19 cm) and P_3 x P_5 (9.57 cm) respectively.

4.2.5 Fruit Weight (g)

The average fruit weight among the parents ranged from 62.66g (P_3) to 128.33g (P_8). The hybrids showed a variation from 70.46g (P_3 x P_5) to 133.33g (P_1 x P_7). The KAU brinjal hybrid Neelima (check) recorded average fruit of 123.66g.

4.2.6 Calyx Length (cm)

Among parents, calyx length ranged between 1.87 cm (P_6) and 3.06 cm (P_1). Among hybrids calyx length was the highest for P_4 x P_8 (2.89 cm) and the lowest for the hybrid P_4 x P_6 (2.22 cm).

Table 5. Mean values of eight parents and 28 crosses for yield and yield component characters

Parents and crosses	Days to first flowering	Days to first Harvest	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Calyx length (cm)
P_1	42.93	75.40	15.58	13.69	81.33	3.06
P_2	47.33	70.86	10.26	16.87	77.00	2.60
P_3	40.26	69.93	15.63	10.06	62.66	2.46
P_4	43.26	69.20	9.64	15.07	69.73	2.44
P_5	43.80	72.40	11.36	18.02	106.00	2.74
P_6	43.66	69.73	14.27	12.55	76.33	1.87
P_7	52.13	71.33	14.12	13.32	98.00	2.77
P_8	44.86	71.13	20.59	13.86	128.33	2.94
$P_1 \times P_2$	47.26	73.26	11.52	14.86	80.13	2.74
$P_1 \times P_3$	44.00	68.40	16.48	11.25	89.33	2.52
$P_1 \times P_4$	46.53	68.46	10.70	15.50	82.33	2.32
$P_1 \times P_5$	48.20	69.40	12.40	16.70	101.00	2.84
$P_1 \times P_6$	44.40	69.53	16.56	12.24	89.00	2.54
$P_1 \times P_7$	48.93	70.13	19.57	14.42	133.33	2.85
$P_1 \times P_8$	45.80	69.86	20.36	13.20	115.66	2.66
$P_2 \times P_3$	48.40	70.80	11.33	12.95	74.66	2.38
$P_2 \times P_4$	46.46	71.20	11.20	16.52	91.00	2.46
$P_2 \times P_5$	46.93	70.66	11.86	10.55	91.73	2.77
$P_2 \times P_6$	47.40	70.00	14.17	15.98	110.73	2.76
$P_2 \times P_7$	47.00	71.06	11.68	14.10	83.33	2.86
$P_2 \times P_8$	47.73	72.66	12.34	12.97	90.80	2.80
$P_3 \times P_4$	49.40	72.86	12.55	13.62	96.80	2.87
$P_3 \times P_5$	47.40	70.33	18.20	9.57	70.46	2.58
$P_3 \times P_6$	50.06	67.60	15.32	12.42	77.80	2.70
$P_3 \times P_7$	51.46	67.00	17.97	9.78	74.93	2.55
$P_3 \times P_8$	46.66	69.33	21.16	12.55	98.00	2.82
$P_4 \times P_5$	46.33	73.20	15.58	19.17	122.33	2.88
$P_4 \times P_6$	45.53	77.20	11.27	11.77	79.33	2.22
$P_4 \times P_7$	45.20	69.46	12.34	13.08	87.33	2.44
$P_4 \times P_8$	47.40	70.26	15.27	13.82	106.00	2.89
$P_5 \times P_6$	48.53	71.26	17.10	15.06	93.33	2.77
$P_5 \times P_7$	46.73	71.20	15.32	16.52	102.00	2.82
$P_5 \times P_8$	47.26	72.46	14.21	20.19	111.33	2.42
$P_6 \times P_7$	45.00	68.20	13.78	12.74	115.66	2.86
$P_6 \times P_8$	45.26	69.20	20.47	12.88	106.66	2.87
$P_7 \times P_8$	46.80	71.13	21.26	12.59	109.66	2.85
Check	45.60	70.53	11.8	18.38	123.66	2.67
S. E. M	**0.28**	**0.66**	**0.18**	**0.21**	**1.66**	**0.09**
C.D (0.05)	**0.81**	**1.87**	**0.50**	**0.60**	**4.69**	**0.27**
C.V (%)	**1.07**	**1.62**	**2.07**	**2.64**	**3.04**	**6.35**

Table 5. Continued

Parents and crosses	Fruits per cluster	Fruits per plant	Primary branches per plant	Plant height (cm)	Yield per plant (kg)	Yield per plot (kg)
P_1	2.26	30.33	5.13	92.60	2.45	56.41
P_2	1.06	29.40	4.40	91.73	2.23	44.79
P_3	1.66	27.80	3.93	67.60	1.72	36.28
P_4	1.00	25.53	4.60	68.33	1.80	37.91
P_5	1.20	22.53	4.46	85.40	2.49	52.41
P_6	2.06	25.53	4.13	67.20	1.96	45.24
P_7	1.06	13.86	4.53	82.60	1.36	29.95
P_8	1.20	21.06	4.60	118.33	3.03	66.68
P_1 x P_2	1.06	26.46	5.26	109.53	2.11	48.65
P_1 x P_3	2.60	38.53	5.06	101.46	3.38	74.45
P_1 x P_4	2.53	28.00	4.73	81.86	2.51	57.92
P_1 x P_5	1.00	25.53	5.00	112.80	2.61	62.65
P_1 x P_6	2.26	30.33	4.66	84.20	2.68	56.29
P_1 x P_7	1.26	30.80	4.46	102.40	4.16	91.57
P_1 x P_8	1.40	23.00	5.46	109.40	3.05	70.27
P_2 x P_3	1.00	19.73	3.80	92.26	1.50	31.69
P_2 x P_4	1.13	24.46	4.53	86.80	2.27	45.58
P_2 x P_5	1.20	18.40	5.00	83.66	1.71	36.09
P_2 x P_6	1.13	19.40	4.53	89.00	2.12	48.96
P_2 x P_7	1.20	18.73	3.93	91.00	1.55	31.15
P_2 x P_8	1.26	24.86	4.13	95.60	2.27	52.27
P_3 x P_4	1.06	18.00	4.66	82.13	1.75	38.70
P_3 x P_5	1.73	16.20	4.53	91.93	1.13	27.33
P_3 x P_6	1.73	23.40	4.80	97.53	1.84	36.88
P_3 x P_7	2.46	18.26	4.86	82.40	1.36	30.11
P_3 x P_8	2.06	21.40	5.06	98.26	2.15	47.38
P_4 x P_5	1.00	19.26	6.06	96.33	2.40	50.40
P_4 x P_6	1.26	22.46	4.26	84.06	1.77	44.28
P_4 x P_7	1.20	19.53	4.53	120.46	2.49	52.45
P_4 x P_8	1.26	19.13	5.60	109.33	2.04	40.82
P_5 x P_6	1.20	20.26	5.00	93.53	1.94	44.73
P_5 x P_7	1.06	27.66	4.86	104.33	2.85	68.53
P_5 x P_8	1.06	23.46	5.13	97.33	2.71	65.26
P_6 x P_7	1.66	33.80	4.80	90.00	3.88	89.40
P_6 x P_8	1.06	21.33	5.13	95.93	2.25	49.67
P_7 x P_8	1.26	19.00	5.06	91.86	2.10	48.48
Check	1.13	19.73	5.66	95.20	2.49	52.30
S. E. M	**0.09**	**0.43**	**0.21**	**1.30**	**0.06**	**1.68**
C.D (0.05)	**0.26**	**1.21**	**0.60**	**3.67**	**0.18**	**4.73**
C.V (%)	**11.47**	**3.19**	**7.85**	**2.42**	**4.97**	**5.16**

Table 6. Phenotypic expression of fruit colour and fruit shape in 36 brinjal genotypes

Genotype	Fruit colour	Fruit shape
P_1	Purple	Medium long
P_2	Green with white strips	Round
P_3	Purple	Long
P_4	Deep violet	oval
P_5	Green	Round
P_6	White	Ellipsoid
P_7	Green	Ellipsoid
P_8	Pure Black	Club
$P_1 \times P_2$	Light violet with patches	Obovate
$P_1 \times P_3$	Purple	Club
$P_1 \times P_4$	Deep purple	Ovoid
$P_1 \times P_5$	Light purple	Obovate
$P_1 \times P_6$	Light pink	Ellipsoid
$P_1 \times P_7$	Dark purple	Cylindrical
$P_1 \times P_8$	Light black	Cylindrical
$P_2 \times P_3$	Dark purple with patches	Obovate
$P_2 \times P_4$	Light purple	Ovoid
$P_2 \times P_5$	Green with patches	Ovoid
$P_2 \times P_6$	Light green with white patches	Obovate
$P_2 \times P_7$	Light green with patches	Ellipsoid
$P_2 \times P_8$	Light green	Ellipsoid
$P_3 \times P_4$	Pink	Club
$P_3 \times P_5$	Light pink	Club
$P_3 \times P_6$	Light pink	Club
$P_3 \times P_7$	Light pink	Ellipsoid
$P_3 \times P_8$	Light black	Cylindrical
$P_4 \times P_5$	violet	Globular
$P_4 \times P_6$	Light pink	Ellipsoid
$P_4 \times P_7$	Olive green	Ellipsoid
$P_4 \times P_8$	Black	Ellipsoid
$P_5 \times P_6$	Light green with patches	Ellipsoid
$P_5 \times P_7$	Light green with patches	Ellipsoid
$P_5 \times P_8$	Light green	Ellipsoid
$P_6 \times P_7$	Light green with stripes	Ellipsoid
$P_6 \times P_8$	Light green with patches	Ellipsoid
$P_7 \times P_8$	Light black	Cylindrical

Plate 3. Variations of fruit colour in eight parents

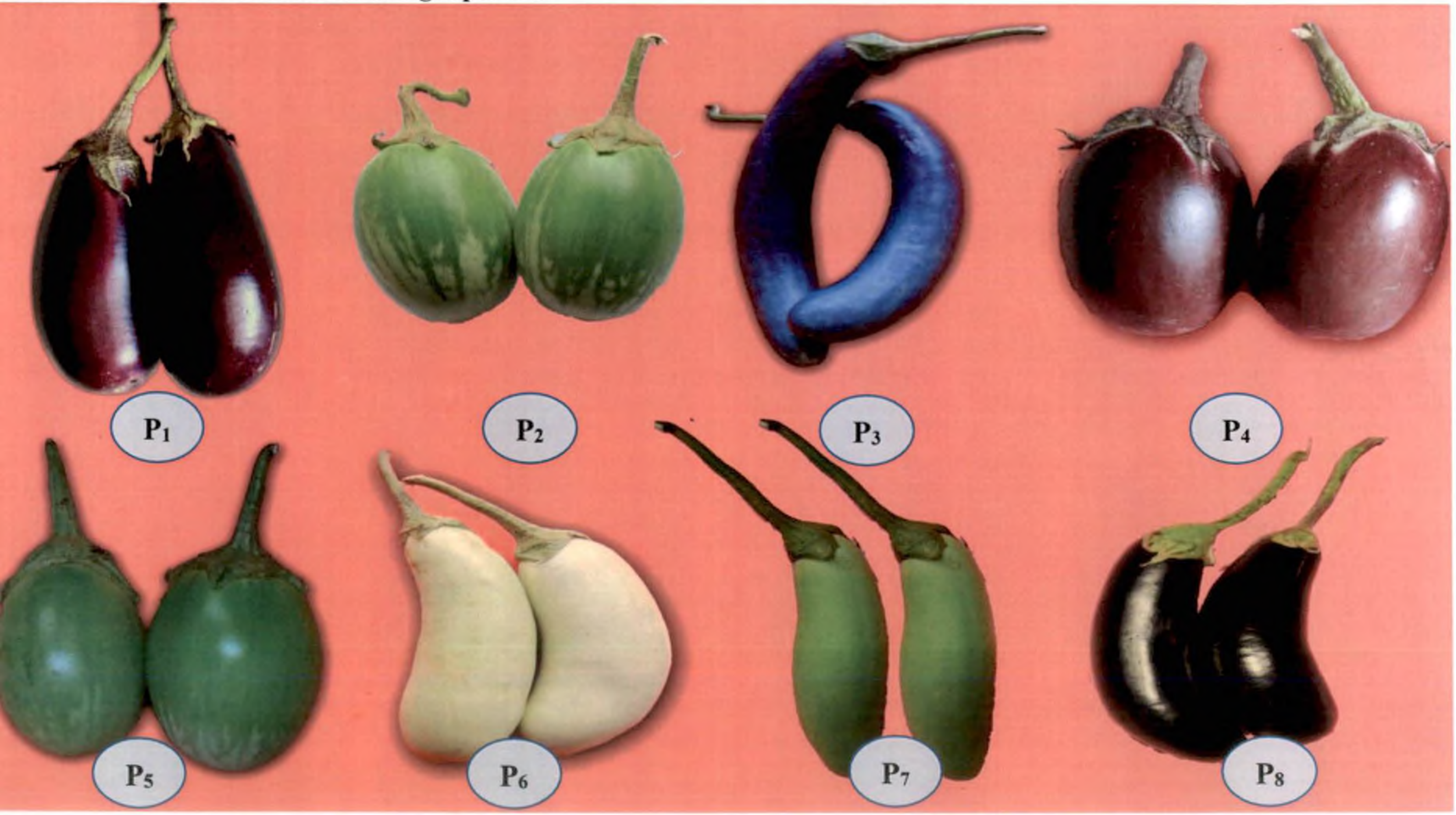
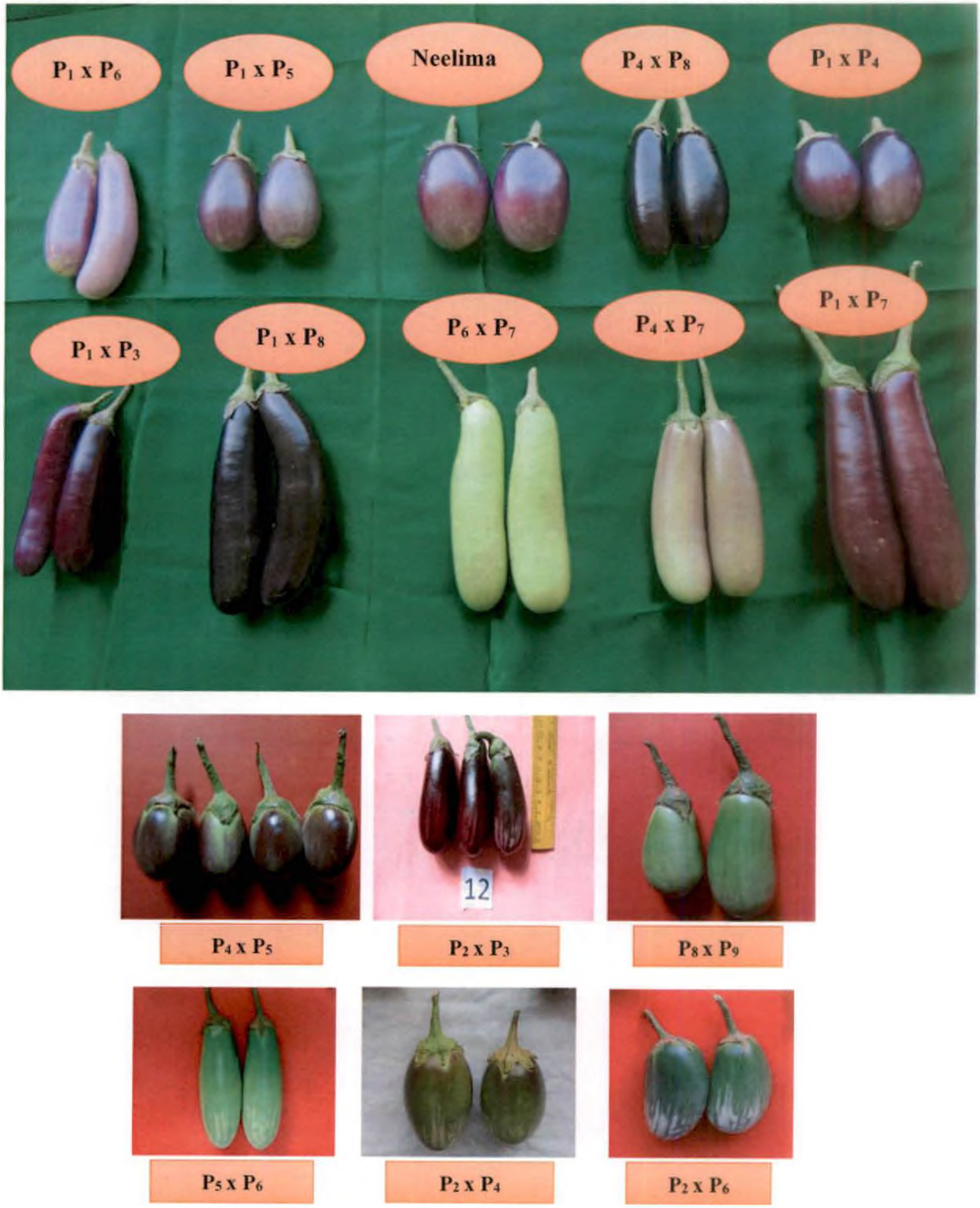


Plate 4. Variations of fruit colour in F_1 hybrids



4.2.7 Fruits per Cluster

The maximum fruits per cluster was produced in P_1 (2.26) and minimum number was noticed in P_4 (1.00). Maximum fruits per cluster among hybrids was observed for P_1 x P_3 (2.60) which was on par with P_1 x P_4 (2.53) and P_3 x P_7 (2.46). The minimum fruits per cluster *i.e.,* one for the hybrid P_1 x P_5, P_2 x P_3 and P_4 x P_5.

4.2.8 Fruits per Plant

Among parents, fruits per plant ranged between 13.86 (P_7) and 30.33 (P_1). Among hybrids, the maximum fruits per plant was observed for P_1 x P_3 (38.53) followed by P_6 x P_7 (33.80), P_1 x P_7 (30.80), P_1 x P_6 (30.33), P_1 x P_4 (28.00) and P_5 x P_7 (27.66). It was minimum for the hybrid P_3 x P_5 (16.20) followed by P_3 x P_4 (18.00), P_3 x P_7 (18.26), P_2 x P_5 (18.40) and P_2 x P_7 (18.73).

4.2.9 Primary Branches per Plant

The primary branches per plant ranged from P_3 (3.93) to P_1 (5.13). Among hybrids this range was 3.80 (P_2 x P_3) to 5.60 (P_4 x P_8).

4.2.10 Plant Height (cm)

Plant height ranged from 67.20 cm (P_6) to 118.33 cm (P_8) for parents. The minimum plant height was recorded for the hybrids P_1 x P_4 (81.86 cm). The tallest hybrid was recorded P_4 x P_7 (120.46 cm) and followed by P_1 x P_5 (112.80 cm).

4.2.11 Yield per Plant (kg)

The parent P_8 recorded the maximum fruit yield of 3.03 kg per plant and it was minimum for P_3 (1.72 kg per plant). Maximum yield was observed for the hybrid P_1 x P_7 (4.16 kg per plant) followed by P_6 x P_7 (3.88 kg per plant), P_1 x P_3 (3.38 kg per plant) and P_1 x P_8 (3.05 kg per plant) while yield was the lowest for P_3 x P_5 (1.13kg per plant) followed by P_3 x P_7 (1.36 kg per plant), P_2 x P_3 (1.50 kg per plant) and P_2 x P_7 (1.55 kg per plant).

4.3 ESTIMATION OF HETEROSIS

The magnitude of heterosis, estimated as per cent increase or decrease of F_1 value over mid-parent (relative heterosis), over better parent (heterobeltiosis) and over standard check Neelima (standard heterosis) for 11 characters were presented in Table 7 to 12. The character wise results were summarized in the following paragraphs.

4.3.1 Days to First Flowering

Among 28 hybrids, seven hybrids showed significant negative heterosis over the better parent. The hybrid P_6 x P_7 (-13.68%) showed earliness in flowering followed by P_4 x P_7 (-13.30%). Two hybrids P_1 x P_3 (-3.51%) and P_1 x P_6 (-2.63%) recorded significant negative heterosis over the standard check.

4.3.2 Days to First Harvest

The estimates of relative heterosis revealed that out of 28 hybrids, nine hybrids depicted significant and negative relative heterosis, for days to first harvest. The relative heterosis ranged from -6.09% (P_1 x P_5) to 11.13% (P_4 x P_6). Heterobeltiosis for days to first harvest ranged from -9.28% (P_1 x P_3) to 10.71% (P_4 x P_6). Eleven showed significant negative heterobeltiosis. Five hybrids exhibited significant negative standard heterosis over Neelima. The estimates of standard heterosis over the check Neelima varied from -5.01% (P_3 x P_7) to 9.45% (P_4 x P_6).

4.3.3 Fruit Length (cm)

Among 28 hybrids, sixteen hybrids showed significant positive relative heterosis over mid parent. The magnitude of heterosis ranged between -20.01% (P_2 x P_8) and 48.40% (P_4 x P_5) over mid parent. Eleven hybrids showed significant positive heterosis over better parent. The heterosis over better parent varied between -40.08% (P_2 x P_8) and 37.13% (P_4 x P_5). While 21 hybrids showed significant positive standard heterosis over standard check which ranged from 0.51% (P_2 x P_5) to 80.23% (P_7 x P_8).

Table 7. Heterosis (%) for days to first flowering and days to first harvest

Crosses	Days to first flowering			Days to first harvest		
	RH	HB	SH	RH	HB	SH
$P_1 \times P_2$	4.73**	-0.14	3.65**	0.18	-2.83*	3.88**
$P_1 \times P_3$	5.77**	2.48*	-3.51**	-5.87**	-9.28**	-3.02*
$P_1 \times P_4$	7.97**	7.55**	2.05*	-5.30**	-9.20**	-2.93*
$P_1 \times P_5$	11.15**	10.05**	5.70**	-6.09**	-7.96**	-1.61
$P_1 \times P_6$	2.54**	1.68	-2.63**	-4.18**	-7.78**	-1.42
$P_1 \times P_7$	2.95**	-6.14**	7.31**	-4.41**	-6.98**	-0.57
$P_1 \times P_8$	4.33**	2.08*	0.44	-4.64**	-7.34**	-0.95
$P_2 \times P_3$	10.50**	2.25*	6.14**	0.57	-0.09	0.38
$P_2 \times P_4$	2.58**	-1.83*	1.90*	1.67	0.47	0.95
$P_2 \times P_5$	3.00**	-0.85	2.92**	-1.35	-2.39	0.19
$P_2 \times P_6$	4.18**	0.14	3.95**	-0.43	-1.22	-0.76
$P_2 \times P_7$	-5.50**	-9.85**	3.07**	-0.05	-0.37	0.76
$P_2 \times P_8$	3.54**	0.85	4.68**	2.35	2.16	3.02*
$P_3 \times P_4$	18.28**	14.18**	8.33**	4.74**	4.19**	3.31*
$P_3 \times P_5$	12.77**	8.22**	3.95**	-1.17	-2.85*	-0.28
$P_3 \times P_6$	19.30**	14.66**	9.80**	-3.20**	-3.34*	-4.16**
$P_3 \times P_7$	11.40**	-1.28	12.87**	-5.14**	-6.07**	-5.01**
$P_3 \times P_8$	9.63**	4.01**	2.34*	-1.70	-2.53	-1.70
$P_4 \times P_5$	6.43**	5.78**	1.61	3.39**	1.10	3.78**
$P_4 \times P_6$	4.75**	4.27**	-0.15	11.13**	10.71**	9.45**
$P_4 \times P_7$	-5.24**	-13.30**	-0.88	-1.14	-2.62	-1.51
$P_4 \times P_8$	7.56**	5.65**	3.95**	0.14	-1.22	-0.38
$P_5 \times P_6$	10.98**	10.81**	6.43**	0.28	-1.57	1.04
$P_5 \times P_7$	-2.57**	-10.36**	2.49**	-0.93	-1.66	0.95
$P_5 \times P_8$	6.62**	5.35**	3.65**	0.98	0.09	2.74
$P_6 \times P_7$	-6.05**	-13.68**	-1.32	-3.31**	-4.39**	-3.31*
$P_6 \times P_8$	2.26**	0.89	-0.73	-1.75	-2.72	-1.89
$P_7 \times P_8$	-3.51**	-10.23**	2.63**	-0.14	-0.28	0.85

RH-Relative heterosis HB- Heterobeltiosis SH- Standard heterosis

*Significant at 5 per cent level **Significant at 1 per cent level

Table 8. Heterosis (%) for fruit length and fruit girth

Crosses	Fruit length (cm)			Fruit girth (cm)		
	RH	HB	SH	RH	HB	SH
P_1 x P_2	-10.86**	-26.09**	-2.37	-2.73	-11.89**	-19.11**
P_1 x P_3	5.62**	5.46**	39.72**	-5.25*	-17.82**	-38.77**
P_1 x P_4	-15.17**	-31.35**	-9.32**	7.76**	2.83	-15.67**
P_1 x P_5	-7.99**	-20.44**	5.08*	5.36**	-7.29**	-9.10**
P_1 x P_6	10.96**	6.29**	40.40**	-6.68**	-10.56**	-33.37**
P_1 x P_7	31.75**	25.58**	65.88**	6.81**	5.36**	-21.51**
P_1 x P_8	12.55**	-1.13	72.54**	-4.21*	-4.81*	-28.18**
P_2 x P_3	-12.46**	-27.51**	-3.95	-3.81*	-23.23**	-29.52**
P_2 x P_4	12.56**	9.16**	-5.08*	3.46*	-2.05	-10.08**
P_2 x P_5	9.68**	4.34	0.51	-39.51**	-41.44**	-42.58**
P_2 x P_6	15.54**	-0.70	20.11**	8.61**	-5.29**	-13.06**
P_2 x P_7	-4.16*	-17.27**	-0.96	-6.56**	-16.40**	-23.25**
P_2 x P_8	-20.01**	-40.08**	4.58*	-15.59**	-23.11**	-29.42**
P_3 x P_4	-0.66	-19.70**	6.38**	8.38**	-9.64**	-25.90**
P_3 x P_5	34.86**	16.46**	54.29**	-31.81**	-46.87**	-47.91**
P_3 x P_6	2.45	-2.00	29.83**	9.91**	-1.01	-32.39**
P_3 x P_7	20.79**	14.97**	52.32**	-16.28**	-26.53**	-46.75**
P_3 x P_8	16.86**	2.78*	79.38**	4.93*	-9.47**	-31.70**
P_4 x P_5	48.40**	37.13**	32.10**	15.87**	6.40**	4.32**
P_4 x P_6	-5.72**	-21.02**	-4.46*	-14.77**	-21.89**	-35.94**
P_4 x P_7	3.84*	-12.65**	4.58*	-7.82**	-13.18**	-28.80**
P_4 x P_8	1.04	-25.83**	29.44**	-4.49**	-8.31**	-24.81**
P_5 x P_6	33.44**	19.85**	44.97**	-1.44	-16.39**	-18.03**
P_5 x P_7	20.19**	8.45**	29.83**	5.47**	-8.29**	-10.08**
P_5 x P_8	-11.06**	-30.98**	20.45**	26.66**	12.06**	9.87**
P_6 x P_7	-2.96	-3.46	16.78**	-1.47	-4.30*	-30.65**
P_6 x P_8	17.44**	-0.58	73.50**	-2.50	-7.12**	-29.92**
P_7 x P_8	22.50**	3.27**	80.23**	-7.36**	-9.18**	-31.48**

RH-Relative heterosis HB- Heterobeltiosis SH- Standard heterosis

*Significant at 5 per cent level **Significant at 1 per cent level

4.3.4 Fruit Girth (cm)

The extent of heterosis over mid parent ranged between -39.51% (P_2 x P_5) and 26.66% (P_5 x P_8). Ten hybrids showed significant positive heterosis over mid parent. Three hybrids showed significant and positive heterosis over better parent. The magnitude of heterobeltiosis varied from -46.87% (P_3 x P_5) to 12.06% (P_5 x P_8). Two hybrids P_4 x P_5 (4.32%) and P_5 x P_8 (9.87%) showed significant and positive heterosis over check Neelima.

4.3.5 Fruit Weight (g)

The heterosis over mid parent varied from -16.44% (P_3 x P_5) to 48.70% (P_1 x P_7). Sixteen hybrids showed significant desirable heterosis over mid parent in positive direction. Only eight hybrids exhibited significant heterobeltosis and the range of heterosis over better parent was between -33.52% (P_3 x P_5) and 43.81% (P_2 x P_6). Only one hybrid P_1 x P_7 (7.82%) recorded significant positive heterosis over standard check Neelima.

4.3.6 Calyx Length (cm)

Relative heterosis for calyx length ranged from -15.64 % (P_1 x P_4) to 24.92% (P_3 x P_6). Seven out of 28 hybrids showed significant positive heterosis for this trait. The top ranking hybrids were P_3 x P_6 (24.92%) and P_2 x P_6 (23.40%). Better parent heterosis for this trait ranged from -24.18% (P_1 x P_4) to 16.80% (P_3 x P_4). Out of twenty eight hybrids, only one hybrid P_3 x P_4 (16.80) showed significant positive heterosis over better parent. The standard heterosis for this character ranged from -16.71% (P_4 x P_6) to 8.23% (P_4 x P_8).

4.3.7 Fruits per Cluster

The magnitude of heterosis over mid parent ranged between -42.31% (P_1 x P_5) to 80.49% (P_3 x P_7). Five crosses expressed significant positive relative heterosis. The magnitude of heterosis over better parent ranged between -55.88% (P_1 x P_5) to 48.00% (P_3 x P_7). The standard heterosis ranged from -11.76% to 129.41%. The maximum standard heterosis was noticed in P_1 x P_3.

Table 9. Heterosis (%) for fruit weight and calyx length

Crosses	Fruit weight (g)			Calyx length (cm)		
	RH	HB	SH	RH	HB	SH
$P_1 \times P_2$	1.22	-1.48	-35.20**	-3.18	-10.46*	2.49
$P_1 \times P_3$	24.07**	9.84**	-27.76**	-8.45	-17.43**	-5.49
$P_1 \times P_4$	9.00**	1.23	-33.42**	-15.64**	-24.18**	-13.22*
$P_1 \times P_5$	7.83**	-4.72*	-18.33**	-1.95	-6.97	6.48
$P_1 \times P_6$	12.90**	9.43**	-28.03**	3.24	-16.78**	-4.74
$P_1 \times P_7$	48.70**	36.05**	7.82**	-2.17	-6.75	6.73
$P_1 \times P_8$	10.33**	-9.87**	-6.47**	-11.33**	-13.07**	-0.50
$P_2 \times P_3$	6.92*	-3.03	-39.62**	-5.67	-8.21	-10.72*
$P_2 \times P_4$	24.03**	18.18**	-26.42**	-2.12	-5.13	-7.73
$P_2 \times P_5$	0.26	-13.46**	-25.82**	3.74	0.97	3.74
$P_2 \times P_6$	44.43**	43.81**	-10.46**	23.40**	6.15	3.24
$P_2 \times P_7$	-4.76	-14.97**	-32.61**	6.45	3.12	6.98
$P_2 \times P_8$	-11.56**	-29.25**	-26.58**	1.08	-4.76	4.74
$P_3 \times P_4$	46.22**	38.81**	-21.73**	17.28**	16.80**	7.48
$P_3 \times P_5$	-16.44**	-33.52**	-43.02**	-0.64	-5.83	-3.24
$P_3 \times P_6$	11.94**	1.92	-37.09**	24.92**	10.03	1.25
$P_3 \times P_7$	-6.72*	-23.54**	-39.41**	-2.42	-7.93	-4.49
$P_3 \times P_8$	2.62	-23.64**	-20.75**	4.69	-3.85	5.74
$P_4 \times P_5$	39.23**	15.41**	-1.08	11.05*	4.85	7.73
$P_4 \times P_6$	8.63**	3.93	-35.85**	3.25	-8.74	-16.71**
$P_4 \times P_7$	4.13	-10.88**	-29.38**	-6.14	-11.78*	-8.48
$P_4 \times P_8$	7.03**	-17.40**	-14.29**	7.56	-1.59	8.23
$P_5 \times P_6$	2.38	-11.95**	-24.53**	20.06**	0.97	3.74
$P_5 \times P_7$	0.00	-3.77	-17.52**	2.42	1.92	5.74
$P_5 \times P_8$	-4.98**	-13.25**	-9.97**	-14.65**	-17.46**	-9.23
$P_6 \times P_7$	32.70**	18.03**	-6.47**	23.10**	3.12	6.98
$P_6 \times P_8$	4.23*	-16.88**	-13.75**	19.39**	-2.27	7.48
$P_7 \times P_8$	-3.09	-14.55**	-11.32**	-0.12	-2.95	6.73

RH-Relative heterosis HB- Heterobeltiosis SH- Standard heterosis

*Significant at 5 per cent level **Significant at 1 per cent level

Table 10. Heterosis (%) for fruits per cluster and fruits per plant

Crosses	Fruits per cluster			Fruits per plant		
	RH	HB	SH	RH	HB	SH
$P_1 \times P_2$	-36.00**	-52.94**	-5.88	-11.38**	-12.75**	34.12**
$P_1 \times P_3$	32.20**	14.71*	129.41**	32.57**	27.03**	95.27**
$P_1 \times P_4$	55.10**	11.76	123.53**	0.24	-7.69**	41.89**
$P_1 \times P_5$	-42.31**	-55.88**	-11.76	-3.40	-15.82**	29.39**
$P_1 \times P_6$	4.62	0.00	100.00**	8.59**	0.00	53.72**
$P_1 \times P_7$	-24.00**	-44.12**	11.76	39.37**	1.54	56.08**
$P_1 \times P_8$	-19.23**	-38.24**	23.53	-10.51**	-24.18**	16.55**
$P_2 \times P_3$	-26.83**	-40.00**	-11.76	-31.00**	-32.88**	0.00
$P_2 \times P_4$	9.68	6.25	0.00	-10.92**	-16.78**	23.99**
$P_2 \times P_5$	5.88	0.00	5.88	-29.14**	-37.41**	-6.76*
$P_2 \times P_6$	-27.66**	-45.16**	0.00	-29.37**	-34.01**	-1.69
$P_2 \times P_7$	12.50	12.50	5.88	-13.41**	-36.28**	-5.07
$P_2 \times P_8$	11.76	5.56	11.76	-1.45	-15.42**	26.01**
$P_3 \times P_4$	-20.00*	-36.00**	-5.88	-32.50**	-35.25**	-8.78**
$P_3 \times P_5$	20.93*	4.00	52.94**	-35.63**	-41.73**	-17.91**
$P_3 \times P_6$	-7.14	-16.13*	52.94**	-12.25**	-15.83**	18.58**
$P_3 \times P_7$	80.49**	48.00**	117.65**	-12.32**	-34.29**	-7.43*
$P_3 \times P_8$	44.19**	24.00**	82.35**	-12.41**	-23.02**	8.45**
$P_4 \times P_5$	-9.09	-16.67	-11.76	-19.83**	-24.54**	-2.36
$P_4 \times P_6$	-17.39*	-38.71**	11.76	-12.01**	-12.01**	13.85**
$P_4 \times P_7$	16.13	12.50	5.88	-0.85	-23.50**	-1.01
$P_4 \times P_8$	15.15	5.56	11.76	-17.88**	-25.07**	-3.04
$P_5 \times P_6$	-26.53**	-41.94**	5.88	-15.67**	-20.63**	2.70
$P_5 \times P_7$	-5.88	-11.11	-5.88	52.01**	22.78**	40.20**
$P_5 \times P_8$	-11.11	-11.11	-5.88	7.65**	4.14	18.92**
$P_6 \times P_7$	6.38	-19.35**	47.06**	71.57**	32.38**	71.28**
$P_6 \times P_8$	-34.69**	-48.39**	-5.88	-8.44**	-16.45**	8.11*
$P_7 \times P_8$	11.76	5.56	11.76	8.78**	-9.81**	-3.72

RH-Relative heterosis   HB- Heterobeltiosis   SH- Standard heterosis

*Significant at 5 per cent level   **Significant at 1 per cent level

Plate 5. Fruits per cluster

Wardha local x Palakurthi local

Wardha local x Surya

Palakurthi local x Vellayani local

Wardha local x Swetha

Plate 6. Fruits per plant

Wardha local x Palakurthi local

Swetha x Vellayani local

Wardha local x Vellayani local

Wardha local x Swetha

4.3.8 Fruits per Plant

Among the 28 hybrids, seven hybrids showed positive heterosis over mid parent with maximum heterosis of 71.57% (P_6 x P_7). Heterosis over better parent ranged from -41.73% (P_3 x P_5) to 32.38% (P_6 x P_7). Three hybrids had significant positive heterobeltiosis. Sixteen hybrids recorded standard heterosis, the maximum heterosis was observed in P_1 x P_3 (95.27%) followed by P_6 x P_7 (71.28%) and was on par with P_1 x P_7 (56.08).

4.3.9 Primary Branches per Plant

The hybrid P_4 x P_8 (21.74%) recorded heterosis over mid parent and P_4 x P_5 (31.88%) showed heterosis over better parent. None of the hybrids showed heterosis over standard check.

4.3.10 Plant Height (cm)

Out of 28 hybrids, 22 hybrids exhibited significant positive relative heterosis and 4 hybrids showed negative relative heterosis over mid parent. The magnitude of heterosis over mid parent ranged between -8.98% (P_2 x P_8) to 59.63% (P_4 x P_7). Heterobeltiosis for plant height ranged from -22.37% (P_7 x P_8) to 45.84% (P_4 x P_7). Among 28 hybrids, thirteen hybrids and eleven hybrids showed significant positive and negative heterosis over better parent respectively. Eight and ten hybrids exhibited significant positive and negative heterosis respectively over standard check.

4.3.11 Yield per Plant (kg)

The relative heterosis ranged from -46.07% (P_3 x P_5) to 133.55% (P_6 x P_7) and heterobeltiosis from -54.37% (P_3 x P_5) to 97.61% (P_6 x P_7) and standard heterosis from -54.27% (P_3 x P_5) to 67.12% (P_1 x P_7). Ten hybrids exhibited significant positive heterosis over mid parent. Six hybrids recorded significant positive heterosis over better parent and standard check.

Table 11. Heterosis (%) for primary branches per plant and plant height

Crosses	Primary branches per plant			Plant height (cm)		
	RH	HB	SH	RH	HB	SH
P_1 x P_2	10.49	2.60	-7.06	18.84**	18.29**	15.06**
P_1 x P_3	11.76	-1.30	-10.59	26.67**	9.58**	6.58**
P_1 x P_4	-2.74	-7.79	-16.47**	1.74	-11.59**	-14.01**
P_1 x P_5	4.17	-2.60	-11.76*	26.74**	21.81**	18.49**
P_1 x P_6	0.72	-9.09	-17.65**	5.38**	-9.07**	-11.55**
P_1 x P_7	-7.59	-12.99*	-21.18**	16.89**	10.58**	7.56**
P_1 x P_8	12.33*	6.49	-3.53	3.73*	-7.55**	14.92**
P_2 x P_3	-8.80	-13.64	-32.94**	15.82**	0.58	-3.08
P_2 x P_4	0.74	-1.45	-20.00**	8.45**	-5.38**	-8.82**
P_2 x P_5	12.78*	11.94	-11.76*	-5.53**	-8.79**	-12.11**
P_2 x P_6	6.25	3.03	-20.00**	12.00**	-2.98	-6.51**
P_2 x P_7	-11.94	-13.24	-30.59**	4.40*	-0.80	-4.41*
P_2 x P_8	-8.15	-10.14	-27.06**	-8.98**	-19.21**	0.42
P_3 x P_4	9.38	1.45	-17.65**	20.84**	20.20**	-13.73**
P_3 x P_5	7.94	1.49	-20.00**	20.17**	7.65**	-3.43
P_3 x P_6	19.01**	16.13*	-15.29**	44.71**	44.28**	2.45
P_3 x P_7	14.96*	7.35	-14.12*	9.72**	-0.24	-13.45**
P_3 x P_8	18.75**	10.14	-10.59	5.70**	-16.96**	3.22
P_4 x P_5	33.82**	31.88**	7.06	25.33**	12.80**	1.19
P_4 x P_6	-2.29	-7.25	-24.71**	24.05**	23.02**	-11.69**
P_4 x P_7	-0.73	-1.45	-20.00**	59.63**	45.84**	26.54**
P_4 x P_8	21.74**	21.74**	-1.18	17.14**	-7.61**	14.85**
P_5 x P_6	16.28*	11.94	-11.76*	22.59**	9.52**	-1.75
P_5 x P_7	8.15	7.35	-14.12*	24.21**	22.17**	9.59**
P_5 x P_8	13.24*	11.59	-9.41	-4.45**	-17.75**	2.24
P_6 x P_7	10.77	5.88	-15.29**	20.16**	8.96**	-5.46**
P_6 x P_8	17.56**	11.59	-9.41	3.41	-18.93**	0.77
P_7 x P_8	10.95	10.14	-10.59	-8.56**	-22.37**	-3.50

RH-Relative heterosis HB- Heterobeltiosis SH- Standard heterosis

*Significant at 5 per cent level **Significant at 1 per cent level

Table 12. Heterosis (%) for yield per plant

Crosses	Yield per plant (kg)						
	RH	HB	SH	Crosses	RH	HB	SH
$P_1 \times P_2$	-9.83**	-13.75**	-15.06**	$P_3 \times P_5$	-46.07**	-54.37**	-54.27**
$P_1 \times P_3$	61.90**	37.97**	35.88**	$P_3 \times P_6$	-0.18	-6.25	-25.96**
$P_1 \times P_4$	18.29**	2.67	1.12	$P_3 \times P_7$	-11.37*	-20.76**	-45.03**
$P_1 \times P_5$	5.50	4.59	4.82	$P_3 \times P_8$	-9.48**	-28.94**	-13.52**
$P_1 \times P_6$	21.30**	9.28*	7.63	$P_4 \times P_5$	11.59**	-3.85	-3.64
$P_1 \times P_7$	118.23**	69.68**	67.12**	$P_4 \times P_6$	-6.09	-9.95*	-28.88**
$P_1 \times P_8$	11.42**	0.79	22.67**	$P_4 \times P_7$	57.75**	38.36**	0.29
$P_2 \times P_3$	-23.91**	-32.61**	-39.40**	$P_4 \times P_8$	-15.59**	-32.66**	-18.04**
$P_2 \times P_4$	12.68**	1.76	-8.50*	$P_5 \times P_6$	-12.84**	-22.08**	-21.91**
$P_2 \times P_5$	-27.41**	-31.14**	-30.99**	$P_5 \times P_7$	48.05**	14.41**	14.65**
$P_2 \times P_6$	1.21	-4.95	-14.53**	$P_5 \times P_8$	-1.60	-10.29**	9.18*
$P_2 \times P_7$	-13.50**	-30.45**	-37.46**	$P_6 \times P_7$	133.55**	97.61**	56.06**
$P_2 \times P_8$	-13.76**	-25.02**	-8.74*	$P_6 \times P_8$	-9.65**	-25.51**	-9.34*
$P_3 \times P_4$	-0.40	-2.54	-29.35**	$P_7 \times P_8$	-4.03	-30.46**	-15.36**

RH-Relative heterosis HB- Heterobeltiosis SH- Standard heterosis

*Significant at 5 per cent level **Significant at 1 per cent level

Plate 7. Yield per plant for first four superior hybrids

Wardha local x Vellayani local

Swetha x Vellayani local

Plate 7. Continued

Wardha local x Palakurthi local

Wardha local x Selection Pooja

4.4 COMBINING ABILITY ANALYSIS

The analysis of variance for combining ability revealed significance of general combining ability and specific combining ability for all the characters.

4.4.1 Estimation of Combining ability (*gca* and *sca*) Effects

The estimates of general combining ability effects of parents and specific combining ability effects of hybrids for 11 traits are presented in Table 13 and 14. The salient features of the results on combining ability effects for different characters are presented as under

4.4.1.1 Days to First Flowering

Four parents *viz.,* P_1 (-0.810), P_4 (-0.570), P_6 (-0.557) and P_8 (-0.243) exhibited significant negative *gca* effect for days to first flowering and two parents P_7 and P_2 exhibited positive *gca* effect.

Seven hybrids showed significant negative *sca* effect, which ranged from -2.64 (P_6 x P_7) to -0.80 (P_1 x P_6).

4.4.1.2 Days to First Harvest

The parents, P_3 (-1.035), P_6 (-0.408) and P_7 (-0.568) had significant negative *gca* effect for days to first harvest. While P_2 (0.485), P_4 (0.452) and P_5 (0.678) had significant positive *gca* effects. In two parents, P_1 (0.332) and P_8 (0.065) *gca* effects were non-significant.

Among the hybrids *sca* effects ranged between -3.04 (P_1 x P_4) to 6.43 (P_4 x P_6). Seven hybrids showed significant negative *sca* effect, while five hybrids showed significant positive *gca* effects. P_1 x P_4 was significantly different from others.

Table 13. General combining ability effects of parents

Characters	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
Days to first flowering	-0.810 **	0.677 **	-0.117	-0.570 **	-0.010	-0.557 **	1.630 **	-0.243 **
Days to first harvest	0.332	0.485 *	-1.035 **	0.452 *	0.678 **	-0.408 *	-0.568 **	0.065
Fruit length (cm)	0.540 **	-2.875 **	1.092 **	-2.518 **	-0.596 **	0.386 **	0.681 **	3.290 **
Fruit girth (cm)	0.044	0.656 **	-2.286 **	0.850 **	1.869 **	-0.692 **	-0.523 **	0.080
Fruit weight (g)	0.743	-6.963 **	-13.870 **	-4.143 **	5.817 **	-2.083 **	5.623 **	14.877 **
Calyx length (cm)	0.060 *	-0.002	-0.063 *	-0.102 **	0.060 *	-0.152 **	0.079 **	0.120 **
Fruits per cluster	0.373 **	-0.280 **	0.307 **	-0.147 **	-0.227 **	0.153 **	-0.067 *	-0.113 **
Fruits per plant	5.145 **	-0.102	-0.075	-0.995 **	-1.602 **	1.018 **	-1.635 **	-1.755 **
Primary branches per plant	0.223 **	-0.270 **	-0.203 **	0.090	0.183 **	-0.123	-0.110	0.210 **
Plant height (cm)	4.955 **	-0.598	-5.612 **	-3.965 **	1.342 **	-6.865 **	1.035 **	9.708 **
Yield per plant (kg)	0.498 **	-0.239 **	-0.384 **	-0.158 **	-0.008	-0.001	0.070 **	0.222 **

*Significant at 5 per cent level

**Significant at 1 per cent level

4.4.1.3 Fruit Length (cm)

All the eight parents differed significantly from one another with respect to their *gca* effects. P_1 (0.54), P_3 (1.09) P_6 (0.38), P_7 (0.68) and P_8 (3.29) showed positive significant *gca* effects and P_2 (-2.87), P_4 (-2.51) and P_5 (-0.59) had negative *gca* effects. P_8 significantly differed from other parents.

All the hybrids except P_1 x P_3 and P_4 x P_8 had significant *sca* effects, 14 were in positive direction and 12 were in negative direction. The values ranged between -3.30 (P_5 x P_8) to 3.88 (P_4 x P_5).

4.4.1.4 Fruit Girth (cm)

Highly significant *gca* effects were observed for all the parents included in the study except P_1 and P_8. Positive values were recorded for P_2 (0.65), P_4 (0.85) and P_5 (1.8) and negative for P_3 (-2.8), P_6 (-0.69) and P_7 (-0.15).

Twelve hybrids had positively significant *sca* effects with maximum value for P_5 x P_8 (4.34), whereas 12 hybrids showed negative and significant *sca* effects.

4.4.1.5 Fruit Weight (g)

Three parents P_8 (14.87), P_5 (5.81) and P_7 (5.62) exhibited significant *gca* effects for fruit weight. Four parents *viz.,* P_2 (-6.96), P_3 (-13.87), P_4 (-4.13) and P_6 (-2.08) recorded negative *gca* effect.

Eight hybrids had positive and significant *sca* effects and 13 hybrids showed negative and significant *sca* effects. Maximum *sca* effect was obtained for hybrid P_1 x P_7 (32.96) and minimum *gca* effect was noticed for the hybrid P_3 x P_5 (-15.48).

Table 14. Specific combining ability effects of hybrids

Crosses	Days to first flowering	Days to first harvest	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Calyx length (cm)
$P_1 \times P_2$	0.83**	1.72**	-0.97**	0.26	-7.65**	0.01
$P_1 \times P_3$	-1.64**	-1.62*	0.03	-0.41*	8.46**	-0.14
$P_1 \times P_4$	1.35**	-3.04**	-2.14**	0.70**	-8.27**	-0.31**
$P_1 \times P_5$	2.45**	-2.34**	-2.36**	0.89**	0.44	0.06
$P_1 \times P_6$	-0.80**	-1.12	0.82**	-1.01**	-3.66*	-0.03
$P_1 \times P_7$	1.55**	-0.36	3.53**	1.00**	32.96**	0.05
$P_1 \times P_8$	0.29	-1.26*	1.71**	-0.83**	6.04**	-0.19*
$P_2 \times P_3$	1.27**	0.62	-1.70**	0.68**	1.50	-0.22*
$P_2 \times P_4$	-0.21	-0.46	1.77**	1.12**	8.10**	-0.10
$P_2 \times P_5$	-0.30	-1.22	0.51**	-5.88**	-1.12	0.05
$P_2 \times P_6$	0.71*	-0.80	1.84**	2.11**	25.78**	0.25**
$P_2 \times P_7$	-1.87**	0.42	-0.94**	0.07	-9.33**	0.12
$P_2 \times P_8$	0.73**	1.39*	-2.90**	-1.67**	-11.12**	0.01
$P_3 \times P_4$	3.52**	2.72**	-0.84**	1.15**	20.81**	0.37**
$P_3 \times P_5$	0.96**	-0.04	2.89**	-3.91**	-15.48**	-0.08
$P_3 \times P_6$	4.17**	-1.68**	-0.98**	1.50**	-0.25	0.25**
$P_3 \times P_7$	3.39**	-2.12**	1.38**	-1.31**	-10.82**	-0.13
$P_3 \times P_8$	0.46	-0.42	1.96**	0.85**	2.99	0.10
$P_4 \times P_5$	0.35	1.34*	3.88**	2.55**	26.66**	0.25**
$P_4 \times P_6$	0.09	6.43**	-1.42**	-2.29**	-8.44**	-0.19*
$P_4 \times P_7$	-2.43**	-1.14	-0.64**	-1.15**	-8.15**	-0.20*
$P_4 \times P_8$	1.65**	-0.98	-0.32	-1.02**	1.26	0.21*
$P_5 \times P_6$	2.53**	0.27	2.50**	-0.02	-4.40**	0.20*
$P_5 \times P_7$	-1.45***	0.36	0.41*	1.28**	-3.44*	0.02
$P_5 \times P_8$	0.95**	1.00	-3.30**	4.34**	-3.36*	-0.42**
$P_6 \times P_7$	-2.64***	-1.55*	-2.11**	0.06	18.12**	0.26**
$P_6 \times P_8$	-0.50	-1.18	1.98**	-0.41*	-0.13	0.24*
$P_7 \times P_8$	-1.15***	0.91	2.48**	-0.87**	-4.84**	-0.01

*Significant at 5 per cent level ** Significant at 1 per cent level

Table 14. Continued

Crosses	Fruits per cluster	Fruits per plant	Primary branches per plant	Plant height (cm)	Yield per plant (Kg)
$P_1 x P_2$	-0.46**	-2.12**	0.57**	12.14**	-0.42**
$P_1 x P_3$	0.48**	9.92**	0.30	9.09**	1.00**
$P_1 x P_4$	0.87**	0.31	-0.32	-12.16**	-0.09
$P_1 x P_5$	-0.58**	-1.55**	-0.15	13.47**	-0.15*
$P_1 x P_6$	0.30**	0.63	-0.18	-6.93**	-0.09
$P_1 x P_7$	-0.48**	3.75**	-0.39	3.37**	1.32**
$P_1 x P_8$	-0.30**	-3.93**	0.29	1.70	0.06
$P_2 x P_3$	-0.46**	-3.63**	-0.47*	5.44**	-0.14*
$P_2 x P_4$	0.12	2.02**	-0.03	-1.67	0.40**
$P_2 x P_5$	0.27**	-3.44**	0.34	-10.11**	-0.31**
$P_2 x P_6$	-0.18	-5.06**	0.18	3.43**	0.10
$P_2 x P_7$	0.11	-3.07**	-0.43*	-2.47*	-0.55**
$P_2 x P_8$	0.22*	3.18**	-0.55**	-6.55**	0.02
$P_3 x P_4$	-0.53**	-4.47**	0.04	-1.33	0.03
$P_3 x P_5$	0.22*	-5.67**	-0.19	3.17*	-0.74**
$P_3 x P_6$	-0.16	-1.09*	0.38	16.97**	-0.04
$P_3 x P_7$	0.79**	-3.57**	0.44*	-6.06**	-0.59**
$P_3 x P_8$	0.44**	-0.31	0.32	1.13	0.04
$P_4 x P_5$	-0.06	-1.68**	1.05**	5.92**	0.29**
$P_4 x P_6$	-0.18	-1.10**	-0.44*	1.86	-0.34**
$P_4 x P_7$	-0.02	-1.38**	-0.19	30.36**	0.31**
$P_4 x P_8$	0.09	-1.66**	0.56**	10.55**	-0.30**
$P_5 x P_6$	-0.16	-2.69**	0.20	6.02**	-0.32**
$P_5 x P_7$	-0.08	7.36**	0.05	8.92**	0.52**
$P_5 x P_8$	-0.03	3.28**	0.00	-6.75**	0.23**
$P_6 x P_7$	0.14	10.87**	0.29	2.79*	1.54**
$P_6 x P_8$	-0.41**	-1.47**	0.30	0.05	-0.24**
$P_7 x P_8$	0.01	-1.15**	0.22	-11.91**	-0.46**

*Significant at 5 per cent level ** Significant at 1 per cent level

4.4.1.6 Calyx Length (cm)

The parents namely, P_1 (0.06), P_5 (0.06), P_7 (0.07) and P_8 (0.12) showed significant positive *gca* effect. While parents, P_3 (-0.06), P_4 (-0.10) and P_6 (-0.15) had significant negative *gca* effect.

Of all the hybrids, *sca* effect was significant positive for 8 hybrids. While significant negative *sca* effect was recorded for 6 hybrids. The maximum *sca* effect was noticed for P_3 x P_4 (0.37) and minimum *sca* effect was noticed for P_5 x P_8 (-0.42). Remaining 14 hybrids had non-significant *sca* effects of which seven hybrids had positive value and remaining seven had negative value.

4.4.1.7 Fruits per Cluster

All the parents had significant *gca* effects of which 3 parents (P_1, P_3 and P_6) had positive value and 5 parents (P_2, P_4, P_5, P_7 and P_8) recorded negative *gca* values. P_1 had maximum *gca* effect of 0.37, followed by P_3 (0.30) and P_6 (0.15) and P_2 had minimum *gca* effect of -0.28.

Significant positive *sca* effects was noticed for seven hybrids with maximum value of 0.87 (P_1 x P_4) followed by 0.79 (P_3 x P_7), 0.48 (P_1 x P_3), 0.44 (P_3 x P_8), 0.30 (P_1 x P_6), 0.27 (P_2 x P_5) and 0.22 (P_3 x P_8), while 7 hybrids had significant negative *sca* effects. Remaining 14 hybrids showed non-significant *sca* effects.

4.4.1.8 Fruits per Plant

Among the eight parents, two parents (P_1 and P_6) recorded significant and positive *gca* effects for fruits per plant. Four parents (P_4, P_5, P_7 and P_8) had *gca* effects in negative direction. The *gca* effect ranged from -1.75 (P_8) and 5.14 (P_1).

Out of 28 hybrids, 25 had significant *sca* effects, of which 7 hybrids had positive significant *sca* effects, while 18 hybrids showed significant negative *sca* effects. The maximum *sca* effect was noticed for P_6 x P_7 (10.87) and minimum *sca* effect was noticed for P_3 x P_5 (-5.67).

4.4.1.9 Primary Branches per Plant

Positively significant *gca* effects as showed by P_1, P_8 and P_5, whereas P_2 and P_3 had negative and significant *gca* effects. The hybrids P_4 x P_5, P_1 x P_2, P_4 x P_8 and P_3 x P_7 were found to have significant positive *sca* effects.

4.4.1.10 Plant Height (cm)

Estimates of *gca* effects of parents revealed that three parents showed significant negative *gca* effects for this trait *i.e.,* P_6, P_5 and P_4 indicating that they were good combiners for dwarfness. In contrast to this, four parents registered significant and positive *gca* effects and were good general combiners for tallness.

The significant *sca* effects in desirable direction for plant height were observed in eight hybrids. Magnitude of *sca* effects among these hybrids varied from -12.16 (P_1 x P_4) to -2.47 (P_2 x P_7) and hence were considered to be best hybrids for dwarfness, while 13 hybrids showed significant and positive *sca* effects for plant height and were best hybrids with respect to tallness.

4.4.1.11 Yield per Plant (kg)

Three parents P_1, P_8 and P_7 recorded significant positive *gca* effects for yield per plant and three parents showed significant negative *gca* effects.

The results revealed significant positive *sca* effects for eight hybrids which ranged from 0.23 (P_5 x P_8) to 1.54 (P_6 x P_7). The highest *sca* effect was observed in cross P_6 x P_7 (1.54) followed by P_1 x P_7 (1.32).

Discussion

5. DISCUSSION

In the recent years, exploitation of hybrid vigour or heterosis by inter varietal hybridization has been a very promising line of breeding approaches in many vegetable crops like tomato, chilli, sweet pepper and brinjal. With ever-growing need to increase vegetable production in Asian countries and with increasing consumption of eggplant, vegetable breeders are showing greater interest in this vegetable. The productivity of F_1 hybrids in brinjal has been reported to be high, compared to varieties and the use of hybrid cultivars has been predicted to increase in the country during the ensuing years.

Brinjal has considerable preference for shape, size and colour of fruits. Therefore brinjal breeders have to aim at evolving genotypes based on regional preference and that show substantial increase over the existing types in respect to yield and other economic characters. This would mainly depend upon the nature, magnitude and inter-relationship of heritable variation.

The salient results gathered in the present investigation are discussed hereunder.

5.1 HALF DIALLEL ANALYSIS

Various biometrical methods can be used to evaluate the combining ability of genotypes for developing a suitable breeding strategy. Half diallel analysis is a method (Griffing, 1956) in which the selected parents are crossed in all possible combinations excluding reciprocals. Combining ability analysis enables a plant breeder to decide the choice of parents for hybridization, construction of inbreds or composite breeding programme. It also helps to employ suitable selection procedures (Dabholkar, 1992).

Half diallel analysis was carried out to evaluate the parents and hybrids on the basis of mean performance, general combining ability of parents and specific combining ability of hybrids. Significant variations existed for most of the traits are revealed by ANOVA.

5.2 COMBINING ABILITY AND HETEROSIS

Combining ability is the relative ability to transmit the desirable attributes of genotype to its crosses (Sprague and Tatum, 1942). General combining ability is the average performance of a strain in a series of crosses which reflects the additive gene effects of the parents. Specific combining ability indicates situations where particular cross do relatively better or worse than would be expected on the basis of average performance of their respective parents and is a measure of non-additive gene action (Rojas and Sprague, 1942).

5.3 GENE ACTION

Nature of gene action as measured by *GCA* and *SCA* variances is particularly useful in deciding the inheritance of character and thereby selection of a suitable breeding programme. Greater *GCA* variance for a character indicates the predominance of additive gene action and if *SCA* variance is greater non-additive gene action plays an important role in controlling that trait. Simple selection is enough for a character controlled by additive gene action as it as fixable, but if non-additive gene action is predominant for a character, which is non-fixable, heterosis breeding may be rewarding or selection has to be postponed to later generations.

The variance due to *sca* was higher than that due to *gca* for all the characters indicating the predominant role of non-additive gene action. The presence of predominantly large amount of non-additive gene action observed for various yield attributing characters would necessitate the maintenance of heterozygosity in the population. Breeding methods such as biparental mating followed by reciprocal recurrent selection may increase frequency of genetic recombination and hasten the rate of genetic improvement (Hanson, 1960).

Table 15. Analysis of variance for combining ability of different characters in brinjal

Character	GCA	SCA	Error	$\sigma^2 gca$	$\sigma^2 sca$	$\sigma^2 gca/\sigma^2 sca$
Days to first flowering	6.40**	5.47**	0.09	0.63128	5.38506	0.11723
Days to first harvest	3.68**	4.35**	0.45	0.32285	3.90289	0.08272
Fruit length (cm)	39.83**	4.52**	0.03	3.97960	4.48570	0.88717
Fruit girth (cm)	15.19**	3.88**	0.04	1.51498	3.83888	0.39464
Fruit weight (g)	785.28**	180.66**	2.81	78.24721	177.79543	0.44010
Calyx length (cm)	0.09**	0.05**	0.01	0.00840	0.03992	0.21053
Fruits per cluster	0.61**	0.15**	0.01	0.05988	0.14098	0.42472
Fruits per plant	52.61**	21.76**	0.18	5.24340	21.58278	0.24294
Primary branches per plant	0.40**	0.19**	0.05	0.03493	0.14013	0.24930
Plant height (cm)	309.10**	127.57**	1.68	30.74281	125.89278	0.24420
Yield per plant (kg)	0.76**	0.36**	0.00	0.07551	0.35999	0.20976

*Significant at 5 per cent level **Significant at 1 per cent level

Table 16. Diallel cross ANOVA summary

Source of variation	Days to first flowering	Days to first harvest	Fruit length (cm)	Fruit girth (cm)	Fruit weight (cm)	Calyx length (cm)
Replicates	0.07	0.96	0.01	0.05	5.21	0.04
Treatments	16.97**	12.65**	34.73**	18.42**	904.61**	0.17**
Parents	38.09**	11.55**	37.99**	18.64**	1425.06**	0.41**
Hybrids	8.49**	13.10**	34.28**	18.95**	753.73**	0.12**
Parents Vs. Hybrids	98.13**	8.42*	24.19**	2.38**	1335.48**	0.10
Error	0.26	1.35	0.09	0.11	8.42	0.03

Source of variation	Fruits per cluster	Fruits per plant	Primary branches per plant	Plant height (cm)	Yield per plant (kg)
Replicates	0.00	0.38	0.28	7.44	0.02
Treatments	0.72**	83.81**	0.69**	491.63**	1.33**
Parents	0.74**	85.62**	0.38*	905.44**	0.83**
Hybrids	0.75**	85.38**	0.71**	313.84**	1.49**
Parents Vs. Hybrids	0.00	28.78**	2.24**	2395.11**	0.59**
Error	0.03	0.55	0.14	5.03	0.01

*Significant at 5 per cent level **Significant at 1 per cent level

In the present study, the characters *viz.,* days to first flowering, days to first harvest, fruit length, fruit girth, fruit weight, calyx length, fruits per plant, fruits per cluster, primary branches per plant, plant height, yield per plant and yield per plot were influenced by non-additive gene action as evidenced from the low additive : dominance (σ^2A/σ^2D) ratio. Similar findings were reported by Chaudhary and Pathania (2000) and Shanmugapriya *et al.* (2009) for days to first flowering, Chaudhary and Pathania (2000), Patel (2003) and Sane *et al.* (2011) for days to first harvest, Rao (2003), Patel (2003) and Shanmugapriya *et al.* (2009) for fruit length, fruit girth, fruit weight and fruits per plant, Prakash (2007) and Sao and Mehta (2010) for fruits per cluster, Pachiyappan *et al.* (2012) for primary branches per plant, Shanmugapriya *et al.* (2009) and Sane *et al.* (2011) for plant height, Pachiyappan *et al.* (2012) for yield per plant.

Additive and non-additive gene action had equal importance for the control of the trait, crop duration, where σ^2A: σ^2D value was more or less unity.

Considering the preponderance of non-additive gene action for all the characters, it can be concluded that heterosis breeding would yield better results in the improvement of those characters.

5.4 EVALUATION OF PARENTS

According to Yadav and Murthy (1966), the choice of parents especially for heterosis breeding should be based on the combining ability test and their mean performance. Dhillon (1975) pointed out that combining ability of parents give useful information on the choice of parents in terms of expected performance of their progenies. Therefore, the parents chosen for present study were assessed based on their mean performance and general combining ability effects.

For fruit yield and yield related characters P_1 was the best compared to other parents and it showed good *per se* performance for yield per plant, fruits per plant, fruits per cluster, fruit length, primary branches per plant, calyx length and

Table 17. Evaluation of parents based on *gca* effects and mean performance

Characters	Mean performance	*gca* effects	Mean performance and *gca* effects
Days to first flowering	P_3, P_1, P_4, P_6, P_5	P_1, P_4, P_6, P_8	P_1, P_4, P_6
Days to first harvest	P_3, P_4, P_6	P_3, P_6, P_7	P_3, P_6
Fruit length (cm)	P_1, P_3, P_8	P_1, P_3, P_6, P_7, P_8	P_1, P_3, P_8
Fruit girth (cm)	P_2, P_4, P_5	P_2, P_4, P_5	P_2, P_4, P_5
Fruit weight (g)	P_5, P_7, P_8	P_5, P_7, P_8	P_5, P_7, P_8
Calyx length (cm)	P_1, P_7, P_8	P_1, P_5, P_7, P_8	P_1, P_7, P_8
Fruits per cluster	P_1, P_3, P_6	P_1, P_3, P_6	P_1, P_3, P_6
Fruits per plant	P_1, P_2, P_3	P_1, P_6	P_1
Primary branches per plant	P_1, P_4, P_7, P_8	P_1, P_5, P_8	P_1, P_8
Plant height (cm)	P_8, P_1, P_2	P_1, P_5, P_7, P_8	P_8, P_1
Yield per plant (kg)	P_1, P_5, P_8	P_1, P_7, P_8	P_1, P_8

days to first flowering. P_3 showed superiority for traits like fruits per plant, fruits per cluster, days to first flowering, fruit length, days to first harvest and plant height. For days to first flowering, yield per plant, fruit weight and fruit girth P_5 showed comparatively better performance, while P_4 was good for primary branches per plant, fruit girth, days to first harvest, plant height, and days to first flowering. P_8 also showed superiority for yield per plant, primary branches per plant, fruit weight and fruit length.

P_1 was a good combiner for seven traits *viz.,* days to first flowering, primary branches per plant, fruits per plant, yield per plant, fruits per cluster, fruit length and calyx length. For primary branches per plant, days to first flowering, yield per plant, fruit weight, fruit length and calyx length P_8 was good general combiner. P_6 was the best general combiner for days to first flowering, fruit per plant, fruits per cluster, days to first harvest, fruit length, and plant height. P_5 showed superiority for primary branches per plant, fruit weight, calyx length and fruit girth. P_7 was good general combiner for yield per plant, days to first harvest, fruit length and calyx length.

Considering overall performance, superiority can be attributed to P_1 (Wardha local) and P_8 (Selection Pooja) for yield and yield related traits.

P_3 (Palakurthi local) and P_4 (Surya) showed best performance for four yield contributing characters. P_4 (Surya) was also good for days to first flowering, fruit girth and plant height, while P_5 (NBR-38) and P_7 (Vellayani local) good for fruit weight.

5.5 EVALUATION OF HYBRIDS

The aim of any hybridization programme is to bring together desirable genes present in parents into a single variety. Better hybrids were generally identified based on their mean performance, *sca* effects and heterotic expression. The hybrids thus obtained either can be used as F_1 hybrid to exploit heterosis or forwarded to further generations for selecting superior recombinants with desirable gene combinations from the segregating population.

As mean performance is the reflection of field performance of hybrids, it should be given prime importance. The selection of combinations either for heterosis breeding or for recombination breeding largely depends on the *sca* effects of hybrids as well as *gca* effects of parents. This was based on the assumption that additive gene action is reflected by *gca* effects and hence immediate hybrid may perform poorly but selection for elite genotypes in subsequent generations would be fruitful. On the contrary, high *sca* effect of hybrids is a reflection of non additive gene action, so that superiority can be expected in the F_1 hybrids (Singh and Narayanan, 1993). The expression of heterosis even to a small magnitude for individual component character is desirable factor (Hotchcock and McDaniel, 1973).

5.5.1 Days to First Flowering

Earliness is considered an important character in any crop improvement programme, which is manifested in F_1 hybrids and preferred for commercial cultivation when high yield is coupled with earliness. With respect to mean performance P_1 x P_3, P_1 x P_6, and P_6 x P_7 were superior. The parents P_1, P_4, P_6, and P_8 were good general combiners for this trait. P_6 x P_7, P_4 x P_7, P_2 x P_7, P_1 x P_3, P_5 x P_7, P_7 x P_8 and P_1 x P_6 were found good with regard to *sca* effects. The hybrids P_1 x P_3, P_1 x P_6 had significant standard heterosis. While P_2 x P_7, P_4 x P_7, P_6 x P_7 had significant relative heterosis as well as heterobeltiosis for earliness. P_1 x P_3 projected as the best hybrid for earliness. Heterosis for earliness was also reported by Chowdhury *et al.* (2010), Nalini *et al.* (2011) and Reddy and Patel (2014) in brinjal. Hybrids those expressed earliness had parents which are also early in flowering indicating the presence of additive gene action.

5.5.2 Days to First Harvest

The hybrids P_3 x P_7 (good x good general combiner), P_1 x P_3 (Poor x good general combiner) and P_1 x P_4 (poor x poor general combiner) were superior based on mean performance, *sca* effects and standard heterosis. The hybrid P_1 x P_5 also had high *sca* effects but mean performance was not satisfactory. In earlier studies, Suneetha and Kathiria (2006), Chowdhury *et al.* (2010), Makani (2013) also found similar results in brinjal.

5.5.3 Fruit Length (cm)

Fruit length is an important parameter deciding consumer preference. The hybrid P_7 x P_8 different from other hybrids in having high mean value, *sca* effect and standard heterosis. Other hybrids with high *sca* effects and significant heterosis were P_4 x P_5, P_1 x P_7, P_3 x P_5 and P_5 x P_6. Relative heterosis was significant for sixteen hybrids and twenty one hybrids had positive and significant standard heterosis for this trait. Similar results were reported by Reddy and Patel (2014) in brinjal.

5.5.4 Fruit Girth (cm)

Fruit girth is another important character as that of fruit length. Best *per se* performance for fruit girth was exhibited by P_5 x P_8. It was on par with P_4 x P_5. High *sca* effects were shown by the hybrids P_5 x P_8, P_4 x P_5, P_2 x P_6, P_3 x P_6 and P_3 x P_4 of which both standard heterosis and heterobeltiosis was the highest for the hybrid P_5 x P_8 followed by P_4 x P_5. Most of the hybrids were having both negative standard heterosis and heterobeltiosis. This can be due to the predominance of additive variance in controlling this trait. Further, many hybrids having high *sca* effects were poor in *per se* performance and all had good x poor combiners as parents. It was reported that hybrids with low mean values also possess high *sca* effects (Grakh and Chaudhary, 1985) and hence, *sca* effect alone may not be the appropriate criterion for the choice of a hybrid for heterosis exploitation. In earlier studies, Kumar *et al.* (1999), Bulgundi (2000), Mallikarjun

Table 18. Evaluation of hybrids on the basis of mean performance, *sca* effects and standard heterosis

Characters	Mean performance	*sca* effects	Standard heterosis	Superior hybrids
Days to first flowering	$P_1 \times P_3$, $P_1 \times P_6$, $P_6 \times P_7$	$P_6 \times P_7$, $P_4 \times P_7$, $P_2 \times P_7$, $P_1 \times P_3$	$P_1 \times P_3$, $P_1 \times P_6$	$P_1 \times P_3$
Days to first harvest	$P_3 \times P_7$, $P_3 \times P_6$, $P_6 \times P_7$, $P_1 \times P_3$, $P_1 \times P_4$	$P_1 \times P_4$, $P_1 \times P_5$, $P_3 \times P_7$, $P_1 \times P_3$	$P_1 \times P_3$, $P_1 \times P_4$, $P_3 \times P_6$, $P_3 \times P_7$, $P_6 \times P_7$	$P_3 \times P_7$, $P_1 \times P_3$, $P_1 \times P_4$
Fruit length (cm)	$P_7 \times P_8$, $P_3 \times P_8$, $P_6 \times P_8$, $P_1 \times P_8$	$P_4 \times P_5$, $P_1 \times P_7$, $P_3 \times P_5$, $P_7 \times P_8$, $P_5 \times P_6$	$P_7 \times P_8$, $P_3 \times P_8$, $P_6 \times P_8$, $P_1 \times P_8$	$P_7 \times P_8$,
Fruit girth (cm)	$P_5 \times P_8$, $P_4 \times P_5$	$P_5 \times P_8$, $P_4 \times P_5$, $P_2 \times P_6$, $P_3 \times P_6$, $P_3 \times P_4$	$P_5 \times P_8$, $P_4 \times P_5$	$P_5 \times P_8$, $P_4 \times P_5$
Fruit weight (g)	$P_1 \times P_7$, $P_4 \times P_5$, $P_1 \times P_8$, $P_6 \times P_7$	$P_1 \times P_7$, $P_4 \times P_5$, $P_2 \times P_6$, $P_3 \times P_4$	$P_1 \times P_7$	$P_1 \times P_7$
Fruits per cluster	$P_1 \times P_3$, $P_1 \times P_4$, $P_3 \times P_7$, $P_1 \times P_6$, $P_3 \times P_8$	$P_1 \times P_4$, $P_3 \times P_7$, $P_1 \times P_3$	$P_1 \times P_3$, $P_1 \times P_4$, $P_3 \times P_7$, $P_1 \times P_6$	$P_1 \times P_3$, $P_1 \times P_4$, $P_3 \times P_7$
Fruits per plant	$P_1 \times P_3$, $P_6 \times P_7$, $P_1 \times P_7$, $P_1 \times P_6$	$P_6 \times P_7$, $P_1 \times P_3$, $P_5 \times P_7$, $P_1 \times P_7$	$P_1 \times P_3$, $P_6 \times P_7$, $P_1 \times P_7$, $P_1 \times P_6$	$P_1 \times P_3$, $P_6 \times P_7$, $P_1 \times P_7$, $P_1 \times P_6$
Primary branches per plant	$P_4 \times P_5$, $P_4 \times P_8$, $P_1 \times P_8$	$P_4 \times P_5$, $P_1 \times P_2$, $P_4 \times P_8$	--	--
Plant height (cm)	$P_4 \times P_7$, $P_1 \times P_5$, $P_1 \times P_2$	$P_4 \times P_7$, $P_3 \times P_6$, $P_1 \times P_5$, $P_1 \times P_2$, $P_4 \times P_8$	$P_4 \times P_7$, $P_1 \times P_5$, $P_1 \times P_2$, $P_1 \times P_8$, $P_4 \times P_8$	$P_4 \times P_7$, $P_1 \times P_5$, $P_1 \times P_2$
Yield per plant (kg)	$P_1 \times P_7$, $P_6 \times P_7$, $P_1 \times P_3$, $P_1 \times P_8$	$P_6 \times P_7$, $P_1 \times P_7$, $P_1 \times P_3$	$P_1 \times P_7$, $P_6 \times P_7$, $P_1 \times P_3$, $P_1 \times P_8$	$P_1 \times P_7$, $P_6 \times P_7$, $P_1 \times P_3$

(2002), Shafeeq (2005) and Timmapur *et al.* (2008) also found similar results in brinjal.

5.5.5 Fruit Weight (g)

Fruit weight is one of the component character directly influencing the fruit yield. The hybrid P_1 x P_7 (good x poor general combiner) was superior based on the mean performance, *sca* effect and standard heterosis. Other hybrids P_2 x P_6 and P_3 x P_4 also had high *sca* effects but mean performance was not satisfactory. Similar results are putforth by Bulgundi (2000), Mallikarjun (2002), Suneetha *et al.* (2008), Timmapur *et al.* (2008) Chowdhury *et al.* (2010) and Reddy and Patel (2014) in brinjal.

5.5.6 Calyx Length (cm)

For this trait none of the hybrids was superior with respect to all the three selection criteria. Though mean performance was superior for P_4 x P_8, P_4 x P_5, P_3 x P_4 and P_6 x P_8, they showed non significant values of standard heterosis. As for as *sca* effects were concerned P_3 x P_4, P_6 x P_7, P_2 x P_6, P_3 x P_6 and P_4 x P_5 exhibited high values.

5.5.7 Fruits per Cluster

Standard heterosis for fruits per cluster were observed for P_1 x P_3, P_1 x P_4, P_3 x P_7 and P_1 x P_6. As for as *sca* effects were concerned P_1 x P_4 and P_3 x P_7 exhibited high values and both had good x poor parentage indicating the interaction between additive and non additive genetic factors. In P_1 x P_3 both the parents were good general combiners and the interaction of additive factors lead to hybrid vigour fixable by selection. Thus the list of best hybrids for fruits per cluster include P_1 x P_4, P_3 x P_7 and P_1 x P_3. Similar findings have also been reported by Bulgundi (2000), Mallikarjun (2002), Nalini *et al.* (2011), Reddy *et al.* (2011) and Reddy and Patel (2014).

5.5.8 Fruits per Plant

Fruits per plant is a commercially important trait to gain high market value through high productivity. The mean value and standard heterosis were high for the hybrids P_1 x P_3, P_6 x P_7, P_1 x P_7 and P_1 x P_6. Of these P_6 x P_7 and P_1 x P_3 were having high *sca* effects also. The female parents in both the hybrids were good general combiners while male parents were poor combiners. Similar results were reported by Nalini *et al.* (2011), Makani (2013) and Chowdhury *et al.* (2010) and Reddy and Patel (2014) in brinjal.

5.5.9 Primary Branches per Plant

The primary branches per plant is one of the major parameters contributing for total yield per plant. High *per se* performance, high *sca* effects were showed by P_4 x P_5, P_4 x P_8. For these hybrids one parent was good general combiner indicating the promising interaction between desirable and undesirable alleles. No hybrid exhibited positive standard heterosis but possessed high relative heterosis as well as heterobeltiosis. These results are in accordance with the findings of Shafeeq (2005), Nalini *et al.* (2011) and Reddy and Patel (2014).

5.5.10 Plant Height (cm)

On the basis of mean performance, the hybrids P_4 x P_7, P_1 x P_5 and P_1 x P_2 were found to be superior. The female parent in P_4 x P_7 and male parent in P_1 x P_2 were poor general combiners. The parents in the hybrid P_1 x P_5 were good general combiners. High mean performance of crosses between poor and general combiners can be attributed to interaction between genes as reported by Dubey (1975). High *sca* effects were noticed for the crosses P_4 x P_7, P_3 x P_6, P_1 x P_5, P_1 x P_2 and P_4 x P_8. The hybrids P_4 x P_7, P_1 x P_5 and P_1 x P_2 showed significant positive heterosis over mid parent, better parent and standard parent. Similar findings have also been reported by earlier workers, Prabhu *et al.* (2005), Suneetha *et al.* (2008) and Reddy and Patel (2014).

5.5.11 Yield per Plant (kg)

Yield per plant is the ultimate and the most important trait. It is dependent mainly on the fruits per plant and fruit weight. The highest yield per plant was recorded in the hybrid P_6 x P_7 based on the *sca* effects. It was a product of poor x good combiners pointing out the favourable interplay of desirable and undesirable alleles present in both the parents there by revealing the combined involvement of additive and dominance factors. Overall performance of P_1 x P_7 (good x good) and P_1 x P_3 (good x poor) also were outstanding. The presence of at least one good general combiner in the case of all these excellent hybrids is noteworthy. These results are in conformation with the results of earlier workers. Prabhu *et al.* (2005), Shafeeq (2005), Suneetha *et al.* (2008), Nalini *et al.* (2011), Reddy *et al.* (2011) and Reddy and Patel (2014) also reported heterosis for fruit yield in brinjal.

P_1 x P_7 was produced from two good general combiners indicating additive interaction behind its superiority, which may be responsible for its lower *sca* effects than that of other best hybrids mentioned above. This implies that P_1 x P_7 is a good combination for heterosis breeding as well as for yield improvement by selection in advanced generations.

P_1 x P_3, a hybrid of good x average parentage, involved the interaction of additive and non-additive components of gene action which implies that this is suited for heterosis breeding.

The study revealed the superiority of certain hybrids for yield and yield attributes. In the present study P_1 was the best general combiner. The manifestation of heterosis was at different levels for different characters. None of the hybrids were found to be superior for all the characters studied. However the hybrid P_1 x P_7 (Wardha local x Vellayani local) was found to the best in terms of yield and yield contributing characters like fruits per plant and fruit weight followed by P_6 x P_7 (Swetha x Vellayani local), P_1 x P_3 (Wardha local x Palakurthi local) and P_1 x P_8 (Wardha local x Selection Pooja). The hybrid P_4 x P_5 (Wardha local x Surya) showed superiority for yield attributing characters like fruits per cluster, days to harvest and plant height. The identified hybrids can be effectively used for heterosis breeding to exploit maximum hybrid vigour.

Summary

6. SUMMARY

The present investigations on "Diallel analysis in brinjal (*Solanum melongena* L.)" were conducted at the College of Agriculture, Vellayani during 2013-2014 with the major objective to estimate heterosis, combining ability and gene action in brinjal (*Solanum melongena* L.) to identify superior hybrids.

Materials for the study consists of eight parents, 28 hybrids and one standard check (Neelima) from KAU were evaluated for following traits *viz.,* days to first flowering, days to first harvest, fruit length (cm), fruit girth (cm), fruit weight (g), calyx length (cm), colour of fruit, fruits per cluster, fruits per plant, primary branches per plant, plant height (cm), yield per plant (kg) and yield per plot (kg).

The important findings of the present study are summarized below.

The analysis of variance indicated significant differences among the genotypes for all the traits studied. Partitioning of genotypes revealed significant differences among the parents as well as hybrids for all the traits under study. This indicated that materials used for present investigation had adequate diversity for different traits.

The data on heterosis calculated over better parent and standard check Neelima revealed superiority of some outstanding cross combinations.

The hybrids *viz.,* Wardha local x Palakurthi local, Wardha local x Swetha, Wardha local x Vellayani local, Surya x Vellayani local, NBR-38 x Vellayani local and Swetha x Vellayani local showed significant and desirable heterosis for yield per plant over better parent. Among the above hybrids Wardha local x Palakurthi local, NBR-38 x Vellayani local and Swetha x Vellayani local also exhibited maximum heterobeltiosis for fruits per plant and plant height.

Wardha local x Palakurthi local and Swetha x Vellayani local exhibited standard heterosis for days to first harvest, fruits per plant and yield per plant while

Wardha local x Vellayani local showed standard heterosis for fruit weight, fruits per plant and yield per plant and Wardha local x Selection Pooja showed standard heterosis for fruit length, yield per plant and plant height.

A perusal of *per se* performance and heterosis indicated that hybrids Wardha local x Vellayani local, Swetha x Vellayani local and Wardha local x Palakurthi local found to be most promising for fruit yield and other desirable traits, hence could be further evaluated to exploit the heterosis or utilize in future breeding programme to obtain desirable segregants for the development of superior genotypes.

The *gca* and *sca* mean squares were significant for all the traits. The dominance ratio ($\sigma^2 gca/\sigma^2 sca$) indicated the preponderance of non-additive gene effects for the inheritance of all the traits.

The estimates of general combining ability suggested that parent Wardha local was a good general combiner for all the yield attributing characters except days to first harvest, fruit girth and fruit weight. Moreover, Swetha was a good general combiner for days to first flowering, days to first harvest, fruit weight, fruits per plant and fruits per cluster and Vellayani local was a good general combiner for days to first harvest, fruit length, fruit weight, calyx length, yield per plant and plant height.

The estimates of *sca* effects revealed that the cross combinations Wardha local x Palakurthi local, Wardha local x Vellayani local and Swetha x Vellayani local were most promising for fruit yield and some of its related traits *viz.*, days to first flowering and fruits per plant.

Considering the *gca* effects of parents involved in a particular hybrid, cross combinations that expressed significant *sca* effects for different traits were having at least one or both the parents as good general combiners. Therefore, it can be concluded that in order to get high frequency of significant *sca* effect for a particular trait, at least one of the parent should possess good *gca* effect.

6.1 FUTURE LINE OF WORK

1. The stability of the superior hybrids need to be assessed and the superior hybrids can be released for cultivation.
2. Pedigree method of selection can be followed to select superior recombinants from the segregating generations which on attaining uniformity can be released as varieties for cultivation.

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Diallel Analysis in Brinjal (*Solanum melongena* L.)

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ABSTRACT

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ABSTRACT

The present study entitled "Diallel analysis in brinjal (*Solanum melongena* L.)" was conducted at College of Agriculture, Vellayani during kharif –rabi 2013-14 with major objective to estimate heterosis, combining ability and gene action and to identify superior hybrids.

The experimental material consists of eight parents and 28 hybrids. The hybrids were produced in a half-diallel pattern. The hybrid Neelima released from KAU was used as check for the estimation of standard heterosis.

The experiment was laid out in Randomized Block Design (RBD) with three replications. Heterosis and combining ability was estimated for days to first flowering, days to first harvest, fruit length (cm), fruit girth (cm), fruit weight (g), calyx length (cm), fruits per cluster, fruits per plant, primary branches per plant, plant height (cm) and yield per plant (kg)

Analysis of variance revealed significant differences among the genotypes for all the traits.

Six hybrids exhibited standard heterosis for yield per plant, fruits per plant and fruits per cluster. On the basis of *per se* performance and estimates of heterosis, hybrids Wardha local x Vellayani local (4.16 kg per plant), Swetha x Vellayani local (3.88 kg per plant) and Wardha local x Palakurthi local (3.38 kg per plant) were found to be the most promising for fruit yield and other desirable traits.

The general and specific combining ability variances were significant for all the traits. The $\sigma^2 gca$ and $\sigma^2 sca$ ratio indicated that non-additive gene action was predominant for the inheritance of all the traits.

The estimates of general combining ability effects suggested that parents Wardha local was good general combiner for yield per plant, fruits per plant and

fruits per cluster, while Vellayani local and Selection Pooja were good general combiners for yield per plant.

The estimates of specific combining ability effects indicated that cross combinations *viz.,* Swetha x Vellayani local, Wardha local x Vellayani local, Wardha local x Palakurthi local, NBR-38 x Vellayani local, Gopulapur local x Surya, Surya x Vellayani local, Surya x NBR-38 and NBR-38 x Selection Pooja were most promising for yield per plant. These hybrids could be further evaluated to exploit the heterosis to obtain desirable segregants for the development of superior genotypes in future breeding programme.

സംഗ്രഹം

വെള്ളായണി കാർഷിക കോളേജിൽ 2013-14ൽ "ഡൈ അലിൽ അനാലിസിസ് ഇൻ ബ്രിഞ്ചാൾ (*സൊ ളാനം മെലൻജീന* എൽ.)" എന്ന വിഷയത്തെ ആസ്പദമാക്കി ഒരു പഠനം നടത്തുകയുണ്ടായി. വഴുതിന ചെടി യുടെ സങ്കരവീര്യം നിർണ്ണയിക്കുക, വിവിധ ഇനങ്ങൾ തമ്മിൽ സങ്കരണം നടത്തുന്നതിനുള്ള അനുയോജ്യത നിർണ്ണയിക്കുക, ജീൻ പ്രവർത്തനം മനസ്സിലാക്കുക, മുന്തിയ സങ്കരങ്ങൾ കണ്ടെത്തുക ഇവയായിരുന്നു പ്രധാന ലക്ഷ്യം.

തെരഞ്ഞെടുക്കപ്പെട്ട എട്ടു വഴുതിന ഇനങ്ങളും അവയുടെ 28 സങ്കരങ്ങളും പഠന വിധേയമാക്കി. കേരള കാർഷിക സർവ്വകലാശാല പുറത്തിറക്കിയ നീലിമ എന്ന സങ്കരവഴുതിന താരതമ്യ പഠനത്തിനായി ഉപയോ ഗിച്ചു.

ആദ്യ പൂവിടുന്നതിന്റെയും ആദ്യ വിളവെടുപ്പിന്റെയും ദൈർഘ്യം, കായ്കളുടെ നീളം, വണ്ണം, തൂക്കം, കാലിക്സിന്റെനീളം, ഓരോകൂട്ടത്തിലും ഉള്ള കായ്കളുടെ എണ്ണം, ഓരോ ചെടിയിലും ഉണ്ടായ കായ്കളുടെ എണ്ണം, പ്രാഥമിക ശിഖരങ്ങളുടെ എണ്ണം, ചെടികളുടെ ഉയരം, ഒരു ചെടിയിൽ നിന്നും ലഭിച്ച വിളവ് എന്നീ സ്വഭാ വങ്ങളിൽ സങ്കരവീര്യം ഉള്ളതായി കണ്ടു.

പഠനവിധേയമാക്കിയ സങ്കരങ്ങളിൽ ആറെണ്ണം വിളവിലും, കായ്കളുടെ എണ്ണത്തിലും മികച്ചവയാണെന്ന് തെളിഞ്ഞു. വർധാലോക്കലും, വെള്ളായണിലോക്കലും തമ്മിലുള്ള സങ്കരത്തിന് ഓരോചെടിയിൽ നിന്നും 4.16 കിലോഗ്രാം വിളവ് ലഭിച്ചപ്പോൾ സ്വേതയും വെള്ളായണിലോക്കലും തമ്മിലുള്ള സങ്കരത്തിന് 3.88 കിലോഗ്രാമും വർധാലോക്കലും പാലകുർത്തിലോക്കലും തമ്മിലുള്ള സങ്കരത്തിന് 3.38 കിലോഗ്രാമും വിളവ് ലഭിച്ചു.

പൊതു ചേർച്ചാ യോഗ്യതയുടെ കാര്യത്തിലും പ്രത്യേക ചേർച്ചാ യോഗ്യതയുടെ കാര്യത്തിലും ഗണ്യമായ വ്യത്യാസം എല്ലാസ്വഭാവങ്ങളിലും ഉള്ളതായി ബോദ്ധ്യപ്പെട്ടു. എല്ലാ സ്വഭാവങ്ങളുടെയും പിൻതുടർച്ച നിയന്ത്രി ക്കുന്നതിന് നോൺ ആഡിറ്റീവ് ജീൻ പ്രവർത്തനത്തിന് പ്രകടമായ സ്വാധീനം ഉണ്ട്.

വർധാലോക്കൽ, വെള്ളായണിലോക്കൽ, സെലക്ഷൻ പൂജ എന്നീ ഇനങ്ങൾ സങ്കരണത്തിനുപയോഗിച്ച് മികച്ച സങ്കരങ്ങൾ ഉണ്ടാക്കാം. സങ്കരണത്തിന്റെ അനുയോജ്യതയുടെ അടിസ്ഥാനത്തിൽ മികവുകാട്ടിയ സങ്കര ങ്ങളാണ് സ്വേത X വെള്ളായണിലോക്കൽ, വർധാലോക്കൽ X പാലകുർത്തി ലോക്കൽ, എൻ,.ബി.ആർ 38 X വെള്ളായണിലോക്കൽ, ഗോപാൽപൂർ ലോക്കൽ X സൂര്യ, സൂര്യ X വെള്ളായണിലോക്കൽ, സൂര്യ X എൻ. ബി.ആർ 38.

ആവർത്തന പരീക്ഷണത്തിലൂടെയും, വിലയിരുത്തലിലൂടെയും സങ്കരങ്ങളുടെ ഉല്പാദനസ്ഥിരതഉ റപ്പു വരുത്താവുന്നതാണ്. ഒന്നാം തലമുറയിൽ നിന്നും തുടർന്നുള്ള തലമുറകളിൽനിന്നും സ്വപരാഗണത്തിലൂടെ ഉല്പാദിപ്പിക്കുന്ന ചെടികളിൽ നിന്ന് നിർദ്ധാരണം വഴി സങ്കര ഇനങ്ങൾ വികസിപ്പിച്ചെടുക്കാനുള്ള സാദ്ധ്യതകൾ ഉണ്ട്.