“BREEDING INVESTIGATIONS IN BRINJAL (*Solanum melongena* L.)”

A

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IN

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BY

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TO

MY BELOVED

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ABSTRACT

"BREEDING INVESTIGATIONS IN BRINJAL

(*Solanum melongena* L.)"

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ABSTRACT

A field experiment was carried out with a view to estimate heterosis and combining ability and gene effects in brinjal (*Solanum melongena* L.). The experimental material comprised of 8 parents, 28 hybrids and one standard check (Surati Ravaiya) and was laid out in randomized block design with three replications at Regional Horticultural Research Station (R.H.R.S), Navsari Agricultural University, Navsari, Gujarat during *Rabi* 2014-15 (crossing programme) and *Rabi* 2015-16 (evaluation programme). The data were obtained for ten characters including fruit yield and its components.

Significant differences were observed among parents and hybrids, indicating considerable genetic variation among genotypes.

The crosses *viz.*, AB-09-1 × AB-12-10, AB-09-1 × AB-08-5, AB-08-5 × JBL-08-8, GJB-3 × AB-12-10, JBGR-1 × NSR-1, NSR-1 × AB-12-10 and AB-09-1 × NSRP-1 showed significant and desirable heterosis for fruit yield per plant over standard check. Where as crosses *viz.*, AB-09-1 × NSR-1,

AB-09-1 × AB-12-10, NSRP-1 × NSR-1, JBGR-1 × NSR-1, JBGR-1 × JBL-08-8 and GJB-3 × JBL-08-8 showed significant and positive heterobeltiosis for fruit yield per plant.

Combining ability analysis revealed that both additive as well as non-additive gene effects were important in the inheritance of all the traits studied. However, magnitude of variances due to SCA were comparatively larger than those of GCA for days to fifty per cent flowering, plant height at harvest, number of branches per plant at harvest, fruit length, average fruit weight, number of fruit per plant and total soluble solids indicated preponderance of non-additive gene action. While, magnitude of variance due to GCA were comparatively larger than those of SCA for fruit diameter, fruit yield per plant and total phenol content indicated preponderance of additive component of genetic variance.

Among the parents, *viz.*, JBGR-1, NSR-1 and JBL-08-8 were found good general combiners for majority of the characters. Hybrids *viz.*, AB-09-1 × AB-12-10, AB-09-1 × AB-08-5, AB-08-5 × JBL-08-8, GJB-3 × AB-12-10, JBGR-1 × NSR-1, NSR-1 × AB-12-10 and AB-09-1 × NSRP-1 showed higher order *sca* effects for fruit yield and its component characters.

In the present investigation, entitled “Breeding investigations in brinjal (*Solanum melongena* L.)” the crosses *viz.*, AB-09-1 × AB-08-5, AB-09-1 × NSRP-1, AB-09-1 × JBGR-1, AB-09-1 × GJB-3, AB-09-1 × AB-12-10, JBGR-1 × GJB-3, JBGR-1 × JBL-08-8, NSR-1 × GJB-3, NSR-1 × JBL-08-8, GJB-3 × JBL-08-8, and GJB-3 × AB-12-10 as well as parent AB-09-1 recorded the lowest shoot and fruit borer infestation. All the parents (except JBGR-1) and all the crosses (except AB-09-1 × GJB-3, AB-08-5 × GJB-3, NSRP-1 × GJB-3, JBGR-1 × GJB-3 and NSR-1 × GJB-3) recorded the least bacterial wilt infection in field condition.

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CERTIFICATE

This is to certify that the thesis entitled **"BREEDING INVESTIGATIONS IN BRINJAL (*Solanum melongena* L.)"** submitted by **DESAI KARAMASHIBHAI MALAJIBHAI** in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **VEGETABLE SCIENCE** to the Navsari Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place: Navsari **(S. N. Saravaiya)**

Date: 29, April, 2016 **Major Guide**

DECLARATION

This is to declare that the whole of the research work reported in this thesis in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **VEGETABLE SCIENCE** by the undersigned is the result of investigation carried out by me under the direct guidance and supervision of **Dr. S. N. Saravaiya**, Associate Professor, Department of Vegetable Science, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari and that no part of the work has been submitted for any other degree so far.

Place: Navsari **(Desai Karamashibhai. M.)**

Date: 29, April, 2016

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Place: Navsari

Date: 29, April, 2016 **(Desai Karamashibhai M.)**

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LIST OF SYMBOLS AND ABBREVIATIONS

Symbols	
*	Asterisk
:	colon
=	is equal to
-	Minus
×	Multiply
/	Per
%	per cent
+	Plus
±	plus or minus
( )	small Bracket, parentheses
;	semi colon
Abbreviations	
AAU	Anand Agricultural University
ANOVA	Analysis of Variance
a.m.	After Meridian
et al.	And his co-workers
BP	Better Parent
BSFB	Brinjal Shoot and Fruit Borer
C.D.	Critical Difference
C.V.	Co-efficient of Variation
Cm	Centimeter
Contd…	Continued
˚C	Degree Celsius or centigrade
d.f	Degrees of freedom
E.M.S	Error Mean of Square

Contd…

Contd…

F_1	Filial
g	Gram
gca	General Combining Ability
IIHR	Indian Institute of Horticultural Research
IIVR	Indian Institute of Vegetable Research
JAU	Junagadh Agricultural University
Kg	Kilogram
Max.	Maximum
M.S.S.	Mean Sum of Square
M	meter
MP	Middle Parent
Mg	milligram
Min.	Minimum
viz.	Namely
NAU	Navsari Agricultural University
No.	Number
p.m.	Post Meridian
R.B.D.	Randomized Block Design
RHRS	Regional Horticultural Research Station
S.Em.	Standard Error of Mean
SC	Standard Check
sca	Specific Combining Ability
S.S	Sum of Square
t ha^{-1}	tonne per hectare
TSS	Total soluble solids
USA	The United States of America
VRS	Vegetable Research Scheme
vs.	Versus

❖ B. The Text ❖

1. Introduction
2. Review of Literature
3. Materials and Methods
4. Results
5. Discussion
6. Summary and Conclusions

INTRODUCTION

CHAPTER 1
INTRODUCTION

Vegetables occupy an important place in diversification of agriculture and have played a vital role in food and nutritional security of ever-growing population of our large vegetarian society. Among the vegetables, brinjal, a native of India is an important solanaceous vegetable crop in countries, like India, Japan, Indonesia, China, Bulgaria, Italy, France, USA and several African countries. Confirmation of this fact was made by Isshiki *et al.* (1994) based on isozyme and morphological variation noticed in large germplasm collections from India. It shows the secondary diversity in China and South East Asia (Zeven and Zhukovsky, 1975). However, it is widely cultivated in both temperate and tropical regions of the globe, mainly for their immature fruits as vegetable (Rai *et al.*, 1995). It is the fourth most important vegetable crop in India and contributes 8.3 per cent of total production of vegetables in the country. It is known as “Poor man’s Vegetable” because of its low cost of production, ease of culture and availability throughout the year. As fruits are widely used in various culinary preparations *viz.*, sliced bhaji, stuffed, curry, bertha, chutney, vangibath, pickles *etc*. Contrary to the common belief, it is quite high in nutritive value being rich in vitamins and minerals (calcium, magnesium, phosphorus) and fatty acids (Tomar and Kalda, 1996).

India ranks 2nd in area and production as well as 8th in terms of productivity of brinjal at global level after China (Anon., 2014). Total area and production under brinjal in India is 7.11 lakh ha and 135.57 lakh tonne, respectively with an average productivity of 19.06 t ha^{-1}. The area under brinjal in Gujarat is 76 thousand ha and production is 14.77 lakh tonne with an average productivity of 19.43 t ha^{-1}. Gujarat ranks 3rd in area and has 11 % share in production. West Bengal is leading in area and production followed by Odisha. Karnataka has the highest productivity (25.04 t ha^{-1}) followed by Madhya Pradesh (25 t ha^{-1}) and Maharashtra (23 t ha^{-1}).

Looking to the increasing population, there is an urgent need to satisfy the demand. The incidence of hunger (malnutrition) and poverty in the country is stubbornly high and India is way off the *Millennium Development Goal*. Moreover, the country is expected to attain the dubious distinction of being the most populous country in the world by 2020s and its population may stabilize at 1.5 to 1.7 billion by the year 2050- 2070. On the other hand, per capita land and water availability and quality are shrinking whereas additional 7 to 8 million tonnes of food would need to be produced every year towards the year 2020 to maintain even the current level of consumption. There are specific genotypes suited for specific preparations apart from the large genetic variation observed with regards to colour, shape and size of fruits. In addition, variation is also noticed for characters like vegetative growth, maturity and presence or absence of spines on leaves, stem and fruit calyx among the indigenous material. To have such kind of plant profile, we have some different breeding methods. One of such method is exploitation of hybrid vigour through hybridization. However, none of the hybrids exhibited any heterosis. Nagai and Kada (1926) were probably the first to observe hybrid vigour, hoping some commercial acceptance in crosses among some Japanese varieties. Since then many public and private sectors had developed various hybrids in India, but these hybrids lacked regional preferences for colour, shape and presence or absence of spines.

Exploiting hybrid vigour in a single cross hybrid depends on the two parents complementing each other with special reference to desirable characters. However, it is often noticed that all the desirable characters need not to be distributed between only these two parents. Therefore, it might be necessary to involve multiple cross combinations of parents to have wider genetic content and thus broaden the genetic base. This also improves the chances of accumulating maximum number of desirable genes distributed between the parents so that heterosis is envisaged (Sherawath and Rana, 1993; Rao and Gulati, 2002).

Therefore, the exploitation of hybrid vigour in brinjal has been recognized as a practical tool in providing the breeder a means of increasing yield and other economic characters. Most of the local varieties which are grown by farmers in India have not been fully utilized in any genetic improvement programme on scientific line. The development of an effective heterosis breeding programme in brinjal needs to elucidate the genetic nature and magnitude of quantitatively inherited traits and judge the potentiality of parents in hybrid combinations. Combining ability studies like Diallel Analysis provide information in this direction particularly when large numbers of parents are to be screened for combining ability. Study of *gca* of genotypes helps in selection of superior parents while *sca* of genotypes helps in deciding superior hybrid. The information generated in the process is used to understand the magnitude of heterosis of F_1 hybrids.

The low fruit yield levels in India are due to the lack of sufficient crop genetic improvement and development of promising genotypes. Therefore, brinjal needs a constant genetic improvement. Thus, under such circumstances, it is necessary to develop hybrids superior to these types for qualitative and quantitative characters. With keeping this in view, the present investigation entitled "Breeding investigations in brinjal (*Solanum melongena* L.)" was conducted at Regional Horticultural Research Station (RHRS), ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during *rabi* 2015-16 with the following objectives:

(i) To estimate the magnitude of heterosis for fruit yield and its components characters.

(ii) To study the general as well as specific combining ability and variances.

(iii) To identify the good general as well as specific combiners for use in future breeding programme.

REVIEW OF LITERATURE

CHAPTER 2
REVIEW OF LITERATURE

Several studies have been conducted on heterosis breeding in horticultural crops including vegetables. Development of commercial hybrids becomes an important tool in improving the yield and quality of crop plants substantially.

Knowledge of heterosis and combining ability is having vital importance to the plant breeders in the evaluation and selection of variety as well as in formulating the appropriate breeding procedure for crop improvement.

The reports available in literature pertinent to Hybrid performance and heterosis as well as Combining ability and gene action are given as under.

2.1. HYBRID PERFORMANCE AND HETEROSIS

The term heterosis refers to the phenomenon in which the F_1 population obtained by crossing between two genetically dissimilar individuals which may shows increase or decrease in vigour over the better parent (heterobeltiosis) or over the standard check (standard heterosis). Heterosis in desirable direction (hybrid vigour) is the ultimate aim of breeders.

The phenomenon of heterosis of hybrid vigour in plant is well known today and breeders exploit it for higher production. The first positive report of heterosis in the eggplant came from Munson(1892). Subsequently, Halsted(1901) reported that one of his cross was double the size of the parents and also yielded more. 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.

Heterosis for some traits as reported by various scientist is presented in **Table 2.1.**

2.2. COMBINING ABILITY AND GENE EFFECT

The knowledge of combining ability was first proposed by Sprague and Tatum (1942) in corn as a measure of gene action. It not only helps to identify parents and crosses which are likely to give maximum improvement for the characters under consideration, but also provides means of understanding the genetic architecture of metric traits. They coined two terms: General Combining Ability (*gca*) and Specific Combining Ability (*sca*). They defined general combining ability as the average performance of lines in hybrid combination while the term specific combining ability was used to designate deviation of certain combinations from the expectations on the basis of the average performance of the lines involved. 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, *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 and/or cross combination(s).

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

Brief review of work pertaining to combining ability reported by different scientists are presented in **Table 2.2.**

Table 2.1: Review of literature on heterosis for different traits in brinjal.

Sr. No.	Characters	Number of crosses studied	Range of heterosis (%) over			References
			MP (Mid parent)	BP (Better parent)	Commercial check	
1.	**Plant height at harvest (cm)**					
		36 F_1 hybrids	-11.39 to 19.46	-	-	Bulgundi (2000)
		28 F_1 hybrids	-20.93 to 16.25-	-25.55 to 10.95	12.43 to 30.47	Bavage (2002)
		25 F_1 hybrids	59.35 to 28.65	-63.10 to 21.81	-	Singh *et al.* (2004)
		05 F_1 hybrids	4.53 to 27.45	-3.73 to 27.45	32.31 to 57.36	Prabhu *et al.* (2005)
		45 F_1 hybrids	-22.50 to 46.05	-25.90 to 27.01	-25.90 to 12.61	Ajjappalavara (2006)
		24 F_1 hybrids	0.8 to 47.27	-3.94 to 45.27	-4.14 to 25.47	Shafeeq *et al*. (2007)
		47 F_1 hybrids	-28.81 to 22.01	27.59 to 47.27	-10.53 to 32.90	Neelima Joshi *et al.* (2008)
		45 F_1 Hybrids	-	-2.59 to 23.38	-	Suneetha *et al.* (2008)
		45 F_1 hybrids	45.89 to 47.48	40.15 to 45.94	-	Bisht *et al.* (2009)
		24 F_1 hybrids	-	2.12 to 22.36	-16.96 to 1.91	Chowdhury *et al.* (2010)
		30 F_1 hybrids	-	-11.03 to 46.80	-29.43 to 17.55	Sharma (2010)
		36 F_1 hybrids	16.51 to 29.57	8.86 to 22.67	18.77 to 20.31	Bhusan and Singh (2013)
		60 F_1 Hybrids	-	13.40 to 19.10	-1.14 to 20.45	Dudhat *et al.* (2013)
		28 F_1 Hybrids	-	-18.64 to 86.05	-26.15 to 69.74	Leena Biswas *et al.* (2013)
		20 F_1 Hybrids	-122.35 to 42.19	41.84 to 53.82	16.65 to 40.53	Makani *et al.* (2013)
		36 F_1 hybrids	-	-	4.36 to 61.66	Reddy and Patel (2014a)
2.	**Number of branches per plant at harvest**					
		60 F1 hybrids	-16.04 to 37.48	-	-27.88 to 20.0	Patil (1998)

Table 2.1: Review of literature on heterosis for different traits in brinjal.

Sr. No.	Characters	Number of crosses studied	Range of heterosis (%) over			References
			MP (Mid parent)	BP (Better parent)	Commercial check	
		30 F_1 hybrids	-36.75 to -5.25	-	-9.30 to 37.46	Bulgundi (2000)
		28 F_1 hybrids	-35.23 to 76.68	-35.60 to 62.31	-	Bavage (2002)
		36 F_1 hybrids	53.98 to 40.66	-52.75 to 50.68	-	Singh *et al.* (2004)
		05 F_1 hybrids	-2.06 to 55.52	-5.91 to 32.63	26.02 to 82.13	Prabhu *et al.* (2005)
		25 F_1 hybrid	-5.88 to 31.03	-15.79 to 23.44	-18.90 to 0.11	Ajjappalavara (2006)
		24 F_1 hybrids	-29.04 to 26.02	-33.07 to 22.76	-13.07 to 23.07	Shafeeq *et al.* (2007)
		47 F_1 hybrids	-43.75 to 70.00	-43.75 to 142.8	-30.76 to 38.47	Neelima Joshi *et al.* (2008)
		45 F_1 hybrids	53.95 to 58.22	39.44 to 51.34	-	Bisht *et al.* (2009)
		30 F_1 Hybrids	-	-7.59 to 23.53	-3.05 to 28.09	Sharma (2010)
		28 F_1 Hybrids	-	-	-28.0 to 14.02	Nalini Dharwad *et al.* (2011)
		24 F_1 hybrids	18.85 to 55.29	-	26.54 to 27.77	Bhusan and Singh (2013)
		36 F_1 hybrids	-	13.40 to 19.10	17.05 to 25.00	Dudhat *et al.* (2013)
		60 F_1 Hybrids	-	-37.78 to 33.75	-48.89 to 18.89	Leena Biswas *et al.* (2013)
		20 F_1 Hybrids	-	-	-9.00 to 23.74	Reddy and Patel (2014a)
		36 F_1 hybrids	-	1.38 to 52.23	-	VenkataNaresh *et al.* (2014)
3.	**Days to 50 % flowering**					
		60 F_1 hybrids	-37.79 to 43.07	-	-49.14 to 27.43	Patil (1998)
		30 F_1 hybrids	-19.23 to 19.05	-	-13.40 to 13.04	Bulgundi (2000)
		28 F_1 hybrids	-18.00 to 11.81	-	-	Bavage (2002)

Table 2.1: Review of literature on heterosis for different traits in brinjal.

Sr. No.	Characters	Number of crosses studied	Range of heterosis (%) over			References
			MP (Mid parent)	BP (Better parent)	Commercial check	
		30 F_1 Hybrids	-	-26.85 to -19.30	-25.77 to 15.06	Kumar and Pathania (2004)
		25 F_1 hybrids	-19.51 to 9.04	-26.23 to 5.38	-25.00 to 8.88	Ajjappalavara (2006)
		24 F_1 hybrids	-28.08 to 7.78	-19.78 to 10.34	-24.74 to 2.06	Shafeeq *et al.* (2007)
		47 F_1 Hybrids	-32.99 to 31.54	-32.65 to 84.91	-32.65 to 11.23	Neelima Joshi *et al.* (2008)
		15 F_1 Hybrids	-	-27.59 to 1.21	-7.83 to 32.24	Chowdhury *et al.* (2010)
		24 F_1 hybrids	-23.53 to -21.67	-21.43 to -21.39	-23.93 to -23.40	Bhusan and Singh (2013)
		60 F_1 hybrids	-	-9.52 to 38.64	-13.06 to 38.64	Leena Biswas *et al.* (2013)
		28 F_1 Hybrids	-12.59 to -10.27	-9.46 to -9.30	-9.36 to -3.95	Makani *et al.* (2013)
		20 F_1 Hybrids	-	-	-22.51 to 2.09	Reddy and Patel (2014a)
4.	**Fruit length(cm)**					
		30 F_1 hybrids	-18.4 to 36.1	-	-	Bulgundi (2000)
		28 F_1 hybrids	-18.01 to 39.97	-10.59 to 52.24	-24.11 to 31.25	Bavage (2002)
		30 F_1 hybrids	-	54.67 to 116.61	27.16 to 78.09	Kumar and Pathania (2004)
		10 F_1 hybrids	-	-	8.8 to 59.5	Panda *et al.* (2004)
		36 F_1 hybrids	-	-33.38 to 40.50	-37.9 to 41.4	Singh *et al.* (2004)
		25 F_1 hybrids	-24.87 to 29.82	-45.37 to 0.57	-3.45 to 112.07	Ajjappalavara (2006)
		24 F_1 hybrids	16.58 to 33.95	-50.0 to 18.46	-	Shafeeq (2007)
		47 F_1 hybrids	-31.09 to 36.08	-17.57 to 53.33	-33.87 to 51.62	Neelima Joshi *et al.* (2008)
		45 F_1 hybrids	26.13 to 36.92	18.30 to 24.95	-	Bisht *et al.* (2009)

Table 2.1: Review of literature on heterosis for different traits in brinjal.

Sr. No.	Characters	Number of crosses studied	Range of heterosis (%) over			References
			MP (Mid parent)	BP (Better parent)	Commercial check	
		15 F_1 Hybrids	-	-33.97 to 32.35	-7.85 to 93.17	Chowdhury *et al.* (2010)
		30 F_1 Hybrids	-	-42.06 to 71.16	-26.95 to 105.4	Sharma (2010)
		24 F_1 Hybrids	35.97 to 76.80	19.79 to 23.66	22.90 to 73.04	Bhusan and Singh (2013)
		60 F_1 hybrids	-	-69.95 to 27.55	-43.18 to 80.46	Leena Biswas *et al.* (2013)
		28 F_1 Hybrids	10.78 to 21.11	6.25 to 12.11	10.25 to 12.09	Makani *et al.* (2013)
		20 F_1 Hybrids	-	-	4.66 to 69.57	Reddy and Patel (2014a)
		36 F_1 hybrids	-	- 1.94 to 70.57	-	VenkataNaresh *et al.* (2014)
5.	**Fruit diameter (cm)**					
		60 F_1 hybrids	-39.31 to 21.97	-	-	Patil (1998)
		30 F_1 hybrids	-13.13 to 26.02	-	-5.93 to 28.66	Bulgundi (2000)
		28 F_1 hybrids	-14.97 to 23.91	-16.90 to 22.48	-13.14 to 13.58	Bavage (2002)
		30 F_1 hybrids	-	37.67 to 54.62	115.27 to 142.7	Kumar and Pathania (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)
		25 F_1 hybrids	-26.92 to 32.18	-28.89 to 24.03	-45.34 to 9.83	Ajjappalavara (2006)
		47 F_1 hybrids	-54 .15 to 23.68	-36.38 to 70.23	7.85 to 200.42	Neelima Joshi *et al.* (2008)
		45 F_1 hybrids	22.98 to 36.22	17.39 to 33.26	-	Bisht *et al.* (2009)
		30 F_1 Hybrids	-	-48.90 to 4.13	-23.34 to 114.6	Sharma (2010)
		24 F_1 Hybrids	21.83 to 37.19	-	23.67 to 28.34	Bhusan and Singh (2013)

Table 2.1: Review of literature on heterosis for different traits in brinjal.

Sr. No.	Characters	Number of crosses studied	Range of heterosis (%) over			References
			MP (Mid parent)	BP (Better parent)	Commercial check	
		20 F_1 Hybrids	-	-	-13.94 to 30.78	Reddy and Patel (2014a)
		36 F_1 hybrids	-	- 8.0 to 63.27	-	VenkataNaresh *et al.* (2014)
6.	**Average fruit weight(g)**					
		60 F_1 hybrids	-26.50 to 40.77	-	-	Patil (1998)
		30 F_1 hybrids	-13.47 to 60.43	-	-41.50 to 14.07	Bulgundi (2000)
		28 F_1 hybrids	-35.39 to 75.75	-	-19.81 to 88.25	Bavage (2002)
		36 F_1 hybrids	-58.06 to 160.87	-61.54 to 67.44	-	Singh *et al.* (2004)
		5 F_1 hybrids	-7.55 to 27.75	-24.06 to 5.37	-32.79 to -9.55	Prabhu *et al.* (2005)
		26 F_1 hybrids	-	-74.28 to 120.95	-51.43 to 19.04	Ajjappalavara (2006)
		24 F_1 hybrids	-17.18 to 96.31	-20.18 to 69.22	-11.84 to 137.7	Shafeeq *et al.* (2007)
		45 F_1 hybrids	41.69 to 59.36	-3.09 to 91.84	38.01 to 81.73	Bisht *et al.* (2009)
		30 F_1 Hybrids	-	7.98 to 32.24	6.21 to 110.25	Sharma (2010)
		48 F_1 hybrids	-	65.02 to 83.2	-	Sao and Mehta (2010)
		28 F_1 Hybrids	-	-	-22.53 to 30.33	Nalini Dharwad *et al.* (2011)
		60 F_1 hybrids	-	-79.47 to 4.26	-84.47 to -39.87	Leena Biswas *et al.* (2013)
		28 F_1 Hybrids	33.76 to 46.79	32.39 to 46.95	-	Makani *et al.* (2013)
		20 F_1 Hybrids	-	-	-14.29 to 36.69	Reddy and Patel (2014a)

Table 2.1: Review of literature on heterosis for different traits in brinjal.

Sr. No.	Characters	Number of crosses studied	Range of heterosis (%) over			References
			MP (Mid parent)	BP (Better parent)	Commercial check	
7.	**Number of fruit per plant**					
		30 F_1 hybrids	-57.28 to 102.41	-	-46.94 to 87.07	Bulgundi (2000)
		28 F_1 hybrids	-45.16 to 37.41	-50.75 to 15.55	-41.82 to 56.53	Bavage (2002)
		5 F_1 hybrids	-14.84 to 52.82	-15.81 to 42.37	-8.28 to 64.50	Prabhu *et al.* (2005)
		24 F_1 hybrids	-42.18 to 22.91	-43.62 to 4.56	-26.98 to 33.95	Shafeeq *et al.* (2007)
		47 F_1 hybrids	-65.51 to 68.98	-65.51 to 138.0	-70.13 to -28.28	Neelima Joshi *et al.* (2008)
		45 F_1 hybrids	-	-77.19 to 53.03	-	Suneetha *et al.* (2008)
		45 F_1 hybrids	55.78 to 66.08	54.30 to 58.83	63.69 to 65.11	Bisht *et al.* (2009)
		15 F_1 Hybrids	-	-72.81 to 105	-60.97 to 253.6	Chowdhury *et al.* (2010)
		48 F_1 hybrids	-	45.42 to 102.79	-	Sao and Mehta (2010)
		28 F_1 Hybrids	-	-	-30.17 to 26.42	Nalini Dharwad *et al.* (2011)
		24 F_1 Hybrids	23.87 to 29.41	-	-	Bhusan and Singh (2013)
		60 F_1 hybrids	-	-63.33 to 471.41	-9.09 to 845.45	Leena Biswas *et al.* (2013)
		28 F_1 Hybrids	105.88 to 168.45	126.92 to 190.34	-	Makani *et al.* (2013)
		20 F_1 Hybrids	-	-	21.68 to 245.26	Reddy and Patel (2014a)
		36 F_1 hybrids	-	15.39 to 67.0	-	VenkataNaresh *et al.* (2014)
8.	**Fruit yield per plant(kg)**					
		30 F_1 hybrids	-37.81 to 156.58	-	-41.62 to 59.96	Bulgundi (2000)
		28 F_1 hybrids	-50.58 to 64.42	-53.17 to 55.92	-58.94 to 59.74	Bavage (2002)

Table 2.1: Review of literature on heterosis for different traits in brinjal.

Sr. No.	Characters	Number of crosses studied	Range of heterosis (%) over			References
			MP (Mid parent)	BP (Better parent)	Commercial check	
		36 F_1 hybrids	- 72.16 to 333.75	-68.80 to 275.22	-	Singh *et al.* (2004)
		10 F_1 hybrids	-	-	32 to 41.1	Panda *et al.* (2005)
		05 F_1 hybrids	-22.10 to 52.36	-26.80 to 41.33	-10.63 to 51.74	Prabhu *et al.* (2005)
		24 F_1 hybrids	-37.99 to 162.89	-41.94 to 153.01	-46.17 to 75.87	Shafeeq (2007)
		25 F_1 hybrids	-62.44 to 52.44	-66.10 to 38.57	-65.81 to 4.27	Ajjappalavara (2006)
		47 F_1 hybrids	-45.36 to 67.28	-32.34 to 71.15	-32.22 to 100.2	Neelima Joshi *et al.* (2008)
		45 F_1 hybrids	-	-68.07 to 38.77	-	Suneetha *et al.* (2008)
		45 F_1 hybrids	104.45 to 132.34	67.06 to 99.97	-	Bisht *et al.* (2009)
		15 F_1 Hybrids	-	-34.62 to 74.89	-58.06 to 72.60	Chowdhury *et al.* (2010)
		48 F_1 hybrids	-	69.40 to 115.84	-	Sao and Mehta (2010)
		28 F_1 Hybrids	-	-	-33.97 to 31.04	Nalini Dharwad *et al.* (2011)
		36 F_1 Hybrids	-	26.48 to 47.25	13.12 to 27.94	Dudhat *et al.* (2013)
		60 F_1 hybrids	-	-50.24 to 88.18	-51.37 to 46.86	Leena Biswas *et al.* (2013)
		28 F_1 Hybrids	97.63 to 136.39	72.09 to 125.78	42.59 to 50.41	Makani *et al.* (2013)
		20 F_1 Hybrids	-	-	-12.69 to103.59	Reddy and Patel (2014a)
		36 F_1 hybrids	-	14.02 to 122.48	-	VenkataNaresh *et al.* (2014)
9.	**Total Phenol content (mg/100g)**					
		60 F_1 hybrids	20.83 to 23.23	-	-50.00 to 36.32	Patil (1998)
		25 F_1 hybrids	-30.22 to 22.59	-31.14 to 11.37	-29.28 to 15.54	Ajjappalavara (2006)

Table 2.1: **Review of literature on heterosis for different traits in brinjal.**

Sr. No.	Characters	Number of crosses studied	Range of heterosis (%) over			References
			MP (Mid parent)	BP (Better parent)	Commercial check	
		45 F_1 hybrids	-	-75.58 to 326.27	-73.70 to101.13	Suneetha *et al.* (2008)
		28 F_1 Hybrids	-19.38 to -13.64	-24.09 to -18.25	-10.96 to -9.20	Makani *et al.* (2013)
10.	**TSS(%)**					
		45 F_1 hybrids		-99.23 to 1462.4	-98.51 to 132.8	Suneetha *et al.* (2008)
		28 F_1 hybrids	19.86 to 23.48	18.43 to 21.16	02.07	Makani *et al.* (2013)

Table 2.2 Review of literature on gene action governing different traits in brinjal

Sr. No.	Characters	Additive	Non-additive	Additive and non-additive
1	**Plant height at harvest(cm)**	Chezhian *et al.* (2000)	Padmanabham and Jagadish (1996)	Baig and Patil (2002)
		Singh *et al.* (2002)	Singh *et al.* (2003)	Aswani and Khandelwal (2005)
		Singh *et al.* (2002)	Suneetha *et al.* (2005)	Dhameliya and Dobariya (2009)
		Bisht *et al.* (2006)	Ajjappalavara (2006)	Choudhary and Didel (2014)
		Shafeeq (2007)	Kamalakkannan *et al.* (2007)	Rai and Asati (2011)
		Prasad *et al.* (2010)	Nalini Dharwad (2007)	Sane *et al.* (2011)
		Reddy and Patel (2014b)	Ram and Singh (2007)	Patel *et al.* (2013)
			Timmapur (2007)	
			Suneetha *et al.* (2008)	
			Shanmugapriya *et al.* (2009)	
			Sao and Mehta (2010)	
			Ramireddy *et al.* (2011)	
			Shinde *et al.* (2011)	
			Bhusan *et al.* (2012)	
			Singh *et al.* (2013)	
			Tiwari *et al.* (2013)	
			VenkataNaresh *et al.* (2014)	
2	**Number of branches per**	Singh *et al.* (2002)	Singh *et al.* (2003)	Baig and Patil (2002)
		Singh *et al.* (2002)	Panda and Singh (2004)	Dhameliya and Dobariya (2009)

Table 2.2 Contd…

Sr. No.	Characters	Additive	Non-additive	Additive and non-additive
	plant at harvest	Bisht *et al.* (2006) Prasad *et al.* (2010)	Ajjappalavara (2006) Kamalakkannan *et al.* (2007) Nalini Dharwad (2007) Ram and Singh (2007) Shafeeq (2007) Timmapur (2007) Shanmugapriya *et al*. (2009) Sao and Mehta (2010) Nalini Dharwad *et al.* (2011) Ramireddy *et al.* (2011) Shinde *et al.* (2011) Bhusan *et al.* (2012) Singh *et al.* (2013) Tiwari *et al.* (2013) Reddy and Patel (2014b) VenkataNaresh *et al.* (2014)	Rai and Asati (2011) Patel *et al.* (2013) Choudhary and Didel (2014)
3	**Days to 50 % flowering**	Prasad *et al.* (2010)	Rai *et al*. (2005) Ajjappalavara (2006) Nalini Dharwad (2007) Shafeeq (2007) Timmapur (2007)	Baig and Patil (2002) Patel *et al.* (2013)

Table 2.2 Contd…

Sr. No.	Characters	Additive	Non-additive	Additive and non-additive
			Sao and Mehta (2010) Ramireddy *et al.* (2011) Shinde *et al.* (2011) Bhusan *et al.* (2012) Tiwari *et al.* (2013) Reddy and Patel (2014b)	
4	**Fruit length(cm)**	Singh *et al.* (2002) Singh *et al.* (2002) Bisht *et al.* (2006)	Singh *et al.* (2003) Ajjappalavara (2006) Kamalakkannan *et al.* (2007) Nalini Dharwad (2007) Ram and Singh (2007) Shanmugapriya *et al.* (2009) Sao and Mehta (2010) Ramireddy *et al.* (2011) Shinde *et al.* (2011) Bhusan *et al.* (2012) Singh *et al.* (2013) Tiwari *et al.* (2013) VenkataNaresh *et al.* (2014)	Baig and Patil (2002) Aswani and Khandelwal (2005) Dhameliya and Dobariya (2009) Rai and Asati (2011) Patel *et al.* (2013) Choudhary and Didel (2014) Reddy and Patel (2014b)
5	**Fruit diameter (cm)**	Singh *et al.* (2002) Singh *et al.* (2002)	Singh *et al.* (2003) Ajjappalavara (2006)	Patel *et al.* (2013) Choudhary and Didel (2014)

Table 2.2 Contd…

Sr. No.	Characters	Additive	Non-additive	Additive and non-additive
		Panda and Singh (2004) Bisht *et al.* (2006)	Nalini Dharwad (2007) Shafeeq (2007) Timmapur (2007) Sao and Mehta (2010) Ramireddy *et al.* (2011) Shinde *et al.* (2011) Singh *et al.* (2013) Reddy and Patel (2014b) VenkataNaresh *et al.* (2014)	
6	**Average fruit weight(g)**	Chezhian *et al.* (2000) Bisht *et al.* (2006)	Padmanabham and Jagadish (1996) Ajjappalavara (2006) Nalini Dharwad (2007) Shafeeq (2007) Bhakta *et al.* (2009) Sao and Mehta (2010) Nalini Dharwad *et al.* (2011) Bhusan *et al.* (2012) Singh *et al.* (2013) Tiwari *et al.* (2013) VenkataNaresh *et al.* (2014)	Baig and Patil (2002) Aswani and Khandelwal (2005) Rai and Asati (2011) Patel *et al.* (2013) Choudhary and Didel (2014) Reddy and Patel (2014b)

Table 2.2 Contd…

Sr. No.	Characters	Additive	Non-additive	Additive and non-additive
7	**Number of fruits per plant**	Chezhian *et al.* (2000) Singh *et al.* (2002) Singh *et al.* (2002) Panda and Singh (2004) Bisht *et al.* (2006) Kamalakkannan *et al.* (2007) Prasad *et al.* (2010)	Padmanabham and Jagadish (1996) Singh *et al.* (2003) Nalini Dharwad (2007) Ram and Singh (2007) Timmapur (2007) Suneetha *et al.* (2008) Shanmugapriya *et al.* (2009) Sao and Mehta (2010) Nalini Dharwad *et al.* (2011) Ramireddy *et al.* (2011) Shinde *et al.* (2011) Bhusan *et al.* (2012) Singh *et al.* (2013) Tiwari *et al.* (2013) Reddy and Patel (2014b) VenkataNaresh *et al.* (2014)	Aswani and Khandelwal (2005) Dhameliya and Dobariya (2009) Rai and Asati (2011) Sane *et al.* (2011) Patel *et al.* (2013) Choudhary and Didel (2014)
8	**Fruit yield per plant (kg)**	Chezhian *et al.* (2000) Singh *et al.* (2002) Singh *et al.* (2002) Bisht *et al.* (2006)	Padmanabham and Jagadish (1996) Singh *et al.* (2003) Suneetha *et al.* (2005)	Chaudhary and Malhotra (2000) Baig and Patil (2002) Aswani and Khandelwal (2005) Dhameliya and Dobariya (2009)

Table 2.2 Contd…

Sr. No.	Characters	Additive	Non-additive	Additive and non-additive
		Kamalakkannan *et al.* (2007) Prasad *et al.* (2010)	Ajjappalavara (2006) Nalini Dharwad (2007) Ram and Singh (2007) Shafeeq (2007) Timmapur (2007) Shanmugapriya *et al*. (2009) Sao and Mehta (2010) Nalini Dharwad *et al.* (2011) Ramireddy *et al.* (2011) Singh *et al.* (2013) Tiwari *et al.* (2013) Reddy and Patel (2014b) VenkataNaresh *et al.* (2014)	Rai and Asati (2011) Sane *et al*. (2011) Patel *et al.* (2013) Choudhary and Didel (2014)
9	**Total Phenol content (mg/100g)**		Ajjappalavara (2006) Suneetha *et al.* (2008) Bhusan *et al.* (2012)	Chadha and Sharma (1991)
10	**TSS (%)**		Suneetha *et al.* (2005) Ramireddy *et al.* (2011) Bhusan *et al.* (2012)	

2.3 PEST AND DISEASES INCIDENCE

The major constraints in brinjal cultivation are occurrence of shoot and fruit borer, leaf hoppers, bacterial wilt, other insect pests and diseases. The crosses and parents were studied against shoot and fruit borer and bacterial wilt infestation and reviews on same are presented below.

Brinjal shoot and fruit borer

Shoot and fruit borer (*Leucinodes orbonalis* Guen.) is the most destructive pest of brinjal. This is a serious pest and causes heavy losses (52 to 74 %) to brinjal fruits (Gambhiri and Kumar, 1998). The insect starts damaging the plant at early stage and continues t ill the fruiting stage. Its larvae damage the plant by tunneling inside the tender shoots and also bore into the fruits, by there rendering them unfit for human consumption.

Darekar *et al.* (1991) carried out screening experiment by taking nine eggplant cultivars for resistance to fruit and shoot borer under field conditions and noticed that PBR-129-5, Arka Kusumkar and Wild Brinjal were resistant.

Patel *et al*. (1995) screened 28 varieties of brinjal against brinjal shoot and fruit borer and noticed that Pusa Purple Long, Pusa Purple Cluster, Junagadh Long, S-71-5-39-9, S-71, 21-4-22 and Arka Kusumkar were found to be comparatively resistant.

Jat *et al.* (2003) carried out experiment to know the resistance level of brinjal shoot and fruit borer and not iced that, percentage of shoot and fruit borer infestation varied from 3.28 to 12.71 and 18.33 to 46.51, respectively and also reported that, Arka Kusumkar and SM-10 were resistant to fruit borer.

Yadav and Sharma (2005) conducted a field experiment to evaluate eleven varieties of brinjal for their resistance against *Leucinodes orbonalis* Guen. Out of these, Brinjal Green Long, Select ion Puja and Pusa Purple Long were found relatively less susceptible followed by Pusa Hybrid -5, Pusa Krant i, Kokila, Pusa Upkar and Aarti as moderately susceptible.

Bacterial wilt

Bacterial Wilt (*Ralstonia solanacearum* E. F. Smith) disease causes severe problem in brinjal cultivation. The characteristic symptoms of the disease are wilting of the foliage followed by collapse of the entire plant. The wilting is characterized by gradual, sometimes sudden, yellowing, withering and drying of the entire plant or some of its branches.

Based on overall superiority in terms of yield, consumer acceptability and resistance to wilt, two purple fruited hybrids *viz.* , Surya × SM-116 (purple, round to oval) and Arka Keshav × SM-71 (purple, long) were selected and evaluated further for two more seasons. Both the hybrids were resistant to wilt and had a yield potential of 91.31 and 89.07 t/ha respectively (Gopalkrishnan *et al.* , 2000).

Twenty two promising varieties /cultivars of eggplant were screened against bacterial wilt under field condition (sick plots) for two successive years. IHR-12, IHR- 21, IHR-54, BB-44, BB-7, DPL-B-1, SM-6-6 and BB-60-C were highly resistant. Bandhtiware -1, Bandhtiware (local), CHES-243, CHES-249 and DPL-B-3-91-1 were moderately resistant (Fugro, 2001).

Dalal *et al*. (2002) reported that the varieties SM-141, SM-6-6-C, DPL-B-4 and Arka Keshav had shown the least mortality due to bacterial wilt (0.01%) in brinjal.

Manna *et al.* (2003) reported fifty genotypes of aubergine, including promising cultivars, lines and local cultivars were evaluated for resistance to bacterial wilt. Eleven genotypes showed resistance to the disease *viz.* , Makra Round, Singhnath, Makra, Kata Makra, Pusa Anupam, Bhagyamat i, NDBS-26, BB-40, Sada Lamba, Melwanki Local
and Co2.

Hussain *et al.* (2005) found that the accession EG 203 was resistant against the bacterium with the lowest wilt incidence. The accession EG 193 was moderately susceptible. Rest of the accessions was susceptible.

Ajjappalavara (2006) not iced that DWD-1, DWD-2 and DWD-3 were the best desirable combiners for the bacterial wilt incidence.

MATERIALS & METHODS

CHAPTER 3

MATERIALS AND METHODS

The present investigation was carried out at the Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during *Rabi* 2014-15 (crossing programme) and *Rabi* 2015-16 (evaluation programme). Geographically, Navsari is located at 20° 37’ N latitude and 72° 54’E longitude. It has an average elevation of 11.89 m above Mean Sea Level. It has tropical climatic conditions of south Gujarat agro climatic zone – III of Gujarat state. The meteorological observations comprising week wise data on maximum and minimum temperature, relative humidity, wind velocity and rainfall during the crop duration are given in **Appendix-I.**

Materials used and methods employed in the present investigation are presented below:

3.1 EXPERIMENTAL MATERIAL

The experimental material consisted of eight diverse genotypes *viz*., AB-09-1, AB-08-5, NSRP-1, JBGR-1, NSR-1, GJB-3, JBL-08-8 and AB-12-10 were obtained from various SAUs of Gujarat. These eight genotypes were crossed in all possible combinations excluding reciprocals to get 28 F_1s. These 28 F_1s, 8 parents and a commercial check (Surati Ravaiya) composed the material for the present investigation on heterosis and combining ability (Plate 1).

PLATE 1: General view of experimental plot

The source of material and their important features are given in below **Table : 3.1**

Table : 3.1 Source of material and important features.

Sr. No.	Genotype	Source	Features
1.	AB-09-1	AAU, Anand.	• Semi erect plant with more branching • Fruits are solitary or cluster, medium, round, purple black in colour.
2.	AB-08-5	AAU, Anand.	• Semi erect plant • profuse branching • Prolific bearer, fruits bear in clusters • Medium and oblong fruit with shiny purple to light black in colour
3.	NSRP-1	VRS, RHRS, NAU, Navsari.	• Spreading type with more branches • Fruits are solitary or cluster, medium, round, shiny purple in colour.
4.	JBGR-1	JAU, Junagadh.	• Semi erect plant type • Fruits are solitary, large, round, greenish white in colour.
5.	NSR-1	VRS, RHRS, NAU, Navsari.	• Spreading type with more branches • Fruits are solitary or cluster, medium and round in size.
6.	GJB-3	JAU, Junagadh.	• Semi spreading type medium size plant • Fruit pulp is creamy white with less seed.
7.	JBL-08-8	JAU, Junagadh.	• Short statured with less branches • Leaves are thick • Late bearer, fruits are solitary, round to oblong with light green colour.

8.	AB-12-10	AAU, Anand.	• Semi erect plant with more branching • Fruits are oblong with purple to light black colour.

3.2 CROSSING PROGRAMME

A set of 8 × 8 diallel crosses, excluding reciprocals was attempted during *Rabi* 2014-15 (crossing programme) and *Rabi* 2015-16 (evaluation programme) at Vegetable Research Scheme, Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari. In order to obtain hybrid seed in each cross; emasculation was done during 5 to 7 pm a day before pollination. Buds were selected just to open in the next morning for emasculation. All the anthers were removed from the flower buds with the help of forceps and covered with butter paper bags. In the next morning pollens collected from desired male parents were dusted on emasculated buds for the purpose of pollination. Pollinated buds were again covered with butter paper bags to avoid contamination. In male parents wire rings were kept on the buds to keep them unopened. Pollens of these buds were used to pollinate desired emasculated flowers. Crossed seeds and selfed seeds of parents were harvested separately.

3.3 EXPERIMENTAL DESIGN AND CROP HUSBANDRY

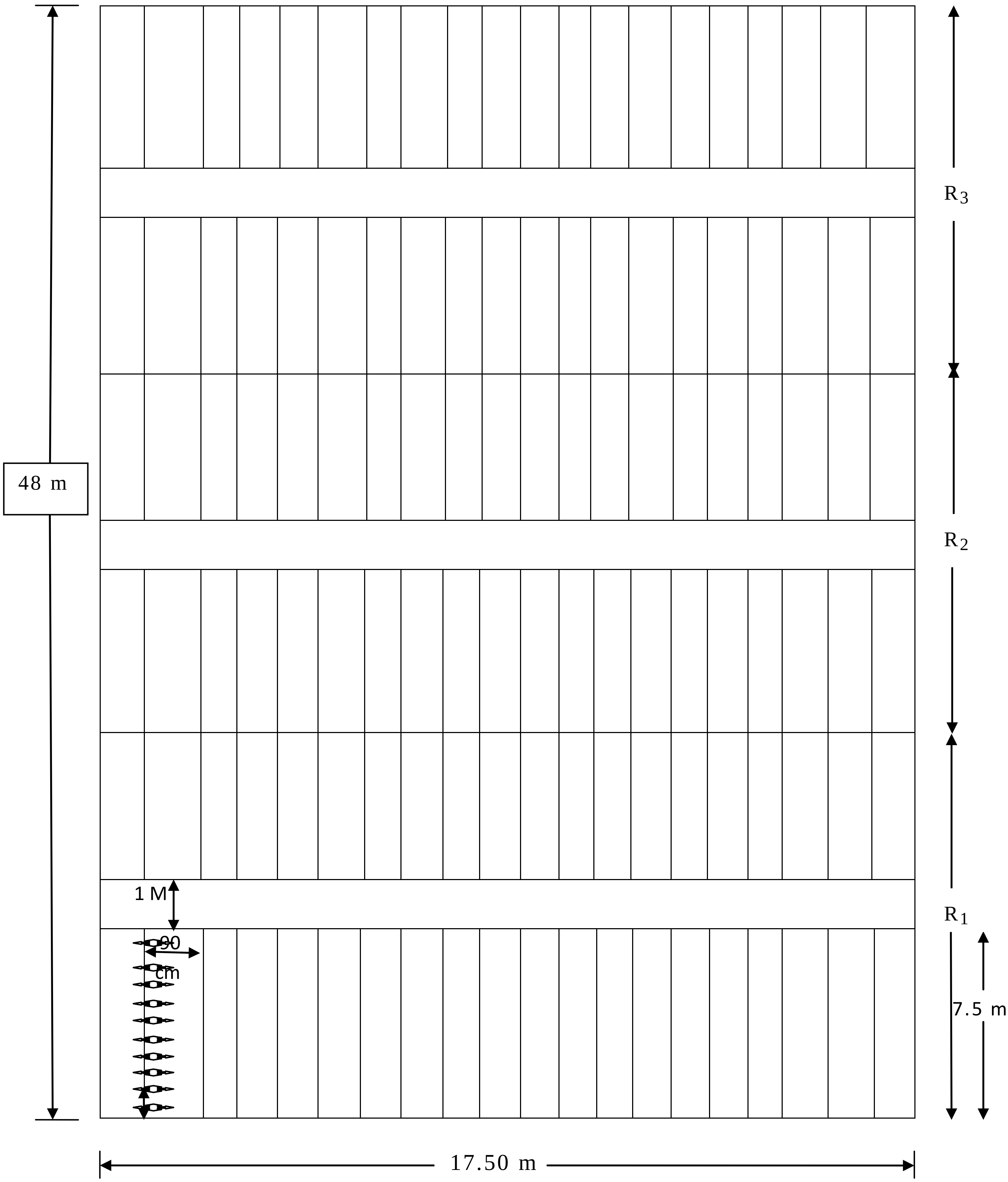
The 37 entries, comprising of eight parents, their 28 F_1s excluding reciprocals and a commercial check **(Table : 3.2)** were transplanted in a Randomized Block Design with three replications at Vegetable Research Scheme, Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during

Rabi 2014-15 (crossing) and *Rabi* 2015-16 (evaluation). Each entry was represented by a single row of 7.5 m length. Row to row and plant to plant distance was 90 cm and 75 cm, respectively. **(Figure : 1)**. The guard rows were provided surrounding the experiment to avoid border effects. All the recommended agronomical practices and plant protection measures were carried out periodically for raising a good crop.

Table : 3.2 List of cross combinations.

Sr. No	Parents	Cross combinations
1.	AB-09-1	AB-09-1 × AB-08-5
2.		AB-09-1 × NSRP-1
3.		AB-09-1 × JBGR-1
4.		AB-09-1 × NSR-1
5.		AB-09-1 × GJB-3
6.		AB-09-1 × JBL-08-8
7.		AB-09-1 × AB-12-10
8.	AB-08-5	AB-08-5 × NSRP-1
9.		AB-08-5 × JBGR-1
10.		AB-08-5 × NSR-1
11.		AB-08-5 × GJB-3
12.		AB-08-5 × JBL-08-8
13.		AB-08-5 × AB-12-10
14.	NSRP-1	NSRP-1 × JBGR-1
15.		NSRP-1 × NSR-1
16.		NSRP-1 × GJB-3
17.		NSRP-1 × JBL-08-8
18.		NSRP-1 × AB-12-10
19.	JBGR-1	JBGR-1 × NSR-1
20.		JBGR-1 × GJB-3
21.		JBGR-1 × JBL-08-8
22.		JBGR-1 × AB-12-10
23.	NSR-1	NSR-1 × GJB-3
24.		NSR-1 × JBL-08-8
25.		NSR-1 × AB-12-10
26.	GJB-3	GJB-3 × JBL-08-8
27.		GJB-3 × AB-12-10
28.	JBL-08-8	JBL-08-8 × AB-12-10

Figure : 1. Plan of Layout.



TOTAL AREA : 840 m^2 (17.50 m X 48 m)

R X R : 90 cm AND P X P : 75 cm

3.4 TRAITS RECORDED

The observations were recorded for twelve traits. Five plants from each entry per replication were selected randomly in the beginning and targeted for recording the field observations. The techniques for recording observations for various traits are described below.

1. Days to fifty per cent flowering :

Number of days taken from transplanting to first flowering in 50 per cent of plants in an entry was noted and averaged.

2. Plant height at harvest (cm) :

The height of plant was recorded in centimeters from ground surface to the tip of main shoot at the last picking of mature fruit.

3. Number of branches per plant at harvest :

Total number of branches per plant was counted at the final fruit harvesting stage and average was calculated.

4. Fruit length (cm):

Fruit length was measured in centimeters from the base of calyx to the tip of the fruit. For recording this observation five marketable fruits were selected randomly from each entry and the mean was worked out.

5. Fruit diameter (cm) :

Fruits selected from five plants for the fruit length were also used to note the diameter of the fruit in centimeters at widest point by using vernier caliper and the mean was computed.

PLATE 2: Biochemical analysis of brinjal fruit

6. Average fruit weight (g) :

Fresh and marketable fruits were selected from the randomly selected five plants at peak fruiting stage and average fruit weight was recorded in gram (g) and mean was computed.

7. Number of fruits per plant :

The marketable fruits harvested from each tagged plant over the different pickings during cropping season were recorded and mean was computed.

8. Fruit yield per plant (kg) :

Weight of the marketable fruits from different pickings from each of five labeled plants in each entry was calculated and expressed in kilogram.

9. Total phenol content (mg/100g) :

Total phenol content of five different fruits from each entry was analyzed in laboratory and recorded in percentage (Plate 2).

10. Total Soluble Solids (%) :

TSS of five randomly selected fruits was measured by Hand Refractometer in the laboratory and recorded in percentage.

11. Infestation of key pest : brinjal shoot and fruit borer :

The no. of plant infested by BSFB and infected by bacterial wilt disease were calculated and analyzed in *per cent.*

a) Per cent shoot damage.

Number of shoots bored by BSFB showing the symptoms of drying the tip of shoots (dead heart) were counted in 10 plants at 30 and 60 days after transplanting. The total of these two reading was computed.

$$\text{Per cent shoot damage} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots}} \times 100$$

b) Per cent fruit damage.

The number of damaged fruits was recorded from the first three harvests and mean per cent infested fruits per plant was worked out with the help of following formula.

$$\text{per cent fruit damage} = \frac{\text{Number of infested fruits}}{\text{Total number of marketable fruits}} \times 100$$

The degree of resistance or susceptibility was noted by using following scale given by Lal *et al.* (1976).

Per cent borer infestation (Scale)	**Reaction**
0	Immune
1-10	Highly resistant (HR)
11-20	Moderately resistant (MR)
21-30	Tolerant (T)
31-40	Susceptible (S)
Above 41	Highly susceptible

12. Infection of Bacterial wilt disease :

At final harvest stage, number of plants wilted in each treatment plot was counted and expressed in percentage by using the following formula.

$$\text{Wilt infection (\%)} = \frac{\text{Number of plants wilted}}{\text{Total number of plants}} \times 100$$

The degree of resistance or susceptibility was noted by using following scale given by Mew and Ho (1976).

Per cent wilted plants (Scale)	Disease reaction
0-4	Highly resistant (HR)
5-10	Resistant (R)
11-20	Moderately resistant (MR)
21-40	Moderately susceptible (MS)
41-70	Susceptible (S)
71-100	Highly susceptible (HS)

3.5 STATISTICAL ANALYSIS

The replication wise mean values of each genotype for various traits were analyzed using Randomized Block Design as suggested by Panse and Sukhatme (1967). The mean values for parental lines and F_1s of all the traits studied were used for statistical analysis on following aspects:

3.5.1. Analysis of variance for experimental design

3.5.2. Estimation of heterosis

3.5.3. Combining ability analysis

3.5.4.

3.5.1 Analysis of variance for experimental design

The averaged mean values were subjected to statistical analysis to test the significance of variation for the experiment design by using following model of Panse and Sukhatme (1978).

$$Y_{ij} = \mu + g_i + r_j + eij$$

Where,

i	=	1, 2,…,g
j	=	1, 2,…,r
Y_{ij}	=	Mean performance of i^{th} genotype in j^{th} replication
μ	=	General mean
g_i	=	Effect of i^{th} genotype
r_j	=	Effect of j^{th} replication
e_{ij}	=	Experimental error associated with i^{th} genotypes in j^{th} replication.

The analysis of variance and expectations of mean squares are given in **Table 3.3**

Table 3.3. Analysis of variance for experimental design

Source	d.f.	M.S.S.	E.M.S.	F
Replications	(r-1)	M_r	$\sigma^2_e + g\sigma^2 r$	M_r/M_e
Genotypes	(g-1)	M_g	$\sigma^2_e + r\sigma^2 g$	M_g/M_e
Parents	(p-1)	M_p	$\sigma^2_e + r\sigma^2 p$	M_p/M_e
Hybrids	(h-1)	M_h	$\sigma^2_e + r\sigma^2 h$	M_h/M_e
Parents vs. Hybrid	1	M_{ph}	$\sigma^2_e + r\sigma^2 ph$	M_{ph}/M_e
Error	(r-1)(g-1)	M_e	σ^2_e	-

Where,

r	=	Number of replications
g	=	Number of genotypes (Parents + Hybrids)
p	=	Number of parents
h	=	Number of hybrids

For comparing mean squares, standard error of mean (S.Em.) was computed as under:

$$S.Em. = (M_e/r)^{0.5}$$

Where,

M_e = Error mean square

r = Number of replications

Critical difference (C.D.) for comparing any two genotypic means was estimated as follows.

C.D. at 5 % and 1 % = S.Em. x $(2)^{0.5}$ x't' at error d.f. at P = 0.05 and P = 0.01 level of significance.

3.5.2 Estimation of heterosis :

The formulae used in estimation of heterosis over better parent (Fonseca and Patterson, 1968) and heterosis over standard check (Meredith and Bridge, 1972) are as under.

Per cent heterosis over better parent (BP) (Heterobeltiosis) $= \dfrac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$

Per cent heterosis over standard Check (Standard heterosis) $= \dfrac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$

Where,

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

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

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

Standard errors and critical differences for heterosis, heterobeltiosis and standard heterosis were calculated by using following formulae.

S.E. (B.P.) = $(2\ M_e/r)^{0.5}$

C.D. (B.P.) = S.E. $_{(BP)}$ x table $t_{0.05}$ and $t_{0.01}$ at error d.f.

S.E. (S.C.) = $(2\ M_e/r)^{0.5}$

C.D. (S.C.) = S.E. $_{(SC)}$ x table $t_{0.05}$ and $t_{0.01}$ at error d.f.

Where,

r = Number of replications

M_e = Error mean square

t = Table value of 't' at error degree of freedom corresponding to 5 per cent and 1 per cent level of significance

Alternatively, significance of heterosis value was tested using ‘t’ test.

$$t = \frac{\overline{F_1} - \overline{BP} \text{ or } \overline{SC}}{\text{S.E. of heterosis over MP or BP or SC}}$$

Calculated ‘t’ values were compared with table‘t’ values at error degree of freedom for test of significance.

3.5.3 Combining ability analysis

Mean value of 36 entries (parents and hybrids) were entered in computer and combining ability analysis was carried out according to the procedure given by Griffing (1956) as per Method 2 (in which parents and a set of F_1s without reciprocals are included) and Model I [which assumes that the genotypes and block effects are constant (fixed) but environmental effect is variable].

3.5.3.1 Analysis of variance:

The analysis of variance for combining ability based on the following linear mathematical model:

$$Y_{ijk} = \mu + g_i + g_j + s_{ij} + \frac{1}{bc} \sum_{k} \sum_{l} e_{ijk}$$

c = 1, 2 ... (number of plants)

Where,

Y_{ijk}	=	Performance of y_{ij}^{th} genotypes in k^{th} replication
i,j	=	1,2,3,...,p (Number of parents)
K	=	1,2,3,...,b (Number of replications)
μ	=	Population mean
g_i	=	*gca* effect of i^{th} parent
g_j	=	*gca* effect of j^{th} parent
s_{ij}	=	*sca* effect of the hybrid between i^{th} and j^{th} parent
e_{ijk}	=	Environmental effect pertaining to ijk^{th} observations
P	=	Number of parents
B	=	Number of blocks

Restriction was imposed on the utility of this model was:

$$\sum_{i} g_i = 0 \text{ and } \sum_{j} s_{ij} + s_{ii} = 0 \text{ (for each i)}$$

Based on this model, the analysis of variance for combining ability was as follows:

Table 3.4: Analysis of variance for combining ability

Source	d.f.	S.S.	M.S.S.	E.M.S.
GCA	(p-1)	SSg	Mg	$\sigma^2 e + (p+2) \frac{1}{(p-1)} \sum_i g_i^2$
SCA	$\frac{p(p-1)}{2}$	SSs	Ms	$\sigma^2 e + \frac{2}{p(p-1)} \sum \sum_{i \le j} S^2_{ij}$
Error	(r-1)(g-1)	SSe	Me'	$\sigma^2 e$

Sum of squares (SSg) for general combining ability effects were calculated as:

$$Sg = \frac{1}{p+2} \sum_{i=1}^{p} (X_i . + X_{ii})^2 - \frac{4}{p} X..^2$$

Sum of squares due to *sca* effects (SSs) were estimated as:

$$Ss = \sum_{i \le j} \sum X^2_{ij} - \frac{1}{p+2} \sum_i (Xi . + X_{ii})^2 + \frac{2}{(p+1)(p+2)} X..^2$$

Where,

P = Number of parents

$X_i.$ = Array total involving 'i' as recurrent parent

X_{ii} = Mean value of i^{th} parent

X.. = Grand total of 'p' parents and p(p-1)/2, F_1's

X_{ij} = Mean value of ij^{th} cross, such that 'i' is equal to or greater than 'j'

Me' = Error mean square (Me/r)

For "F" test, each of the mean squares were tested against Me'.

3.5.3.2 Estimation of genetic components of variance :

Griffing (1956) suggested techniques for the estimation of second degree heredity parameters. Variance due to *gca* effects and *sca* effects were made free from environmental variation. This was done by using following equations:

Estimation of genetic components of variance:

$$\hat{g}^2 i = (Mg - Me') / p + 2$$

$$\hat{S}^2 ij^2 = (Ms - Me')$$

Where,

Mg = Mean squares due to *gca*

Ms = Mean squares due to *sca*

p = Number of parents

The relative importance of general and specific combining ability variance was assessed by the ratio:

$$(\sum_i g_i^2) / (\sum_{i \leq j} s^2_{ij})$$

Estimates of general and specific combining ability were calculated for only those traits where variances due to general combining ability or specific combining ability were significant.

3.5.3.3 Estimation of *gca* and *sca* effects:

gca effect $\hat{g}_i$ of ith parent was estimated as :

$$g_i = \frac{1}{(p+2)} \left[\sum (X_{i.} + X_{ii}) \right] - \frac{2}{P} X_{..}$$

sca effect of ijth cross was calculated as :

$$s_{ij} = X_{ij} - \frac{1}{(p+2)} \left[X_{i.} + X_{ii} + X_{.j} + X_{j} + \right] - \frac{2}{(p+1)\ (p+2)} X_{..}$$

Where,

$X_i + X_{ii}$	=	Total of ith array + mean value of parent i
$X_j + X_{jj}$	=	Total of jth array + mean value of parent j
p	=	Number of parents
g_i	=	*gca* effect of ith parent
s_{ij}	=	*sca* effect of the i x jth cross
$x_{i.}$	=	Total of ith array
$x_{.j}$	=	Total of jth array
x_{ii}	=	Mean value of ith parent
xjj	=	Mean value of jth parent
X..	=	Grand total of parents and F1's

3.5.3.4 Standard errors of the estimates:

To test significance of various *gca* and *sca* effects, standard errors were obtained as:

$$\text{S.E.} (\hat{g}_i) = [(p-1)\ \sigma^2 e / p\ (p+2)]^{0.5}$$

to test individual *gca* effects

$$\text{S.E.} (\hat{s}_{ij}) = [(p^2 + p + 2)\ \ \sigma^2 e / (p+1)\ \ (p+2)]^{0.5}$$

to test individual *sca* effects

$$\text{S.E.} (\hat{g}_i - \hat{g}_j) = [2\ \ \sigma^2 e / (p+2)]^{0.5}$$

to test difference between two *gca* effect

$$S.E. (\hat{S}_{ij} - \hat{S}_{ik}) = [2 (p+1) \sigma^2 e / (p+2)]^{0.5}$$

to test the difference between *sca*'s of two crosses having 'i' as a common parent

$$S.E. (\hat{S}_{ij} - \hat{S}_{kl}) = [2 p \sigma^2 e / (p+2)]^{0.5}$$

to test the *sca* of any two crosses having no parent in common

Where,

p = Number of parents

$\sigma^2 e$ = Error m.s. (Me')

Each of the *gca* and *sca* effects were subjected to "t" test for significance.

For 't' test of *gca* ;

$$t = (g_i - 0) / S.E. (g_i)$$

and for 't' test of *sca* ;

$$t = (sij - 0) / S.E. (s_{ij})$$

Since error degree of freedom are greater than 30, the value of calculated 't' is regarded as significant, if it exceeds 1.96 and 2.58 at 5 per cent and 1 per cent levels, respectively.

Alternatively *gca* and *sca* effects were compared with critical difference calculated by following formule :

$$C. D._{(gi)} = \hat{S}.E._{(gi)} \text{ x table } t_{0.05} \text{ and } t_{0.01}$$

$$C. D._{(sij)} = \hat{S}.E._{(sij)} \text{ x table } t_{0.05} \text{ and } t_{0.01}$$

RESULTS

CHAPTER 4

RESULTS

The experimental results obtained for the present investigation entitled "Breeding investigations in Brinjal (*Solanum melongena* L.)" was carried out by using diallel analysis excluding reciprocals, for the study of different traits are presented in this chapter under following heads:

4.1. Analysis of variance for experimental design

4.2. Mean performance of parents and their hybrids

4.2.1. Days to fifty per cent flowering

4.2.2. Plant height at harvest (cm)

4.2.3. Number of branches per plant at harvest

4.2.4. Fruit length (cm)

4.2.5. Fruit diameter (cm)

4.2.6. Average fruit weight (g)

4.2.7. Number of fruits per plant

4.2.8. Fruit yield per plant (kg)

4.2.9. Total phenol content (mg/100g)

4.2.10. Total soluble solids (%)

4.3. Magnitude of heterosis

4.3.1. Days to fifty per cent flowering

4.3.2. Plant height at harvest (cm)

4.3.3. Number of branches per plant at harvest

4.3.4. Fruit length (cm)

4.3.5. Fruit diameter (cm)

4.3.6. Average fruit weight (g)

4.3.7. Number of fruits per plant

field condition

4.5.2. Screening against fruit borer infestation in field condition

4.5.3. Screening for resistance against bacterial wilt in field condition

4.1. Analysis of variance for experimental design

The mean square due to genotype, parents, hybrids and parents v/s hybrids was carried out to test the differences among parents and hybrids for eleven different traits. Data for mean squares are presented in **Table 4.1** and **Table 4.2.** The genotype showed highly significant differences for all characters studied except plant height at harvest, indicates the sufficient amount of variability among them. The mean squares due to hybrids showed highly significant differences for all the characters indicating significant differences among hybrids. Parents v/s. hybrid showed significant differences for total phenol content and Total Soluble Solids, which indicated that heterosis was related in hybrids.

Table 4.1: Analysis of variance for parents and hybrids in respect of different characters in brinjal.

Sr. No.	Source of Variations	df	Days to 50 % flowering	Plant height at harvest (cm)	Number of branches per plant at harvest	Fruit length (cm)	Fruit diameter (cm)
1	Replicates	2	12.90	14.49	0.11	0.10	0.84
2	Treatments	35	90.89**	89.26	3.32**	4.12**	1.65**
3	Parents	7	64.90	66.22	2.60**	3.54**	3.83**
4	Hybrids	27	100.70**	98.36*	3.62**	4.42**	1.11**
5	Parent v/s. Hybrids	1	7.76	4.74	0.04	0.06	1.00
6	Error	70	45.46	56.23	0.04	0.66	0.35
7	Total	107	59.70	66.26	1.31	1.78	0.79

** Significant at 1% level, * Significant at 5% level

Table 4.2: Analysis of variance for parents and hybrids in respect of different characters in brinjal.

Sr. No.	Source of Variations	Df	Average fruit weight (g)	Number of fruits per plant	Fruit yield per plant (kg)	Total phenol content (mg/100g)	Total Soluble Solids (%)
1	Replicates	2	4.66	0.51	0.01	0.017**	0.18**
2	Treatments	35	452.75**	12.56**	0.49**	0.016**	1.69**
3	Parents	7	355.10**	9.51*	0.43**	0.015**	1.36**
4	Hybrids	27	494.70**	13.79**	0.57**	0.017**	1.84**
5	Parent v/s. Hybrids	1	3.60	0.85	0.05	0.002*	0.01*
6	Error	70	81.70	3.95	0.07	0.0007	0.001
7	Total	107	201.63	6.70	0.17	0.006	0.56

** Significant at 1% level, * Significant at 5% level

4.2. Mean performance of parents and their hybrids

The characteraise mean performance of eight parents and its resultant 28 crosses are presented in Appendix-II.

4.2.1. Days to fifty per cent flowering

The mean days to fifty per cent flowering was observed from 69 days (JBGR-1) to 81.66 days (NSRP-1) among the parents while it was from 64.66 days (AB-09-1 × AB-12-10) to 86 days (AB-08-5 × GJB-3) in hybrids.

Average of days to fifty per cent flowering among parents was 74.81 days, while among hybrids it was 74.37 days. Hybrid AB-09-1 × AB-12-10 (64.66) was the earliest for days to fifty per cent flowering followed by GJB-3 × AB-12-10 (67.33).

4.2.2. Plant height at harvest (cm)

Among parents, the parental mean for plant height was ranged from 92.50 cm (AB-08-5) to 105.80 cm (AB-12-10) while for hybrids it was from 86.92 cm (AB-09-1 × AB-12-10) to 108.48 cm (AB-08-5 × GJB-3).

Average of plant height among parents was 100 cm, while among hybrids it was 99.50 cm. Hybrid AB-09-1 × AB-12-10 (86.92 cm) was the dwarfest followed by AB-09-1 × AB-08-5 (92.23 cm).

4.2.3. Number of branches per plant at harvest

The mean performance for no. of primary branches for parents ranged from 6.95 (AB-12-10) to 9.22 (AB-08-5) while hybrids laid between 6.02 (AB-08-5 × GJB-3) to 10.33 (AB-09-1 × AB-12-10)

Average of no. of primary branches among parents was 7.74, while among hybrids it was 7.78. Hybrid AB-09-1 × AB-12-10 (10.33) was significantly better performer for this trait. It was followed by AB-09-1 × AB-08-5 (9.57).

4.2.4. Fruit length (cm)

The minimum and the maximum fruit length among parents were observed from 10.21 cm (AB-09-1) to 13.43 cm (JBL-08-8), respectively while it was 9.85 cm (AB-08-5 × GJB-3) to 14.66 cm (AB-09-1 × AB-12-10) among the hybrids.

Average of fruit length among parents was 11.75 cm, while among hybrids it was 11.80 cm. Hybrid AB-09-1 × AB-12-10 (14.66 cm) was significantly better performer for this trait. It was followed by AB-09-1 × AB-08-5 (13.82 cm).

4.2.5. Fruit diameter (cm)

The minimum and the maximum fruit diameter range in parents was 3.23 cm (AB-08-5) to 6.79 cm (JBGR-1), respectively while it was 4.75 cm (AB-08-5 × GJB-3) to 7.03 cm (AB-09-1 × AB-12-10) among the hybrids.

Average of fruit diameter among parents was 5.89 cm, while among hybrids it was 6.12 cm. Hybrid AB-09-1 × AB-12-10 (7.03 cm) was better performer for this trait. It was followed by AB-09-1 × AB-08-5 (6.89 cm).

4.2.6. Average fruit weight (g)

The mean value for average fruit weight was noticed from 81.13 g (NSRP-1) to 112.30 g (JBGR-1), among the parents. It ranged from 74.86 g (AB-09-1 × NSR-1) to 125.18 g (AB-09-1 × AB-12-10) among the hybrids.

Average of fruit weight among parents was 95.01 g, while among hybrids it was 95.45 g. Hybrid AB-09-1 × AB-12-10 (125.18 g) produced heaviest fruit followed by AB-09-1 × AB-08-5 (116.37 g).

4.2.7. Number of fruits per plant

The number of fruits per plant in parents ranged between 13.81 (NSRP-1) to 19.34 (JBGR-1). In hybrids, it varied from 13.10 (AB-09-1 × NSR-1) to 21.48 (AB-09-1 × AB-12-10).

Average of no. of fruits per plant among parents was 16.28, while among hybrids it was 16.50. Hybrid AB-09-1 × AB-12-10 (21.48) produced highest no. of fruits followed by AB-09-1 × AB-08-5 (20.01).

4.2.8. Fruit yield per plant (kg)

The mean yield performance of parents ranged between 1.30 kg (NSRP-1) to 2.20 kg (JBGR-1) among the parents. While it was from 1.10 kg (GJB-3 × JBL-08-8) to 2.80 kg (AB-09-1 × AB-12-10) among the hybrids.

Average of yield per plant among parent was 1.65 Kg, while among hybrids it was 1.66 kg. Hybrid AB-09-1 × AB-12-10 (2.80 kg) was the best productive followed by AB-09-1 × AB-08-5 (2.40 kg).

4.2.9. Total phenol content (mg/100g)

The minimum and maximum phenol content of parents were notice 0.73 mg/100g (GJB-3) and 0.93 mg/100g (AB-08-5) respectively and for hybrid it was noticed from 0.69 mg/100g (AB-08-5 x GJB-3) to 1.01 mg/100g (AB-09-1 × AB-12-10).

Average of total phenol content among parents was 0.85 mg/100g, while among hybrids it was 0.86 mg/100g. AB-09-1 × AB-12-10 (1.01 mg/100g) was significantly superior followed by AB-09-1 × AB-08-5 (0.99 mg/100g).

4.2.10. Total Soluble Solids (%)

The mean range for TSS varies 2.33 % (NSRP-1) to 4.10 % (JBGR-1) among the parents while it was from 2.03 % (AB-08-5 × GJB-3) to 4.89 % (AB-09-1 × AB-12-10) among the hybrids.

Average of TSS among parents was 3.25, while among hybrids it was 3.26. Hybrid AB-09-1 × AB-12-10 (4.89 %) was significantly better performer for this trait. It was followed by AB-09-1 × AB-08-5 (4.47 %).

4.3. Magnitude of heterosis

The estimation of heterosis of 28 crosses over better parents and standard check (Surati Ravaiya) for 10 characters are presented in **Table 4.3, Table 4.4** and **Table 4.5.**

4.3.1. Days to 50% flowering

Heterobeltiosis varied from -18.76% (AB-08-5 × GJB-3) to 17.10% (GJB-3 × JBL-08-8) while standard heterosis varied from -12.82% (AB-08-5 × GJB-3) to 16.03% (AB-09-1 × NSR-1). Among the 28 hybrids, two hybrids AB-08-5 × GJB-3 (-18.76%) and NSR-1 × AB-12-10 (-14.17) registered significant negative heterobeltiosis while not a single hybrid registered significant negative standard heterosis.

4.3.2. Plant height at harvest (cm)

For this traits, negative heterosis is desirable.

Heterobeltiosis for hybrids ranged from -16.31% (AB-09-1 × AB-12-10) to 12.22% (AB-09-1 × NSR-1), while standard heterosis for hybrid ranged from -13.39% (AB-09-1 × AB-12-10) to 8.1% (AB-08-5 × GJB-3). Among all, only three hybrids AB-09-1 × AB-12-10 (-16.31%), AB-09-1 × AB-08-5 (-13.12%) and AB-08-5 × JBL-08-8 (-12.84%) registered significant negative heterobeltiosis while one hybrid AB-09-1 × AB-12-10 (-13.39%) registered standard heterosis.

4.3.3. Number of branches per plant at harvest

Heterobeltiosis varied -34.66% (AB-08-5 × GJB3) to 37.44% (AB-09-1 × AB-12-10) while standard heterosis varied from -21.22% (AB-08-5 × GJB3) to 34.99% (AB-09-1 × AB-12-10). Among all the 28 hybrids, sixteen hybrids registered significant negative heterobeltiosis while five hybrid registered significant negative heterosis for standard heterosis.

The hybrids which showed higher heterobeltiosis for number of branches per plant at harvest were AB-09-1 × AB-12-10 (37.44%), AB-09-1 × AB-08-5 (27.42%) and AB-09-1 × NSRP-1 (13.58%), while hybrids for standard heterosis are AB-09-1 × AB-12-10 (34.99%), AB-09-1 × AB-08-5 (25.14%) and AB-08-5 × JBL-08-8 (19.91%).

4.3.4. Fruit length (cm)

Better parent and standard heterosis ranged from -25.55% (AB-09-1 × JBL-08-8) to 26.49% (AB-09-1 × AB-08-5) and -15.60% (AB-08-5 × GJB3) to 25.66% (AB-09-1 × AB-12-10), respectively. Two hybrids AB-09-1 × AB-08-5 (26.49%) and AB-09-1 × AB-12-10 (16.13%) registered significant positive heterobeltiosis and five AB-09-1 × AB-12-

10 (25.66%), AB-09-1 × AB-08-5 (18.43%), AB-08-5 × JBL-08-8 (14.66%), JBGR-1 × NSR-1 (12.97%) and GJB-3 × AB-12-10 (12.71%) registered standard heterosis.

4.3.5. Fruit diameter (cm)

Heterosis range varied from -20.98% (AB-08-5 × GJB3) to 22.40% (NSR-1 × GJB-3) and -26.96% (AB-08-5 × GJB3) to 8.26% (AB-09-1 × AB-12-10) in heterobeltiosis and standard heterosis, respectively. Six hybrids registered significant heterobeltiosis while ten hybrids manifested significant standard heterosis.

Best top three hybrids for heterobeltiosis were NSR-1 × GJB-3 (22.40%), AB-09-1 × AB-08-5 (10.01%) and AB-09-1 × AB-12-10 (8.21%), while for standard heterosis were AB-09-1 × AB-12-10 (8.26%), AB-09-1 × AB-08-5 (6.00%) and AB-08-5 × JBL-08-8 (5.49%).

4.3.6. Average fruit weight (g)

For this trait, heterobeltiosis ranged from -27.31% (NSRP-1 × JBGR-1) to 35.49% (AB-09-1 × AB-12-10) and standard heterosis ranged from -19.98% (AB-09-1 × NSR-1) to 33.80% (AB-09-1 × AB-12-10). Four hybrids registered significant positive heterobeltiosis and five hybrids registered significant positive standard heterosis for this trait.

Top three hybrids for heterobeltiosis were viz., AB-09-1 × AB-12-10 (35.49%), AB-09-1 × AB-08-5 (25.95%) and NSR-1 × AB-12-10 (24.14%) and for standard heterosis viz., AB-09-1 × AB-12-10 (33.80%), AB-09-1 × AB-08-5 (24.38%) and AB-08-5 × JBL-08-8 (19.40%).

Table 4.3 : Estimation of heterosis for days to fifty per cent flowering, plant height at harvest (cm), no. of branches per plant at harvest and fruit length (cm).

Sr. No.	Crosses	Days to fifty per cent flowering		Plant height at harvest (cm)		No. of branches per plant at harvest		Fruit length (cm)	
		BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)
1	AB-09-1 × AB-08-5	-12.64	-8.5	-13.12 *	-10.23	27.42 **	25.14 **	26.49 **	18.43 **
2	AB-09-1 × NSRP-1	-11.30	-2.23	-5.96	-4.41	13.58 *	11.55	7.67	6.31
3	AB-09-1 × JBGR-1	-6.79	-5.81	-5.96	-4.41	0.08	11.59	0.05	8.51
4	AB-09-1 × NSR-1	14.83*	16.03 *	12.22	7.45	-29.35 **	-14.81 *	-11.24	-10.86
5	AB-09-1 × GJB3	4.42	5.51	1.59	3.27	-19.29 **	-10.28	-0.95	-7.57
6	AB-09-1 × JBL-08-8	9.14	10.29	1.06	6.56	-20.07 **	-19.65 **	-25.55 **	-14.31 *
7	AB-09-1 × AB-12-10	-8.61	-7.66	-16.31 **	-13.39 *	37.44 **	34.99 **	16.13 **	25.66 **
8	AB-08-5 × NSRP-1	-5.90	3.73	1.93	1.74	-20.85 **	-4.58	-3.76	-3.34
9	AB-08-5 × JBGR-1	-4.43	-3.43	4.33	-0.25	-9.47	9.15	-1.58	6.74
10	AB-08-5 × NSR-1	-8.77	-2.11	-10.44	-7.47	-11.64 *	6.54	4.41	4.86
11	AB-08-5 × GJB3	-18.76**	-12.82	6.35	8.1	-34.66 **	-21.22 **	-15.96 **	-15.60 **
12	AB-08-5 × JBL-08-8	-13.36	-9.26	-12.84 *	-8.1	-0.54	19.91 **	5.97	14.66 *
13	AB-08-5 × AB-12-10	2.11	6.95	0.94	4.47	-23.71 **	-8.02	-12.97 *	-5.83
14	NSRP-1 × JBGR-1	4.60	15.30 *	5.42	5.22	-22.59 **	-13.68 *	-17.04 **	-10.03
15	NSRP-1 × NSR-1	-4.87	4.86	-2.72	0.51	5.31	-4.01	-1.65	-2.89
16	NSRP-1 × GJB3	-10.55	-1.4	-2.03	-2.21	-4.82	5.8	5.56	4.23
17	NSRP-1 × JBL-08-8	-4.60	5.16	-2.68	2.61	-22.73 **	-6.84	-17.48 **	-5.03
18	NSRP-1 × AB-12-10	-10.71	-1.58	-6.58	-3.31	-9.87	8.67	-1.64	6.43
19	JBGR-1 × NSR-1	-12.16	-5.75	-9.75	-6.75	-2.39	17.69 **	4.16	12.97 *
20	JBGR-1 × GJB-3	10.09	4.68	4.24	-0.2	-15.94 **	1.35	-6.85	1.03
21	JBGR-1 × JBL-08-8	14.04	8.56	-2.94	2.34	-22.15 **	-6.14	-17.01 **	-4.49
22	JBGR-1 × AB-12-10	4.78	9.74	-0.37	3.11	-23.89 **	-8.24	-13.30 *	-5.97
23	NSR-1 × GJB-3	-7.23	-0.45	-5.29	-2.14	-12.40 *	5.62	11.2	4.11
24	NSR-1 × JBL-08-8	-1.66	5.52	-3.14	2.13	-21.68 **	-5.58	-16.63 **	-4.06
25	NSR-1 × AB-12-10	-14.17*	-7.9	-8.72	-5.53	-5.02	14.51 *	2.24	10.63
26	GJB-3 × JBL-08-8	17.10*	11.47	1.21	6.71	-31.66 **	-17.60 **	-24.33 **	-12.91 *
27	GJB-3 × AB-12-10	9.37	10.52	-10.71	-7.59	-0.54	19.91 **	-2.06	12.71 *
28	JBL-08-8 × AB-12-10	-3.71	0.85	-7.05	-1.99	-19.48 **	-2.92	-14.90 **	-2.06
	CD (5%)	**10.97**	**10.97**	**12.61**	**12.61**	**0.94**	**0.94**	**1.32**	**1.32**
	CD (1%)	**14.57**	**14.57**	**16.21**	**16.21**	**1.25**	**1.25**	**1.32**	**1.32**

Table 4.4 : Estimation of heterosis for fruit diameter (cm), average fruit weight (g) and no. of fruits per plant.

Sr. No.	Crosses	Fruit diameter (cm)		Average fruit weight (g)		No. of fruits per plant	
		BP (%)	**SC (%)**	**BP (%)**	**SC (%)**	**BP (%)**	**SC (%)**
1	AB-09-1 × AB-08-5	10.01	6.00	25.95 **	24.38 **	24.41 *	23.01 *
2	AB-09-1 × NSRP-1	-15.26	-17.39 *	12.83	11.43	11.85	10.59
3	AB-09-1 × JBGR-1	-9.82	-16.62 *	-7.17	11.43	-6.93	10.61
4	AB-09-1 × NSR-1	2.98	1.08	-20.70 **	-19.98 *	-19.93 *	-19.5
5	AB-09-1 × GJB3	-20.71 **	-17.09 *	-18.51 *	-9.51	-17.88	-9.47
6	AB-09-1 × JBL-08-8	-3.25	-6.77	-26.67 **	-18.33 *	-20.73 *	-17.91
7	AB-09-1 × AB-12-10	8.21	8.26	35.49 **	33.80 **	33.55 **	32.04 **
8	AB-08-5 × NSRP-1	-16.42 *	-18.52 *	-4.87	-4	-4.69	-4.18
9	AB-08-5 × JBGR-1	-7.51	-3.28	-9.1	9.11	-8.81	8.38
10	AB-08-5 × NSR-1	2.31	2.36	5.73	6.69	5.5	6.06
11	AB-08-5 × GJB3	-20.98 *	-26.94 **	-22.40 **	-13.83	-21.63 *	-13.6
12	AB-08-5 × JBL-08-8	0.88	5.49	6.95	19.40 *	14.24	18.32
13	AB-08-5 × AB-12-10	-5.38	-7.13	-8.12	-7.28	-7.83	-7.33
14	NSRP-1 × JBGR-1	-13.53	-15.70 *	-27.31 **	-12.74	-26.43 **	-12.56
15	NSRP-1 × NSR-1	-0.72	-0.67	4.91	-3.45	4.74	-3.65
16	NSRP-1 × GJB3	-3.43	0.97	-4.62	5.91	-4.46	5.33
17	NSRP-1 × JBL-08-8	-11.84	-14.06	-15.79 *	-6.2	-9.54	-6.31
18	NSRP-1 × AB-12-10	-2.67	-4.46	18.57 *	8.6	17.87	7.97
19	JBGR-1 × NSR-1	-20.51 **	-20.47 **	-2.28	17.30 *	-2.21	16.23
20	JBGR-1 × GJB-3	-16.34 *	-12.52	-15.29 *	1.68	-14.79	1.27
21	JBGR-1 × JBL-08-8	-0.05	-3.69	-21.28 **	-5.51	-20.58 *	-5.61
22	JBGR-1 × AB-12-10	-0.26	-2.1	-22.89 **	-7.44	-22.15 *	-7.48
23	NSR-1 × GJB-3	22.40 *	4.87	-4.78	5.73	-4.63	5.14
24	NSR-1 × JBL-08-8	-5.9	-5.85	-14.69 *	-4.97	-8.39	-5.12
25	NSR-1 × AB-12-10	-4.62	-4.57	24.14 **	14.24	23.16 *	13.3
26	GJB-3 × JBL-08-8	-2.85	1.59	-25.02 **	-16.48 *	-26.63 **	-19.11
27	GJB-3 × AB-12-10	-3.39	1.03	7.53	19.13 *	3.98	14.63
28	JBL-08-8 × AB-12-10	3.76	1.85	-12.33	-2.35	-5.95	-2.6
	CD (5%)	**0.97**	**0.97**	**14.71**	**14.71**	**3.23**	**3.23**
	CD (1%)	**1.28**	**1.28**	**14.71**	**14.71**	**4.29**	**4.29**

**Significant at 1% level, * Significant at 5% level

4.3.7. Number of fruits per plant

Heterobeltiosis varied from -26.63% (GJB-3 × JBL-08-8) to 33.55% (AB-09-1 × AB-12-10) and standard heterosis ranged from -19.11% (GJB-3 × JBL-08-8) to 32.04% (AB-09-1 × AB-12-10). Three hybrids registered significant positive heterobeltiosis and two hybrids registered significant positive standard heterosis for this trait.

Highest heterobeltiosis was observed in AB-09-1 × AB-12-10 (33.55%) followed by AB-09-1 × AB-08-5 (24.41%) and NSR-1 × AB-12-10 (23.16%). While AB-09-1 × AB-12-10 (32.04%) registered highest standard heterosis followed by AB-09-1 × AB-08-5 (23.01%).

4.3.8. Fruit yield per plant (kg)

For this trait, heterobeltiosis ranged from -31.88% (AB-08-5 × NSR-1) to 48.95% (AB-09-1 × AB-12-10) and standard heterosis ranged from -18.96% (AB-09-1 × GJB3) to 46.29% (AB-09-1 × AB-12-10). Five hybrids registered significant positive heterobeltiosis while nine hybrids registered significant positive standard heterosis for this trait.

Best three hybrids for heterobeltiosis were AB-09-1 × AB-12-10 (48.95%), GJB-3 × JBL-08-8 (48.60%) and JBGR-1 × NSR-1 (35.10%). Highest standard heterosis were observed in AB-09-1 × AB-12-10 (46.29%) followed by AB-09-1 × AB-08-5 (42.02%) and AB-08-5 × JBL-08-8 (32.69%).

4.3.9. Total phenol content (mg/100g)

Heterobeltiosis ranged from -23.13% (JBGR-1

× JBL-08-8) to 17.87% (GJB-3 × JBL-08-8) and standard heterosis ranged from -29.25 (AB-08-5 × GJB3) to 3.4% (AB-09-1 × AB-12-10). Nineteen hybrids heterobeltiosis and twenty three hybrids for standard heterosis registered significant heterosis.

Best three hybrids for heterobeltiosis were GJB-3 × JBL-08-8 (17.87%), AB-08-5 × JBL-08-8 (10.98%) and AB-09-1 × AB-08-5 (8.73%). While top three for standard heterosis were AB-09-1 × AB-12-10 (3.4%), AB-09-1 × AB-08-5 (1.7%) and AB-08-5 × JBL-08-8 (-0.34%).

4.3.10. Total Soluble Solids (%)

Heterobeltiosis varied from -44.91% (GJB-3 × JBL-08-8) to 56.67% (AB-09-1 × AB-12-10) while standard heterosis ranged from -36.06% (GJB-3 × AB-12-10) to 53.88% (AB-09-1 × AB-12-10). Among these, ten and thirteen hybrids had significant positive heterosis over better parents and standard check, respectively.

Best top three hybrids for heterobeltiosis were viz., AB-09-1 × AB-12-10 (56.67%), NSR-1 × AB-12-10 (47.75%) and NSRP-1 × AB-12-10 (38.38%) and for standard heterosis AB-09-1 × AB-12-10 (53.88%), AB-09-1 × AB-08-5 (40.67%) and AB-08-5 × JBL-08-8 (40.15%).

Table 4.5 : Estimation of heterosis for fruit yield per plant (kg), Total phenol (mg/100g) and TSS (%).

Sr. No.	Crosses	Fruit yield per plant (kg)		Total phenol content (mg/100g)		TSS (%)	
		BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)
1	AB-09-1 × AB-08-5	13.55	42.02**	8.73 **	1.7	15.19 **	40.67 **
2	AB-09-1 × NSRP-1	-2.84	22.25**	-4	-10.20 **	9.61 **	7.65 **
3	AB-09-1 × JBGR-1	-8.62	14.97*	-2.18	-8.50 **	-4.23 **	23.48 **
4	AB-09-1 × NSR-1	16.08*	14.01*	2.14	-2.38	30.63 **	28.30 **
5	AB-09-1 × GJB3	-28.74**	-18.96**	-9.45 **	-15.31 **	-34.97 **	-19.71 **
6	AB-09-1 × JBL-08-8	-5.59	-4.95	1.82	-4.76 *	-42.83 **	-30.19 **
7	AB-09-1 × AB-12-10	48.95**	46.29**	8.19 **	3.4	56.67 **	53.88 **
8	AB-08-5 × NSRP-1	7.23	7.97	-5.69 *	-9.86 **	-9.38 **	-9.85 **
9	AB-08-5 × JBGR-1	-26.11**	-15.25*	-5.82 *	-11.90 **	-9.19 **	17.09 **
10	AB-08-5 × NSR-1	-31.88**	-14.29*	-12.46 **	-16.33 **	12.33 **	11.74 **
11	AB-08-5 × GJB3	-22.16**	-10.71	-19.38 **	-29.25 **	-41.34 **	-27.57 **
12	AB-08-5 × JBL-08-8	9.78	32.69**	10.98 **	-0.34	13.50 **	40.15 **
13	AB-08-5 × AB-12-10	9.26	-1.10	-2.14	-6.46 **	-14.54 **	-14.99 **
14	NSRP-1 × JBGR-1	-18.24**	-7.01	-4.17	-13.95 **	-38.05 **	-20.13 **
15	NSRP-1 × NSR-1	22.22**	10.30	-5.68 *	-15.31 **	4.83 *	-13.63 **
16	NSRP-1 × GJB3	-6.71	7.01	-17.79 **	-21.43 **	-11.21 **	9.64 **
17	NSRP-1 × JBL-08-8	-18.78**	2.20	7.95 **	-3.06	-29.10 **	-13.42 **
18	NSRP-1 × AB-12-10	-25.22**	-5.91	-9.63 **	-17.01 **	38.38 **	16.04 **
19	JBGR-1 × NSR-1	35.10**	24.86**	1.55	-10.88 **	7.40 **	38.47 **
20	JBGR-1 × GJB-3	-16.91**	-5.49	1.94	-10.54 **	-21.14 **	1.68
21	JBGR-1 × JBL-08-8	30.05**	17.72**	-23.13 **	-26.53 **	-31.30 **	-11.43 **
22	JBGR-1 × AB-12-10	-28.50**	-17.99**	-13.70 **	-20.75 **	-34.96 **	-16.14 **
23	NSR-1 × GJB-3	-8.46	-7.83	0	-17.69 **	-10.87 **	10.06 **
24	NSR-1 × JBL-08-8	-14.61*	-2.88	6.61 *	-12.24 **	-27.04 **	-10.90 **
25	NSR-1 × AB-12-10	8.62	24.59**	-7.41 **	-14.97 **	47.75 **	23.90 **
26	GJB-3 × JBL-08-8	48.60**	-15.05	17.87 **	-5.78 *	-44.91 **	-31.97 **
27	GJB-3 × AB-12-10	-22.16	30.26**	-7.78 **	-15.31 **	-35.72 **	-36.06 **
28	JBL-08-8 × AB-12-10	-22.93 *	-4.86	-7.41 **	-14.97 **	-23.18 **	-6.18 **
	CD (5%)	**0.31**	**0.31**	**0.04**	**0.04**	**0.11**	**0.11**
	CD (1%)	**0.45**	**0.45**	**0.06**	**0.06**	**0.14**	**0.14**

** Significant at 1% level, * Significant at 5% level

4.4 Combining ability analysis

In any breeding programme, it is necessary to identify superior genotypes which are to be used as parents in hybridization. In this context, the concept of combining ability is become popular in plant breeding. Before adopting productional breeding programme, plant breeders confront with the crucial question of choosing suitable parents. Combining ability analysis provides clues to the usefulness of individuals to be employed as the parents in the hybridization programme as well as simultaneously to screen the hybrids. Besides, it also ascertains the magnitude and nature of quantitative genetic variation which could be of great use to plant breeders for deciding efficient and effective breeding programme.

Combining ability is the relative ability of a genotype to transmit superior performance to its progeny. General combining ability is the average performance of a line in a series of crosses [Sprague and Tatum (1942)]. According to them, the term specific combining ability is used to designate those crosses in which certain combinations do relatively better or worse than would be expected on the basis if the average performance of lines involved. They further emphasized the importance of specific combining ability for choice among the crosses. General combining ability is attributed to additive and additive x additive type of gene effects and is fixable. On the other hand, specific combining ability is attributed to the non-additive gene action, which may be due to dominance or epistasis (except additive x additive) or both and is not fixable.

Selection of parents with desirable traits having good general combining ability effects for yield and its attributes and cross having good specific combining ability effects is essential.

4.4.1. Analysis of variance for combining ability

The analysis of variance for combining ability of various traits is presented in **Table 4.6.** It was observed that *gca* and *sca* variances were significant for all the traits, except *gca* effect for days to 50% flowering, plant height at harvest and number of fruits per plant. The significance of both *gca* and *sca* variances for most of the traits indicated that both additive as well as non-additive type of gene actions were involved in the inheritance of these traits. However, the *gca*/*sca* variance ratio was less than unity for all of the traits under study except days to fifty per cent flowering and plant height at harvest. Thus, indicating the greater role of non-additive genetic variance in the inheritance of these traits. Thus, these traits might be governed by dominance, additive x dominance and/or dominance x dominance type of gene action.

Table 4.6: Analysis of variance for combining ability effects for different characters in brinjal.

Sr. No.	Source of Variations	df	Days to fifty per cent flowering	Plant height at harvest (cm)	Number of branches per plant at harvest	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits per plant	Fruit yield per plant (kg)	Total phenol content (mg/100g)	TSS (%)
1	*gca*	7	14.43	17.82	0.56**	1.09**	1.03**	79.18*	2.72	0.32**	0.006**	0.39**
2	*sca*	28	34.26**	32.73*	1.23**	1.46**	0.43**	168.85**	4.55**	0.19**	0.005**	0.63**
3	Error	70	15.15	18.74	0.11	0.22	0.19	27.23	1.32	0.01	0.0002	0.00
4	σ2 *gca*		-0.07	-0.12	0.05	0.08	0.10	5.19	0.14	0.02	0.0006	0.03
5	σ2 *sca*		19.11	13.99	1.12	1.25	0.31	141.61	3.23	0.11	0.005	0.62
6	σ2 *gca* / σ2 *sca*		-0.003	-0.01	0.04	0.06	0.32	0.04	0.04	0.18	0.12	0.05

**Significant at 1% level, * Significant at 5% level

4.4.2. General combining ability effects

The estimates of general combining ability (*gca*) effects of eight parents for various traits presented in Table 4.7. The salient features of the result of general combining ability effects of different traits are presented below:

4.4.2.1. Days to fifty per cent flowering

Among all the eight parents, NSR-1 (-1.37), AB-12-10 (-1.08), AB-09-1 (-0.79), JBGR-1 (-0.42) and GJB-3 (-0.18) had non-significant negative *gca* effect, while parents AB-08-5 (0.87), NSRP-1 (2.21) and JBL-08-8 (0.75) had significant positive *gca* effects.

4.4.2.2. Plant height at harvest (cm)

Out of eight genotype parent JBL-08-8 (2.79) had significant positive and parents NSRP-1 (0.64), GJB-3 (0.34) and AB-12-10 (1.06) had positive *gca* effects, while remaining parents had negative *gca* effects.

4.4.2.3. Number of branches per plant at harvest

The *gca* effect for this traits varied from -0.40 (JBL-08-8) to 0.21 (NSR-1). Two parents such as JBL-08-8 (-0.40) and NSRP-1 (-0.35) had significant negative effect, were parent NSR-1 (0.21) had significant positive effect.

4.4.2.4. Fruit length (cm)

Minimum and maximum *gca* effect has been noticed in parent -0.35 (GJB-3) and 0.59 (AB-12-10). Parents AB-12-10 manifested significant positive *gca* effect while two parents such as NSR-1 (0.25) and JBGR-1 (0.19) had non-significant *gca* effect in desirable direction.

4.4.2.5. Fruit diameter (cm)

The *gca* effect for fruit diameter ranged from -0.55 (AB-08-5) to 0.29 (JBGR-1). Parents JBGR-1 (0.29), NSR-1 (0.29), AB-12-10 (0.27) and JBL-08-8 (0.21) had significant positive *gca* effect while parents AB-08-5 (-0.54) and GJB-3 (-0.35) had significant negative *gca* effect.

4.4.2.6. Average fruit weight (g)

The *gca* effect for parents ranged from -4.15 (NSRP-1) to 3.42 (JBGR-1). Parents NSRP-1 (-4.15) had significant negative effect, were parent JBGR-1 (3.42) had significant positive *gca* effect. AB-12-10 (2.33), AB-09-1 (1.26) and NSR-1 (2.49) had non-significant positive *gca* effects and parents AB-08-5 (-2.39), JBL-08-8 (-2.73) and GJB-3 (-0.21) had negative *gsc* effects.

4.4.2.7. Number of fruits per plant

The *gca* effect felt between -0.70 (NSRP-1) to 0.63 (JBGR-1). Parent NSRP-1 had significant negative *gca* effect while parents NSR-1 (0.47), AB-12-10 (0.39) and AB-09-1 (0.28) had non-significant positive *gca* effect.

4.4.2.8. Fruit yield per plant (kg)

Minimum *gca* effect has been noticed in parent -0.16 (NSRP-1) while maximum *gca* effect recorded by parent 0.11 (JBGR-1). Parent NSR-1 (0.09) and JBGR-1 (0.11) registered positive significant *gca* effect while parent JBL-08-8 (-0.08) and NSRP-1 (-0.16) had registered negative significant *gca* effect.

4.4.2.9. Total phenol content (mg/100g)

The *gca* effect ranged between -0.032 (GJB-3) to 0.044 (AB-09-1). All the parents had significant effect except AB-12-10 (0.009) and JBGR-1 (0.006). Among that Parents AB-09-1 (0.044), AB-08-5 (0.020) and NSRP-1 (0.018) had positive significant *gca* effects.

4.4.2.10. Total Soluble Solid (%)

The *gca* effect for TSS ranged -0.302 (NSRP-1) 0.231 (JBGR-1). Out of eight parents only one AB-09-1(0.02) had non-significant *gca* effects were remaining all parents had significant *gca* effects. Parents AB-08-5 (-0.121), NSRP-1 (-0.302) and JBL-08-8 (-0.119) had negative were remaining had positive significant *gca* effects.

Table 4.7: Estimation of general combining ability effects of parents for different characters in brinjal.

Sr. No	Parents	Days to fifty per cent flowering	Plant height at harvest (cm)	Number of branches per plant at harvest	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits per plant	Fruit yield per plant (kg)	Total phenol content (mg/100g)	TSS (%)
1	AB-09-1	-0.79	-0.46	0.11	-0.15	-0.07	1.26	0.28	0.07	0.044 **	0.02
2	AB-08-5	0.87	-0.31	0.10	-0.23	-0.55 **	-2.39	-0.33	-0.07	0.020 **	-0.121 **
3	NSRP-1	2.21	0.64	-0.35 **	-0.19	-0.09	-4.15 **	-0.70 *	-0.16*	0.018 **	-0.302 **
4	JBGR-1	-0.42	-0.31	0.15	0.19	0.29 **	3.42 *	0.63	0.11**	-0.006	0.231 **
5	NSR-1	-1.37	-1.62	0.21 *	0.25	0.29 **	2.49	0.47	0.09*	-0.012 **	0.191 **
6	GJB-3	-0.18	0.34	-0.02	-0.35 *	-0.35 **	-0.21	-0.08	0.01	-0.032 **	0.035 **
7	JBL-08-8	0.75	2.79 *	-0.40 **	-0.11	0.21 *	-2.73	-0.66	-0.08*	-0.022 **	-0.119 **
8	AB-12-10	-1.08	1.06	0.19	0.59 **	0.27 **	2.33	0.39	0.08	-0.009	0.066 **
	S.Em (±) (gi)	1.51	1.29	0.10	0.14	0.10	1.54	0.34	0.32	0.00	0.01

** Significant at 1% level, * Significant at 5% level

4.4.3. Specific combining ability effects

The specific combining ability (*sca*) effects of All 28 crosses for different traits are presented in **Table 4.8** and **Table 4.9** and results for *sca* effects is described below:

4.4.3.1. Days to fifty per cent flowering

The *sca* effect ranged from -8.54 (AB-08-5 × GJB-3) to 10.62 (AB-09-1 × AB-12-10). Crosses like AB-08-5 × GJB-3 (-8.54), AB-08-5 × JBL-08-8 (-8.49), GJB-3 × AB-12-10 (-6.22) and GJB-3 × JBL-08-8 (-6.18) resulting into significant negative *sca* effect, while Crosses like AB-09-1 × AB-12-10 (10.62), NSRP-1 × JBGR-1 (8.36), JBGR-1 × AB-12-10 (7.54), AB-09-1 × AB-08-5 (6.75) and AB-09-1 × JBL-08-8 (6.47) had significant positive *sca* effects**.**

4.4.3.2. Plant height at harvest (cm)

Minimum and maximum *sca* effect for plant height has been noticed -11.17 (AB-09-1 × AB-12-10) and 9.64 (AB-08-5 × GJB-3), respectively. Among these three hybrids had significant negative and two hybrids had significant positive *sca* effetcs.

Hybrids AB-09-1 × AB-12-10 (-11.17), AB-08-5 × JBL-08-8 (-9.86) and AB-09-1 × NSR-1 (-7.44) were good specific combiners.

4.4.3.3. Number of branches per plant at harvest

The *sca* effect for this trait ranged from -1.96 (AB-08-5 × GJB3) to 2.25 (AB-09-1 × AB-12-10). Nine hybrids registered significant *sca* effect in desirable direction for above trait while seven combiners exhibited significant *sca* effect in undesirable direction.

Top three specific combiners were AB-09-1 × AB-12-10 (2.25), AB-08-5 × JBL-08-8 (1.70) and AB-09-1 × NSR-1 (1.48).

4.4.3.4. Fruit length

The *sca* effect laid within -1.60 (JBGR-1 × AB-12-10) to 2.43 (AB-09-1 × AB-12-10). Eight hybrids noticed significant *sca* effect in desirable direction while nine hybrids had significant *sca* effect in undesirable direction.

Top three performing specific combiner are AB-09-1 × AB-12-10 (2.43), AB-09-1 × NSR-1 (1.92) and AB-08-5 × JBL-08-8 (1.70).

4.4.3.5. Fruit diameter

The *sca* effect ranged from -0.90 (AB-08-5 × GJB3) to 1.37 (AB-08-5 × JBL-08-8). Among all the hybrids, four hybrids manifested significant positive *sca* effect while another four hybrids had significant negative *sca* effect.

Leading specific combiner of this traits were AB-08-5 × JBL-08-8 (1.37), AB-09-1 × NSR-1 (1.23) and AB-09-1 × AB-12-10 (0.78).

4.4.3.6. Average fruit weight (g)

The *sca* effects ranged from -19.35 (AB-09-1 × NSR-1) to 26.25 (AB-09-1 × AB-12-10). Among all crosses, six combiners resulted into significant *sca* effect while eight combiners registered significant *sca* effect in negative direction.

AB-09-1 × AB-12-10 (26.25) had highest desirable *sca* effect followed by AB-08-5 × JBL-08-8 (21.23) and AB-08-5 × GJB3 (17.26).

4.4.3.7. Number of fruits per plant

The *sca* effect ranged from -2.71 (AB-09-1 × JBL-08-8) to 4.36 (AB-09-1 × AB-12-10). Five crosses registered significant *sca* effect in desirable direction while seven hybrids had negative 9undesirable) *sca* effect.

Best three specific combiner were AB-09-1 × AB-12-10 (4.36), AB-08-5 × JBL-08-8 (3.80) and AB-09-1 × AB-08-5 (2.81).

4.4.3.8. Fruit yield per plant (kg)

Minimum and maximum *sca* effect has been noticed -0.57 (AB-08-5 × GJB3) to 0.90 (AB-09-1 × AB-12-10), respectively. Twelve hybrids registered significant positive *sca* effect while thirteen hybrids registered significant *sca* effect in undesirable direction.

Leading combiners were AB-09-1 × AB-12-10 (0.90), AB-08-5 × JBL-08-8 (0.68) and AB-09-1 × AB-08-5 (0.57).

4.4.3.9. Total phenol content (mg/100g)

Minimum and maximum *sca* effect has been noticed from -0.30 (NSRP-1 × JBGR-1) to 0.14 (AB-09-1 × AB-12-10). Eleven hybrids recorded significant *sca* effect in desirable as well as twelve hybrids registered undesirable direction.

Promising combiners were AB-09-1 × AB-12-10 (0.14), NSRP-1 × GJB3 (0.13) and GJB-3 × JBL-08-8 (0.12).

4.4.3.10. TSS (%)

The *sca* effect for TSS content ranged from -1.11 (AB-08-5 × GJB3) to 1.47 (AB-08-5 × GJB3). Twelve hybrids registered positive significant *sca* effect while fourteen hybrids registered significant negative *sca* effect.

Top three combiner was AB-08-5 × JBL-08-8 (1.47), AB-09-1 × AB-12-10 (1.44) and GJB-3 × AB-12-10 (1.11).

Table 4.8: **Magnitude of specific combining ability (*sca*) effects of hybrids for different characters in brinjal.**

Sr. No.	Crosses	Days to fifty per cent flowering	Plant height at harvest (cm)	Number of branches per plant at harvest	Fruit length (cm)	Fruit diameter (cm)
1	AB-09-1 × AB-08-5	6.75*	8.18**	-1.34**	-0.90**	0.69**
2	AB-09-1 × NSRP-1	-4.27	-3.87	1.01**	0.96**	-0.05
3	AB-09-1 × JBGR-1	-4.29	-2.92	0.50	0.83*	0.25
4	AB-09-1 × NSR-1	5.92	-7.44*	1.48**	1.92**	1.23**
5	AB-09-1 × GJB3	3.87	4.14	-1.00**	-0.50	-0.43
6	AB-09-1 × JBL-08-8	6.47*	4.99	-1.33**	-1.53**	0.33
7	AB-09-1 × AB-12-10	10.62**	-11.17**	2.25**	2.43**	0.78**
8	AB-08-5 × NSRP-1	-1.51	2.15	-0.22	-0.09	-0.60*
9	AB-08-5 × JBGR-1	-4.18	1.11	0.32	0.71	0.00
10	AB-08-5 × NSR-1	-2.25	-4.82	0.06	0.42	0.37
11	AB-08-5 × GJB3	-8.54**	9.64**	-1.96**	-1.56**	-0.90**
12	AB-08-5 × JBL-08-8	-8.49**	-9.86**	1.70**	1.70**	1.37**
13	AB-08-5 × AB-12-10	4.18	6.60	-1.04**	-1.16**	-0.23
14	NSRP-1 × JBGR-1	8.36**	5.65	-0.97**	-1.29**	-0.14
15	NSRP-1 × NSR-1	1.57	2.24	-0.29	-0.53	0.20
16	NSRP-1 × GJB3	-4.26	-2.47	0.69**	0.91**	0.30
17	NSRP-1 × JBL-08-8	-0.33	-0.07	0.11	-0.41	-0.60*
18	NSRP-1 × AB-12-10	-3.49	-2.16	0.70**	0.23	-0.03
19	JBGR-1 × NSR-1	-3.66	-4.10	0.86**	0.95**	-0.84**
20	JBGR-1 × GJB-3	2.88	0.51	-0.16	0.16	-0.33
21	JBGR-1 × JBL-08-8	4.82	0.61	-0.35	-0.73	0.33
22	JBGR-1 × AB-12-10	7.54**	5.23	-1.11	-1.60**	0.36
23	NSR-1 × GJB-3	0.03	-0.13	0.11	0.45	0.20
24	NSR-1 × JBL-08-8	3.52	1.71	-0.36	-0.74*	-0.44
25	NSR-1 × AB-12-10	-4.59	-2.12	0.58*	0.27	-0.42
26	GJB-3 × JBL-08-8	-6.18*	4.35	-1.05**	-1.17**	0.03
27	GJB-3 × AB-12-10	-6.22*	-6.15	1.22**	1.35**	-0.07
28	JBL-08-8 × AB-12-10	-0.22	-2.98	-0.15	-0.84*	0.07
	CD (5%)	**6.12**	**6.81**	**0.53**	**0.74**	**0.54**
	CD (1%)	**7.03**	**7.83**	**0.61**	**0.85**	**0.62**

Table 4.9: **Magnitude of specific combining ability (*sca*) effects of hybrids for different characters in brinjal.**

Sr. No.	Crosses	Average fruit weight (g)	Number of fruits per plant	Fruit yield per plant (kg)	Total phenol content (mg/100g)	TSS (%)
1	AB-09-1 × AB-08-5	-12.13**	2.81**	0.57**	0.10**	-0.86**
2	AB-09-1 × NSRP-1	11.78**	1.96**	0.36*	-0.04**	0.46**
3	AB-09-1 × JBGR-1	4.21	0.64	0.11*	0.00	0.43**
4	AB-09-1 × NSR-1	-19.35**	-1.97**	-0.36**	0.03**	0.75**
5	AB-09-1 × GJB3	-11.74**	-1.92**	-0.40*	-0.04**	-0.74**
6	AB-09-1 × JBL-08-8	-17.47**	-2.71**	-0.52**	0.05**	-0.92**
7	AB-09-1 × AB-12-10	26.25**	4.36**	0.90**	0.14**	1.44**
8	AB-08-5 × NSRP-1	1.00	0.18	0.04	-0.02*	0.05
9	AB-08-5 × JBGR-1	5.70	0.89	0.15*	-0.03**	0.37**
10	AB-08-5 × NSR-1	4.37	0.67	0.10	-0.05**	0.24**
11	AB-08-5 × GJB3	17.26**	-3.30**	-0.57**	0.05**	-1.11**
12	AB-08-5 × JBL-08-8	21.23**	3.80**	0.68**	-0.09**	1.47**
13	AB-08-5 × AB-12-10	-8.54*	-1.43	-0.27*	0.04*	-0.49**
14	NSRP-1 × JBGR-1	-13.00**	-2.15**	-0.37*	-0.30**	-0.63**
15	NSRP-1 × NSR-1	-3.38	-0.55	-0.36*	-0.04**	-0.39**
16	NSRP-1 × GJB3	8.10	1.47	0.25*	0.13**	0.51**
17	NSRP-1 × JBL-08-8	-0.72	0.16	-0.00	0.09**	-0.07**
18	NSRP-1 × AB-12-10	8.07	1.43	0.25*	-0.06**	0.68**
19	JBGR-1 × NSR-1	8.47*	1.36	0.27*	0.03**	0.74**
20	JBGR-1 × GJB-3	-3.43	-0.52	-0.13*	-0.13**	-0.28**
21	JBGR-1 × JBL-08-8	-7.64	-1.05	-0.25*	-0.14**	-0.54**
22	JBGR-1 × AB-12-10	-14.51**	-2.41**	-0.48**	-0.07**	-0.87**
23	NSR-1 × GJB-3	1.28	0.27	0.01	-0.01	0.03
24	NSR-1 × JBL-08-8	-6.21	-0.82	-0.21*	0.03**	-0.48**
25	NSR-1 × AB-12-10	6.70	1.12	0.19*	-0.01	0.44**
26	GJB-3 × JBL-08-8	-14.27**	-2.54**	-0.42*	0.12**	-1.00**
27	GJB-3 × AB-12-10	14.24**	1.90*	0.44*	0.01	1.11**
28	JBL-08-8 × AB-12-10	-3.58	-0.32	-0.14*	0.00	-0.30**
	CD (5%)	**8.21**	**1.80**	**0.11**	**0.02**	**0.06**
	CD (1%)	**9.44**	**2.07**	**0.43**	**0.03**	**0.07**

** Significant at 1% level, * Significant at 5% level

4.5. Pest and disease incidence

The data pertaining to per cent of shoot and fruit damage infestation and bacterial wilt disease infection for 37 genotype of brinjal.

4.5.1. Screening against shoot borer infestation in field condition

The infestation of shoot borer ranged from 4.21 (AB-09-1) to 21.65 (GJB-3) per cent among parents and 3.60 (AB-09-1 × AB-12-10) to 13.20 (AB-08-5 × GJB3) per cent in crosses. Out of 37 genotypes, none of the genotype was immune for shoot borer infestation. However parents *viz.*, AB-09-1 × AB-08-5, AB-09-1 × NSRP-1, AB-09-1 × JBGR-1, AB-09-1 × GJB3, AB-09-1 × AB-12-10, AB-08-5 × NSRP-1, AB-08-5 × NSR-1, AB-08-5 × AB-12-10, NSRP-1 × GJB3, NSRP-1 × JBL-08-8, JBGR-1 × NSR-1, JBGR-1 × GJB-3, JBGR-1 × JBL-08-8 and JBL-08-8 × AB-12-10 exhibited highly resistant and remaining genotypes exhibited moderately resistant against this important insect.

4.5.2. Screening against fruit borer infestation in field condition

The infestation of borer on fruits ranged from 5.20 (AB-09-1) to 30.85 (AB-08-5) and 4.70 (AB-09-1 × AB-12-10) to 30.40 (AB-09-1 × GJB3) per cent in parents and hybrids, respectively. Out of 37 genotypes, none of the genotype was immune for fruit borer infestation . However, parents *viz.*, AB-09-1 as well as hybrids *viz.*, AB-09-1 × AB-08-5, AB-09-1 × NSRP-1, AB-09-1 × JBGR-1, AB-09-1 × AB-12-10, JBGR-1 × JBL-08-8, NSR-1 × GJB-3, NSR-1 × JBL-08-8, GJB-3 × JBL-08-8 and GJB-3 × AB-12-10 exhibited highly resistant against fruit borer. Parents like NSRP-1, JBGR-1, NSR-1, GJB-3 and JBL-08-8 as well as hybrids like AB-09-1 × NSR-1, AB-08-5 × NSRP-1, AB-08-5 × JBGR-1, AB-08-5 × NSR-1, AB-08-5 × GJB3, AB-08-5 × JBL-08-8, AB-08-5 × AB-12-10, NSRP-1 × JBGR-1, NSRP-1 × NSR-1, NSRP-1 × GJB3, NSRP-1 × JBL-08-8, NSRP-1 × AB-12-10, JBGR-1 × NSR-1, JBGR-1 × AB-12-10, NSR-1 × AB-12-10 and JBL-08-8 × AB-12-10 exhibited moderately resistant against fruit borer. In remaining genotypes, parents like AB-08-5 and AB-12-10 as well as hybrids like AB-09-1 × GJB3, AB-09-1 × JBL-08-8.

4.5.2. Screening for resistance against bacterial wilt in field condition

The bacterial wilt incidence in parents ranged from 0.00 (AB-09-1, AB-08-5, NSRP-1, NSR-1, GJB-3, JBL-08-8 and AB-12-10) to 3.33 (JBGR-1) per cent. Similarly in hybrids 0.00 (AB-09-1 × AB-08-5, AB-09-1 × NSRP-1, AB-09-1 × JBGR-1, AB-09-1 × NSR-1, AB-09-1 × JBL-08-8, AB-09-1 × AB-12-10, AB-08-5 × NSRP-1, AB-08-5 × JBGR-1, AB-08-5 × NSR-1, AB-08-5 × JBL-08-8, AB-08-5 × AB-12-10, NSRP-1 × JBGR-1, NSRP-1 × NSR-1, NSRP-1 × JBL-08-8, NSRP-1 × AB-12-10, JBGR-1 × NSR-1, JBGR-1 × JBL-08-8, JBGR-1 × AB-12-10, NSR-1 × JBL-08-8, NSR-1 × AB-12-10, GJB-3 × JBL-08-8, GJB-3 × AB-12-10 and JBL-08-8 × AB-12-10) to 6.66 (AB-08-5 × GJB3 and NSR-1 × GJB-3) was observed. Most of the hybrids exhibited very low disease reaction in field condition.

Table 4.10: Shoot and Fruit borer infestation (%) and bacterial wilt incidence (%) in brinjal.

Sr. No.	Parents	Shoot damage (%)	Fruit damage (%)	Bacterial wilt incidence (%)
1	**AB-09-1**	4.21	5.20	0.00
2	**AB-08-5**	12.31	30.85	0.00
3	**NSRP-1**	13.5	14.60	0.00
4	**JBGR-1**	12.42	17.00	3.33
5	**NSR-1**	11.25	15.70	0.00
6	**GJB-3**	21.65	18.90	0.00
7	**JBL-08-8**	11.34	19.50	0.00
8	**AB-12-10**	14.80	20.21	0.00
Sr. No.	**Hybrids**			
1	**AB-09-1 × AB-08-5**	6.68	5.60	0.00
2	**AB-09-1 × NSRP-1**	7.46	6.20	0.00
3	**AB-09-1 × JBGR-1**	7.60	9.50	0.00
4	**AB-09-1 × NSR-1**	11.20	19.10	0.00
5	**AB-09-1 × GJB3**	9.50	30.40	3.33
6	**AB-09-1 × JBL-08-8**	12.40	28.20	0.00
7	**AB-09-1 × AB-12-10**	3.60	4.70	0.00
8	**AB-08-5 × NSRP-1**	7.00	19.50	0.00
9	**AB-08-5 × JBGR-1**	10.10	18.70	0.00
10	**AB-08-5 × NSR-1**	7.20	14.30	0.00
11	**AB-08-5 × GJB3**	13.20	17.46	6.66
12	**AB-08-5 × JBL-08-8**	10.30	14.80	0.00
13	**AB-08-5 × AB-12-10**	7.40	16.45	0.00
14	**NSRP-1 × JBGR-1**	12.40	19.50	0.00
15	**NSRP-1 × NSR-1**	11.60	19.90	0.00
16	**NSRP-1 × GJB3**	9.40	12.20	3.33
17	**NSRP-1 × JBL-08-8**	8.20	19.20	0.00
18	**NSRP-1 × AB-12-10**	10.96	20.00	0.00
19	**JBGR-1 × NSR-1**	7.90	18.35	0.00
20	**JBGR-1 × GJB-3**	5.90	10.00	3.33
21	**JBGR-1 × JBL-08-8**	8.47	9.45	0.00
22	**JBGR-1 × AB-12-10**	12.68	14.60	0.00
23	**NSR-1 × GJB-3**	13.10	8.40	6.66
24	**NSR-1 × JBL-08-8**	11.50	7.60	0.00
25	**NSR-1 × AB-12-10**	10.60	12.90	0.00
26	**GJB-3 × JBL-08-8**	11.50	8.20	0.00
27	**GJB-3 × AB-12-10**	13.65	7.40	0.00
28	**JBL-08-8 × AB-12-10**	7.46	15.70	0.00
Sr.No	**Check**			
1	**Surati Ravaiya**	09.50	18.50	0.00

DISCUSSION

CHAPTER 5

DISCUSSION

In the recent years, exploitation of hybrid vigour or heterosis by intervarietal hybridization has been a very promising line of breeding approaches in many vegetable crops like, brinjal, chili, sweet pepper and tomato. With ever-growing need to increase vegetable production in Asian countries and with increasing consumption of brinjal, vegetable breeders are showing greater interest in brinjal. The productivity of F_1 hybrids in brinjal has been reported to be high, compared to varieties (Varghese and Vahab, 1994) and the use of hybrid cultivars has been predicted to increase in the country during the ensuing years (Singh, 2000).

Unlike tomato and sweet pepper, brinjal has considerable preference for shape, size and colour of fruits. Therefore, brinjal breeders have to aim at evolving genotypes that are more preferred for each region and yet are efficient and 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.

Consumers of south Gujarat region prefer purple round-oval shape, spineless, medium size fruits and long cylindrical large size fruits. The local varieties suffer from low yield and susceptibility to disease and pests. Under these circumstances, it is necessary to improve genotypes or to develop hybrids superior in yield and yield contributing characters. But the degree of improvement depends upon the beneficial and utilizable genetic variability. The diverse pure line parentages under experimentation at Navsari Agricultural University, Navsari (Gujarat) were investigated for exploitation of hybrid vigour and to find out the best combiners who would give F_1 hybrids with higher fruit yield and acceptable fruit size as well as quality. Yield is the most important economic at tribute in brinjal. Standard heterosis is manifested in eggplant for greater vigour, faster growth and development, earliness in maturity, increased productivity, better quality attributes, and higher levels of resistance to biotic stresses reported by Chadha *et al.* (1990), Sawant *et al.* (1991), Patil (1998), Kumar *et al.* (1999), Bulgundi (2000), Kaur *et al.* (2001), Bavage (2002), Prabhu *et al.* (2005), Suneetha *et al.* (2008), Timmapur *et al.* (2007), Chowdhury *et al.* (2010), Nalini Dharwad *et al.* (2011), Reddy *et al.* (2011), Pachiyappan *et al.* (2012), Bhushan and Singh (2013), Biswas *et al.* (2013), Naresh *et al.* (2013), Reddy and Patel (2014a) and VenkataNaresh *et al* . (2014). Heterobeltiosis is also manifested in eggplant for such a important view like presence of dominance and over dominance type of gene action in the expression of various traits and economic characters reported by Das *et al.* (2009), Bavage (2002), Prabhu *et al.* (2005), Shafeeq *et al.* (2007), Neelima Joshi *et al.* (2008) and Bhushan and Singh (2013).

The results of the present experiment on heterosis and combining ability are described in this chapter.

5.1. Analysis of variance

The analysis of variance indicated highly significant difference for both parents and hybrids for all the traits (except parents for days to fifty per cent flowering and plant height at harvest) indicating the existence of enormous amount of genetic variability in the genotype. The interaction effect of parent vs. hybrids was significant for total phenol content and TSS indicated that the appropriate for the study of manifestation of heterosis and gene effects involve in inheritance of different traits

5.2. Mean performance and magnitude of heterosis

Heterosis is the superiority of F_1 over the mean of the parents or over the better parents or over the standard checks (Hayes *et al.* 1955). The earliest record instance of artificial hybridization for improvement of eggplant was in 1889 in USA by Bailey and Munson (1891). From then, many reports of heterosis in brinjal have been registered. This is evident from hybrids that were released from private and public sector institutes.

The parents for present investigation were selected on the basis of their gross morphological diversity with a view to develop productive hybrids. The superiority of the hybrids in crosses was estimated over standard check for all the 10 characters studied. The range of heterosis over standard check was presented in the **Table 5.1.**

Growth parameters

Heterosis for growth parameters is an indication of heterosis for yield because growth and yield parameters are strongly associated. The longer plant height at harvest and more number of branches per plant was the major parameter which acts as source trait to support yield and its component traits. For plant height at harvest, parents (100 cm) as well as crosses (99.50 cm) showed higher mean values over standard check (99 cm). Out of 28 crosses, 13 showed positive standard heterosis for plant height.

Table 5.1: Range of heterosis over better parents and standard heterosis by 28 crosses for different characters in brinjal.

Sr. No.	Characters	Better parent heterosis (%) range	Standard heterosis (%) range
1	Days to fifty per cent flowering	-18.76 to 17.10	-12.82 to 16.03
2	Plant height at harvest (cm)	-16.31 to 12.22	-13.39 to 8.1
3	No. of branches per plant at harvest	-34.66 to 37.44	-21.22 to 34.99
4	Fruit length (cm)	-25.55 to 26.49	-15.66 to 25.66
5	Fruit diameter (cm)	-20.98 to 22.40	-26.96 to 8.26
6	Average fruit weight (g)	-27.31 to 35.49	-19.98 to 33.80
7	No. of fruits per plant	-26.63 to 33.50	-19.11 to 32.04
8	Fruit yield per plant (kg)	-31.88 to 48.95	-18.96 to 46.29
9	Total phenol content (mg/100g)	-23.13 to 17.87	-29.25 to 3.4
10	TSS (%)	-44.91 to 56.67	-36.06 to 53.88

The cross AB-08-5 × GJB-3 (8.1%) showed the highest standard heterosis followed by AB-09-1 × NSR-1 (7.45%) and GJB-3 × JBL-08-8 (6.71%) for plant height. This suggests the importance of dominant gene action. The results are in agreement with Bavage (2002), Prabhu *et al.* (2005), Ajjappalavara (2006), Shafeeq *et al.* (2007), Neelima Joshi *et al.* (2008), Chowdhury *et al.* (2010), Sharma (2010), Bhusan and Singh (2013), Dudhat *et al.* (2013), Leena Biswas *et al.* (2013), Makani *et al.* (2013) and Reddy and Patel (2014a) in brinjal. Out of 28 crosses, 10 crosses showed positive heterobeltiosis for plant height. The cross AB-09-1 × NSR-1 (12.22%) showed the highest heterobeltiosis followed by AB-08-5 × GJB-3 (6.35%) and NSRP-1 × JBGR-1 (5.42%) for plant height. The results are in agreement with Bavage (2002), Singh *et al.* (2004), Prabhu *et al.* (2005), Ajjappalavara (2006), Shafeeq *et al.* (2007), Neelima Joshi *et al.* (2008), Suneetha *et al.* (2008), Bisht *et al.* (2009), Chowdhury *et al.* (2010), Sharma (2010), Bhusan and Singh (2013), Dudhat *et al.* (2013), Leena Biswas *et al.* (2013) and Makani *et al.* (2013).

Number of branches per plant is one of the major parameter contributing for total fruit yield per plant. The mean value of crosses (7.78) was higher than parents (7.74) and standard check (7.65). Out of 28 crosses, six showed significant and positive standard heterosis indicating predominance of non-additivity. The cross AB-09-1 × AB-12-10 (34.99%) showed highest standard heterosis for this character followed by AB-09-1 × AB-08-5 (25.14%), AB-08-5 × JBL-08-8; GJB-3 × AB-12-10 (19.91%). These results are in conforming with the result of earlier workers *viz.*, Patil (1998), Bulgundi (2000), Prabhu *et al.* (2005), Ajjappalavara (2006), Shafeeq *et al.* (2007), Neelima Joshi *et al.* (2008), Sharma (2010), Nalini Dharwad *et al.* (2011), Bhusan and Singh (2013), Dudhat *et al.* (2013), Leena Biswas *et al.* (2013) and Reddy and Patel (2014a).

Out of 28 crosses, three showed significant and positive heterobeltiosis for number of branches per plant at harvest. The crosses AB-09-1 × AB-12-10 (37.44%) showed highest heterobeltiosis for this character followed by AB-09-1 × AB-08-5 (27.42%) and AB-09-1 × NSRP-1 (13.58%). These results are in conforming with the result of earlier workers *viz.*, Bavage (2002), Singh *et al.* (2004), Prabhu *et al.* (2005), Ajjappalavara (2006), Shafeeq *et al.* (2007), Neelima Joshi *et al.* (2008), Suneetha *et al.* (2008), Bisht *et al.* (2009), Sharma (2010), Dudhat *et al.* (2013), Leena Biswas *et al.* (2013) and VenkataNaresh *et al.* (2014).

Phenological parameters

Days to fifty per cent flowering is generally an indication of early yield (Yordanor, 1983) and also early hybrids fit well in multiple cropping systems (Kamalakannan *et al.* 2007). For these traits, negative heterosis is considered to be desirable. For days to fifty per cent flowering the mean value of parents (74.81) as well as crosses (74.37) were similar to mean value of standard check (74.33). Out of 28 crosses, thirteen crosses recorded negative standard heterosis. This indicates the non-additive gene action. The maximum negative heterosis over the commercial check (-12.82%) followed by AB-08-5 × JBL-08-8 (-9.26%), AB-09-1 × AB-08-

5 (-8.5%) and NSR-1 × AB-12-10 (-7.9%). Similar results were also reported by Patil (1998), Bulgundi (2000), Kumar and Pathania (2004), Ajjappalavara (2006), Shafeeq *et al*. (2007), Neelima Joshi *et al.* (2008), Chowdhury *et al.* (2010), Bhushan and Singh (2013), Leena Biswas *et al.* (2013), Makani *et al.* (2013) and Reddy and Patel (2014a). Out of 28 crosses, Sixteen crosses recorded negative and two crosses recorded significant negative heterobeltiosis for this traits. Cross AB-08-5 × GJB-3 (-18.76%) recorded highest heterobeltiosis for days to fifty per cent flowering followed by NSR-1 × AB-12-10 (-14.17%) and AB-08-5 × JBL-08-8 (-13.36%). Similar results were also reported by Kumar and Pathania (2004), Ajjappalavara (2006), Shafeeq *et al.* (2007), Neelima Joshi *et al.* (2008), Chowdhury *et al.* (2010), Bhushan and Singh (2013), Leena Biswas *et al.* (2013) and Makani *et al.* (2013).

Yield and its components

Yield components greatly influences the yield and expression of heterosis for fruit length, fruit diameter, average fruit weight and number of fruits per plant can greatly contribute for total fruit yield per plant. For all these traits, positive heterosis is desirable except fruit length.

Fruit length is an important parameter of fruit deciding consumer preference. Mean value of crosses for fruit length (11.80 cm) was higher to parents (11.75 cm) and standard check (11.65 cm). In south Gujarat region, high fruit length is not preferred. Therefore, the crosses showing negative heterosis are useful. For fruit length, thirteen crosses exhibited negative heterosis over the standard check. Out of the thirteen crosses, AB-08-5 × GJB-3 (-15.60%), AB-09-1 × JBL-08-8 (-14.31%) and GJB-3 × JBL-08-8 (-12.91%) showed the highest negative heterosis. These are in conformity with the studies of Bavage (2002), Kumar and Pathania (2004), Panda *et al.* (2004), Singh *et al.* (2004), Ajjappalavara (2006), Neelima joshi *et al.* (2008), Chowdhury *et al.* (2010), Sharma (2010), Bhushan and Singh (2013), Leena Biswas *et al.* (2013) and Makani *et al.* (2013) and Reddy and Patel (2014a). For this traits eighteen crosses exhibited negative heterobeltiosis, among cross AB-09-1 × JBL-08-8 (-25.55%) exhibited highest heterobeltiosis for fruit length followed by GJB-3 × JBL-08-8 (-24.33%) and NSRP-1 × JBL-08-8 (-17.48%). These are in conformity with the studies of Bavage (2002), Kumar and Pathania (2004), Singh *et al.* (2004), Ajjappalavara (2006), Shafeeq (2007), Neelima joshi *et al.* (2008), Bisht *et al.* (2009), Chowdhury *et al.* (2010), Sharma (2010), Bhushan and Singh (2013), Leena Biswas *et al.* (2013) and Makani *et al.* (2013) and VenkataNaresh *et al.* (2014).

Fruit diameter is another important character as that of fruit length. The mean fruit diameter of crosses (6.12 cm) were lower than the standard check (6.56 cm) but higher than the parental mean (5.89 cm). Out of 28 crosses, majority of the crosses showed negative heterosis over standard check for fruit diameter. Cross AB-08-5 × GJB-3 (-26.94%) exhibited highest negative standard heterosis. In earlier studies of Bulgundi (2000), Bavage (2002), Kumar and Pathania (2004), Shafeeq (2005), Ajjappalavara (2006), Neelima joshi *et al.* (2008), Sharma (2010), Bhushan and Singh (2013) and Reddy and Patel (2014a) also found similar results in brinjal. Where cross AB-08-5 × GJB-3 (-20.98%) also exhibited highest negative heterobeltiosis for fruit diameter in brinjal. In earlier studies of Bavage (2002), Kumar and Pathania (2004), Singh *et al.* (2004), Shafeeq (2005), Ajjappalavara (2006), Neelima joshi *et al.* (2008), Bisht *et al.* (2009), Sharma (2010) and VenkataNaresh *et al.* (2014) also found similar results in brinjal.

Total yield per plant is dependent mainly on the number of fruits per plant and average fruit weight. Average fruit weight is one of the component characters directly influencing the fruit yield. In the present study, average fruit weight of crosses (95.45 g) was superior to the both standard check (93.56 g) as well as parents (95.01 g). Out of 28 crosses, five crosses were exhibited positive and significant heterosis over the standard check and cross AB-09-1 × AB-12-10 showed highest positive and significant heterosis of 33.80 per cent over the standard check. Similar view are put forth by Bulgundi (2000), Bavage (2002), Prabhu *et al.* (2005), Ajjappalavara (2006), Shafeeq (2007), Bisht *et al.* (2009), Sharma (2010), Nalini Dharwad *et al.* (2011), Leena Biswas *et al.* (2013) and Reddy and Patel (2014a). Out of 28 crosses, four crosses were exhibited positive and significant heterobeltiosis for average fruit weight. Cross AB-09-1 × AB-12-10 (35.49%) showed highest positive and significant heterobeltiosis for this trait. Similar results were also reported by Singh *et al.* (2004), Prabhu *et al.* (2005), Ajjappalavara (2006), Shafeeq (2007), Bisht *et al.* (2009), Sharma (2010), Sao and Mehta (2010), Leena Biswas *et al.* (2013) and Makani *et al.* (2013).

Higher number of fruits per plant is commercially important traits to gain high market value through high productivity. Out of 28 crosses, 14 were exhibited heterosis in positive direction, thus showing role of non-additive and wide range of heterosis. Two crosses were exhibited positive and significant heterosis over the standard check. The cross AB-09-1 × AB-12-10 showed the maximum positive heterosis of 32.04 per cent over the commercial check. Similar finding for number of fruits per plant over standard heterosis were also reported by Bulgundi (2000), Bavage (2002), Prabhu *et al.* (2005), Shafeeq (2007), Neelima joshi *et al.* (2008), Bisht *et al.* (2009), Chowdhury *et al.* (2010), Nalini Dharwad *et al.* (2011), Leena Biswas *et al.* (2013) and Reddy and Patel (2014a). Out of 28 crosses, 9 were exhibited heterobeltiosis in positive direction, among three crosses were exhibited positive and significant heterobeltiosis for number of fruits per plant. Cross AB-09-1 × AB-12-10 (33.55%) showed maximum positive heterobeltiosis. Similar finding for this trait were also reported by Bavage (2002), Prabhu *et al.* (2005), Shafeeq (2007), Neelima joshi *et al.* (2008), Suneetha *et al.* (2008), Bisht *et al.* (2009), Chowdhury *et al.* (2010), Sao and Mehta (2010), Leena Biswas *et al.* (2013) and Makani *et al.* (2013) and VenkataNaresh *et al.* (2014).

Fruit yield per plant is the ultimate and the most important trait. However, yield of a crop can not be taken as a single entry; since it is associated with many yield attributing characters. In brinjal, heterosis in yield per plant was positively associated with the heterosis in number of fruits per plant (Singh and Nandpuri, 1974), in some cases it associated with number of branches per plant, plant height and fruit weight (Chadha and Sidhu, 1982). Similar reports were made by Patil and Shinde (1984), Mandal *et al.* (1994), Padmanabhan and Jagadish (1996), Pratibha *et al.* (2004), Suneetha *et al.* (2008).

For fruit yield per plant the overall mean of crosses (1.66 kg/plant) was higher than the parental mean (1.65 kg/plant) and standard check (1.60 kg/plant). However, the highest mean value which was shown by the hybrid AB-09-1 × AB-12-10 (2.80 kg/plant) followed by AB-09-1 × AB-08-5 (2.40 kg/plant), AB-08-5 × JBL-08-8 (2.25 kg/plant).

A total of 10 crosses *viz.*, AB-09-1 × AB-12-10 (46.29%), AB-09-1 × AB-08-5 (42.02%), AB-08-5 × JBL-08-8 (32.69%), GJB-3 × AB-12-10 (30.26%), JBGR-1 × NSR-1 (24.86%), NSR-1 × AB-12-10 (24.59%), AB-09-1 × NSRP-1 (22.25%), JBGR-1× JBL-08-8 (17.72%), AB-09-1 × JBGR-1 (14.97%) and AB-09-1 × NSR-1 (14.01%) were exhibited significant and positive heterosis over the standard check for fruit yield per plant. These results are in conformation of the results of earlier workers reported by Bulgundi (2000), Bavage (2002), Panda *et al.* (2005), Prabhu *et al.* (2005), Shafeeq (2007), Ajjappalavara (2006), Neelima joshi *et al.* (2008), Chowdhury *et al.* (2010), Nalini Dharwad *et al.* (2011), Dudhat *et al.* (2013), Leena Biswas *et al.* (2013), Makani *et al.* (2013) and Reddy and Patel (2014a). Out of 28 crosses, 6 crosses exhibited significant positive heterobeltiosis. Cross AB-09-1 × AB-12-10 (48.95%) showed highest heterobeltiosis. Similar results were also reported by Bavage (2002), Singh *et* *al.* (2004), Prabhu *et al.* (2005), Shafeeq (2007), Ajjappalavara (2006), Neelima joshi *et al.* (2008), Suneetha *et al.* (2008), Bisht *et al.* (2009), Chowdhury *et al.* (2010), Sao and Mehta (2010), Dudhat *et al.* (2013), Leena Biswas *et al.* (2013), Makani *et al.* (2013) and VenkataNaresh *et al.* (2014).

Quality parameters

Phenol content is the one of the most important character to reduce the shoot and fruit borer incidence. If the phenol content is high, borer infestation will be less (Prabhu *et al.,* 2008). The mean phenol content of crosses (0.86 mg/100g) was superior to the parents (0.85 mg/100g) while it was less than standard check (0.98 mg/100g). Among 28 crosses, two exhibited positive heterosis over standard check. The results are agreement with Patil (1998), Ajjappalavara (2006), Suneetha *et al.* (2008) and Makani *et al.* (2013). Were 9 crosses exhibited positive heterobeltiosis for total phenol content. The results are agreement with Ajjappalavara (2006), Suneetha *et al.* (2008) and Makani *et al.* (2013).

Total soluble solids is another important character to reduce the shoot and fruit borer incidence. If the total soluble solids content is low borer infestation will be less by (Makani *et al.*, 2013). The mean total soluble solids content of crosses (3.26 %) was more than parents mean (3.25 %) and standard check (3.18 %). Among 28 crosses, fourteen exhibited significant negative heterosis over standard check. The results were also reported for this trait by Suneetha *et al.* (2008) and Makani *et al.* (2013). A total of them eighteen resulted significant negative heterobeltiosis for total soluble solids. Results earlier studied by Makani *et al.* (2013).

Characterization of the best heterotic crosses for productivity

The top seven heterotic crosses over local check Surati Ravaiya were AB-09-1 × AB-12-10, AB-09-1 × AB-08-5, AB-08-5 × JBL-08-8, GJB-3 × AB-12-10, JBGR-1 × NSR-1, NSR-1 × AB-12-10 and AB-09-1 × NSRP-1 showed significant positive standard heterosis ranging from 17.72 per cent to 46.29 per cent for fruit yield. The relative performance of these crosses in respect of 10 traits studied along with the standard check (Surati Ravaiya) and the parental lines of these crosses are given in Table 5.2. The seven productive crosses had higher *per se* value than the standard check in respect of, days to fifty per cent flowering, plant height at harvest, number of branches per plant at harvest, fruit length, fruit diameter, average fruit weight, number of fruits per plant and fruit yield per plant. This indicates that higher productivity in these crosses were attributed to better growth and yield parameters observed in crosses compared to parents. The high heterotic response observed in most of the crosses further supported the predominant role of non-additive component in most of the characters studied. Dispersion of favourable dominant genes coupled with complementary epistasis has been considered to be the major components of heterosis. Similar finding are reported by Singh *et al.* (2003) and Sao and Mehta (2010).

Table 5.2: Promising crosses for fruit yield per plant with standard checks, their *sca*, *gca* effects and different characters showing significant desired heterosis in brinjal.

Most heterotic crosses	Mean fruit yield per plant (kg)	Heterosis (%) over Surati Ravaiya	*sca* effect for fruit yield per plant	*gca* effect for fruit yield per plant				Significant standard heterosis for other traits in desirable diraction
				P1		P2		
AB-09-1 × AB-12-10	2.80	46.29**	0.90**	0.07	A	0.08	A	PH, NBP, FL, AFW, NFPP, TSS
AB-09-1 × AB-08-5	2.40	42.02**	0.57**	0.07	A	-0.07	A	NBP, FL, AFW, NFPP, TSS
AB-08-5 × JBL-08-8	2.25	32.69**	0.68**	-0.07	A	-0.08*	P	NBP, FL, AFW, TSS
GJB-3 × AB-12-10	2.13	30.26**	0.44*	0.01	A	0.08	A	NBP, FL, AFW
JBGR-1 × NSR-1	2.10	24.86**	0.27*	0.11**	G	0.09*	G	NBP, FL, AFW, TSS
NSR-1 × AB-12-10	2.05	24.59**	0.19*	0.09*	G	0.08	A	NBP, TSS
AB-09-1 × NSRP-1	2.00	22.25**	0.36*	0.07	A	-0.16*	P	TSS

*Significant at 5% level ** Significant at 1% level

PH : Plant height at harvest (cm) AFW : Average fruit weight (g) A : Average

NBP : Number of branches per plant at harvest NFPP: Number of fruits per plant G : Good

FL : Fruit length (cm) TSS : Total soluble solids P : Poor

5.3 Combining ability variances and effects

The combining ability concept was proposed by Sprague and Tatum (1942) in corn. According to them, the general combining ability (*gca*) of the mean performance of all the crosses involving a parent from over all mean. Specific combining ability (*sca*) was defined as the deviation in the performance of specific cross from the performance of expected on the basis of the general combining ability effects of parents involved in the crosses.

The combining ability analysis gives an indication of the variance due to *sca* and *gca*, which represents a relative measure of non-additive and additive gene actions, respectively. It is an established fact that the dominance is a component of non-additive genetic variance. Breeders use these variance components to infer the gene action and assess the genetic potentialities of the parents in hybrid combination.

The ultimate choice of parents to be used in a heterosis breeding programme is determined by *per se* performance and their behavior in hybrid combination, some idea on the usefulness of the parents may be obtained from their individual performance particularly in respect of yield components. It is therefore necessary to assess genetic potentialities of the parents in hybrid combination through systematic studies in relation to general and specific combining abilities. Half diallel method has been used in the present study for estimating combining abilities.

5.3.1 Analysis of variance for combining ability

In the present study, both *gca* and *sca* variances were highly significant for days to fifty per cent flowering, number of branches of branches per plant, fruit length, fruit diameter, average fruit weight, number of fruits per plant, fruit yield per plant, total phenol content and TSS content. This suggested that both additive and non-additive variances were important in the expression of these traits. For days to fifty per cent flowering significance of both the variances have been reported by Baig and Patil (2002) and Patel *et al.* (2013).

Significance of both the variances for number of branch per plant at harvest had reported by Baig and Patil (2002), Dhameliya and Dobariya (2009), Rai and Asati (2011), Patel *et al.* (2013) and Choudhary and Didel (2014). For fruit length results was earlier reported by Baig and Patil (2002), Aswani and Khandelwal (2005), Dhameliya and Dobariya (2009), Rai and Asati (2011), Patel *et al.* (2013), Choudhary and Didel (2014) and Reddy and Patel (2014b). For fruit diameter results was reported by Patel *et al.* (2013) and Choudhary and Didel (2014).

For average fruit weight significance of both variances was reported by Baig and Patil (2002), Aswani and Khandelwal (2005), Dhameliya and Dobariya (2009), Rai and Asati (2011), Patel *et al.* (2013), Choudhary and Didel (2014) and Reddy and Patel (2014b). For number of fruits per plant results were reported by Aswani and Khandelwal (2005), Dhameliya and Dobariya (2009), Rai and Asati (2011), Sane *et* *al.* (2011), Patel *et al.* (2013) and Choudhary and Didel (2014).

Significance of both variances for fruit yield per plant were reported by Chaudhary and Malhotra (2000), Baig and Patil (2002), Aswani and Khandelwal (2005), Dhameliya and Dobariya (2009), Rai and Asati (2011), Sane *et al.* (2011), Patel *et al.* (2013) and Choudhary and Didel (2014). For total phenol content result was earlier reported by Chadha and Sharma (1991).

The characters *viz.*, Fruit diameter, Fruit yield per plant and total phenol content were found strictly under the control of additive genetic variance. Predominance of additive type of gene action have been reported for fruit diameter (cm) by Singh *et al.* (2002), Singh *et al.* (2002), Panda and Singh (2004) and Bisht *et al.* (2006). For fruit yield per plant predominance of additive type of gene action was reported by Chezhian *et al.* (2000), Singh *et al.* (2002), Singh *et al.* (2002), Bisht *et al.* (2006), Kamalakkannan *et al.* (2007) and Prasad *et al.* (2010).

Preponderance of non-additive type of gene action was observed in days to fifty per cent flowering, plant height at harvest, number of branches per plant at harvest, fruit length, average fruit weight, number of fruit per plant and total soluble solids. Preponderance of non-additive gene action have been reported for days to fifty per cent flowering by Rai *et al.* (2005), Ajjappalavara (2006), Nalini Dharwad (2007), Shafeeq (2007), Timmapur (2007), Sao and Mehta (2010), Ramireddy *et al.* (2011), Shinde *et al.* (2011), Bhusan *et al.* (2012), Tiwari *et al.* (2013) and Reddy and Patel (2014b).

For plant height at harvest predominance of non-additive gene action have been reported by Padmanabham and Jagdish (1996), Singh *et al.* (2003), Suneetha *et al.* (2005), Ajjappalavara (2006), Kamalakkannan *et al.* (2007), Nalini Dharwad (2007), Ram and Singh (2007), Timmapur (2007), Suneetha *et al.* (2008), Shanmugapriya *et al.* (2009), Sao and Mehta (2010), Ramireddy *et al.* (2011), Shinde *et al.* (2011), Bhusan *et al.* (2012), Singh *et al.* (2013), Tiwari *et al.* (2013) and VenkataNaresh *et al.* (2014).

Preponderance of non-additive type of gene action for number of branches per plant at harvest was reported by Singh *et al.* (2003), Panda and Singh (2004), Ajjappalavara (2006), Kamalakkannan *et al.* (2007), Nalini Dharwad (2007), Ram and Singh (2007), Shafeeq (2007), Timmapur (2007), Shanmugapriya *et al.* (2009), Sao and Mehta (2010), Nalini Dharwad *et al.* (2011), Ramireddy *et al.* (2011), Shinde *et al.* (2011), Bhusan *et al.* (2012), Singh *et al.* (2013), Tiwari *et al.* (2013), Reddy and Patel (2014b) and VenkataNaresh *et al.* (2014).

For fruit length Preponderance of non-additive type of gene action have been reported by Singh *et al.* (2003), Ajjappalavara (2006), Kamalakkannan *et al.* (2007), Nalini Dharwad (2007), Ram and Singh (2007), Shanmugapriya *et al.* (2009), Sao and Mehta (2010), Ramireddy *et al.* (2011), Shinde *et al.* (2011), Bhusan *et al.* (2012), Singh *et al.* (2013), Tiwari *et al.* (2013) and VenkataNaresh *et al.* (2014). For average fruit weight the results have been reported by Padmanabham and Jagdish (1996), Ajjappalavara (2006), Nalini Dharwad (2007), Shafeeq (2007), Bhakta *et al.* (2009), Sao and Mehta (2010), Nalini Dharwad (2011), Bhusan *et al.* (2012), Singh *et al.* (2013), Tiwari *et al.* (2013) and VenkataNaresh *et al.* (2014).

For number of fruits per plant Preponderance of non-additive type of gene action have been reported by Padmanabham and Jagdish (1996), Singh *et al.* (2003), Nalini Dharwad (2007), Ram and Singh (2007), Timmapur (2007), Suneetha *et al.* (2008), Shanmugapriya *et al.* (2009), Sao and Mehta (2010), Nalini Dharwad *et al.* (2011), Ramireddy *et al.* (2011), Shinde *et al.* (2011), Bhusan *et al.* (2012), Singh *et al.* (2013), Tiwari *et al.* (2013), Reddy and Patel (2014b) and VenkataNaresh *et al.* (2014). For total soluble solids Preponderance of non-additive type of gene action have been reported by Suneetha *et al.* (2005), Ramireddy *et al.* (2011) and Bhusan *et al.* (2012).

5.3.2 Combining ability effect

Nature and magnitude of combining ability effects provide guidelines in identifying parents and their utilization. Combining ability analysis provides clues to the usefulness of individuals to be employed as the parents in the hybridization programme as well as simultaneously to screen the crosses. Besides, it also ascertains the magnitude and nature of quantitative genetic variation which could be of great use to plant breeders for deciding efficient and effective breeding programme. This phenomenon has been extensively used in self-pollinated crops to assess the nicking abilities of genotypes.

The parents were estimated and accordingly the parents were classified as good, average and poor combiners based on the estimates of *gca* effects (Table 5.3).

It was observed that none of the parent was showing simultaneously significant *gca* effects favourably for all the characters. These findings are supported by Patel *et al.* (1994), Prakash *et al.* (1994), Kumar *et al.* (1996), Varshney *et al.* (1999), Das and Barua (2001), Singh *et al.* (2003), Aswani and Khandelwal (2005), Suneetha *et al.* (2008) and Sao and Mehta (2010).

Among the parents, JBGR-1 was found good combiner for fruit diameter, average fruit weight and fruit yield per plant. NSR-1 was found good combiner for number of branches per plant at harvest, fruit diameter and fruit yield per plant. AB-12-10 was found good combiner for fruit diameter. Parents AB-09-1, AB-08-5 and NSRP-1 was founded good general combiner for total phenol content, JBL-08-8 was found good general combiner for fruit diameter, plant height at harvest and total soluble solids. AB-08-5 and NSRP-1 was also founded good general combiner for total soluble solids. GJB-3 was found good general combiner for fruit length and total soluble solids. The parents with good general combining ability for a trait also exhibited well *per se* performance. This is true with the parents JBGR-1, NSR-1 and JBL-08-8 for most of the characters. Therefore, these parents were noted as good source of favourable genes for increasing fruit yield per plant through various yield contributing characters and use of these parental lines would be more rewardaring for boosting fruit yield in brinjal.

Table 5.3: Classification of parents with respect to general combining ability effect for different characters in brinjal.

Sr no.	Parents	1	2	3	4	5	6	7	8	9	10
P_1	AB-09-1	A	A	A	A	A	A	A	A	G	A
P_2	AB-08-5	A	A	A	A	G	P	A	A	G	G
P_3	NSRP-1	A	A	P	A	A	P	P	P	G	G
P_4	JBGR-1	A	A	A	A	G	G	A	G	A	P
P_5	NSR-1	A	A	G	A	G	A	A	G	P	P
P_6	GJB-3	A	A	A	G	P	A	A	A	P	P
P_7	JBL-08-8	A	G	P	A	G	A	A	P	P	G
P_8	AB-12-10	A	A	A	P	G	A	A	A	A	P

G = Good general combiners
A = Average general combiners
P = Poor general combiners

1. Days fifty per cent flowering
2. Plant height at harvest (cm)
3. Number of branches per plant at harvest
4. Fruit length (cm)
5. Fruit diameter (cm)
6. Average fruit weight (g)
7. Number of fruits per plant
8. Fruit yield per plant
9. Total phenol content (mg/100g)
10. TSS (%)

A summarized account of the best parent *per se*, general combiner, the best F_1 *per se*, the most heterotic crosses and the best specific combination (Table 5.4 and Table 5.5) revealed that the best *per se* per forming parents were the best general combiner for most of the characters. It indicated that, if a character unidirectionally controlled by a set of alleles and have enormous amount of additive genetic diversity. Therefore, both *gca* and *per se* performance should be taken together in the choice of parents for crossing programme and for assessing true breeding potential. Similar results were also reported by Kumar and Ram (1987), Rashid *et al*. (1988), Ingale and Patil (1997), Singh *et al*. (2002) and Aswani and Khandelwal (2005).

For exploitation of heterosis, the information on *gca* should be supplemented with *sca* and hybrid performance. The estimates of *sca* effects revealed that none of the crosses was constantly superior for all the traits. These results are strengthened by the findings of Patel *et al.* (1994), Aswani and Kandelwal (2005) and Sao and Mehta (2010).

The crosses exhibiting high *per se* performance may results from either good x good, good x average, average x average and poor x poor general combining parents. The good general combining parents when crossed do not always produce high *sca* effects while poor general combining parents not always produce low *sca* effects. Similar results have been reported by Patil and Ajri (1993), Kale *et al.* (1992), Prakash *et al.* (1994), Padmanaban and jagdish (1996), Ramesh *et al,* (1996), Ingale and Patil (1997), Singh *et al.* (2002), Venkatesan (2007) and Pachiyappan *et al.* (2012).

Table 5.4: The best parent, good general combiner and the best specific cross combination for different characters in brinjal.

Sr. No.	Characters	Best parents for *per se* performance		Good general combiner		Best specific cross	
		Parents	*per se* performance	Parents	*gca* effects	Crosses	*sca* effects
1	DFPF	JBGR-1	69.00	NSR-1	-1.37	AB-08-5 × GJB-3	-8.54**
2	PH	AB-12-10	105.80	JBL-08-8	2.79*	AB-08-5 × GJB-3	9.64**
3	NBP	AB-08-5	9.22	NSR-1	0.21*	AB-09-1 × AB-12-10	2.25**
4	FL	JBL-08-8	13.43	AB-12-10	0.59**	AB-09-1 × AB-12-10	2.43**
5	FD	JBGR-1	6.79	NSR-1	0.29*	AB-08-5 × JBL-08-8	1.37**
6	AFW	JBGR-1	112.30	JBGR-1	3.42*	AB-09-1 × AB-12-10	26.25**
7	NFP	JBGR-1	19.34	JBGR-1	0.63	AB-09-1 × AB-12-10	4.36**
8	FYP	JBGR-1	2.20	JBGR-1	0.11**	AB-09-1 × AB-12-10	0.90**
9	TPC	AB-08-5	0.93	AB-09-1	0.044**	AB-09-1 × AB-12-10	0.14**
10	TSS	JBGR-1	4.1	JBGR-1	0.231**	AB-08-5 × JBL-08-8	1.47**

*Significant at 5 % level ** Significant at 1 % level

DFPF Days to fifty per cent flowering
PH Plant height at harvest (cm)
NBP Number of branches per plant at harvest
FL Fruit length (cm)
FD Fruit diameter (cm)
AFW Average fruit weight (g)
NFP Number of fruits per plant
FYP Fruit yield per plant (kg)
TPC Total phenol content (mg/100g)
TSS Total soluble solids (%)

Table 5.5: The best top three cross with *per se* performance and the best cross with high heterosis and heterobeltiosis for different characters in brinjal.

Sr no.	Traits	Best cross for *Per se* performance	Best crosses over standard check	Best crosses over better parents
		Hybrids	Heterosis (%)	Heterobeltiosis (%)
1	Days to fifty per cent flowering	AB-09-1 × AB-12-10 (64.66)	AB-08-5 × GJB3 (-12.82)	AB-08-5 × GJB3 (-18.76**)
		GJB-3 × AB-12-10 (67.33)	AB-08-5 × JBL-08-8 (-9.26)	NSR-1 × AB-12-10 (-14.17*)
		AB-09-1 × AB-08-5 (68.00)	AB-09-1 × AB-08-5 (-8.5%)	AB-08-5 × JBL-08-8 (-13.36)
2	Plant height at harvest (cm)	AB-09-1 × AB-08-5 (68.00)	AB-09-1 × AB-12-10 (-13.39*)	AB-09-1 × AB-12-10 (-16.31**)
		AB-09-1 × NSR-1 (90.08)	AB-09-1 × AB-08-5 (-10.23)	AB-09-1 × AB-08-5 (-13.12*)
		AB-09-1 × AB-08-5 (92.23)	AB-08-5 × JBL-08-8 (-8.1)	AB-08-5 × JBL-08-8 (-12.84*)
3	Number of branches per plant at harvest (cm)	AB-09-1 × AB-12-10 (10.33)	AB-09-1 × AB-12-10 (34.99**)	AB-09-1 × AB-12-10 (37.44**)
		AB-09-1 × AB-08-5 (9.57)	AB-09-1 × AB-08-5 (25.14**)	AB-09-1 × AB-08-5 (27.42**)
		GJB-3 × AB-12-10 (9.17)	AB-08-5 × JBL-08-8 (19.91**)	AB-09-1 × NSRP-1 (13.58*)
4	Fruit length (cm)	AB-09-1 × AB-12-10 (14.66)	AB-09-1 × AB-12-10 (25.66**)	AB-09-1 × AB-08-5 (26.49**)
		AB-09-1 × AB-08-5 (13.82)	AB-09-1 × AB-08-5 (18.43**)	AB-09-1 × AB-12-10 (16.13**)
		AB-08-5 × JBL-08-8 (13.38)	AB-08-5 × JBL-08-8 (14.66*)	NSR-1 × GJB-3 (11.2)
5	Fruit diameter (cm)	AB-09-1 × AB-12-10 (7.03)	AB-09-1 × AB-12-10 (8.26)	NSR-1 × GJB-3 (22.40*)
		AB-09-1 × AB-08-5 (6.89)	AB-09-1 × AB-08-5 (6.00)	AB-09-1 × AB-08-5 (10.01)
		AB-08-5 × JBL-08-8 (6.85)	AB-08-5 × JBL-08-8 (5.49)	AB-09-1 × AB-12-10 (8.21)

Contd…

Table 5.5. Contd…

Sr no.	Traits	Best cross for *Per se* performance	Best crosses over standard check	Best crosses over better parents
		Hybrids	Heterosis (%)	Heterobeltiosis (%)
6	Average fruit weight (g)	AB-09-1 × AB-12-10 (125.18)	AB-09-1 × AB-12-10 (33.80**)	AB-09-1 × AB-12-10 (35.49**)
		AB-09-1 × AB-08-5 (116.37)	AB-09-1 × AB-08-5 (24.38**)	AB-09-1 × AB-08-5 (25.95**)
		AB-08-5 × JBL-08-8 (111.71)	AB-08-5 × JBL-08-8 (19.40*)	NSRP-1 × AB-12-10 (18.57*)
7	Number of fruits per plant	AB-09-1 × AB-12-10 (21.48)	AB-09-1 × AB-12-10 (32.04**)	AB-09-1 × AB-12-10 (33.55**)
		AB-09-1 × AB-08-5 (20.01)	AB-09-1 × AB-08-5 (23.01*)	AB-09-1 × AB-08-5 (24.41*)
		AB-08-5 × JBL-08-8 (19.25)	AB-08-5 × JBL-08-8 (18.32)	NSR-1 × AB-12-10 (23.16*)
8	Fruit yield per plant (kg)	AB-09-1 × AB-12-10 (2.80)	AB-09-1 × AB-12-10 (46.29**)	AB-09-1 × AB-12-10 (48.95**)
		AB-09-1 × AB-08-5 (2.40)	AB-09-1 × AB-08-5 (42.02*)	GJB-3 × JBL-08-8 (48.60**)
		AB-08-5 × JBL-08-8 (2.25)	AB-08-5 × JBL-08-8 (32.69**)	JBGR-1 × NSR-1 (35.10**)
9	Total phenol content (mg/100g)	AB-09-1 × AB-12-10 (1.01)	AB-09-1 × AB-12-10 (3.4)	GJB-3 × JBL-08-8 (17.87**)
		AB-09-1 × AB-08-5 (0.99)	AB-09-1 × AB-08-5 (1.7)	AB-08-5 × JBL-08-8 (10.98**)
		AB-08-5 × JBL-08-8 (0.98)	AB-08-5 × JBL-08-8 (-0.34)	AB-09-1 × AB-08-5 (8.73**)
10	TSS (%)	AB-08-5 ×GJB-3 (2.03)	GJB-3 × AB-12-10 (-36.06**)	GJB-3 × JBL-08-8 (-44.91**)
		GJB-3 × JBL-08-8 (2.16)	GJB-3 × JBL-08-8 (-31.97**)	AB-09-1 × JBL-08-8 (-42.83)
		AB-09-1 × JBL-08-8 (2.22)	AB-09-1 × JBL-08-8 (-30.19**)	AB-08-5 ×GJB-3 (-41.34**)

The most heterotic crosses for fruit yield per plant over standard check, *sca* effects and component characters showing significant heterosis were summarized in Table 5.2. Cross combinations *viz.,*AB-09-1 × AB-12-10, AB-09-1 × AB-08-5, AB-08-5 × JBL-08-8, GJB-3 × AB-12-10, JBGR-1 × NSR-1, NSR-1 × AB-12-10 and AB-09-1 × NSRP-1 manifested high heterosis coupled with high *sca* effects for fruit yield. Out of seven top yielding crosses, AB-09-1 × AB-12-10 involved average × average, AB-09-1 × AB-08-5 involved average × average, AB-08-5 × JBL-08-8 involved average × poor, GJB-3 × AB-12-10 involved average × average, JBGR-1 × NSR-1 involved good × good, NSR-1 × AB-12-10 involved good × average and AB-09-1 × NSRP-1 involved average × poor general combining ability parents.

From the observations made in the present study the following relevant points are emerged,

- The inspection of *sca* effects and mean performance of individual crosses indicated that the crosses having high *sca* effects did not always possess high mean (Table 5.4).
- The crosses exhibiting high *sca* effects do not always involved the parents having high *gca* effects (Table 5.4). Any parental combination either good x good, average x good average x average or poor x poor may result into high *sca* effects (Table 5.2).
- The crosses exhibiting high *sca* effects were not always the result of good x good combination with respect to mean performance.

5.4 Varietal screening

Use of resistant varieties is the ideal, the simplest and the cheapest method for the control of plant insect-pest and diseases. Moreover, it doesn't disturb natural ecosystem and avoids hazards of population. The identification of the source of the resistance is of basic need in breeding for disease resistance. Considering these facts, 37 brinjal genotypes were sown in the field to test for incidence against shoot and fruit borer infestation and bacterial wilt disease under natural condition at Regional Horticultural Research Stat ion, N.A.U., Navsari. The per cent pest and disease intensity and react ion of different varieties are presented in Table 4.10. In field condition out of 37 genotypes, none of the genotype was found free from shoot and fruit borer infestation but many of the genotypes found free from bacterial wilt incidence.

Heterosis exploitation is the best method for exploiting total free phenols and total sugar for resistance. Thus, parents producing heterotic crosses for high phenol content and low total sugar may be preferred, while, aiming to produce shoot and fruit borer resistant crosses.

In case of fruit characters, the fruit length is the important trait as it indirectly influences the fruit borer incidence. Less incidence of fruit borer was not iced when the fruits were long. Round fruit with high girth invites the fruit borer since the pest has physical adopt ion with that the pest can comfortably sit and lay eggs on the fruit [Kalloo *et al.* (1989)]. For shoot and fruit borer infestation, out of 28 crosses one AB-09-1 × GJB-3 found susceptible. The crosses *viz*., AB-09-1 × AB-08-5, AB-09-1 × NSRP-1, AB-09-1 × JBGR-1, AB-09-1 × GJB-3, AB-09-1 × AB-12-10, JBGR-1 × GJB-3, JBGR-1 × JBL-08-8, NSR-1 × GJB-3, NSR-1 × JBL-08-8, GJB-3 × JBL-08-8, and GJB-3 × AB-12-10 exhibited highly resistant to shoot and fruit borer infestation. Hybrids AB-08-5 × NSR-1, AB-08-5 × AB-12-10, NSRP-1 ×GJB-3, NSRP-1 × JBL-08-8, JBGR-1 × NSR-1, JBGR-1 × GJB-3, JBGR-1 × JBL-08-8 and JBL-08-8× AB-12-10 shows individual resistance against shoot borer infestation. Hybrids NSR-1 × GJB-3, NSR-1 × JBL-08-8 and GJB-3 × AB-12-10 shows individual resistance against fruit borer infestation. Parent AB-09-1 can be used as a promising source of shoot and fruit borer resistant for further breeding programme. Similar findings were observed by Darekar *et al*. (1991), Patel *et al.* (1995), Jat *et al.* (2003) and Yadav and Sharma (2005) for shoot and fruit borer complex.

In the present investigation, out of 37 genotype only one parent JBGR-1 and five crosses *viz*,. AB-09-1 × GJB-3, AB-08-5 × GJB-3, NSRP-1 × GJB-3, JBGR-1 × GJB-3 and NSR-1 × GJB-3 were affected by bacterial wilt symptoms. Similar findings were observed by Gopalkrishnan *et al*. (2000), Fugro (2001), Dalal *et al.* (2002), Manna *et al.* (2003), Hussain *et al.* (2005) and Ajjappalavara (2006) for bacterial wilt disease intensity.

SUMMARY & CONCLUSIONS

CHAPTER 6

SUMMARY AND CONCLUSIONS

The present experiment entitled "Breeding investigations in brinjal (*Solanum melongena* L.)" was undertaken to estimate the heterosis and gene action; identify good general and specific combiners and promising hybrids for yield and its component traits by involving eight genotype as a parents *viz,*. AB-09-1, AB-08-5, NSRP-1, JBGR-1, NSR-1, GJB-3, JBL-08-8 and AB-12-10 along with 28 hybrids derived through half-diallel mating and the standard check as Surati Ravaiya. The experimental material was raised in Randomized Complete Block Design with three replications at R.H.R.S., ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during *Rabi*, 2014-15 (crossing programme) and *Rabi* 2015-16 (evaluation programme). The observations were recorded on five randomly taken plants for various traits *viz*., days to fifty per cent flowering, plant height at harvest, number of branches per plant at harvest, fruit length, fruit diameter, average fruit weight, number of fruits per plant, fruit yield per plant, total phenol content and total soluble solids. The data were subjected to statistical analysis and the results obtained are summarized below.

Analysis of variance revealed sufficient genetic variability among treatment for fruit yield along with most of the traits under investigation, thus showing the importance for exploitation in recombination breeding.

Heterosis in desirable direction over standard check was observed in respect of all the characters. For fruit yield per plant, values of standard heterosis varied from 17.72 to 46.29 per cent. Seven crosses *viz,.* AB-09-1 × AB-12-10, AB-09-1 × AB-08-5, AB-08-5 × JBL-08-8, GJB-3 × AB-12-10, JBGR-1 × NSR-1, NSR-1 × AB-12-10 and AB-09-1 × NSRP-1 showed significant and positive standard heterosis for fruit yield per plant. The values of heterobeltiosis varied from 7.23 to 48.15 per cent. Six crosses *viz,.* AB-09-1 × NSR-1, AB-09-1 × AB-12-10, NSRP-1 × NSR-1, JBGR-1 × NSR-1, JBGR-1 × JBL-08-8 and GJB-3 × JBL-08-8 showed significant positive heterobeltiosis for fruit yield per plant. These hybrids can be used for exploitation of heterosis after further evaluation considering regional preferences.

The variance component for combining ability studies indicated that both additive and non-additive gene effects were important for all the characters. However, the characters *viz,.* Fruit diameter, Fruit yield per plant and total phenol content were found strictly under the control of additive genetic variance, while the remaining characters were found under the control of non-additive genetic variance.

Among the parents, *viz.*, JBGR-1, NSR-1 and JBL-08-8 were found to be good general combiners for majority of the characters. Hybrids *viz.*, AB-09-1 × AB-12-10, AB-09-1 × AB-08-5, AB-08-5 × GJB-3, AB-08-5 × JBL-08-8, GJB-3 × JBL-08-8, GJB-3 × AB-12-10, JBGR-1 × NSR-1, NSR-1 × AB-12-10 and AB-09-1 × NSRP-1 recorded higher *per se* performance along with higher *sca* effects and also standard heterosis as well as heterobeltiosis. The crosses identified to have high *sca* effects for at least one major yield components like number of fruits per plant, average fruit weight etc. The crosses showing high *sca* effects were not always the results of good × good *gca* combiners.

The experimental material was screened for pest and disease incidence under natural field conditions. In respect of fruit borer, no genotype was immune. Parents AB-09-1 and The crosses *viz.*, AB-09-1 × AB-08-5, AB-09-1 × NSRP-1, AB-09-1 × JBGR-1, AB-09-1 × GJB-3, AB-09-1 × AB-12-10, JBGR-1 × GJB-3, JBGR-1 × JBL-08-8, NSR-1 × GJB-3, NSR-1 × JBL-08-8, GJB-3 × JBL-08-8, and GJB-3 × AB-12-10 exhibited highly resistant to shoot and fruit borer infestation. A moderate resistant was exhibited in parents *viz.*, NSRP-1, JBGR-1, NSR-1 and JBL-08-8 as well as crosses *viz.*, AB-09-1 × NSR-1, NSRP-1 × JBGR-1, NSRP-1 × NSR-1, NSRP-1 × AB-12-10, JBGR-1 × AB-12-10 and NSR-1 × AB-12-10 and Surati Ravaiya. As range of per cent shoot and fruit borer incidence was high, the factor should be considered seriously in further breeding programmes.

Of all genotype, seven parents *viz.*, AB-09-1, AB-08-5, NSRP-1, NSR-1, GJB-3, JBL-08-8 and AB-12-10, 23 crosses and standard check (Surati Ravaiya) were found free of bacterial wilt incidence which indicates that the per cent disease infection was considerably low in south Gujarat environment condition.

From the results, it can be suggested that the crosses *viz.*, AB-09-1 × AB-12-10, AB-09-1 × AB-08-5 and AB-08-5 × JBL-08-8 were found to be good for further testing over location and /or seasons to confirm their potentiality.

❖ C. The References and Appendices ❖

1. References
2. Appendices

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APPENDICE

Appendix I

Meteorological parameters recorded during the growth and development phases of brinjal (monthly mean).

Month and Year	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
	Max.	Min.	Max.	Min.	
September-14	31.3	24.5	92.6	75.9	379.0
October-14	35.9	22.4	83.2	43.0	0.0
November-14	33.6	19.2	85.5	42.6	67.0
December-14	30.4	14.0	72.8	40.5	0.0
January-15	28.9	12.9	79.5	36.8	0.0
February-15	30.9	14.1	83.4	38.9	0.0
March-15	35.7	13.9	67.9	35.8	10.0
April-15	33.3	22.8	88.0	53.0	0.0
May-15	35.0	26.4	83.0	58.0	0.0
June-15	32.0	25.7	86.7	74.5	12.7
July-15	30.7	26.2	87.0	78.0	10.4
August-15	30.6	25.3	90.0	74.0	2.1
September-15	31.0	23.4	92.0	69.0	14.7
October-15	35.5	23.1	86.0	45.0	0.1
November-15	34.1	20.3	78.0	41.0	0.0
December-15	31.3	13.1	72.0	29.0	0.0
January-16	30.8	15.1	81	31.0	0.0
February-16	30.0	13.8	80.2	33.0	0.0
March-16	35.4	18.6	86.0	30.0	0.1

Appendix II

Mean performance of parents, hybrids and standard check for various traits.

Sr. No.	Parents	Days to fifty per cent flowering	Plant height at harvest (cm)	No. of branches per plant at harvest	Fruit length (cm)
1	AB-09-1	75.00	102.0	7.51	10.21
2	AB-08-5	75.00	92.50	9.22	11.72
3	NSRP-1	81.66	100.2	6.56	11.52
4	JBGR-1	69.00	95.9	8.53	12.65
5	NSR-1	79.66	103.7	6.97	10.92
6	GJB-3	70.33	96.1	8.50	10.89
7	JBL-08-8	70.66	103.9	7.69	13.43
8	AB-12-10	77.66	105.80	6.95	12.62
	Average	74.81	100	7.74	11.75
Sr.No.	**Hybrids**				
1	AB-09-1 × AB-08-5	68.00	92. 23	9.57	13.82
2	AB-09-1 × NSRP-1	72.66	95.93	9.17	12.4
3	AB-09-1 × JBGR-1	69.33	95.93	8.54	12.66
4	AB-09-1 × NSR-1	82.00	90.08	6.52	10.4
5	AB-09-1 × GJB3	78.33	103.63	6.86	10.78
6	AB-09-1 × JBL-08-8	82.00	106.93	6.15	10.00
7	AB-09-1 × AB-12-10	64.66	86.92	10.33	14.66
8	AB-08-5 × NSRP-1	77.00	102.1	7.30	11.28
9	AB-08-5 × JBGR-1	71.66	100.1	8.35	12.45
10	AB-08-5 × NSR-1	72.66	92.86	8.15	12.23
11	AB-08-5 × GJB3	86.00	108.48	6.02	9.85
12	AB-08-5 × JBL-08-8	68.66	92.74	8.53	13.38
13	AB-08-5 × AB-12-10	79.33	104.84	7.04	10.99
14	NSRP-1 × JBGR-1	85.66	105.59	6.60	10.50
15	NSRP-1 × NSR-1	77.66	100.87	7.34	11.33
16	NSRP-1 × GJB3	73.00	98.13	8.09	12.16
17	NSRP-1 × JBL-08-8	78.00	102.98	7.13	11.08
18	NSRP-1 × AB-12-10	73.00	97.03	8.31	12.42
19	JBGR-1 × NSR-1	70.00	93.58	9.00	13.18
20	JBGR-1 × GJB-3	77.66	100.16	7.75	11.79
21	JBGR-1 × JBL-08-8	80.66	102.7	7.18	11.14
22	JBGR-1 × AB-12-10	81.33	103.47	7.02	10.97
23	NSR-1 × GJB-3	74.00	98.20	8.08	12.15
24	NSR-1 × JBL-08-8	78.33	102.49	7.22	11.19
25	NSR-1 × AB-12-10	68.33	94.80	8.76	12.91
26	GJB-3 × JBL-08-8	82.66	107.09	6.3	10.16
27	GJB-3 × AB-12-10	67.33	107.83	9.17	13.15
28	JBL-08-8 × AB-12-10	74.66	98.35	7.43	11.43
	Average	74.37	99.50	7.78	11.80
Sr.No.	**Check**				
1	Surati Ravaiya	74.33	99.00	7.65	11.65

Contd...

Appendix II (Contd.2)…

Sr. No.	Parents	Fruit diameter (cm)	Average fruit weight (g)	No. of fruits per plant
1	AB-09-1	5.57	92.39	16.09
2	AB-08-5	3.23	94.41	16.36
3	NSRP-1	6.33	81.13	13.81
4	JBGR-1	6.79	112.30	19.34
5	NSR-1	6.50	86.10	14.97
6	GJB-3	6.01	103.89	17.94
7	JBL-08-8	6.26	104.21	16.85
8	AB-12-10	6.38	85.69	14.90
	Average	5.89	95.01	16.28
Sr.No.	**Hybrids**			
1	AB-09-1 × AB-08-5	6.89	116.37	20.01
2	AB-09-1 × NSRP-1	5.37	104.25	17.99
3	AB-09-1 × JBGR-1	5.42	104.25	18.00
4	AB-09-1 × NSR-1	6.57	74.86	13.10
5	AB-09-1 × GJB3	5.39	84.66	14.73
6	AB-09-1 × JBL-08-8	6.81	76.41	13.36
7	AB-09-1 × AB-12-10	7.03	125.18	21.48
8	AB-08-5 × NSRP-1	5.29	89.81	15.59
9	AB-08-5 × JBGR-1	6.28	102.08	17.63
10	AB-08-5 × NSR-1	6.65	99.82	17.26
11	AB-08-5 × GJB3	4.75	80.61	14.06
12	AB-08-5 × JBL-08-8	6.85	111.71	19.25
13	AB-08-5 × AB-12-10	6.03	86.75	15.08
14	NSRP-1 × JBGR-1	5.48	81.63	14.23
15	NSRP-1 × NSR-1	6.45	90.33	15.68
16	NSRP-1 × GJB3	6.56	99.09	17.14
17	NSRP-1 × JBL-08-8	5.58	87.75	15.24
18	NSRP-1 × AB-12-10	6.21	101.60	17.57
19	JBGR-1 × NSR-1	5.17	109.74	18.91
20	JBGR-1 × GJB-3	5.68	95.13	16.48
21	JBGR-1 × JBL-08-8	6.26	88.40	15.36
22	JBGR-1 × AB-12-10	6.36	86.59	15.05
23	NSR-1 × GJB-3	6.06	98.92	17.11
24	NSR-1 × JBL-08-8	6.12	88.90	15.44
25	NSR-1 × AB-12-10	6.20	106.88	18.43
26	GJB-3 × JBL-08-8	6.60	78.14	13.16
27	GJB-3 × AB-12-10	6.56	111.45	18.65
28	JBL-08-8 × AB-12-10	6.62	91.36	15.85
	Average	6.12	95.45	16.50
Sr.No.	**Check**			
1	Surati Ravaiya	6.56	93.56	16.27

Contd…

Appendix II (Contd.3)…

Sr. No.	Parents	Fruit yield per plant (kg)	Total phenol content (mg/100g)	TSS (%)
1	AB-09-1	1.60	0.92	3.12
2	AB-08-5	1.64	0.93	3.16
3	NSRP-1	1.30	0.88	2.33
4	JBGR-1	2.20	0.86	4.1
5	NSR-1	1.40	0.81	2.62
6	GJB-3	1.96	0.73	3.93
7	JBL-08-8	1.80	0.78	3.88
8	AB-12-10	1.35	0.90	2.67
	Average	1.65	0.85	3.25
Sr.No.	**Hybrids**			
1	AB-09-1 × AB-08-5	2.40	0.99	4.47
2	AB-09-1 × NSRP-1	2.00	0.88	3.42
3	AB-09-1 × JBGR-1	1.95	0.90	3.93
4	AB-09-1 × NSR-1	1.15	0.96	4.08
5	AB-09-1 × GJB3	1.30	0.83	2.55
6	AB-09-1 × JBL-08-8	1.11	0.93	2.22
7	AB-09-1 × AB-12-10	2.80	1.01	4.89
8	AB-08-5 × NSRP-1	1.45	0.88	2.87
9	AB-08-5 × JBGR-1	1.85	0.86	3.72
10	AB-08-5 × NSR-1	1.80	0.82	3.55
11	AB-08-5 × GJB3	1.20	0.69	2.03
12	AB-08-5 × JBL-08-8	2.25	0.98	4.40
13	AB-08-5 × AB-12-10	1.40	0.92	2.70
14	NSRP-1 × JBGR-1	1.20	0.84	2.54
15	NSRP-1 × NSR-1	1.45	0.83	2.75
16	NSRP-1 × GJB3	1.75	0.77	3.49
17	NSRP-1 × JBL-08-8	1.38	0.95	2.75
18	NSRP-1 × AB-12-10	1.83	0.81	3.69
19	JBGR-1 × NSR-1	2.10	0.87	2.30
20	JBGR-1 × GJB-3	1.61	0.88	3.23
21	JBGR-1 × JBL-08-8	1.40	0.72	2.82
22	JBGR-1 × AB-12-10	1.32	0.78	2.67
23	NSR-1 × GJB-3	1.75	0.81	3.50
24	NSR-1 × JBL-08-8	1.43	0.86	2.83
25	NSR-1 × AB-12-10	2.05	0.83	3.94
26	GJB-3 × JBL-08-8	1.10	0.92	2.16
27	GJB-3 × AB-12-10	2.13	0.83	4.46
28	JBL-08-8 × AB-12-10	1.50	0.83	2.98
	Average	1.66	0.86	3.26
Sr.No.	**Check**			
1	Surati Ravaiya	1.60	0.98	3.18

C E R T I F I C A T E

This to certify that I have no objection to supply one copy of any part of thesis at a time to any scientist through reprographic process if necessary for rendering reference service in a library of documentation centre.

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Date : 29, April-2016