HETEROSIS, COMBINING ABILITY AND STABILITY ANALYSIS IN OKRA [*Abelmoschus esculentus* (L.) Moench]

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HETEROSIS, COMBINING ABILITY AND STABILITY ANALYSIS IN OKRA [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

In the present investigation, information on the magnitude of heterosis, combining ability and its experiment was conducted on one location in four different environments, G x E interactions and stability parameters was obtained for fruit yield per plant and its related components following line x tester mating design involving 15 diverse varieties/strains of okra [*Abelmoschus esculentus* (L.) Moench]. The 15 parents and their 50 resultant F_1's with one standard check (GJOH-3) were tested for fourteen traits under four environments *viz.*, Timely summer-2014 (E_1), Late summer-2014, (E_2) Timely *kharif*-2014 (E_3) and Late *kharif*-2014 (E_4) at Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan (District - Mehsana) in a randomized block design with three replications.

Analysis of variance for individual as well as pooled over environments indicated significant differences among genotypes (Parents + F_1s) for all the characters for yield and yield contributing traits except days to first picking. The varying magnitude of heterosis for days to first picking, fruit length, fruit girth, internodal length, plant height, fruit yield per plant, total number of fruits per plant, total number of seeds per fruit, crude fiber and vitamin-C was indicated. Environment x parents vs hybrids were significant for all the characters except days to 50 per cent flowering, days to first picking, fruit length, total number of fruits per plant, total number of seeds per fruit, crude protein content and crude fiber content. This indicated the presence of varying magnitude of heterosis for these traits over environments.

On the basis of mean value of hybrids JOL-08-7 x Parbhani Kranti followed by JOL-08-12 x Pusa Sawani, JDNOL-11-14 x Parbhani Kranti, and JOL-08-12 x VRO-6 and female parents *viz.,* AOL-07-9, JDNOL-11-14 and JDNOL-11-3 recorded the highestfruit yield per plant, whereas, male parents VRO-6 and Parbhani Kranti recorded the highest fruit yield per plant.

The best hybrids on the basis of significant and desirable heterosis over better parent were JOL-6k-2 x GO-2 (46.90 %), JOL-6k-2 x Parbhani Kranti (37.77 %) in E_1, over mid parent and better parent were JOL-6k-2 x GO-2 (46.90 %), JOL-6k-2 x Parbhani Kranti (34.50 %) in E_2. The

cross JOL-08-7 x GO-2 exhibited significant and positive heterosis over mid parent and better parent (33.77 and 32.74 per cent, respectively) in E_3. These crosses showed heterotic response over mid and better parent for fruit yield per plant. None of the hybrids exhibited significant and positive heterosis over standard check across the environment and in the individual environment for fruit yield per plant. These indicating that none of the hybrids offer possibilities of further exploitation for development of high yielding varieties over the standard check.

Combining ability analysis revealed that non-additive variances were significant for fruit yield per plant and its related traits indicated their involvement in the expression of various traits. The magnitude of non-additive variance was higher for fruit yield per plant and its contributing traits indicated the predominant role of non-additive gene action in the inheritance of the traits.

None of the parents were good general combiner for all the traits under study. Among female parents, AOL-08-5, JDNOL-11-12 and JOL-08-7 and male parents VRO-6 and Parbhani Kranti were classified as good general combiners for fruit yield per plant and related traits. The parents with high *per se* performance had high gca effects for most of the traits indicated that selection for good combiners for different characters could also be made on the basis of *per se* performance of the parents. The hybrids across the environments on the basis of sca effects for fruit yield per plant were JOL-08-7 x Parbhani Kranti, JOL-08-12 x Pusa Sawani, JDNOL-11-14 x Parbhani Kranti, JOL-08-12 x VRO-6 and JDNOL-11-3 x Parbhani Kranti.

On the basis of *per se* performance, gca effects of parents, exploitable heterosis, sca effects of hybrid for fruit yield per plant and its component characters, VRO-6, Parbhani Kranti (male) and JOL-08-12 and AOL-08-5 (female) parents and JOL-08-7 x Parbhani Kranti, JDNOL-11-3 x Arka Anamika and JDNOL-11-1 x GO-2 among hybrids were found to be most promising for exploitation in practical breeding programme.

The mean squares due to genotypes were highly significant for all the traits except days to first picking indicating considerable genetic variation among the genotypes. Similarly, mean square due to environments was highly significant for all the characters except crude fiber content and vitamin-C. which showed inconsistent performance over environments. The environment (linear) component was significant for all the characters except crude fiber content and vitamin-C indicated inconsistent environmental differences at four environments. The mean squares due to G x E (linear) was significant for fruit girth, plant height and total number of fruits per plant. This suggested that linear components play an important role in building up total G x E interaction for these traits. The mean squares due to pooled deviation were significant for all characters, but its magnitude was lesser than linear component, only in case of days to 50 per cent flowering, fruit girth, days to last picking and crude fiber content. For remaining traits, the linear component was greater, thereby suggested the prediction of performance of genotypes over environments based on regression analysis could be reliable with respect to these characters.

The female parents AOL-07-9, JDNOL-11-14, whereas, male parent VRO-6 and Parbhani Kranti were found to be average stable with good (high) gca effect for fruit yield per plant and its attributes. The crosses JOL-08-7 x Parbhani Kranti, JOL-08-12 x VRO-6 and JDNOL-11-3 x Parbhani Kranti were the best for fruit yield per plant.

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CERTIFICATE – I

Dated: 26/09/2017

This is to certify that the thesis entitled **"HETEROSIS, COMBINING ABILITY AND STABILITY ANALYSIS IN OKRA [*Abelmoschus esculentus* (L.) Moench]"** submitted for the degree of **DOCTOR OF PHILOSOPHY** in the subject of **GENETICS AND PLANT BREEDING** is a record of bonafide research work carried out by **KHADIA SATISHKUMAR MANUBHAI** under my guidance and supervision and that no part of this thesis has been submitted for any other degree, diploma, associateship, fellowship or other similar titles. The assistance and help received during the course of investigation have been fully acknowledged.

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Place : Sardarkrushinagar
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LIST OF SYMBOLS AND ABBREVIATIONS

Symbols

=	is equal to
x	Multiply
( )	Bracket
;	semi colon
%	Per cent
/	per

Abbreviations

SDAU	Srdarkrushinagar Dantiwada Agricultural University
ANOVA	Analysis of Variance
a.m.	After Meridian
p.m.	Past Meridian
C.D.	Critical Difference
C.V.	Co-efficient of Variation
S.Em ±	Standard error of mean
et al.	and his co-workers
$^{\circ}$C	Degree Celsius
cm	Centimeters
g	Gram
GCA	General Combining Ability
SCA	Specific Combining Ability
Max.	Maximum
Min.	Minimum
viz.,	Namely
R.B.D.	Randomized Block Design
MP	Mid Parent
BP	Better Parent
SC	Standard Check
vs.	Versus
No.	Number
IIHR	Indian Institute of Horticultural Research
JAU	Junagadh Agricultural University
AAU	Anand Agricultural University
IARI	Indian Agricultural Research Institute
IIVR	Indian Institute of Vegetable Research
MAU	Maharashtra Agricultural University
D50F	Days to 50 per cent Flowering

DFP	Days to first picking
FL	Fruit length
FG	Fruit girth (cm)
NBP	Number of branches per plant
IL	Internodal length
PH	Plant height
FYP	Fruit yield per plant
TNFP	Total number of fruits per plant
TNSF	Total number of seeds per fruit
DLP	Days to last picking
CPC	Crude protein content
CFC	Crude fiber content
V-C	Vitamin-C

Dedicated to my father

Late, Sh. Manubhai. B. Khadia

INTRODUCTION

I. INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is one of the most important vegetable crops grown extensively throughout the country during summer and rainy seasons. It has been one of the most popular vegetable crops in the tropics because of its easy cultivation, dependable yield, year round export potential, high nutritive value, wide adaptability to varying moisture conditions and resistance to diseases and pests (Martin and Ruberte, 1978). This plant is being native of tropical Africa (Yawalkar, 1980). It has been known by different names in different languages: Okra or ladyfinger in English, gombo in French, guinogombo in Spanish, guibeiro in Portuguese, bhindi in Hindi and bamiah in Arabic. Important okra cultivating states are Uttar Pradesh, Panjab, Madhya Pradesh, Karnataka, Maharashtra, Gujarat and some parts of Rajasthan. It is cultivated as a garden crop as well as on large commercial farms with high potential for foreign exchange earnings.

Okra belongs to genus Abelmoschus of *Malvaceae* family. Varying number of chromosomes has been reported by several workers. It range from 2n = 56 to 2n = 200 (Siemonsma, 1982 and Anonymous, 2011), but chromosome number within *Abelmoschus esculentus*, is 2n = 72, 108, 120, 132 and 144 are in regular series of polyploids with n = 12 (Datta and Naug, 1968). It is an often cross pollinated crop and occurrence of out crossing to an extent of 4 to 19 per cent with the maximum of 42.2 per cent is noticed with the insect assisted pollination (Kumar, 2006). It's fast growth, short duration and photo-insensitive nature enables plant breeders to raise two crops in a year and thus, genetic studies can be completed in short span of time. Moreover, its large flowers and monodelphous nature of the stamens make emasculation and pollination process easier. With the ease in fruit set and good number of seeds per pod, okra can be well exploited for hybrid vigour.

India is a major okra producing country in the world comprising of 72 per cent of total area under okra. The area under okra cultivation in India is 503.68 (‘000 ha) with production of 5708.69 (‘000 mt) and productivity of 11.5 mt/ha, containing 5.7 per cent of the total area under vegetable crops and 3.9 per cent of total vegetable production (Anonymous, 2015). It is also an important vegetable crop in Gujarat state and is mainly grown in Banaskantha, Bhavnagar, Junagadh, Navsari, Surat, Tapi and Vadodara Districts. It occupies an area of 73.84 (‘000 ha) with a production of 857.49 (‘000 mt) having average productivity of 11.5 mt/ha. West Bengal is a leading okra producing state with 14 per cent of production share, while Gujarat comprised of 12 per cent production share (Anonymous, 2015).

Vegetables are considered as ‘protective supplementary food’ as they contain minerals, vitamins and essential amino acids which are required for normal functions of the human metabolic processes. The green pods of okra have various uses. They are cooked as vegetables, in curries and also as a soup product. They can also be canned and dried. It is good source of nutrients and minerals as each 100 g edible portion contain 1.9 g protein, 0.2 g fat, 0.7 g minerals, 0.4 g carbohydrates, 66 mg calcium, 43 mg magnesium, 1.5 mg iron, 6.9 mg sodium, 10.3 mg copper, 30 mg sulphur, 8 mg oxalic acid, 88 I.U. vitamin A, 63 I.U. vitamin B, 13 mg vitamin 'C,' 0.07 mg thiamine, 0.1 mg riboflavin and 0.6 mg nicotinic acid (Gopalan *et al.,* 2007; Babel and Yadav, 1971 and Rekhi, 1976). Besides being used as a food product, mature fruits and stem of the plant containing crude fibers are used in the paper industry. Furthermore, the plant extract is also used as a purifier in the manufacture of jaggery. Apart from its commercial uses, it is said to be very useful against genitourinary disorders, spermatorrhoea and chronic dysentery (Krishnamurthy, 1994). Okra contains special fiber which takes sugar levels in blood under control. Fiber in okra ensures proper intestine functionality (Kumar *et al.*, 2013). Okra leaves are used in Turkey, for preparing medicine to sooth and reduce inflammation (Mehta, 1959). Another important quality parameters from the consumer's point of view is colour of the pod as well as pod stalk. Okra with deep green skin colour are considered more mucilaginous than others, its consumers prefer them most (Udengwu, 2008).

In spite of its importance, no major breakthrough has been made in this crop and the farmers are still growing their own local varieties or open pollinated varieties. There is very less total area under F_1 hybrids. Yield is mear universal breeding objective. To optimize yield, one has to select varieties for resistance or tolerance to pest and diseases and abiotic stresses.

To exploit the heterosis and measuring combining ability of potential yield components, line x tester analysis method of crossing is used. The concept of line x tester analysis was developed by Kempthorne in 1957. It is a good approach for screening the germplasm on the basis of GCA and SCA variances, effects and to understand the nature of gene action involved in the expression of various quantitative traits for further development of promising hybrids in okra.

Okra is one vegetable crop where heterosis has been exploited successfully. Vijayaraghavan and Wariar (1946) have first reported hybrid vigour in okra. The term heterosis was coined by Shull in 1948 which refers to a superiority or inferiority of F_1 hybrids in one or more characters over its parents. The magnitude of heterosis provides a basis for genetic diversity and a guide to the choice of desirable parents for developing superior F_1 hybrids. The extent of heterosis in okra in relation to yield and its components has earlier been reported by Poshiya and Shukla (1986), Kumbhani *et al.* (1993) and Khatik *et al.* (2012). The most important factor for determining the feasibility of hybrid is the nature and extent of heterosis and its exploitation. Hence, choice of right type of parents for hybridization is important for improving the genetic yield potentiality of the varieties and hybrids. This emphasises importance of testing the parents for their combining ability and manifestation of hybrid vigour, because many a times the high yielding parents may not combine well to give good hybrids.

In any crop improvement programme, the proper choice of parents based on their combining ability is useful to study and compare the performance of the lines in hybrid combinations. Sprague and Tatum (1942) proposed concept of General Combining Ability (GCA) and Specific Combining Ability (SCA). GCA that is defined as the average performance of the progeny of an individual when, it is mated to a number of other individuals and the SCA, a term that refers to the deviation in performance of a cross from what would be expected on the basis of the GCA of the parents.

Phenotypic variation is a composite of three variables, *viz.*, genetic, environmental and Genotype x Environment interaction. It is a common practice in trials involving varieties and breeding lines to grow a series of genotypes in a range of different environments. If, all the genotypes respond similarly to all the environments tested, their relative performance in other environments may be predicted with some confidence. A Genotype x Environment (G x E) interaction exists where the relative performance of varieties changes from environment to environment. The presence of G x E interaction is a major problem in getting a reliable estimate of heritability and it makes, it difficult to predict with greater accuracy rate of the genetic progress under selection for a given character.

Keeping all the facts in view, the present investigation using line x tester mating design involving fifteen genetically diverse genotypes of okra was undertaken over three consecutive seasons with the following objectives:

Objectives of the study:

[1] Study the extent of heterosis for yield and its contributing traits

[2] Study the genetic nature and relative magnitude of general as well as specific combining ability of parents and crosses, respectively

[3] Study Genotype x Environment interactions and stability analysis

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Several studies have been conducted on genetics of horticultural crops including vegetables. Information on genetic architecture of various quantitative traits, particularly of those that contributed yield would be most useful in planning of the breeding programme for effective selection. Such information could be used for developing more sophisticated and efficient approach to select and test the parents that will produce superior hybrids. Various biometrical techniques have been developed for studying the genetics of different trait.

Development of commercial hybrids has provided an important tool in improving the yield of crop plants substantially. Knowledge of heterosis and combining ability could be of vital importance to the plant breeders in the evaluation and selection of variety and in formulating the appropriate breeding procedure for crop improvement.

A brief review of the work done in the light of the present investigation, pertaining to heterosis, combining ability and stability of okra for various characters relevant to the present study is reviewed and presented under the following headings.

2.1 Magnitude of heterosis

2.2 Estimation of combining ability

2.3 Genotype x environment interaction and stability parameters

2.1 Magnitude of heterosis

Heterosis refers to the phenomenon that progeny of diverse varieties of a species or crosses between species exhibit greater biomass and fertility than both parents. Term 'Heterosis' was first coined by Shull (1908) and first reported in plants by Koelreuter (1766). He noted that vigour in crosses increased with the increase in dissimilarity of parents. If, heterosis of F_1 hybrid is estimated over the mid parental value, it is regarded as average heterosis. If, it is estimated over the superior parent, such an estimate is referred as heterobeltiosis. The term 'Heterobeltiosis' was proposed by Fonseca and Paterson (1968) and they used it to describe improvement of heterozygotes in relation to better parent. Standard heterosis/economic heterosis are a recent phenomenon which refers to superiority of F_1 in comparison to adopted variety/hybrid. According to Mather and Jinks (1971), heterosis means the amount by which average of F_1 family exceeds its better parent. Heterosis being a complex phenomenon, no single conclusive or clear cut explanation is available to account for its manifestation.

The term useful heterosis was used by Meredith and Bridge (1972). It refers to the superiority of F_1 over the standard commercial check variety, hence also called standard heterosis.

Poshiya and Vashi (1995) studied 45 okra genotype derived from 9 x 9 diallel fashion and reported the heterobeltiosis to the extent of 27.72 per cent for yield per plant, 30.77 per cent for fruits per plant, 17.36 per cent for fruit girth, 11.71 per cent for fruit length, 22.67 per cent for plant height, -12.04 per cent for internodal length and -4.34 per cent for days to flowering.

Pathak and Shymal (1997) studied heterobeltiosis in six lines and three testers of thirteen crosses of okra showed high heterobeltiosis for yield per plant. They suggested that heterosis for pod yield could be due to manifestation of high heterosis of important yield component characters.

Panda and Singh (1999) studied heterotic effects of six characters in twenty crosses of okra. Highest value of heterosis was observed for pod yield and number of pods per plant. The extent of heterosis was 45.62 per cent for pod yield and 28.32 per cent for number of pods per plant.

Ahmed *et al.* (1999) revealed highly significant differences among parents, crosses and parents vs. crosses for the characters like internodal length, fruit length, number of branches per plant, number of fruits per plant, fruit weight, number of seeds per fruit, fruit yield per plant and found significant heterosis over better parents for all these characters in okra. The mean value for F_1 hybrid was greater than parental mean for most of the characters.

Sood and Sharma (2001) studied heterosis and gene action in the F_1 and F_2 generations for fruit yield and associated traits in a diallel crosses in okra. P-7 x Arka Abhay had the highest heterosis for yield over the better parent (68 %) and produced 80 per cent more fruit than the control cultivar, Pusa Sawani.

Prakash *et al.* (2002) conducted an experiment on okra genotypes Parbhani Kranti and Arka Abhay, their F_1 hybrids and 2 F_2 populations to assess the genetic architecture of certain quantitative traits. Arka Abhay was best for high seed yield/plant (62.89 g), capsule length (12.64 cm), capsule weight (15.66 g) and seed yield/capsule (3.71 g) whereas, Parbhani Kranti registered as a superior parent for number of capsules/plant (16.60) and days to first flower (44.90). Among the F1 hybrids, PK x AA showed high seed yield/plant (69.28 g), number of seeds/capsule (55.38), 100-seed weight (7.22 g) and capsule weight (20.20 g). Significant heterosis in both generations was observed.

Chauhan and Singh (2002) evaluated 80 crosses of okra using 20 lines and four testers and revealed heterosis over better parent, standard check-1 (Parbhani Kranti) and standard check-2 (Pusa Sawani) for the traits like yield per plant, stem diameter and found significant heterosis. Cross combinations *viz.*, DC-97 x P-7, Arka Anamika x Arka Abhay, Shagun x Varsha Uphar, EMS-8 x P-7, DC-97 x Varsha Uphar, PSB-1 x Varsha Uphar, K-21 x P-7 and Arka Anamika x Arka Abhay also exhibited heterosis over standard check-2.

Yadav *et al.* (2002) studied 45 F_1's of okra for marketable yield and its components traits and observed considerable heterosis over superior and economic parent for number of days to flower, plant height, number of branches per plant, length of first fruiting node, length and width of fruit, number of fruits per plant and yield per plant.

Rani *et al.* (2002) assessed the magnitude of heterobeltiosis in an 8 x 8 diallel set excluding reciprocals and found significant and desirable heterobeltiosis for all the characters studied in okra. The cross Pusa Makhmali x HRB 9-2 showed significant heterotic response for node at which the first flower appeared, number of fruits per plant, fruit weight and total yield.

Singh *et al.* (2002) reported better parent heterosis in okra as high as 141 per cent for length of fruits in genotype (5709 x 6308) and 185 per cent for number of fruits in genotype (6305 x 6901). They also obtained beneficial heterobeltiosis for fruit weight in genotype 6302 x 6308 (67.51 %).

Rewale *et al.* (2003) studied heterosis for yield and yield components in okra. The results revealed significant heterotic effects in the positive direction were expressed for all the yield and yield contributing characters (days to initiation of flowering, days to initiation of fruit, days to maturity for green fruit, plant height, branches per plant, nodes per plant, fruits per plant and yield per plant) of okra. Most of the high heterotic combinations were between geographically diverse parents. The crosses SOH-02 x P.K. and SOH-02 x G.F. exhibited desirable negative and significant heterotic effects for days to initiation of flowering, days to initiation of fruit and days to maturity for green fruit. The cross DVR-3 x G.G. recorded significant heterobeltiosis for yield per plant, fruits per plant, nodes per plant, branches per plant and plant height. The crosses JNDO-5 x P.K. (153.43 %) and NOL-101 x G.G. (147.79 %) also showed a higher magnitude of heterosis over better parent.

Tripathi *et al.* (2004) studied 4 x 4 cross in okra through diallel mating design. The results revealed that heterosis over standard parents and inbreeding depression. A significant amount of useful heterosis was observed for all the characters, except for yield per plant. However, the maximum heterosis with respect to fruit width was observed in cross Azad Bhindi-1 x Parbhani Kranti (131.57 %).

Singh *et al*. (2004) conducted an experiment using 15 female parents and four pollen parents of okra and crossed in line x tester design and thus 60 F_1's were produced for characters like days to 50 per cent flowering, 1st flowering node, green pod weight, green pod length, green pod diameter, internodal length, number of branches plant, number of fruits per plant and fruit yield per plant and found significant heterosis over better and mid parent. There were highly significant differences among the parents, crosses, parents' vs. crosses, lines (females), testers (males) and lines vs. testers for most of the characters under study.

Borgaonkar *et al.* (2005) studied heterosis in okra through 8 x 8 diallel analysis. The results depicted that parents as well as hybrids differed significantly for all the characters studied namely days to 50 per cent flowering, fruit length, internodal length, plant height and yield per plant. Significant parental differences were also observed for all the characters. A comparison of parent's vs. hybrids mean squares indicated that hybrids differed significantly from that of parents for all the characters except for internodal length and plant height. Out of 28 crosses, 10 crosses showed significant positive heterobeltiosis. The cross No. 129 x JNDO 5 (52.22 %) exhibited the maximum heterobeltiosis for yield per plant followed by No. 74 x JNDO 5 (40.45 %).

Singh and Syamal (2006) studies set of 12 x 12 diallel cross in okra. The results recorded heterosis over better parent ranged from 7.19 per cent (Pusa Sawani x Arka Abhay) for plant height to 45.71 per cent (Pusa Sawani x Punjab Padmini) for the number of primary branches. Some crosses showed negative heterosis over better parent ranging from -13.84 per cent (Pusa Sawani x BO-2) to -26.36 per cent (Pusa Sawani x HRB 9-2) for days to flowering, and -28.22 per cent (Arka Abhay x Punjab Padmini) to -29.21 per cent (IC 90202 x P-7) for days to first picking. Heterosis over better parents was to the extent of 53.28 per cent (IC 90177 x IC 90202) for the number of pods per plant, 27.16 per cent (7D2x x Arka Abhay) for pod size, 12.65 per cent (Arka Abhay x BO-1) for pod weight and 54.54 per cent (Arka Abhay x BO-1) for yield per plant. Heterosis for the lowest number of seeds over better parents ranged from 40.78 per cent (Pusa Makhmali x HRB 9-2) to 16.21 per cent (Punjab Padmini x HRB 9-2).

Vermani *et al.* (2006) studied a line x tester involving 14 lines x 2 tester in okra. They recorded no single cross-combination could express significant desirable heterobeltiosis for all the characters simultaneously. The cross Pusa Makhmali x P-8 revealed desirable maximum heterobeltiosis for fruit yield per plant (27.11 %), nodes per plant (19.30 %) and plant height (26.32 %). The cross-combination Dhira x Arka Anamika revealed heterobeltiosis for inter-nodal length (-22.78 %), fruits per plant (20.96 %) and fruit length (39.29 %).

Nichal *et al.* (2006) studied 7 x 7 diallel in okra. Analysis of variance showed significant differences among the parental lines and their hybrids in terms of number of days to flowering, plant height, number of primary branches on the main stem, number of fruiting nodes on the main stem, number of fruits per plant, average fruit weight, fruit length and fruit yield per plant, indicating genetic diversity of the materials tested. The cross VRO-3 x Arka Abhay recorded the highest relative heterosis (132.84 %) and heterobeltiosis (129.22 %) for fruit yield per plant, whereas the crosses Arka Abhay x Arka Anamika and AKO-16 x Pusa A-4 recorded significant heterosis over the mid-parent, better parent and the control cultivar, Pusa A-4.

Mamidwar *et al.* (2006) studied 14 lines (females), 3 testers (males) in okra. The mean value of crosses and heterosis over the better parent was estimated for the 42 crosses. The highest level of heterosis over the better parent for fruit yield per plant was recorded for VRO-6 x Parbhani Kranti (55.57 %), followed by Daftari-1 x Arka Abhay (54.31 %).

Manivannan *et al.* (2007) studied heterosis over better parent in okra. The cross, VRO-5 x IIVR-10 for plant height, Arka Anamika x IIVR-10 for plant spread, Punjab Padmini x Pusa Sawani for number of leaves, Arka Anamika x VRO-6 for days to per cent flowering, Punjab Padmini x VRO-5 for fruits per plant, Pusa Sawani x Parbhani Kranti for fruit weight, Pusa A-4 x VRO-5, for number of seeds per fruit, Arka Anamika x VRO-6 for 100-seed weight and Pusa A-4 x VRO-6 for yield per plant. The crosses Pusa Sawani x IIVR-10 for number of ridges per fruit, Arka Anamika x VRO-6 for 100-seed weight and Pusa A-4 x VRO-6 for yield showing significant heterobeltiosis all showed superiority over the standard check Parbhani Kranti for the respective characters. However, Pusa A-4 x VRO-6 recorded higher mean value for yield per plant and also recorded sustained improvement over check for the above mentioned traits.

An experiment carried out by Yadav *et al.* (2007) in okra through line x tester technique excluding reciprocals to determine heterosis over standard parent (Parbhani Kranti) for yield and yield components (days to flowering, plant height, number of branches per plant, number of first fruiting node, length of first fruiting node, number of nodes per plant, internode length, fruit length, fruit width, tapering length of fruit, number of fruits per plant). The estimate of heterosis for various yield components of the heterosis hybrids indicated that significant yield increase is largely attributed to increased plant height, number of branches per plant, number of fruits per plant and number of nodes per plant.

Amutha *et al.* (2007) estimated relative heterosis, heterobeltosis and standard heterosis in okra for assessing the hybrid value for characters *viz.*, number of branches, fruit length, fruit weight, fruit yield by number and weight. The cross Arka Abhay x Punjab Padmini showed significant positive heterosis over better parent and standard parent for fruit weight (5.9 %, 14.36 %), fruit length (13.5 %, 16.75 %), fruit yield by number (6.77 %, 13.99 %) and weight (14.48 %, 31.40 %).

Shoba and Mariappan (2007) studied 5 lines and 2 testers in okra. The observations recorded for plant height, days to first flowering, number of nodes/plant, fruit length, fruit girth, number of fruits/plant, single fruit weight, number of seeds/fruit, 100-seed weight, crude fibre content, protein content and yield/plant. The results revealed highly significant differences for all the characters among the parent and genotypes indicated wider range of variability. Among all the crosses evaluated, the cross combination IC 169340 x IC 112475 exhibited highest heterosis for all the characters studied.

Mehta *et al.* (2007[a]) studied forty two hybrids of okra generated by crossing three testers with fourteen lines were studied along with parents for studying heterosis and gene action for days to first flowering, days to 50 per cent flowering, fruit weight, fruit length, plant height, number of seeds per fruit, 100-seed weight and fruit yield per plant. The most heterotic combinations were VRO-6 x Parbhani Kranti, VRO-4 x Parbhani Kranti, Daftari-1 x Arka Abhay and Kaveri Selection x Ankur Abhaya for fruit yield per plant. The sca variances for days to fruit flower, days to 50 per cent flowering, fruit weight, fruit length, plant height, number of seeds per fruit and 100-seed weight were higher than so gca variance so there is a preponderance of non-additive gene action. The gca variances was greater than sca variances for fruit yield per plant indicating preponderance of additive gene action for this trait. Overall, the results discussed above are quite indicative of the fact that hybrid okra has great potentialities of maximizing fruit yield.

Dahake *et al.* (2007) assessed the magnitude of heterosis over better parent and standard check for fruit yield and its components in okra. The cross Hissar Unnat x Duptari 45 exhibited the highest magnitude of heterosis to the extent of 24.36 per cent over better parent and 13.93 per cent over standard check for fruit yield per plant. Hissar Unnat x Duptari 45, Parbhani Kranti x Arka Anamika, Arka Anamika x Ankur 40 were identified as promising crosses and they have immense practical value which can be exploited for hybrid vigour.

Kumar and Pathania (2007) carried out heterosis studies involving 10 lines and three testers of okra in line x tester model for characters like first flowering node, internodal length, fruit length, fruit diameter, plant height, fruits per plant, fruit yield per plant and fruit weight and found significant heterosis over better and standard parents for all these characters. ANOVA exhibited significant differences for most of the traits studied.

An experiment was conducted by Desai *et al.* (2007) using 28 okra hybrids and observed that Parbhani Kranti x Gold Finger recorded superior performance for plant height, nodes per plant, fruit weight, fruits per plant and yield per plant. The hybrid, Long Green Smooth Finger x Green Gold also showed superior performance for these traits except fruit weight. Yield per plant exhibited highest heterosis of 558 per cent over mid parent and 447 per cent over better parent. Considering the high magnitude of heterosis and *per se* performance these hybrids were identified as promising hybrids in okra.

Hosamani *et al.* (2008) studied twenty four F_1 hybrids of okra developed from three lines (‘IC-111478’, ‘IC-90044’ and Arka Anamika) and eight testers (‘EC-316046’, ‘IC-111479’, ‘IC-90203’, ‘IC-90273’, ‘IC-90263’, ‘Parbhani Kranti’, ‘VRO-65’ and ‘IC- 89936’) in a line x tester fashion. The parents were selected based on better adaptation and desirable agronomic characters. Parents and F_1’s were evaluated along with a private commercial hybrid as check ‘MHB-10’ in randomized block design. Observations were made on five randomly selected plants in parents, hybrids and a standard check in each replication for nine economic characters *viz.*, plant height, branches per plant, internodal length, first fruiting node, fruit length, fruit diameter, fruit weight, fruits per plant, and fruit yield per plant. The data was subjected to line x tester analysis and the heterosis for Mid Parent (MP), Better Parent (BP) and Standard Check (SC) were worked out using the methods of Turner (1953) and Hayes *et al.* (1956).

Line x tester analysis was carried out to assess the magnitude of heterosis for earliness and yield parameters by Jaiprakashnarayan *et al.* (2008[a]) in okra. Maximum heterosis over better parent and standard parent in desirable direction were found for days to 50 per cent flowering, fruit length, fruit weight, number of fruits per plant and total yield per plant.

Weerasekara *et al.* (2008[a]) estimated heterosis in okra for yield and yield components in okra for different characters like days to 50 per cent flowering, number of branches per plant, number of fruits per plant, fruit weight and fruit yield per plant in a line x tester crossing programme comprising 24 hybrids produced by crossing eight lines and three testers and found significant heterosis over mid and better parents. The analysis of variance indicated highly significant differences for all most all the characters.

Heterosis for fruit yield and its components was studied in okra by Dabhi *et al.* (2009) in a set of 12 lines and four testers cross over better parent and standard check (Arka Anamika). For fruit yield, maximum heterosis of 20.04 per cent (PB-266 x Arka Abhay) and 32.08 per cent (KS-404 x Arka Abhay) was observed over better parent and standard check, respectively. Out of 48 hybrids, four hybrids showed significant positive heterosis over better parent, while 31 hybrids exceeded the standard check for fruit yield over the environments. The highest standard heterosis was depicted by the hybrid KS-404 x Punjab-7 of 49.62 per cent for number of fruits per plant.

Better parent heterosis was studied in direct and reciprocal crosses using nine early and late okra cultivars by Obi (2009) at Nigeria. The ANOVA for various growth and yield parameters showed almost very highly significant differences indicated that the cultivars were genetically diverse. Very highly significant, narrow and intermediate, heterosis was recorded for most of the direct and reciprocal crosses, showing that selection could be made from the hybrids to meet desired local okra qualities. A cross between early - late and late - early parents, using early okra as the maternal parents gave rise to a stable viable bridge hybrid which out-performed the better parent in many respects thereby overcoming the hitherto strong barrier to gene flow in interspecific hybridization studies.

Twelve okra genotypes were crossed in diallel mating design by Jindal *et al.* (2010) to generate 66 one-way hybrids for estimating the extent of heterobeltiosis and economic heterosis for yield and earliness in okra. For number of primary branches per plant, twenty and twenty six hybrids; and for marketable yield per plant, thirty and twenty-nine hybrids showed significant and positive heterosis in E_1 and E_2, respectively. Some of the hybrids *viz.*, PA-4 x NDO-10, PA-4 x

PB-1, NDO-10 x HRB-108-2, HRB-107-4 x HU and VRO-3 x S-2 were of commercial importance in respect of earliness and yield.

Kumar and Sreeparvathy (2010) evaluated five okra genotypes were crossed in full diallel fashion (including the reciprocals). The characters observed were days to 50 per cent flowering, plant height, number of branches per plant, number of fruits per plant, fruit length, fruit weight and fruit yield per plant. The results showed that the standard heterosis for fruit yield per plant were maximum in the hybrid MDU 1 x Hisar Unnat, with a value of 65.23 per cent. This hybrid recorded high standard heterosis for all the characters except number of branches per plant and fruit weight.

The relative heterosis and heterobeltiosis for fruit yield and their attributes were studied in six crosses of okra by Patel *et al.* (2010). They found ample amount of heterosis over mid and better parent for all the traits. Significant and positive heterobeltiosis was observed in KS-404 x HRB-108-2 and VRO-5 x GO-2 for fruit length and fruit yield per plant. Similarly, significant and positive relative heterosis was depicted in KS-404 x HRB-108-2 for number of nodes per plant, number of fruits per plant and fruit length.

Ramya and Kumar (2010[a]) studied heterosis in okra by using diallel analysis (7 x 7) for characters like number of fruits per plant, fruit weight, fruit length, fruit yield per plant and found significant standard heterosis for these characters. The analysis of variance revealed that the parents and hybrids differed among themselves for all the characters studied. The direct and reciprocal cross combinations portrayed high mean and commercial heterosis.

Heterosis were estimated in okra for yield and contributing traits *viz.*, number of primary branches per plant, internodal length, first flowering node, fruit length, fruit diameter, fruit weight, number of fruits per plant and fruit yield per plant by Singh and Sanwal (2010[a]) in line x tester programme involving six lines and four testers and observed significant heterosis over better parent.

Wammanda *et al.* (2010[a]) studied the genetic basis of yield and its components using a 9 x 9 diallel cross in okra, 36 F_1's and the nine parents for characters like days to 50 per cent flowering, plant height, number of branches per plant, internode distance, fruit length, fruit diameter, number of fruit per plant, yield per plant and found significant heterosis over better parents. Their mean performances were also high.

Solankey and Singh (2011) studied manifestation of heterosis in relation to seasonal variation in okra for characters like plant height, number of branches per plant, internodal length, days to 50 per cent flowering, number of fruits per plant, fruit yield per plant and found significant heterosis over better and standard parent.

Kumar and Pathania (2011[a]) carried out heterosis studies involving 10 lines and 3 testers of okra in line x tester model. The study revealed EC-169476 x Arka Abhay and LB Local x P-8 as promising cross combinations over better parent for fruit yield per plant along with node at which first flower appeared, internodal length, fruits per plant and internodal length. Whereas, EC-7194 x P-8, EC-329424 x Arka Abhay, EC- 329424 x Varsha Uphar were the top ranking combinations exhibiting significant standard heterosis for fruit yield per plant along with its components.

Khatik *et al.* (2012) evaluated 36 crosses of okra using 12 lines and 3 testers and revealed that heterosis analysis of variances was highly significant for all the traits under study. The study revealed that cross combination KS-423 x P.K., KS-453 x P.K., KS-439 x P.K., KS-427 x KS 410, KS 453 x KS 410, BO-2 x KS 404 and KS 439 x KS 404 were significant increase over mid parent the cross combinations for yield and its contributing traits. Therefore, these hybrids may be advanced and exploited in future breeding programmes for improving yield and its components in okra.

Aulakh *et al.* (2012) carried out investigation to study the gene action and inheritance pattern for earliness and increased yield in okra. F_1 means of both the crosses surpassed both of their corresponding parental means suggesting over dominance for days to first flowering, days to first fruit set and total yield per plant. They also reported that genetic improvement of okra with respect to these traits in this can be made through hybridization.

Medagam *et al.* (2012) developed 45 F_1 hybrids from 10 elite lines of okra to study heterosis. The overall mean heterosis over mid parent and standard control for total yield per plant was 6.92 per cent and -15.44 per cent, respectively. While for marketable yield per plant were 6.64 per cent and -22.18 per cent, respectively. Negatively heterotic crosses like C19 (P3 x P5) for days to 50 per cent flowering and C4 (P1 x P5) for first flowering and fruiting node (-15.22 %), respectively, were important to exploit heterosis for earliness in okra.

Das *et al.* (2013) studied breeding of okra for higher productivity through a line x tester mating design for characters like nodes at first flowering, fruit length, fruit diameter, fruit weight, number of fruit per plant and fruit yield per plant. Significant heterosis observed over better parent for all these characters.

Heterosis for yield and yield components in okra studied by Jagan *et al.* (2013) using line x tester mating design, comprising 60 hybrids produced by crossing four lines and 15 testers for characters like plant height, days to 50 per cent flowering, first flowering node, number of branches per plant, number of fruits per plant, length of the fruit, diameter of the fruit, pod weight, fruit yield per plant and found significant heterosis over mid and better parents for all these characters. The analysis of variance indicated highly significant differences for most of all the characters suggesting presence of genetic variability.

Kumar *et al.* (2013) estimated heterosis for yield and its contributing characters in okra by line x tester analysis in a set of eight parents (five lines and three testers) by making 15 cross combinations. Highly significant variances due to treatment were obtained for most of the characters studied like plant height, number of primary branches, total number of fruit per plant, fruit length, fruit weight, internodal length, yield per plant and found significant heterosis for all these characters over mid, better and standard parents.

Lyngdoh *et al.* (2013[a]) conducted an experiment to assess the magnitude of heterosis for growth characters in okra. Significant and high magnitude of heterosis over better parent and the commercial check was observed in the desirable direction for plant height, number of branches per plant and internodal length.

Kishor *et al.* (2013) conducted a study in okra at College of Agriculture, Vellayani to identify potential parents and superior crosses for yield and yield related traits. The results indicated that significant standard heterosis for yield per plant was observed in Holavanalli x Mallapalli Local, Thirumala Local x Kattakada Local, Kannapuzha Local x Punjab Phalgani and Thirumala Local x Mallapalli Local. The magnitude of heterobeltiosis for yield per plant was significantly superior in Holavanalli Local x Mallapalli Local and Thirumala Local x Kattakada

Local. These two crosses also exhibited significant heterosis for days to first flowering, number of primary branches, number of fruits per plant, fruit weight, fruit length and fruit girth.

Obiadalla-Ali *et al.* (2013[a]) studied two Egyptian and four exotic parental genotypes of okra were self-pollinated for one generation and crossed in half diallel design to study heterosis for earliness, vegetative and yield components traits like days to 50 per cent flowering, plant height, number of branches per plant, fruit weight, fruit length and fruit diameter. Mean squares of genotypes were found to be highly significant for all studied traits, providing evidence for presence of considerable amount of genetic variation among studied genotypes. The results showed that the majority of crosses exhibited significant heterosis estimates over mid parents for all studied traits.

Badiger *et al.* (2014) undertook the investigation to estimate the heterosis of conventional and genic male sterility (GMS) based hybrids in okra. The magnitude of heterosis over the commercial check hybrid was high in the desirable direction for all the 12 traits studied. The results revealed that the crosses IIHR-294 x JNDO-5, GMS-1 x Varsha Uphar and GMS-1 x Parbhani Kranti were potential heterotic crosses. They also stated that, GMS based hybrids have got great commercial significance of saving 70 per cent of the time and labour required for hybrid seed production.

Chaubey *et al.* (2014) crossed eight okra genotypes in a line x tester mating design. Highly significant and maximum negative heterosis over better parents (-12.27 %) and mid-parent (-9.17 %) was observed in a cross of HRB-9-2 x VRO-5 for days to 50 per cent flowering. Whereas, the cross of DOV-91-4 x VRO-5 displayed highly significant and positive heterosis for fruit length over mid-parent and better parent.

Pathak and Prabhat (2014) evaluated 52 F_1 hybrids generated from 26 lines and two testers of okra. All the hybrids along with parental lines and a standard check *viz.*, Punjab-8 was evaluated for yield and its attributing traits. Positive heterosis ranged from 1.09 to 66.07 per cent for marketable fruit yield. The top five hybrids *viz.*, KS-442 x POS-17 (66.07 %), Arka Abhay x VRO-6 (59.81 %), PB-266 x VRO-22 (52.14 %), Arka Abhay x VRO-21 (51.96 %) and KS-442 x POS-27 (49.1%) exhibited the highest positive heterotic effects for marketable yield. For number of fruits, hybrid PB-266 x VRO-22 exhibited the highest positive and significant (63.61 %) heterosis over better parent. Most of the hybrids exhibited significant heterosis for fruit yield recorded significant heterosis for number of fruits also. Only two crosses namely Arka Abhay x POS-27 (-9.04 %) and Arka Abhay x POS-17 (-9.04 %) exhibited significant heterosis over better parent for early picking.

Nagesh *et al.* (2014[a]) was conducted in okra to estimate the magnitude of heterosis and to identify the good combiners for yield and quality parameters. 54 F_1's hybrids generated by line x tester mating design these F_1's along with 21 parents and commercial check were evaluated in a randomized block design with two replications. Appreciable heterosis was found over better parent and commercial check for all the traits studied in desirable direction. The maximum positive heterosis was observed in the cross KON-8 x IC90174 over better parent (107.90 %) and the commercial check (92.42 %) for total yield per hectare. The crosses KON-8 x IC90174 (92.42 %), KON-5 x AAN (45.83 %), KON-16 x AAN (40.52 %), KON-12 x AAN (35.07 %) and KON-7 x IC90174 (27.11 %) showed significant heterosis over the commercial check in order of merit for total yield per hectare. The present study reveals good scope for commercial exploitation of heterosis in okra.

Tiwari *et al.* (2015) studied heterosis for various horticultural traits of okra in late *kharif*-2013 and summer-2014 by involving five diverse parents in a diallel mating including reciprocals. The analysis of variance reflected considerable variability for yield and other component traits. VRO-6 was excellent over other parents in *per se* performance for majority of traits under investigation except average fruit weight, fruit stalk length and ascorbic acid. The cross-combination VRO-6 x GJO-3 was the only F_1 exhibiting significant heterobeltiosis as well as standard heterosis for yield per plant. Whereas, hybrids AA x AOL-12-52, AA x GJO-3 and VRO-6 x AA also displayed significant heterosis over better parent for this character. The cross-combination VRO-6 x GJO-3 also recorded significant and desirable heterotic gain over standard check for other traits like first flowering node, days to first flowering, number of branches per plant and average fruit weight.

Patel and Patel (2016) studied 45 genotypes including 8 female, 4 male and their 32 resultant hybrids and one commercial check variety (GAO-5) of okra were sown during *kharif* season at Vegetable Research Scheme, Regional Horticultural Research Station, Navsari Agricultural University, Navsari to study the magnitude of heterosis using line x tester analysis for twelve characters. Significant differences were observed among parents and hybrids indicating considerable genetic variation among these genotypes. Significant standard heterosis and high *per se* performance with regards to fruit yield per plant were recorded by the crosses *viz.,* JOL-09-8 x PUSA SAWANI, JOL-10-17 x GJO-3, JOL-09-7 x PUSA SAWANI and AOL-10-18 x VRO-6.

2.2 Estimation of combining ability

Combining ability is the capacity of an individual to transmit superior performance to its offspring. It is the phenomenon with which inbred lines were crossed gave rise to hybrid vigour. In this way, the ability of a strain to produce superior progeny upon hybridization with other strain is called combining ability.

However, the concept of general and specific combining ability which was provided first by Sprague and Tatum (1942) as a measure of gene effect has become very important to plant breeders. The General Combining Ability (GCA) is the comparative ability of the line to combine with other lines. Specific Combining Ability (SCA) was defined as the deviation in the performance of specific cross from the performance expected on the basis for general combining ability effects of parents involved in the crosses. The gca involve additive x additive interaction, whereas sca measures dominance, dominance x dominance and additive x dominance interactions.

Many researchers compared the efficiency of different mating designs in estimating the combining ability effects. However, they advocated the superiority of line x tester analysis as it can evaluate more parents at a time. The concept of line x tester analysis was developed by Kempthorne in 1957. Line x tester analysis is used as a careful tool for selection of parent for hybridization to build-up a population, to determine the combining ability of parents and crosses.

Information on combining ability effects in okra is derived from data on yield-related traits in six inbreds and their hybrids from a full diallel cross by Sundhari *et al.* (1992). The GCA/SCA ratios were lower than unity, indicating the role of non-additive gene action for yield and number of fruits per plant. Arka Abhay was the best combiner for yield and number of fruits per plant.

Sivakumar *et al.* (1995) derived information on combining ability from data on yield components in four okra genotypes and their 12 F_1 diallel. Among the parents, Punjab-7 was the best general combiner for fruit yield and number of fruits per plant. Hybrid Punjab-7 x AE 129 had the greatest SCA for fruit yield and number of fruits. Non additive gene action appeared to be important for number of fruits, fruit weight and fruit yield.

Pal and Hossain (2000) studied combining ability analysis was carried out in a 7 x 7 diallel cross of okra for seed yield and some of its components and some quality traits of seed. Both additive and non additive gene effects were important in the inheritance of most of the traits.

Nichal *et al.* (2000) reported that ANOVA revealed for combining ability in okra for number of primary branches on main stem, number of fruits per plant, fruit weight, fruit length and yield per plant were highly significant indicating the importance of additive and non additive genetic components of variation. Arka Abhay x Arka Anamika exhibited the highest *per se* performance for yield and showed significant SCA effects for all characters. Based on *per se* performance, heterosis percentage, SCA effects of crosses, and GCA effects of parents, Arka Abhay x Arka Anamika, AKO-16 x Pusa A-4, JNDO-5 x AKO-16 and Arka Abhay x Pusa A-4 were identified as the superior crosses that can be exploited for heterosis breeding programmes.

Sood and Kalia (2001) evaluated combining ability in okra for characters like fruit yield, fruits per plant, days to 50 per cent flowering, stem diameter, fruit length, fruit diameter, first flower node and internodal length in eight diverse and widely adapted parental lines in a diallel cross (excluding reciprocals) of okra. IC-9856 was a good general combiner for early flowering, dwarfness and shorter internodal length. Parbhani Kranti, P-7, Harbhajan, Pusa Sawani, Arka Abhay and Arka Anamika were good general combiners for fruit yield and its components. The parents having high performance were also good general combiners for most of the characters under study. The best specific combinations for fruit yield were P-7 x Arka Abhay and P-7 x Arka Anamika.

Rajani *et al.* (2001) conducted an experiment on combining ability using six genetically divergent parental strains of okra by diallel analysis with respect to yield and a few related attributes like plant height, number of branches per plant, length of fruit and weight of fruit. Good general and specific combiner found for all these characters.

Dhankhar and Dhankhar (2001) studied combining ability in okra through a line x tester analysis involving 20 lines (female) and 4 testers (male). The combining ability analysis revealed that variances due to treatments, crosses, lines, testers, and parents vs. crosses were significant for fruit yield, number of fruits per plant, days to 50 per cent flowering, number of branches per plant, plant height, and number of effective nodes on stem, but not for internodal length of stem for tester. The dominant components (sigma D2) was higher than the additive (sigma A2), indicating the role of non-additive gene action.

Thippeswamy (2001) evaluated 30 F_1 hybrids obtained from crossing five lines and six testers for yield and yield components in okra. The estimation of GCA effects of all 11 parents revealed that IIHR-MS-5 and IIHR-MS-2 showed the highest positive significant effects and were good combiner for number of fruits per plants, total yield per plant and fruit weight. IIHR-MS-5 had highest GCA for number of branches per plant and fruit length. Among the testers the magnitude of GCA effects for total yield per plant and node at which first flower appearance was high in the Arka Anamika. Parbhani Kranti had high GCA for fruit weight and fruit length. Significant SCA effect in desirable direction was noticed in the cross combinations in IIHR-MS-5 x 120-11-8-1 for days to first flower appearance. The hybrid, IIHR-MS-2 x Arka Anamika and IIHR-MS-5 x Parbhani Kranti can be exploited commercially for marketable yield, more number of fruits per plant and earliness. In majority of crosses, high SCA effect was due to high x high, high x low and low x low cross combinations, indicating the importance of additive x additive and additive x dominance or dominance x additive type of interaction.

Prakash *et al.* (2002[a]) estimated combining ability analysis of 21 F_1 hybrids developed in a line x tester method in okra. The genotypes Pusa Makhmali, Arka Anamika, Punjab Padmini and Dharmapuri Local proved to be the best general combiners for fruit yield per plant. Punjab Padmini x Pusa Makhmali and Dharmapuri Local x Parbhani Kranti exhibited favourable SCA effects for more number of characters indicating the possibility of utilizing these genotypes for further exploitation. The estimates of general and specific combining ability and their ratio indicated the predominance of non-additive gene action for all traits.

Rani and Arora (2003) reported that the okra parents *viz.,* Punjab-8, HRB 9-2 and Punjab Padmini were found to be the good general combiners for number of fruits per plant and total yield per plant. The best crosses according to specific combining ability were VRO 3 x KS 404, Pusa Makhmali x Punjab-8 and Pusa Makhmali x VRO 3 for number of fruits per plant and total yield per plant.

Sushmita and Das (2005) studied Combining ability analysis in okra was carried out with 10 x 10 diallel cross, excluding reciprocals, to isolate desirable parents and F_1 cross combinations. They reported that variances due to gca and sca were highly significant for days to 50 per cent flowering, internode length, number of nodes per plant, fruit length, fruit girth, number of branches per plant, plant height, number of fruits per plant and yield per plant. The variance due to GCA being higher than all the characters, indicating the preponderance of additive gene action except for days to fifty per cent flowering, number of branches per plant and number of fruits per plant.

Rewale *et al.* (2003[a]) studied nine lines and seven testers of okra. The 63 F_1 hybrids, along with the 16 parents, were grown to estimate the general and specific combining abilities for eight yield contributing characters plant height, branches per plant, fruits per plant, fruit length, fruit weight, seeds per fruit, test weight and yield per plant. The genotype DVR-4 and SOH-02 among the lines and Arka Anamika among the testers showed good GCA effects for yield and most of the yield attributes. Among the hybrids, NK-01 x Ankur-40 and JNDO-5 x Arka Anamika had the highest seed number per fruit, plant height and yield.

Singh and Singh (2003) studied combining ability for yield and yield components (days to flowering, plant height, first fruiting node, internode length, number of branches per plant, fruit length, fruit width, and number of fruits per plant) in 15 okra inbred lines. They reported that the general and specific (SCA) combining abilities were significant for most of the characters, indicating that both the additive and non additive gene effects were involved in the inheritance of these traits.

Ahlawat (2004) evaluated 15 females, five males and their 75 hybrids with standard hybrid check GOH -1 for characters like number of branches per plant, fruit length and weight, fruits per plant and yield per plant. Good general and specific combiner found for all these characters. Non additive gene action played a predominant role in the expression of primary branches per plant and fruits per plant.

Rajendra *et al.* (2005) studied six hybrids of okra were evaluated for their combining ability. They reported that significant general and specific combining ability were recorded for the characters examined. The cultivar AB-2 was a good general combiner for number of days to flowering, number of fruits per plant and yield per plant. The cultivar AB-1 was a good general combiner for number of days to flowering, number of first fruiting node, number of fruits per plant and yield per plant. The cultivar BO-2 was a good general combiner for internode length, whereas Parbhani Kranti was a good general combiner for plant height and fruit length and width. Most of the superior specific combiners for different attributes also had a good *per se* performance.

Dahake and Bangar (2006) reported in okra that the parents, Arka Anamika, Hisar Unnat and Shagun were the best combiners for fruit yield per plant. Among crosses, Parbhani Kranti x Arka Anamika, Hisar Unnat x Duptari 45 and Duptari 45 x Ankur 40 were the best specific combiners for fruit yield per plant and number of fruit per plant.

Kumar *et al.* (2006) carried out a line x tester analysis in okra with six lines and three testers to estimate the combining ability and variance effects for characters like plant height, number of branches per plant, capsule weight, capsule length, number of seeds per capsule, 100-seed weight, number of capsules per plant and capsule yield per plant. Good general and specific combiner found for all these characters. The combining ability and variances indicated the preponderance of non additive gene action for all the characters.

Naphade *et al.* (2006) estimated combining ability in okra using line x tester analysis. The parents Tot-1494 and Tot-1502 proved to be good general combiners for fruit weight, number of primary branches and fruit yield per plant. The parent Tot-1494 also proved to be good general combiner for fruit length. While, Parbhani Kranti x Tot-1494 was found to be the best specific combiner for fruit yield followed by AKO-73 x Tot-1502 and Parbhani Kranti x Tot-1502.

Singh *et al.* (2006) studied experimental material comprised of 60 crosses of okra were produced by crossing of 15 lines and four testers for characters *viz.*, days to 50 per cent flowering, green pod weight, green pod length, green pod diameter, plant height, internodal length, number of branches per plant, number of fruits per plant and fruit yield per plants. ANOVA revealed highly significant difference among all the parents, hybrids, lines, line x testers for all the characters and testers for all the traits except fruit diameter. High average degree of dominance revealed predominance of non additive gene action for all the traits.

Mehta *et al.* (2007[b]) evaluated 42 crosses using 14 lines and three testers of okra and revealed that the SCA variances for days to 50 per cent flowering, fruit weight, fruit length, plant height, number of seeds per fruit and 100 seed weight were higher than GCA variance so there is a preponderance of non additive gene action. The analysis of variance for combining ability revealed that the variance due to lines, testers and line x tester were significant for most of the characters. Good general and specific combiner found for all these characters.

Weerasekara *et al.* (2008[b]) estimated combining ability effects in okra for different characters *viz.,* days to 50 per cent flowering, number of branches per plant, plant height, number of fruits per plant, fruit diameter, fruit weight, number of seeds per fruit and yield per plant in a line x tester crossing programme comprising 24 hybrids produced by crossing eight lines and three testers. Among the lines, KAO-25 and KAO-61; and among the testers KAO-23 and KAO-AA were found to be the best general combiners. Three cross-combiners *viz.,* KAO-53 x KAO-18, KAO-35 x KAO-AA and KAO-17 x KAO-AA were found to be the best specific crosses for yield per plant.

Line x tester analysis was carried out in okra with the objective of identifying good combiners for earliness and yield parameters by Jaiprakashnarayan *et al.* (2008[b]). Characters under study were days to 50 per cent flowering, fruit length, fruit weight, number of fruits per plant and total yield per plant. Good general and specific combiner found for all these characters. Non additive gene action was predominant for days to 50 per cent flowering, fruit weight and total yield per plant.

The combining ability was studied in okra by Srivastava *et al.* (2008) and revealed that parents *viz.*, IC 73352, Okra No. 6, Pb 8, VB 9101 and Punjab Padmini for days to 50 per cent flowering; Pb 8, IC 69117, IC 73352 and Arka Abhay for number of fruits per plant; Punjab Padmini, VRO 3, Arka Abhay, Pb 8 and IC 69117 for fruit yield per plant were found good general combiners. However, in specific combining ability study, the cross VRO-3 x Arka Abhay and Punjab Padmini x Arka Abhay for fruit yield per plant; IC 73352 x Punjab Padmini for number of fruits per plant; VRO 3 x IC 73352 for fruit length; Pb 8 x IC 69117 for fruit weight exhibited high specific combining ability.

Khanpara *et al.* (2009) evaluated eight lines and four testers of okra for general and specific combining ability through line x tester mating method. The parents, Pant Bhindi and D-1-87-5 were good general combiners for fruit yield per plant and number of fruits per plant. Similarly, BO-13 and IC-990049 for shorter internodal length; Parbhani Kranti for fruit length were found good general combiners.

Javia *et al.* (2009) conducted an experiment with 49 entries including 13 genetically diverse parents and their 36 crosses of okra generated by line x tester mating design. The pooled analysis of variance for combining ability revealed that mean squares due to females, males and females x males were significant. Different characters were observed like inter-nodal length, plant height, branches per plant, fruit length, number of fruits per plant and fruits yield per plant. ANOVA indicated greater importance of non additive type of gene action in the inheritance of all these traits. Good general and specific combiner found for all these characters. The crosses exhibiting high positive or negative specific combining ability effects involved either average x poor, average x good, poor x good and poor x poor parents.

Twelve diverse best homozygous cultivars of okra, *viz.,* Pusa Makhmali, Pusa Sawani, 7D2, Arka Abhay, IC-90177, IC-90202, Punjab Padmini, HRB 9-2, P-7, KS 404, BO and BO-2 were crossed in a diallel fashion without reciprocals by Singh *et al.* (2009). They reported that for plant height, the specific combinations producing desirable effects were P9 x P11, P9 x P12, P7 x P12, P7 x P11 and P1 x P6. For number of branches, cross P4 x P8, followed by P2 x P3 and P2 x P7 cross combinations were the best. The basis of performance and desirable SCA effect were found in P2 x P7, P2 x P4 and P2 x P10 crosses for days to flowering, P4 x P7 showed the highest SCA effects for days to first picking, P5 x P6, P5 x P10, P2 x P9 and P4 x P6 were good combinations for number of pods per plant, P3 x P4, P5 x P6, P4 x P12 and P2 x P4 crosses showed good SCA effects for pod size, P1 x P9 was the best combination for yield per plant which showed the highest and positive SCA effect indicated the importance of both additive and non additive gene action.

Wammanda *et al.* (2010[b]) studied the genetic basis of yield and its components in okra using a 9 x 9 diallel cross, 36 F_1's and the 9 parents for characters like days to 50 per cent flowering, plant height, number of branches per plant, internode distance, fruit length, fruit diameter, number of fruit per plant and yield per plant. Good general and specific combiner found for all these characters. The mean performance of parents and crosses can be used to predict high general combining ability of parents as well as high SCA effects and heterotic effects of the crosses.

The combining ability studies were carried out in okra by Dabhi *et al.* (2010[a]) using line x tester (12 lines and four testers) mating method over three environments for 11 characters in okra. The preponderance of non additive gene action in expression of fruit length in lines *i.e.,* KS-404, JOL-06(K)-2, VRO-5, JOL-1, JOL-2K-19 and HRB-108-2, while the testers *viz.*, Arka Abhay and GO-2 were found as good general combiners for fruit yield per plant as they possessed high concentration of favourable genes indicated by significant and positive GCA effects. The parents JOL-06(K)-2, KS-404 and GO-2 were good general combiners for early flowering. Among the crosses, Pant Bhindi x Red Bhindi, KS-404 x Punjab-7, JOL-02-10 x Punjab-7 and JOL-06(K)-2 x GO-2 had high SCA effects for fruit yield per plant and number of fruits per plant. The results revealed that most of the superior combinations involved at least one parent with high GCA effect for most of the traits.

Ramya and Kumar (2010[b]) studied combining ability in okra by using diallel analysis (7 x 7) for characters like number of fruits per plant, fruit weight, fruit length and fruit yield per plant. The direct and reciprocal cross combinations portrayed high mean and commercial heterosis were endowed with significant SCA effects and had both or at least one of the parents with significant GCA effects. Good general and specific combiner found for all these characters.

Combining ability and gene action were estimated in okra for yield and contributing traits namely plant height, number of primary branches per plant, internodal length, first flowering node, fruit length, fruit diameter, fruit weight, number of fruits per plant and fruit yield per plant by Singh and Sanwal (2010[b]) in line x tester programme involving six lines and four testers. Good general and specific combiner found for all these characters. The gene action studies indicated that there was preponderance of non additive (dominance) gene action for all the traits under study.

Solankey and Singh (2010) studied a line x tester analysis in okra with 20 parents (17 lines x 3 testers) and their 51 F_1, in two different seasons. The combining ability variances indicated the preponderance of non additive gene action for all the characters. The lines *viz.*, VRO-5, VRO-6, Arka Abhay, IC-218844 and testers like Arka Anamika proved to be the good general combiner and Arka Abhay x Arka Anamika was the good specific combiner for most of the yield and yield attributing traits.

Kumar and Pathania (2011[b]) studied 10 female and three male parents of okra by using line x tester analysis. The characters, node at which first flower appears, inter-nodal length, fruit length, fruit diameter, fruits per plant, fruit yield per plant, fruit weight and plant height. Good general and specific combiner found for all these characters. Analysis of variance revealed that significant differences among lines for all the characters except node at which first flower appears. The per cent contribution of lines was found to be higher than the testers for all the traits. In the present study, SCA variances were of higher magnitude than GCA variances for the traits *viz.*, node at which first flower appears, inter-nodal length, fruit yield per plant and fruit weight reflecting the role of non additive gene action for these traits.

Raghuvanshi *et al.* (2011) studied the combining ability for yield and its components by using lines x tester cross involving six lines and five tester of okra. The characters studied were first flowering node, plant height, internodal length, number of primary branches per plant, fruit weight, number of fruits per plant, fruit length, fruit diameter and fruit yield per plant. Partitioning of variance due to crosses into lines, tester and crosses shows that crosses interaction component were highly significant for all characters except for first flowering node, plant height and fruit yield per plant. The magnitude of dominance variance was higher than the additive variance except for fruit weight thereby indicating pre-dominance of non additive gene action in their inheritance. Good general and specific combiner found for all these characters. Some crosses showed good x good, good x poor and poor x poor GCA status.

Singh (2011) conducted an experiment on combining ability analysis in okra for yield and yield contributing characters namely plant height, number of branches per plant, length of the fruits, number of fruits per plant and fruit yield per plant in okra with eight parents and 28 F_1's. Analysis of variance for combining ability revealed that the GCA : SCA ratio mostly favoured SCA in all the traits, indicating the preponderance of non additive gene effects in the genetic control of the traits. Good general and specific combiner found for all these characters.

Kumar *et al.* (2012) studied the combining ability of 32 hybrids for 13 traits by line x tester mating design with 8 genetically diverse females and 4 males of okra. Among the female lines, EC-169358 and Sel-1 were found to be good general combiners for pod yield and its major components. Among the testers, VRO-6 was the only parent with significant and positive GCA effect for pod yield and its major components. Another good combiner was Parbhani Kranti noticed for pod yield and a number of component traits. For many of the traits studied, the parents EC-169358, Sel-1, VRO-6 and Parbhani Kranti were found to be good general combiners. Therefore, these lines can be used in hybridization for producing promising recombinants.

Sharma and Singh (2012) estimated combining ability effects for different characters of okra like plant height, number of branches per plant, days to 50 per cent flowering, node at which first flower appear, internodal length, number of seeds per fruit, fruit length, fruit weight, number of pods per plant in a line x tester mating design comprises six lines and four testers and their 24 F_1 hybrids. The analysis of variance showed highly significant differences among the treatments for all the parameters studied. Variance due to line x tester interactions and hybrids were significant for all the characters. Good general and specific combiner found for all these characters. In these crosses involved the parents with high x average, average x low, high x low, low x low, low x high and high x high general combining ability effects.

Reddy *et al*. (2013) evaluated 45 crosses of okra using 10 parents in half diallel fashion. Combining ability analysis of parents revealed that the parental lines IC 45732, IC 89819 and IC 89976 were superior general combiners for total and marketable yield per plant and other traits. The crosses IC 29119-B x IC 99716, IC 27826-A x IC 111443, IC 89976 x IC 111443 and IC 90107 x IC 111443 were superior specific combiners for total as well as marketable yield per plant with the potential of being commercially exploited for the production of F_1 hybrids. The crosses IC 27826-A x IC 111443 and IC 89976 x IC 111443 involving one or both of the parents with positive and significant general combining ability effects for marketable yield per plant could be utilized in recombination breeding. Genetic analysis revealed a preponderance of non additive gene action for plant height, internodal length, days to 50 per cent flowering, first flowering and fruiting node, fruit length and weight, total number of fruits and number of marketable fruits per plant, total yield and marketable yield per plant and yellow vein mosaic virus infestation on fruits and plants and a preponderance of additive gene action for number of branches per plant and fruit and shoot borer infestation on fruits and shoots.

Srivastava *et al*. (2013) studied combining ability in okra by line x tester analysis and magnitude of heterosis, in a set of 8 parents (five lines and three testers) received from IIVR Varanasi by making 15 cross combinations evaluated during summer and *kharif* 2009 in Randomized Block Design with three replications. The data sum total of nine characters *viz.,* plant height, number of primary branches, days to first flowering, total number of fruit plant-1, fruit length, fruit girth, fresh fruit weight, internodal length and yield plant-1 were recorded for conducting the present study. On the basis of GCA effects across nine characters, Arka Abhay, VRO-6, Hissar Unnat and Punjab Padmini were identified as most promising parents for improving number of fruits plant-1, fruit girth and days to 50 per cent flowering. The most promising crosses showing significantly positive SCA effects and standard heterosis for fruit yield were Arka Abhay x Parbhani Kranti, Hissar Unnat x Punjab Padmini, VRO-6 x Parbhani Kranti and VRO-6 x Arka Anamika. These crosses should be exploited for further advancement in breeding programme for HYVs and early maturity, simultaneously.

Adiger *et al*. (2013) estimated combining ability effects in okra for different characters in a line x tester crossing programme comprising 120 crosses produced by crossing of 40 lines and three testers. The analysis of variance showed significant differences among the crosses, lines, testers for most of the traits. The contributions of lines as compared to testers were observed to be higher. Magnitude of sca variance was higher than the gca variance. This shows the predominance of non additive gene action for all the characters, which indicated the scope for heterosis breeding in crop improvement in okra. Majority of the cross combinations recorded high SCA effects and *per se* performance due to low x low, low x high or high x low parental GCA status.

Combining ability effects were estimated for different characters of okra by Jagan *et al.* (2013[a]) using line x tester mating design, comprising 60 hybrids produced by crossing four lines and 15 testers for characters like plant height, days to 50 per cent flowering, first flowering node, number of braches per plant, number of fruits per plant, length of the fruit, diameter of the fruit, pod weight and fruit yield per plant. Good general and specific combiner found for all these characters. Analysis of variance due to different sources of variation for different characters revealed that mean sum of squares due to crosses, lines (females) and testers (males) were significant for all the traits. SCA effect represents the predominance of non additive gene action, is a major component that may be utilized in heterosis breeding.

Kishor *et al*. (2013[a]) evaluated 15 crosses using five lines and three testers of okra to estimate combining ability for characters *viz.,* days to first flowering, number of primary branches, plant height, number of fruits per plant, fruit weight, fruit length and yield per plant. Combining ability analysis showed preponderance of non additive gene action for most of the characters. Good general and specific combiner found for all these characters. Significant variation was observed among treatments and line x tester interaction for all the characters.

Combining ability variance and effect of yield and its components in okra were studied by Kumar *et al.* (2013[a]) through half diallel analysis of 28 F_1 hybrids derived by crossing nearly homozygous germplasm lines namely PK, VRO-35, VRO-54, 7218, BO-2, KS-404, 7109 and P-7. ANOVA revealed the role of non additive gene action for all the characters like plant height, branches per plant, length of internode, length of fruit, number of fruits per plant and yield per plant. Good general and specific combiner found for all these characters. Some crosses showed high x high, high x low and low x low GCA status.

Obiadalla *et al.* (2013[b]) studied two Egyptian and four exotic parental genotypes of okra were self-pollinated for one generation and crossed in half diallel design to study combining ability for earliness, vegetative and yield components traits like days to 50 per cent flowering, plant height, number of branches per plant, fruit weight, fruit length and fruit diameter. Good general and specific combiner found for all these characters. The results suggest the important role of non additive gene action in the inheritance of studied traits.

Lyngdoh *et al.* (2013[b]) conducted an experiment in okra to identifying good combiners. In this experiment, non additive gene action was predominant for most of the traits. Good specific combiners and good general combiners were identified for plant height, number of branches per plant and internodal length.

Patel (2013) estimated the effect of GCA in okra and indicates that, Pusa Sawani was good general combiner for fruit weight and number of seeds per fruit. JOL-09-8 was good general combiner for days to 50 per cent flowering and 100-seed weight. JOL-08-8 was good general combiner for fruit weight and number of seeds per fruit and JOL-55-3 was good general combiner for number of branches per plant and fruit length. It is interesting to note that none of the parent was good general combiner for fruit yield per plant. In addition, females *viz.*, AOL-10-3, AOL-10-18, JOL-09-5 and JOL-09-7 were good general combiner for fruit weight, 100-seed weight, number of seeds per fruit and days to 50 per cent flowering, respectively.

Paul (2013) estimated the general combining ability in okra and observed that HRB-55, AOL-09-17, AOL-09-2 and JOL-09-7 to be good general combiners for fruit yield per plant.

Whereas, parent AOL-09-17 was good combiner for number of primary branches per plant, fruit length, fruit diameter, fruit weight, number of fruits per plant. The parent JOL-09-7 found to be either good or average combiner for all the characters. The result of SCA effects revealed that the cross combinations JOL-55-3 x HRB-55, JOL-09-8 x JOL-09-7 and JOL-09-8 x AOL-09-17 showed the highest SCA effect for fruit yield per plant and also can be said as most promising for fruit yield and some of its related traits.

Eight genotypes of okra were crossed in half diallel fashion by Akotkar *et al.* (2014) to study the combining ability of the parents. Considering the genetic variance, SCA variance was higher for all the characters except for flowering characters. Thus, suggesting greater role of non additive gene action in the expression of former characters. The genotype IC-332453 and Parbhani Kranti were the best general combiners. The mean squares due to all the sources of variation, among parents, among the hybrids and parents vs. hybrids were found to be significant for most of the characters like days to 50 per cent flowering, number of fruits per plant, fruit length, fruit diameter, weight of fruit, plant height, number of primary branches per plant, internodal distance and fruit yield per plant.

Bhalekar *et al.* (2014) studied the general combining ability in okra using parents *viz.*, Phule Utkarsha, Parbhani Kranti and Arka Anamika were found to be the best general combiners as they exhibited significant performance for yield per plant and its components. Specific combining ability studies indicated that the cross combinations *viz.*, P1 x P7 (Phule Utkarsha x IC-89948), P1 x P3 (Phule Utkarsha x Arka Anamika), P2 x P7 (Parbhani Kranti x IC-89948), P3 x P8 (Arka Anamika x VRO-6), P2 x P8 (Parbhani Kranti x VRO-6), P2 x P5 (Parbhani Kranti x IC-282273) and P1 x P6 (Phule Utkarsha x IC-39139-A) were best specific combinations for most of the characters.

Jethava (2014) conducted an experiment on combining ability in okra for characters like plant height, number of branches per plant, stem diameter, internodal length, number of fruits per plant, fruit yield per plant, first flowering node, fruit weight, stalk length, 100-seed weight, fruit length, number of seeds per fruit and fiber content. Good general and specific combiner found for most of the characters. Magnitudes of GCA variance were smaller than SCA for most of the characters indicating the preponderance of non additive gene effect.

Kumar (2014) conducted an experiment on combining ability in okra for characters like days to 50 per cent flowering, number of branches per plant, fruit length, fruit diameter, number of seeds per fruit, fruit yield per plant, first flowering node, fruit weight, number of fruits per plant, stalk length, fiber content and 100-seed weight. Good general and specific combiner found for most of the characters. Magnitudes of SCA variance were higher than GCA for most of the characters indicating the preponderance of non additive gene effect.

Nagesh *et al.* (2014[b]) was conducted experiment in okra to estimate the magnitude of heterosis and to identify the good combiners for yield and quality parameters. 54 F_1 hybrids generated by line x tester mating design these F_1's along with 21 parents and commercial check were evaluated in a randomized block design with two replications. The line KON-5 for fruit length (1.31), fruit diameter (1.87), average fruit weight (2.53), total yield per plant (35.40) and for total yield per hectare (2.18), KON-6 (1.87) for number of fruits per plant, KON-4 (0.33) for number of locules per fruit and KON-15 (9.03) for number of seeds per fruit were identified as good general combiners. In order of merit the crosses KON-8 x IC90174 (6.55), KON-16 x AAN (2.95), KON-5 x AAN and KON-17 x KON-19 (2.04) and KON-18 x IC90174 (2.00) were identified as good specific combiners.

Kumar *et al.* (2014) carried out an experiment with 12 parental lines of okra along with 66 F_1 hybrids based on half-diallel cross excluding reciprocals to the study of combining ability of okra with respect to characters like days to 50 per cent flowering, first flowering node, plant height, number of branches per plant, internodal distance, number of pods per plant, pod length, pod diameter, pod weight, number of seeds per pod and 100-seed weight. Most of the characters exhibited significant SCA effects indicating predominance presence of non additive gene action. The results indicated the importance of heterosis breeding for effective utilization of non additive genetic variance in okra.

Katagi *et al.* (2015) carried out combining ability analysis for fruit yield and its components in okra in a 6 x 6 diallel cross (excluding reciprocals) for characters like days to 50 per cent flowering, total fruit yield per plant, fruit length, number of primary branches per plant, number of fruits per plant, fruit diameter and 100-seed weight. Good general and specific combiner found for all these characters.

2.3 Genotype x Environment interactions and stability parameters

The plant breeders have been aware of genotypic differences in adaptability. They were unable to exploit them fully in breeding programme. A phenotype is the result of interplay of a genotype and its environment. A specific genotype does not exhibit the same phenotypic performance under the changing environment and different genotypes respond differently to a specific environment. This variation arising from the lack of correspondence between the genetic and non-genetic factors on development is known as genotypic-environment interaction (Verma and Gill, 1975). Comstock and Moll (1963) have shown statistically the limiting effects of large G x E interaction on the efficiency of selection programme. G x E interactions is generally considered as an impediment in judging the real potential of a genotype when grown in different environments or at different locations. The existence of interaction between genotype and environmental factors were first recognised by Fisher and MacKenzie (1923).

The identification of a phenotypically stable variety requires information on the extent of genotype x environment interaction for yield and its related traits. Existence of genotype x environment interaction, affecting the performance of a variety in different environments, however, hinders progress in this direction (Comstock and Moll, 1963). Thus, one of the constraints in increasing production is the lack of stability of high yielding varieties. Lewis (1954) proposed the term 'Stability Factor' to measure phenotypic stability as a ratio of mean in high yielding environment to low yielding environment. Stability factor equal to unity was inferred to indicate maximum phenotypic stability, while poor stability of the genotype was indicated by greater deviation of the stability factor from unity. Later, Finlay and Wilkinson (1963) defined stable variety, based on its mean and regression values obtained over environmental means. A stable variety/genotype was inferred to be the one, combining maximal potential in the best environment with low genotype x environment interaction through consistently high performance over environments. Eberhart and Russell (1966) proposed deviation from regression as an additional parameter for estimation of stability. They concluded that a variety with unit regression coefficient and non-significant deviation from zero was a stable one. The joint regression analysis of Perkins and Jinks (1968) for a set of number of inbreds over a number of environments is based on fitting of models which specify the contributions of genetic, environmental and genotype x environment interactions to the generation means and variances allowing for the contribution of additive, dominance and epistatic gene effects to the genetic and interaction components.

Considerable work on G x E interaction and stability of performance has been done in the cereals and other field crops. In case of okra, a few references on genotype x environment interaction and stability parameters are available which are reviewed here.

Babu *et al.* (1983) classified twenty-five genotypes of okra into groups suited for high, medium and low yielding environments by testing them for two seasons each with two contrasting environments *viz.*, high fertility and low fertility. They recorded data on days to first fruit set, plant height, internodal length, number of leaves, fruit length, fruit weight, number of fruits and fruit yield. The analysis of variance showed significant differences among the genotypes, environments and environment (linear) for all the traits. G x E was significant for days to first fruit set, plant height, internode length, fruit weight, number of fruits and fruit yield per plant. G x E (linear) was significant only for three traits *viz.*, internodal length, number of leaves and fruit weight.

Ariyo (1987) evaluated nine varieties of okra over five environments for five agronomic traits and reported a significant G x E interaction for number of days to flowering and number of branches per plant. They also observed significant additive environmental effects for all traits. The cultivar U1313 was stable for fruit yield per plant and edible fruit weight.

Adetunji and Chedda (1989) reported wide ranges of environmental indices (-10.8 to 24.4) and seed yield (2.7 to 38.0 g/plant) in okra which indicated significant variation between the environments even though the trials were conducted at the same location. A regression method of stability analysis showed that the mean differences between environments, varieties and their interactions were highly significant. The results suggested that where limited resources prevent the use of several locations, different dates of planting for two or more years could be used to evaluate okra varieties for yield without losing much information on their relative ranking.

Ariyo (1990) evaluated twenty selected okra genotypes in four different environments for stability of performance for days to flowering, number of branches per plant, plant height, number of pods per plant, pod weight and pod yield per plant. An analysis of the components of G x E interaction showed that it might not always be adequately explained by a linear function of the environment. The stability variances parameters (σ^2), W- mean square and the deviation mean square employed in the analysis of stability indicated that most of the genotypes were unstable in respect of pod yield per plant and for most of other traits.

Desai (1990) evaluated ten varieties of okra in four seasons for traits *viz.*, days to flower, plant height, internodal length, branches per plant, fruit length, fruit girth, fruits per plant, fruit weight and yield per plant. The analysis of variance for stability revealed that the differences among the varieties were significant when tested against the pooled error, pooled deviations and G x E interaction for all the traits except for days to flower, where, it was significant against pooled error only. The differences among the environments were significant against the pooled error, pooled deviations as well as G x E for all the traits except fruit girth which was significant against pooled error and pooled deviation and the differences for fruits per plant were non-significant for all the testing factors, indicating that the seasons of testing were contrasting. The linear content due to G x E interaction was highly significant when tested against pooled error for days to flower, fruit length and fruit girth, fruits per plant, fruit weight and yield per plant. The stability parameters showed that the genotype White Velvet displayed general stability for days to flower and was found to be more responsive to better environments for fruit weight and fruit yield per plant. The genotype Gujarat Okra 1 and AE 3 exhibited general stability for fruit weight.

In their study of G x E interaction in okra for 11 yield components in 50 diverse genotypes, Gondane and Lai (1993) reported that pooled variance due to G x E interaction was significant for days to 50 per cent flowering, plant height, internodal length, fruit length, fruit girth, fruits per plant, fruit weight and yield per plant. They found good stability for most of traits in the variety IC 10643 and 138/2, whereas Pusa Sawani exhibited stability for fruit length, fruit girth and fruits per plant, fruit weight and yield per plant.

Mandal and Dana (1994) studied phenotypic stability in okra for days to 50 per cent flowering, days to first harvest and plant height, and they reported that strain 6316 and Pusa Sawani were the most stable genotypes with respect to days to 50 per cent flowering. The genotype White Velvet showed the stability for days to first harvest and strain 7116 was most stable for plant height.

Poshiya and Vashi (1997) studied phenotypic stability for fruit yield in okra and reported variance due to genotypes, environments; G x E (linear) component was highly significant for this trait and hybrid showed higher yield and better stability.

Ariyo and Vaughan (2000) studied fifteen cultivars of okra during the early, mid and late rainy seasons of 1991, 1992 and 1994, representing different environments. Difference between environments accounted for 27 per cent of the total variation while cultivar x environment interaction accounted for 31 per cent. The first, second and third interaction axes captured 48 per cent, 31 per cent and 7 per cent of the total variation due to G x E interaction, respectively. The

AMMI plot accounted for 81 per cent of the total sum of squares. The seasons differed in main and interaction effects from year to year. Late season was the most variable in interaction while mid-season had the least variation in the main effect. The 1991 and 1994 late-seasons had the largest and the least interaction effects respectively. UI 92 was favoured by 1991 late season and 1994 mid-season but was not favoured during any early season. TAe 38 was adapted to early seasons. Most of the cultivars performed best during the mid-seasons. The 1991-early and 1994-late seasons had a positive correlation suggesting that cultivars would respond similarly in these two environments. The 1991-early and 1991-late seasons showed negative correlation and therefore, the response of cultivars differed in the two environments. Varieties in 1991-early and 1991-late seasons showed opposite response while varieties in 1992-late and 1994-late seasons exhibited similar response.

Nimbalkar *et al.* (2005) evaluated the performance of improved, high yielding genotypes of okra over different agro-climatic locations of Western Maharashtra which were assessed through University multi-locational trial conducted during *kharif*-2001, summer-2002 and *kharif*-2002, comprising of ten okra genotypes including two checks at five locations. Significant G x E interaction influenced the relative ranking of genotypes across the locations. It was evident from AMMI analysis that genotypes, environments and interaction effects accounted 13.8, 78.6 and 7.6 per cent of variance, respectively. The genotype Varsha Uphar has maximum contribution to interaction (4.0 %) followed by GK-IV-3-4-4 and Arka Anamika. Similarly, the check Arka Anamika exhibited maximum deviation from regression component of interaction followed by the genotype Varsha Uphar, indicating its best performance in the favourable environment. The interaction biplot with locations and genotypes superimposed exhibited that the genotype GK-IV-2-413 situated closed to the centre can be regarded as stable, because of their consistent yield performance across locations.

Jindal *et al.* (2008) studied Twelve varieties/inbred lines of okra and their 66 F_1's, were analysed together to study the genotype x environment interactions and to identify more stable genotypes crosses for six earliness related traits in okra. The stability analysis of variance of mean data revealed that there was ample genetic variability among the genotypes and the performance of the genotypes was greatly influenced by the varying environments. Thirty three genotypes were stable for plant height and internodal length as indicated by non-significant deviation from regression. All genotypes were found stable for days to first picking. For number of primary branches per plant, all genotypes possessed regression coefficient greater than unity, thus revealing that the parents and crosses with high mean values were suitable for favourable environments. However, for total yield per plant, none of the parent or cross showed average stability. Five crosses *viz.*, HU x PA-4, HU x PB-I, VRO-4 x PB-I, VU x NDO-IO and NDO-IO x PB-I were found stable for better or favourable environments, whereas, two crosses HRB-I07-4 x HU and PB-1 x S-2 were stable in poor/unfavourable environments.

Babariya *et al.* (2009) studied stability analysis in 44 entries over three seasons in okra and observed significant differences among the genotype (G), environments (E) and G x E interaction for all the traits except variance due to G x E for fruit girth indicating variable response of different genotypes for various traits under varied agro-climatic conditions. The result on environmental index revealed that *kharif* season was most congenial for fruit yield per plant and majority of the yield attributing traits. The parents Parbhani Kranti, US-7109, GO-1 and JOL-01-3 were stable for fruit yield and other components and the cross GO-2 x JOL-01-3 was found to be the best with highest mean yield, regression coefficient near to unity and least deviation from regression indicating its stable performance under all seasons.

Jindal *et al.* (2009) analysed twelve varieties/inbred lines of okra and their 66 F_1's, to study the genotype environment interactions and to identify more stable genotypes/crosses for five different fruit traits in okra. The stability analysis of variance of mean data revealed that the mean squares for genotypes were highly significant for all the traits indicating presence of genetic variability among the genotypes. The mean squares due to environments were also significant for all the traits indicated that the varying environments were effective in influencing the performance of the genotypes. The cross NDO-10 x S-2 was found stable for fruit weight under favourable environment. For fruit diameter, six cross combinations *i.e.,* IIVR-11 x HU, IIVR-11 x VRO-4, IIVR-11 x NDO-10, PP x VU and PP x NDO-10 were stable for favourable environments. All the parents and hybrids were found stable for fruit length under unfavourable environments but their performance cannot be predicted with greater accuracy due to significant deviation from regression. Five crosses were stable for favourable environments for number of fruits per plant. For total yield per plant, the crosses HU x PA-4, VRO-3 x S-2, PA-4 x S-2, VU x NDO-10, VU x NDO-10, VU x HRB-108-2 and NDO-10 x PB-1 were stable for better/favourable environments as these crosses possessed high mean values, regression coefficient greater than unity and non-significant deviation nearly zero.

Dabhi *et al.* (2010) estimated phenotypic stability for fruit yield and its component traits of 64 genotypes (48 hybrids and their 16 parents) of okra grown on three different dates indicated the significant differences among the genotypes (G), environments (E) and G x E interactions for all the characters (except number of nodes at first flowering for environment and G x E interactions) indicating variable response of different genotypes for various traits under varied environmental conditions. Non-significance of G x E (linear) against pooled deviation for most of the characters under study suggested that performance of genotypes remained similar for their linear regression on environmental index. Non-linear component (pooled deviation) also played an important role for all the characters except for number of nodes at first flowering and fruit length. On the basis of mean ($\bar{X}$), regression coefficient (b_i) and deviation from regression (S^2d_i); parents JOL-06(K)-2 and GO-2 as well as hybrid JOL-06(K)-2 x GO-2 were found stable and widely adapted for general cultivation for fruit yield and its components in okra.

Thirty-five okra genotypes were evaluated in three different environments for their stability by Ramya and Senthilkumar (2010). G x E interaction was significant for days to first flowering, number of fruits per plant, plant height and single plant yield. The genotypes *viz.*, Pusa A4, Parbhani Kranti, Varsha Uphar, Punjab Padmini, Hissar Unnat, PB-266, CO-1, Harbhajan, Arka Abhay and AOL-03-01 were found to have significantly higher regression coefficients along with desirable mean value for the trait pod yield per plant. These genotypes said to be average responsive and suitable for all the environments.

Kachhadia *et al.* (2011) studied phenotypic stability for fruit yield and its component traits of 55 genotypes (40 hybrids, their 14 parents and a standard check variety GO-2) of okra grown over three different seasons revealed the significant differences among the genotypes (G), environments (E) and G x E interactions for all the characters (except number of branches per plant for environments and fruit girth for G x E interactions) indicating variable response of different genotypes for various traits under varied environmental conditions. The G x E (linear) interactions was significant for all the characters (except fruit girth) suggesting the genotypes responded considerably to the environmental fluctuations for all the traits. Significant pooled deviation for all the traits, except internodal length, number of fruits per plant and fruit yield per plant indicated difficultly in predicting the performance of genotypes over environments for these characters. The environmental indices revealed that early summer season was most congenial for fruit yield per plant and majority of the yield contributing traits. On the basis of stability parameters, parents

JOL-06-S-7, JOL-1 and JOL-06-1 as well as hybrids GO-2 x Parbhani Kranti and JOL-06-S-6 x HRB-55 were identified as stable with wider adaptability over environments for fruit yield and its components hence, may be utilised in breeding programme for incorporation of stability for most of the traits in okra.

Akotkar *et al.* (2011) tested twelve genotypes of okra in three different environments for stability of eight different yield contributing traits. From the analysis of variance for different traits, the mean sum of square values indicated highly significant difference over three environments tested. Considering pooled deviation, the fruit yield per plant exhibited the highest value while the same for primary branches per plant was the lowest. The mean values for different traits revealed that the genotype which had higher mean for plant height could produce significantly higher mean for number of fruits per plant as well as fruit yield per plant. Considering the regression values the genotypes behaved differently for the different traits. Interestingly, among the genotypes producing significantly higher mean, the genotype IC-433645 produced non significant b_i values and S^2d_i.

Stability among 50 accessions of West African okra (*Abelmoschus caillei*) was assessed by Ezekiel *et al.* (2011) under three diverse ecological environments at Abeokuta, Ibadan and Mokwa in Nigeria. The regression coefficients of accessions mean yields on the environmental index resulted in regression coefficients ranging in values from 0.5549 to 1.6667. OAA/96/175-5328, NGAE-96-011 and NGAE-96-0060 were among the superior genotypes with high yield performance. The large variation in regression values indicated large differences in genotype response to different environments.

Thirteen genotypes of okra (five parents and eight hybrids) were analysed by Senthilkumar (2011) to study the G x E interactions and to identify stable genotypes (parents and hybrids) for seven different fruit traits in okra. The stability analysis of variance of mean data revealed that the significant pooled deviations for all the traits except fruit length indicated predominance of linear component. Estimates of stability parameters revealed that no genotypes were stable for all the traits studied. The parent Punjab Padmini and hybrids, Punjab Padmini x Varsha Uphar and Parbhani Kranti x Punjab Padmini were found to have significantly higher regression coefficients along with desirable mean value for the trait fruit yield per plant. These genotypes said to be average responsive and suitable for all the environments.

The 57 genotypes of okra were subjected to stability analysis in four environments/seasons with respect to eleven yield and yield contributing traits by Srivastava *et al.* (2011). Highly significant G x E interaction was noticed only for six traits, *viz.,* plant height, days to first flowering, days to first picking, fruit weight, total number of pickings and yield plant-1. Rainy season was noted to be congenial for fruit yield plant per plant, plant height and fruit weight. Spring-summer season proved to be ideal for days to first flowering and days to first picking, while summer season appeared to be best for total number of pickings. The cross combination Arka Abhay x Lam-1 was found stable for plant height and Parbhani Kranti x VRO-5 was stable for total number of pickings, days to first flowering, days to first picking, fruit weight and yield plant-1. Among the top ten high yielding hybrid cross combinations, four crosses *viz.,* VRO-6 x Pusa Makhmali, Hisar Unnat x Lam-1, Punjab Padmini x Hisar Unnat and Pusa Sawani x Hisar Unnat were found to be largely adaptable and suitable enough to be recommended for wide cultivation in all the four seasons studied. Pusa Sawani x Arka Abhay cross genotype was found suitable for cultivation under poor environment.

Hamed and Hafiz (2012) investigated genotypic stability (with respect to pods yield) of thirteen local okra genotypes across three locations. Multi-environmental trials (MET), generally, have significant main effects and significant multiplicative G x E interaction effect. The results showed that (i) the obtained results satisfied one of the breeder's goals for selecting the best-suited genotype for cultivation in a wide salinity range of environments; (ii) the analysis of variance of thirteen local okra genotypes in three locations (Kaha, Ras sudr 1 and Ras sudr 2) shows that genotype (G), environment (E) and their interaction were significant ($P < 0.01$) for genotype; (iii) the AMMI model was very effective for studying GEI interaction, the first bilinear AMMI (IPCA1) model terms accounted for 71.268 per cent; (iv) no genotype has superiority performance in under all studied environments; although, the biplot shows that the genotypes BG9, BG6, BR27 and BR20 are best-suited for cultivation in a wide range of environments; (v) the salt stress has affected the okra plant growth and development.

Olayiwola and Ariyo (2013) reviewed that the variation of response of genotypes to environments has made multi-environment study a necessity in plant breeding. Twelve okra genotypes were tested over three environments (locations) to study the effects of Genotype by Environment Interaction (GEI) on seed yield. The GGE biplot and YSi techniques jointly identified NHGB/09/009A as the genotype that best combined high yield and stability; and

FUNAAB-11-4 and FUNAAB-11-6 as having good potential in this regard. The YSi in addition, also selected FUNAAB-11-8, FUNAAB-11-3 and BD-88. The GGE biplot identified two mega-environments *viz.,* Ibadan and Ayetoro where FUNAAB-11-8 was outstanding and Abeokuta where FUNAAB-11-3 was the best. It identified Ayetoro as the best location for the selection of superior genotypes. Okra genotypes NHGB/09/009A, FUNAAB-11-4 and FUNAAB-11-6 would therefore be desirable for cultivation across the three environments.

Stability performance of 49 okra entries including 13 genetically diverse parents and 36 crosses were compared by using stability analysis by Javia (2014) for fruit yield and its yield attributing traits in three consecutive seasons. The analysis of variance for stability revealed that the differences among the genotypes were highly significant for all the traits when tested against the pooled error, pooled deviation and G x E interaction indicated the presence of variability among the genotypes under all the environments. The fruit yield per plant was higher in two female and five male parents and in sixteen hybrids than average. However, none of the parents and crosses was considered stable. None of the parents or hybrids exhibited average stability for all the traits. Thus, any generalization regarding stability of genotypes for all the traits is too difficult since the genotypes may not simultaneously exhibit uniform responsiveness and stability patterns for all the traits. On the basis of overall yield performance, D-l-87-5 was observed to be highest yielder and deserves merit as high yielding variety for *kharif* season. The cross combination HRB-55 x D-l-87-5 was considered as an elite cross as it was highest yielder across the environments and also superior with respect to most of the other traits.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present investigation entitled “Heterosis, Combining Ability and Stability Analysis in Okra [*Abelmoschus esculentus* (L.) Moench]” by Line x Tester mating design was undertaken to investigate the extent of heterosis, combining ability, stability parameter. The field experiment was conducted at Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan during *summer*-2013 (crossing programme) and summer and *kharif*-2014 (Evaluation). The details of materials used, methods followed and the techniques adopted during the period of experiment have been described here under.

3.1 Location

Geographically, Jagudan is situated at 23^{o}-52' North latitude and 72^{o}-43' East longitude and an altitude of 70 metre above mean sea level. The soil of the experimental field was sandy loam with pH 7.9. The climate of this area is typically sub-tropical type characterised by semi-arid conditions. 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.

3.2 Experimental materials

The experimental materials comprised of 15 parents, which involves ten females, five males and their 50 F_1 hybrids along with one commercial check (GJOH-3). The parents were obtained from Vegetable Research Scheme, Sardarkrushinagar Dantiwada Agricultural University, Jagudan. The above materials (66) were used for the experiment to study the heterosis, combining ability and stability. The list of parents is given below (Table 3.1, 3.2 and 3.3):

Table 3.1: Details of environments taken under study

Environment	Sowing time
E_1	Timely sown in *summer* at 20th February, 2014.
E_2	Late sown in *summer* at 10th March, 2014.
E_3	Timely sown in *kharif* at 12th August, 2014.
E_4	Late sown in *kharif* at 1st September, 2014.

Table 3.2: List of parents used in line x tester crossing programme

Lines (10)	Testers (5)	Commercial Check (Hybrid)
JDNOL-11-1	Arka Anamika	GJOH-3
JDNOL-11-3	Pusa Sawani	
JDNOL-11-11	Parbhani Kranti	
JDNOL-11-12	GO-2	
JDNOL-11-14	VRO-6	
AOL-07-9		
AOL-08-5		
JOL-6k-2		
JOL-08-7		
JOL-08-12		

Table 3.3: Salient features of the parents used in the line x tester crossing programme

Sr. No.	Genotype	Source	Specific character
Line (10)			
1	**JDNOL-11-1**	SDAU, Jagudan.	Around 110 cm height, greenish to reddish tinge on leaves and stem, high internodal length, 13-14 cm length of medium green pod with 5 ridges, small lobed leaves and 1-2 branches per plant.
2	**JDNOL-11-3**	SDAU, Jagudan.	Erect, around 100-110 cm height, high internodal length, 10-12 cm length of medium green pod with 5 ridges, small lobed leaves and 2-3 branches per plant.
3.	**JDNOL-11-11**	SDAU, Jagudan.	Medium tall plant, high internodal length, 9-10 cm length of medium green pod with 5 ridges, small lobed leaves and 1-2 branches per plant.
4	**JDNOL-11-12**	SDAU, Jagudan.	Plant height 110-130 cm, greenish to reddish tinge on leaves & stem, high internodal length, 13-14 cm length of medium green pod with

			5 ridges, small lobed leaves and 2-3 branches per plant.
5	**JDNOL-11-14**	SDAU, Jagudan.	Around 110-120 cm height, medium internodal length, 10-12 cm length of dark green pod with 5 ridges, medium to big lobed leaves and 2-3 branches per plant.
6	**AOL-07-9**	AAU, Anand.	Erect tall plant, fruits are smooth, tender and long green pods with 5 ridged and high yield potential.
7	**AOL-08-5**	AAU, Anand.	Around 100 cm height, medium internodal length, 10-11 cm length of medium green pod with 5 ridges, leaves are big and deep lobed and 3-4 branches per plant.
8	**JOL-6k-2**	JAU, Junagadh.	Around 80 cm height, reddish tinge on leaves, short internodal length, dark green pod with 5 ridges, medium lobed leaves
9	**JOL-08-7**	JAU, Junagadh.	Erect, around 80-90 cm height, reddish tinge on middle of leaves and green stem, medium internodal length, 9-10 cm length of light green pod with 5 ridges, small to medium lobed leaves and 1-2 branches per plant.
10	**JOL-08-12**	JAU, Junagadh.	Erect, around 80-90 cm height, reddish tinge on middle of leaves and green stem, medium internodal length, 8-9 cm length of dark green pod with 5 ridges, small to medium lobed leaves and 1-2 branches per plant.
Tester (5)			
1	**Arka Anamika**	IIHR, Bengaluru.	Vigorous, tall erect and well branched plants, bearing fruits in two flushes. During the first flush fruits are borne on the main stem, 40-45 days after sowing. Fruits are long (15-20 cm), spineless, lush green and tender. Highly tolerant to YVMV.
2	**Pusa Sawani**	IARI, New Delhi.	Tall plant, green fruit, 5 ridged and susceptible to YVMV
3	**Parbhani Kranti**	MAU, Parbhani.	Tall plant and resistance to YVMV
4	**GO-2**	JAU, Junagadh.	Fruit are smooth, tender and long green pods with 5 ridged and high yield potential

5	**VRO-6**	IIVR, Varanasi.	Erect, around 80 cm height, reddish tinge on main stem as well as branch and petioles, medium internodal length, 12-13 cm length of medium green pod with 5 ridges, small lobed leaves and 1-2 branches per plant.
Commercial check (Hybrid)			
1	**GJOH-3**	JAU, Junagadh.	Plant height is 130-150 cm., A plant bears 18-25 fruits with 7 ridges, length 13-15 cm at marketable stage Yield 110-140 q/ha; Resistant to YVMV

3.3 Hybridization programme

Seeds of parents were sown during summer-2013 for attempting crosses in line x tester fashion. Sowing was done on 60 cm apart ridges at spacing of 45 cm between plants for easy movement. All packages of cultivation practices were followed to raise a good crop. Selfing is done by tying the closed flower buds with a thread the day before anthesis (Purewal and Randhawa, 1947). Anthesis in okra occurs between 6 to 10 a.m. (Sulikiri and Swamy, 1972). A simple emasculation technique evolved by Giriraj and Swamy (1973) was used. A total of 50 hybrids were developed by crossing ten females parents (lines) with each of five males parents (testers). Flower buds of male and female parents were selected on the previous evening prior to the day of their opening. The flower buds of female parents were emasculated and covered with butter paper bags to avoid out crossing. Pollination was carried out on the next day morning between 8 to 10 a.m. by using pollens of desired male parents. After pollination, the female flower buds were again covered with butter paper bags to avoid contamination and tagged with the details of male parent and date of pollination. Simultaneously, the male and female parents were selfed by bagging the flower buds with butter paper prior to the day of flower opening. Crossed and selfed fruits were harvested separately at full maturity stage. The seeds were threshed by hand and preserved in brown paper bags labeled with the details of cross.

3.4 Evaluation of parents, F_1's and commercial F_1 hybrid

The experimental material consisted of ten lines and five testers, 50 F_1 hybrids derived from (10 x 5) line x tester fashion and one commercial F_1 hybrid.

(a) Evaluation of genotypes

E_1 - *summer* 2014-Timely sown on 20th February, 2014.

E_2 - *summer* 2014-Late sown on 10th March, 2014.

E_3 - *kharif* 2014-Timely sown on 12th August, 2014.

E_4 - *kharif* 2014-Late sown on 1st September, 2014.

(b)	Treatments	**:**	66 (50 single crosses + 15 parents + One commercial check).
(c)	Commercial check	**:**	GJOH-3
(d)	Replications	**:**	Three
(e)	Design	**:**	RBD
(f)	Spacing	**:**	60 cm (between rows) x 30 cm (between plants)
(g)	Plot size	**:**	46.8 m x 13.8 m
(h)	Number of plants per row	**:**	10
(i)	Length of row	**:**	3.6 m

3.5 Observations recorded

The following observations were recorded on the five plants chosen at random in each genotype and some of characters measured on plot basis in each replication. The average values were computed as treatment mean under each replication. The characters studied and techniques adopted to record the observations are given below:

3.5.1 Days to 50 per cent flowering

Days taken from sowing to the opening of first flower in 50 per cent of the plants in plot were recorded as days to flowering.

3.5.2 Days to first picking

Number of days taken from the date of sowing to the date of first harvest of green marketable pods on plot basis was recorded as days to first picking.

3.5.3 Fruit length (cm)

Pod length was measured in centimeters from the base of calyx to the tip of the pod. For recording this observation five green marketable pods were selected randomly from each entry at fifth picking.

3.5.4 Fruit girth (cm)

This observation was noted on five randomly selected green pods from each entry and maximum diameter at the middle of the pod was measured for this purpose.

3.5.5 Number of branches per plant

The total number of main branches per plant was counted at last picking stage and recorded as number of branches per plant.

3.5.6 Internodal length (cm)

The length of the internode in centimeter between the fifth and sixth node was measured at 75 days after sowing.

3.5.7 Plant height (cm)

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

3.5.8 Fruit yield per plant (g)

This observation was recorded by weighing marketable green pods from each five selected plants in grams at each picking. Sum total of all pickings was considered as yield per plant.

3.5.9 Total number of fruits per plant

This observation was recorded by counting harvested fruits from each five selected plants at each picking. Sum total of all pickings was considered as total number of fruits per plant.

3.5.10 Total number of seed per fruit

This observation was noted on five randomly selected fruits from each genotype left over for seed and after last picking dry, it and separated number of seeds was taken for total number of seeds per fruit.

3.5.11 Days to last picking

Number of days taken from the date of sowing to the date of last harvest of green marketable green fruits on plot basis was recorded.

3.5.12 Crude protein content (%)

The total nitrogen content of the fruit was analysed through Micro Kjeldahl's Method (Jackson, 1967) Using Kjehl plus apparatus and the value derived was multiplied with factor 6.25 and the resultant was recorded as crude protein content (%).

3.5.13 Crude fiber content (%)

Crude fiber content in percentage the fruit was estimated by the method proposed by Thimmaiah (1999).

3.5.14 Vitamin 'C' (mg/100 g pulp)

Vitamin 'C' content mg/100 g pulp *i.e.,* ascorbic acid content was estimated by the Method proposed by Ranganna (1977).

3.6 Statistical analysis

The replication-wise mean values of each genotype for various characters were analysed using randomized block design (Line x Tester mating design) as suggested by Panse and Sukhatme (1967). The mean values for parental lines and F_1 hybrids for all characters were subjected for statistical analysis on following aspects.

3.6.1 Analysis of variances for the experimental design in individual environment as well as pooled over environments

3.6.2 Estimation of heterosis

3.6.3 Combining ability analysis for individual environment and pooled over environments

3.6.4 Genotype x environment interactions and stability analysis

3.6.1 Analysis of variances for the experimental design in individual environment as well as pooled over environments

The replicated mean values were subjected to statistical analysis to test the significance of variation for experiment conducted as per RBD was carried out on the following model of Panse and Sukhatme (1967).

3.6.1.1 Analysis of variance for an individual environment

The statistical model for randomized block design followed for analysis of variances under individual environment was as under :

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

Where,

Y_{ij} = Performance of i^{th} genotype in j^{th} replication,

μ = General mean,

g_i = Effect of i^{th} genotype, (i = 1,2,……,g),

r_j = Effect of j^{th} replication, and

e_{ij} = Experimental error associated with i^{th} genotypes in j^{th} replication.

Table 3.4: Analysis of variance for experimental design RBD

Source of variation	**d.f.**	**MS**	**Expected MS**	**F**
Replications	(r-1)	MS_1	$\sigma^2e + g\sigma^2r$	M_1 / M_6
Genotypes	(g-1)	MS_2	$\sigma^2e + r\sigma^2g$	M_2 / M_6
Parents	(p-1)	MS_3	$\sigma^2e + rh\sigma^2p$	M_3 / M_6
Females (F)	(f-1)	MS_4	$\sigma^2 e + rm\sigma^2f$	M_4 / M_6
Males (M)	(m-1)	MS_5	$\sigma^2 e + rf\sigma^2m$	M_5 / M_6
F vs. M	1	MS_6	$\sigma^2 e + r\sigma^2fm$	M_6 / M_6
Parents vs. Hybrids	1	M_7	$\sigma^2e + r\sigma^2ph$	M_7 / M_6
Hybrids	(h-1)	M_8	$\sigma^2e + rp\sigma^2h$	M_8 / M_6
Error	(g-1) (r-1)	M_9	σ^2e	M_9 / M_6
Total	r (g-1)	-	-	-

Where,

r = Number of replications,

g = Number of genotypes (Parents + Hybrids),

p	=	Total number of parents,
h	=	Hybrids,
$\sigma^2 r$	=	Variance due to replication,
$\sigma^2 p$	=	Variance due to parents,
$\sigma^2 g$	=	Variance due to genotypes,
$\sigma^2 h$	=	Variance due to hybrids,
$\sigma^2 h$	=	Variance due to hybrids,
$\sigma^2 ph$	=	variance due to parents vs. hybrids,
$\sigma^2 e$	=	Error variance, and
M	=	Mean sum of squares.

The significance of variance among different components was tested against the error variance ($\sigma^2 e$) by applying the usual 'F' test.

The standard error of mean, critical difference and coefficient of variation were estimated as given below.

The standard error for mean differences between treatments mean was calculated using following formulae:

$$S.Em. = (M_6/r)^{0.5}$$

Where,

S.Em.	=	Standard error of mean differences of treatment means to be compared,
M_6	=	Error mean square, and
r	=	Number of replications.

The critical differences to compare the mean values of various genotypes was calculated by using following formula:

C.D. at 5 % and 1 % = S.Em x $(2)^{0.5}$ x '$t_{0.05}$' at error d.f. at P = 0.05 and P = 0.01 levels of significance, respectively.

The coefficient of variation (C.V. %) was calculated by using following formula:

$$C.V. (\%) = [(MS_9)^{0.5} / \text{General mean}] \times 100$$

3.6.1.2 Analysis of variance pooled over environments

The statistical model for the randomized block design for analysis of variance pooled over environments was as under:

$$Y_{ijk} = \mu + g_i + r_j + e_k + ge_{ik} + e_{ijk}$$

Where,

Yijk	=	Yield of ith genotype of jth replication in kth environment,
μ	=	General mean,
g_i	=	Effect of ith genotype,
r_j	=	Effect of jth replication,
e_k	=	Effect of kth environment,
ge_{ik}	=	Interaction effect of ith genotype with kth environment, and
e_{ijk}	=	Random experimental error associated with ith genotype in jth replication and kth environment, respectively.

Table 3.5: Analysis of variance pooled over environments

Source of variation	**d.f.**	**MS**	**F**
Environments	(e-1)	M	M / M_{14}
Replications within environment	e (r-1)	M_1	M_1 / M_{14}
Parents	(p-1)	M_2	M_2 / M_{14}
Females	(f-1)	M_3	M_3 / M_{14}
Males	(m-1)	M_4	M_4 / M_{14}
Females vs. males	1	M_5	M_5 / M_{14}
Hybrids	(h-1)	M_6	M_6 / M_{14}
Parents vs. hybrids	1	M_7	M_7 / M_{14}
Parents x environments	(p-1) (e-1)	M_8	M_8 / M_{14}
Females x environments	(f-1) (e-1)	M_9	M_9 / M_{14}
Males x environments	(m-1) (e-1)	M_{10}	M_{10} / M_{14}
(Females vs. males) x environments	l (e-1)	M_{11}	M_{11} / M_{14}
Hybrids x environments	(h-1) (e-1)	M_{12}	M_{12} / M_{14}
(Parents vs. hybrids) x environment	l (e-1)	M_{13}	M_{13} / M_{14}
Pooled Error	l (r-1) (p + h-1)	M_{14}	-
Total	(l x r) (p + h-1)	-	-

e = Environment p = Parent m = Male

r = Replication f = Female h = Hybrid

For the combined analysis over environment, a pooled error mean square was calculated by pooling the error mean squares of each individual experiment with the help of following formula:

$$\text{Pooled error mean squares} = \sum \text{EMS}/e$$

Where,

e = Number of environments

The significance of mean squares due to genotypes and environments were tested against the mean squares due to genotype x environment interactions (G x E), while the later was tested against pooled error mean squares.

The estimations of standard error of mean, critical difference and co-efficient of variation were obtained as mentioned below:

S.Em. = $(M_{14}/re)^{0.5}$

C.D. at 5 % and 1 % = S.E (m) x $(2)^{0.5}$ x '$t_{0.05}$' at error d.f. at P = 0.05 and P = 0.01 levels of significance.

C.V. % = $[(MS_{14})^{0.5}$ / General mean] x 100.

3.6.2 Estimation of heterosis

The estimation of heterosis was estimated in relation to mid-parent, better parent and standard check hybrid values. They were thus, calculated as per cent increase or decrease in hybrid (F_1) over its better parent (BP) and standard check (SC) values in the desirable direction was calculated using the following formula given by Fonseca and Patterson (1968).

[A] Heterosis over mid parent (MP) %

$$MP = \frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$$

Where,

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

$\overline{MP}$ = Mean performance of mid parent.

[B] Heterosis over better parent (BP) %

$$BP = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} x100$$

Where,

$\overline{F}_1$ = Mean performance of F_1 hybrid, and

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

[C] Heterosis over standard check (SC) % $SH = \frac{\overline{F}_1 - \overline{SC}}{\overline{SC}} x100$

Where,

$\overline{SC}$ = Mean performance of standard check (GJOH-3).

Test of significance

The differences in magnitude of heterosis were tested with the help of C.D. value. The formula is as under:

S.E. of difference for standard check = $[2Me/r]^{0.5}$

Where,

Me = Error mean square of individual environment, and

C.D. = S.E (d.) x 't' at error d.f. (P = 0.05 and P 0.01 levels of significance)

Significance of heterosis values was tested using 't' test:

$$t = \frac{\overline{F}_1 - \overline{SC}}{\text{S.E. of heterosis over } \overline{SC}}$$

Calculated ‘t’ value was compared with table value at error degrees of freedom for significance.

For computing heterosis for individual environments, mean values of F_1's, and check of a single environment were used while for calculation of heterosis over environments; mean values of F_1's and check over all the environments were used in the above formulae.

3.6.3 Combining ability analysis

3.6.3.1 Analysis of variance for the combining ability (line x tester) in individual environment

The combining ability analysis was carried out as per the method given by Kempthorne (1957) using the following model.

$$Y_{ijk} = \mu + g_{i.} + g_{.j} + s_{ij} + r_k + e_{ijk}$$

Where,

Y_{ijk}	=	Phenotypic expression of ij^{th} cross in k^{th} replication,
μ	=	General mean,
$g_{i.}$	=	General combining ability of i^{th} female parent (i = 1, 2, 3 ... f, number of female parents),
$g_{.j}$	=	General combining ability of j^{th} male parent (j = 1, 2, 3 ... f, number of male parents),
S_{ij}	=	Specific combining ability of crosses between i^{th} female and j^{th} male,
r_k	=	Effect of k^{th} replication (k = 1, 2, 3 ... r, number of replication), and
e_{ijk}	=	Random experiment error associated with i^{jth} genotype in k^{th} replication.

The analysis of variance for combining ability in individual environment was carried out as indicated below:

Table 3.6: Analysis of variance for combining ability for individual environment

Source of variation	d.f.	M.S.	Expected mean squares	
			In terms of F.S. and H.S.	In terms of variance components
Females (F)	(f-1)	M_1	σ^2e + r (Cov. F.S.– 2Cov. H.S.) + rm Cov. H.S.	$\sigma^2e + r\sigma^2mf + rm\ \sigma^2f$
Males (M)	(m-1)	M_2	σ^2e + r (Cov. F.S.– 2Cov. H.S.) + rf Cov. H.S.	$\sigma^2e + r\ \sigma^2mf + rf\ \sigma^2m$
Females x Males	(f-1) (m-1)	M_3	σ^2e + r (Cov. F.S.– 2Cov.H.S)	$\sigma^2e + r\ \sigma^2mf$
Error	(r-1) (mf-1)	M_4	σ^2e	σ^2e

Where,

F	=	Number of female (line)
M	=	Number of male (tester)
Mf	=	Number of hybrid
σ^2f	=	General combining ability variance components of female

$\sigma^2 m$ = General combining ability variance components of male

$\sigma^2 mf$ = Specific combining ability variance components of hybrids

$\sigma^2 e$ = Variance component of error

Estimation of variance components

From the expectation of mean squares, the covariance between half-sibs (Cov.H.S.) and covariance full-sibs (Cov.F.S.) were estimated as below:

Cov.H.S. = $(M_1 + M_2 - 2M_3)/r(f + m)$

$= (m\hat{\sigma}^2 f + f\hat{\sigma}^2 m)/f + m$

= Y

Cov.F.S. = $(1/3r)\,[(M_1 + M_2 + M_3 - 3M_4) + \sigma r$ Cov.H.S. – $r(m + f)$ Cov.H.S.]

$= \sigma^2 mf + 2$ Cov.H.S.

= X

The estimates of Cov.H.S. and Cov.F.S. were used to estimate the variance due to general combining ability ($\hat{\sigma}^2 GCA$) and variance due to specific combining ability ($\hat{\sigma}^2 SCA$) as below :

$\hat{\sigma}^2 GCA$ = Cov.H.S. = y

$\hat{\sigma}^2 SCA$ = Cov.F.S. – 2Cov.H.S. = x – 2y

The estimates of variance components due to females, males and hybrids were obtained as under :

$\hat{\sigma}^2 f$ = $M_1 - M_3/rm$

$\hat{\sigma}^2 m$ = $M_2 - M_3/rf$

$\hat{\sigma}^2 mf$ = $M_3 - M_4/r$

For testing the significance of estimated variance, following tests were made.

$H_0 = \sigma^2 mf$ = 0 was tested by

$F (n_3, n_4)$ = M_3/M_4

If M_3 was significant, then test would be :

$F (n_1, n_3)$ = M_1/M_3 for $\sigma^2 f$ = 0 and

$F (n_2, n_3)$ = M_2/M_3 for $\sigma^2 m = 0$.

If M_3 was not significant, then M_4 was used as denominator. The n_1, n_2, n_3 and n_4 were degrees of freedom associated with M_1, M_2, M_3 and M_4 mean squares, respectively.

3.6.3.2 Analysis of variance for combining ability over environments

Analysis of variance for combining ability over the environments was done in order to have information concerning the influence of genotype-environment interactions on combining ability estimates. The statistical model for this analysis was as under:

$Y_{ijkl} = \mu + Gi. + G.j + S_{ij} + E_1 + R_{kl} + (GE)_{i.l} + (GE)_{.jl} + (SE)_{ijl} + e_{ijkl}$

Where,

i = 1, 2, ..., f (Female parents),

j = 1, 2, ..., m (Male parents),

k = 1, 2, ..., r (Replications),

L = 1, 2, ..., e (Environments),

Y_{ijkl} = The values of i^{th} environment in k^{th} replication of progeny of the i^{th} female and j^{th} male parent,

μ = General mean,

Gi. = An effect common to all progenies of the i^{th} female parent,

G.j = An effect common to all progenies of the j^{th} male parent

S_{ij} = An effect specific to the progenies of the i^{th} female and j^{th} male parent,

E_1 = The average effect of i^{th} environment,

R_{kl} = The effect of k^{th} replication over l^{th} environment,

$(GE)_{i.l}$	=	Interaction effect of i^{th} female with l^{th} environment,
$(GE)_{.jl}$	=	Interaction effect of j^{th} male with l^{th} environment,
$(SE)_{ijl}$	=	Interaction effect of hybrids of i^{th} female and j^{th} male parent with l^{th} environment, and
e_{ijkl}	=	Uncontrolled variation associated with the l^{th} environment in the k^{th} replication with progenies of i^{th} female and j^{th} male parents and assumed to be homogenous for all cultivars and environments.

The form of analysis of variance used for estimation of general and specific combining ability variance components and their interaction with environments for various traits was as under:

Table 3.7: Analysis of variance for combining ability over environments

Source of variation	**d.f.**	**M.S.**	**Expected mean squares**
Environments (E)	(e-1)	-	$\sigma^2 e + r\sigma^2 mfe + rf\sigma^2 me + rm\sigma^2 fe + mfr\ \sigma^2 e$
Females (F)	(f-1)	M_1	$\sigma^2 e + r\sigma^2 mfe + re\sigma^2 mf + rm\sigma^2 fe + rme\ \sigma^2 f$
Males (F)	(m-1)	M_2	$\sigma^2 e + r\sigma^2 mfe + re\sigma^2 mf + rm\sigma^2 me + rfe\ \sigma^2 m$
Females x Males	(f-1) (m-1)	M_3	$\sigma^2 e + r\sigma^2 mfe + re\sigma^2 mf$
F x E	(f-1) (e-1)	M_4	$\sigma^2 e + r\sigma^2 mfe + rm\sigma^2 fe$
M x E	(m-1) (e-1)	M_5	$\sigma^2 e + r\sigma^2 mfe + rf\sigma^2 me$
F x M x E	(f-1) (m-1) (e-1)	M_6	$\sigma^2 e + r\sigma^2 mfe$
Pooled error	E (r-1) (mf-1)	M_7	$\sigma^2 e$

The letters e, f, m and r represent environments, females, males and replications, respectively. $\sigma^2 e$, $\sigma^2 f$, $\sigma^2 m$ and $\sigma^2 mf$ are same as obtained from analysis for combining ability of individual environment. $\sigma^2 fe$, $\sigma^2 me$ and $\sigma^2 fme$ are the variances due to interaction of environment with females, males and hybrids, respectively. Estimates of components of variances were obtained from each analysis of variance by equating mean squares to exception and sorting out the appropriate components.

The estimates of each component from the expected mean squares were obtained as under:

$\hat{\sigma}^2 f$ = $M_1 – M_3 – M_4 + M_6/rme$

$\hat{\sigma}^2 m$ = $M_2 – M_3 – M_5 + M_6/rfe$

$\hat{\sigma}^2 mf$ = $M_3 – M_6/re$

$\hat{\sigma}^2 fe$ = $M_4 – M_6/rm$

$\hat{\sigma}^2 me$ = $M_5 – M_6/rf$

$\hat{\sigma}^2 mfe$ = $M_6 – M_7/r$

$\hat{\sigma}^2 gca_{\text{ x loc.}}$ = $[(M_4 – M_6) + (M_5 – M_6)] / r(f + m)$

$\hat{\sigma}^2 sca_{\text{ x loc.}} = \hat{\sigma}^2 mfe$ = $(M_6 – M_7)/r$

Estimates of covariance of half-sibs and full sibs and variance of GCA and SCA were calculated as under :

Cov.H.S. = $(m\hat{\sigma}^2 f + f\sigma^2 m)/f + m$

Cov.F.S. = $\hat{\sigma}^2 mf$ + 2Cov.H.S.

Variance GCA ($\hat{\sigma}^2 gca$) = Cov.H.S.

Variance SCA ($\hat{\sigma}^2 sca$) = Cov.F.S. – 2Cov.H.S. = $\hat{\sigma}^2 mfe$

'F' test was employed to test the significance of various estimated variance components as under:

H_0 : $\sigma^2 mfe = 0$ was tested by $F(n_6, n_7) = M_6/M_7$

H_0 : $\sigma^2 mf = 0$, $\sigma^2 fe = 0$ and $\sigma^2 me = 0$ were tested by $F(n_5, n_6) = M_5/M_6$, respectively.

If M_6 is found to be non-significant, then M_3, M_4 and M_5 tested against M_7

$H_0 = \sigma^2 f = 0$

$$F = \frac{(M_1 + M_6)^2}{\frac{(M_1)^2}{n_1} + \frac{(M_6)^2}{n_6}}, \frac{(M_3 + M_4)^2}{\frac{(M_3)^2}{n_3} + \frac{(M_4)^2}{n_4}} = \frac{M_1 + M_6}{M_3 + M_4}$$

$H_0 = \sigma^2 m = 0$

$$F = \frac{(M_2 + M_6)^2}{\frac{(M_2)^2}{n_2} + \frac{(M_6)^2}{n_6}}, \frac{(M_3 + M_5)^2}{\frac{(M_3)^2}{n_3} + \frac{(M_5)^2}{n_5}} = \frac{M_2 + M_6}{M_3 + M_5}$$

Where,

n_1, n_2, n_3, n_4, n_5, n_6 and n_7 were degrees of freedom associated with M_1, M_2, M_3, M_4, M_5, M_6 and M_7, respectively.

3.6.3.3 Estimation of general combining ability effects of parents and specific combining ability effects of crosses for individual environment

The general combining ability effects of male and female parents and specific combining ability effects of crosses were obtained from the two way table, females vs. males, in which each figure was a total over replications.

μ = x .../mfr

g_i = x_i .../mr - x .../mfr (g_i = gca effect of lines)

g_j = $x_{.j.}$/fr - x .../mfr (g_j = gca effect of testers)

s_{ij} = $x(_{ij})$./r - x_i .../mr - $x_{.j.}$/fr + x .../mfr
(s_{ij} = specific combining ability effect of ij^{th} cross)

Where,

x ... = Grand total

x_i... = Total of i^{th} female parent over all males and replications

x.j. = Total of j^{th} male parent over all females and replications

$x_{(ij)}.$ = Total of ijth combination over all replications

Standard error for combining ability effects were calculated as follows :

$$S.E.(g_i) = \sqrt{EMS / rm}$$

$$S.E.(g_j) = \sqrt{EMS / rf}$$

$$S.E.(s_{ij}) = \sqrt{EMS / r}$$

Where,

EMS = Error mean squares in the analysis of variance for combining ability, and

r,f,m = Number of replications, females and males, respectively.

The critical differences were calculated by multiplying corresponding S.E. with the table value of ‘t’ at error degree of freedom corresponding to 5 per cent and 1 per cent level of significance.

3.6.3.4 Estimation of general combining ability effects of parents and specific combining ability effects of crosses over environments

General combining ability effects of male and female parents and specific combining ability effects of crosses over environments were computed as below:

(a) Estimation of GCA effects

(i) gca of females = x_i .../mre - x .../fmre

(ii) gca of males = $x_{.j}$../fre - x .../fmre

(b) Estimation of SCA effects

x_{ij}../re - x_i .../mre - x_j.../fre + x .../fmre

Where,

x... = Grand total,

$x_{i}..$	=	Total of i^{th} female parent over all males, replications and environments,
$x_{.j}..$	=	Total of j^{th} male parent over all females, replications and environments, and
$x_{ij}..$	=	Total of ij^{th} combination over all replications and environments.

Standard error of combining ability effects

$$S.E.(g_i) = \sqrt{PEMS/rme}$$

$$S.E.(g_j) = \sqrt{PEMS/rfe}$$

$$S.E.(s_{ij}) = \sqrt{PEMS/re}$$

Where,

PEMS	=	Pooled error mean squares in the analysis of variance for combining ability
r,f,m and e	=	Number of replications, females, males and environments, respectively

3.6.4 Genotype x environment interaction and stability analysis

The mean values recorded for different traits for parents and their hybrids over three environments were subjected to the analysis of variance for phenotypic stability.

3.6.4.1 Analysis of variance for phenotypic stability

The statistical analysis for genotype x environment interaction and stability parameters was carried out according to the method of Eberhart and Russell (1966) to calculate the analysis of variance, which is presented in following table:

Table 3.8: Analysis of variance for phenotypic stability as per Eberhart and Russell (1966) model

Source	**d.f.**	**S.S.**	**M.S.**

Genotypes	(g-1)	$\frac{1}{e}\sum_i Y_{i.}^2 - (\sum_i \sum_j Y_{ij})^2 / ge$	MS_1
Environments	(e-1	$\frac{1}{g}\sum_i \sum_j Y_{.j}^2 - (\sum_i \sum_j Y_{ij})^2 / ge$	-
Genotypes x Environments	(g-1) (e-1)	$\sum_i \sum_j Y_{ij}^2 - \sum_i Y_{i.}^2 / e - \sum_j Y_{.j}^2 / g + (\sum_i \sum_j Y_{ij})^2 / ge$	-
Environments (Linear)	1	$\frac{1}{g}(\sum_j Y_{.j} I_j)^2 / \sum_j I_j^2$	-
Genotypes x Environments (Linear)	(g-1)	$\sum_i [(\sum_j Y_{ij} I_j)^2 / \sum_i I_j^2)]$ - Environment (Linear) S.S.	MS_2
Pooled deviation	g(e-2)	$\sum_i \sum_j \delta_{ij}^2$	MS_3
Deviation of individual genotype	(e-2)	$\{\sum_j Y_{ij}^2 - \frac{[Y_{i.}]^2}{n}\} - \frac{[\sum_j Y_{ij} I_j]^2}{\sum_j I_j^2}$	-
Pooled error	e(r-1) (g-1)	$\sum_i \sum_j e_{ij}^2$	σ^2_e

Where,

r, e and g indicate number of replications, environments and genotypes, respectively. The term σ^2_e represents mean squares due to pooled error.

For ‘F' test, the mean square due to pooled deviation (MS_3) was first tested against pooled error.

$$F = \frac{MS_3}{\text{Pooled error m.s.}}$$

The appropriate 'F' test for testing the significance of difference among genotypes mean was obtained as :

$$F = \frac{MS_1}{MS_3}$$

To test the genetic differences among varieties for their regression on the environment index, the following 'F' ratio was work out.

$$F = \frac{MS_2}{MS_3}$$

3.6.4.2 Stability parameters

The stability parameters for the various traits were computed following the methodology of Eberhart and Russell (1966). For each genotype, stability is described by three parameters, mean performance, the regression of mean performance on an environmental index and the function of squared deviation from this regression. Eberhart and Russell (1966) suggested that ideal variety is one which has a high mean, unit regression coefficient (b_i = 1.0) and the least deviation from regression (S^2d_i = 0).

These parameters are defined in a linear model as follows:

$$Y_{ij} = \mu_i + b_i I_j + \delta_{ij}$$

Where,

Y_{ij} = Mean of i^{th} genotype in j^{th} environment,

μ_i = i^{th} genotype mean over all the environment,

b_i = Regression coefficient that measures the response of the i^{th} genotype to changing environments,

δ_{iij} = Deviation from regression of the i^{th} genotype in the j^{th} environment, and

I_j = Environmental index, obtained as a mean of all the genotypes at the j^{th} environment minus grand mean.

$$\left[I_j = \left(\sum_i Y_{ij} \right) - \left(\sum_i \sum_j Y_{ij} / m \right) \right], \sum_j \sum j = 0$$

Where,

E = Number of environments.

The first stability parameter, regression coefficient was estimated as under:

$$b_i = \sum_j Y_{ij} I_j / \sum_j I_j^2$$

The performance of each variety was predicted by using the estimates of the parameters where,

$$\hat{Y}_{ij} = \bar{X}_i + b_i I_j$$

where, $\bar{X}_i$ is an estimate of the μ_i.

The deviation $(Y_{ij} - \hat{Y}_{ij})$ can be squared and summed to provide an estimate of another stability parameter (S^2d_i).

$$S^2 d_i = \left\{ \sum_j \delta_{ij}^2 / (n-2) \right\} - S_e^2 / r$$

Where, S_e^2 / r is the estimate of pooled error or the variance of a variety mean at the j[th] environment and,

$$\sum_j \delta_{ij}^2 = \{\sum_j Y_{ij}^2 - Y_i^2 / n\} - \{(\sum_j Y_{ij} I_j)^2 / \sum_j I_i^2\}$$

Test of significance

(a) The significance of the differences among genotype means *i.e.*, $H_0 = \mu_1 = \mu_2 ... = \mu_g$, is tested by the 'F' test, (with pooled error as well as with pooled deviation) which is defined as $F = MS_1/MS_3$

(b) To test the genotypes do not differ for their regression on the environmental index $H_0 = B_1 = B_2 . . . = B_g$, is tested by the 'F' test, which is defined as $F = MS_2/MS_3$

(c) Individual deviation from the linear regression was tested as follows:

$$F = \{\sum_j \delta_{ij}^2 / (n-2)\} / \textit{Pooled error}$$

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The present investigation comprising of ten female lines, five testers and their resultant fifty single crosses along with a commercial hybrid check 'GJOH-3' were sown in four different environments *viz.*, E_1 – *summer* 2014 – Timely sown on 20th February-2014, E_2 – *summer* 2014 – Late sown on 10th March-2014, E_3 – *kharif* 2014 – Timely sown on 12th August-2014 and E_4 – *kharif* 2014 – Late sown on 1st September-2014 at Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan (District : Mehsana). The objective was to estimate the magnitude of heterosis, combining ability and stability parameters in okra for 14 traits including fruit yield and its components traits following line x tester mating design. The results of the present investigation entitled "Heterosis, Combining Ability and Stability Analysis in Okra [*Abelmoschus esculentus* (L.) Moench]" are presented under following sub-heads.

4.1 Mean performance of parents and their hybrids

4.2 Analysis of variance for the experimental design

4.3 Magnitude of heterosis

4.4 Combining ability analysis

4.5 Genotype x environment interactions and stability parameters

While interpreting the data, the positive effects were considered as favorable for the traits *viz.,* fruit length, fruit girth, number of branches per plant, fruit yield per plant, total number of fruits per plant, days to last picking, crude protein content, and vitamin 'C.' Similarly, negative effects were considered favorable for the traits *viz.,* days to 50 per cent flowering, days to first picking, internodal length, plant height, total number of seeds per fruit, crude fiber content.

4.1 Mean performance of parents and their hybrids

The mean performance of parents and their hybrids for each environment as well as for pooled over environment is given in Appendices II to VIII.

4.1.1 Days to 50 per cent flowering (Appendix II)

Looking to the data pertaining to days to 50 per cent flowering, it is observed that the range for days taken for first flowering in E_1, E_2, E_3 and E_4 season varied from 44.29 (JDNOL-11-11 x Arka Anamika) to 58.25 days (JOL-08-12 x Pusa Sawani), 43.85 (JOL-08-7 x Arka Anamika) to 57.87 days (AOL-08-5 x Arka Anamika), 40.01 (JOL-08-12 x Pusa Sawani) to 51.52 days (JDNOL-11-1 x VRO-6) and 41.83 (AOL-08-5 x GO-2) to 53.13 days (AOL-07-9 x Arka Anamika), respectively. Duration for first flowering fluctuated between range of 45.21 (JDNOL-11-11 x VRO-6) to 52.74 days (JOL-6k-2 x Arka Anamika) in pooled analysis.

Among parents line 45.91 days (AOL-07-9) and 46.28 days (JDNOL-11-3) took least days for 50 per cent flowering, while, in testers VRO-6 took minimum days for 50 per cent flowering (46.39 days).

4.1.2 Days to first picking (Appendix II)

Data pertaining to days to first picking revealed that the range was 45.21 days (JDNOL-11-11 x VRO-6) to 54.49 days (AOL-08-5 x GO-2), 44.29 days (JDNOL-11-14 x Pusa Sawani) to 52.77 days (JDNOL-11-11 x GO-2), 44.70 days (JDNOL-11-14 x GO-2) to 54.43 days (AOL-07-9 x Pusa Sawani) and 45.90 days (AOL-08-5 x VRO-6) to 57.33 days (JDNOL-11-12 x VRO-6) in E_1, E_2, E_3 and E_4, respectively.

Looking to the pooled analysis of hybrids, range for days to first picking was 46.91 days (JDNOL-11-11 x VRO-6) to 51.66 days (JOL-08-12 x GO-2).

In respect to parents, testers VRO-6 and Pusa Sawani (49.28 and 49.73 days) recorded the minimum days to first picking, while among lines, JDNOL-11-12 (50.18 days) exhibited the minimum days to first picking.

4.1.3 Fruit length (cm) (Appendix III)

The range of variation for this trait among the females and males ranged from 11.29 cm (AOL-08-5) to 12.34 cm (JOL-08-12) and 11.14 cm (GO-2) to 12.12 cm (Pusa Sawani) in the pooled analysis, respectively.

In case of hybrids, the minimum fruit length was recorded in the cross combination of JOL-6k-2 x Arka Anamika (11.50 cm) while, the maximum fruit length was recorded by hybrid JDNOL-11-11 x VRO-6 (12.88 cm) in pooled analysis.

4.1.4 Fruit girth (cm) (Appendix III)

An assessment of mean values in pooled over environments revealed that among parents, female JDNOL-11-14 (Pooled: 6.25 cm) and male Parbhani Kranti (Pooled: 6.22 cm) recorded the highest mean values for fruit girth, whereas, it ranged from 4.90 cm (JDNOL-11-11) cm to 6.25 cm (JDNOL-11-14) and 5.06 cm (GO-2) to 6.22 cm (Parbhani Kranti) for lines and testers, respectively in pooled analysis. Out of 50 hybrids, the minimum fruit girth (4.92 cm) was expressed by the hybrid, JDNOL-11-14 x VRO-6, while, it was the highest (6.67 cm) in AOL-07-9 x VRO-6 in pooled analysis.

4.1.5 Number of branches per plant (Appendix IV)

Number of branches per plant varied from 2.14 (JOL-6k-2 x Parbhani Kranti) to 3.08 (JOL-08-12 x Pusa Sawani), 2.12 (JDNOL-11-3 x Arka Anamika) to 3.08 (JDNOL-11-14 x Pusa Sawani), 2.00 (JOL-08-12 x Arka Anamika) to 3.01 (JDNOL-11-3 x Parbhani Kranti) and 2.00 (AOL-08-5 x Arka Anamika) to 3.01 (JDNOL-11-11 x VRO-6) in E_1, E_2, E_3 and E_4, respectively. Pooled analysis of the data revealed that the range for number of branches per plant was 2.23 (JDNOL-11-12 x GO-2) to 2.82 (JDNOL-11-11 x VRO-6).

Line JDNOL-11-14 (2.60) recorded the maximum number of branches per plant (2.60) while tester Pusa Sawani (2.57) recorded the highest number of branches per plant among all the testers.

4.1.6 Internodal length (cm) (Appendix IV)

Perusal of data regarding to the internodal length revealed that range for E_1, E_2, E_3, E_4 and pooled was 5.58 cm (JDNOL-11-12 x VRO-6) to 7.75 cm (JOL-6k-2 x Parbhani Kranti), 5.13 cm (JDNOL-11-3 x Arka Anamika) to 8.05 cm (JDNOL-11-3 x Parbhani Kranti), 10.85 (JOL-6k-2 x GO-2) to 15.10 cm (JDNOL-11-11 x VRO-6), 10.88 cm (JDNOL-11-1 x Pusa Sawani) to 13.77 cm (JOL-6k-2 x VRO-6) and 8.54 cm (JDNOL-11-12 x VRO-6) to 10.67 cm (JDNOL-11-11 x VRO-6).

Among parents, line AOL-08-5 recorded the minimum internodal length (8.64 cm), while among testers Arka Anamika recorded the minimum length of 8.97 cm.

4.1.7 Plant height (cm) (Appendix V)

Range for plant height was observed between 109.27 cm (JOL-6k-2 x VRO-6) and 129.73 cm (AOL-07-9 x GO-2), 98.09 cm (JDNOL-11-1 x VRO-6) to 132.22 cm (JDNOL-11-11 x VRO-6), 127.67 cm (JDNOL-11-1 x VRO-6) to 187.93 cm (JDNOL-11-3 x Parbhani Kranti) and 135.47 cm (JDNOL-11-1 x VRO-6) to 182.74 cm (JDNOL-11-3 x Parbhani Kranti) in E_1, E_2, E_3 and E_4, respectively. Pooled data projected the range for plant height from 120.20 (JDNOL-11-1 x VRO-6) to 153.58 cm (JDNOL-11-3 x Parbhani Kranti).

Among female parents JOL-6k-2 (123.36 cm) had the lowest plant height while the highest was observed in male parent Pusa Sawani (154.77 cm). It ranged from 123.36 cm to 154.77 cm at pooled level.

4.1.8 Fruit yield per plant (g) (Appendix V)

The spectrum of variability over environments ranged from 165.35 g (JDNOL-11-12 x Parbhani Kranti) to 223.74 g (JDNOL-11-11 x VRO-6), 168.07 g (JOL-08-12 x Arka Anamika) to 248.45 g (JOL-08-12 x Pusa Sawani), 226.58 g (JDNOL-11-11 x Pusa Sawani) to 337.06 g (JOL-08-7 x Parbhani Kranti) and 236.74 g (JDNOL-11-12 x GO-2) to 329.68 g (JOL-08-7 x Parbhani Kranti) in E_1, E_2, E_3 and E_4, respectively. Pooled data projected the range from 211.70 g (JDNOL-11-14 x Arka Anamika) to 279.63 g (JOL-08-7 x Parbhani Kranti).

Parent JOL-6k-2 (169.91 g) had the lowest fruit yield per plant, while, the highest was observed in parent AOL-07-9 (261.70 g) in pooled analysis.

Among hybrids, mean values for pooled analysis ranged from 211.70 g (JDNOL-11-14 x Arka Anamika) to 279.63 g (JOL-08-7 x Parbhani Kranti).

4.1.9 Total number of fruits per plant (Appendix VI)

Number of fruits per plant was observed in the range of 14.56 (AOL-08-5 x Arka Anamika) to 21.60 (JDNOL-11-14 x VRO-6), 15.44 (JOL-08-7 x Arka Anamika) to 20.52 (AOL-08-5 x Pusa Sawani), 17.91 (JOL-6k-2 x Parbhani Kranti) to 26.24 (JDNOL-11-14 x VRO-6) and 18.52 (JOL-

6k-2 x Pusa Sawani) to 23.36 (JOL-08-7 x Parbhani Kranti) in E_1, E_2, E_3 and E_4, respectively. Pooled analysis of the data revealed that the range for number of fruits per plant was from 18.05 (JOL-6k-2 x Pusa Sawani) to 22.29 (JDNOL-11-14 x VRO-6).

Line, AOL-07-9 resulted in the maximum number of fruits per plant (20.93), while, among testers Pusa Sawani resulted in the maximum number of fruits per plant (20.80).

4.1.10 Total number of seeds per fruit (Appendix VI)

Total number of seeds per fruits was observed in the range of 39.36 (JOL-08-7 x Arka Anamika) to 52.51 (JDNOL-11-12 x GO-2), 40.03 (JDNOL-11-1 x VRO-6) to 50.26 (JOL-08-12 x VRO-6), 46.73 (JDNOL-11-3 x GO-2) to 56.07 (AOL-08-5 x Pusa Sawani) and 44.21 (JDNOL-11-3 x VRO-6) to 55.64 (JDNOL-11-12 x VRO-6) in E_1, E_2, E_3 and E_4, respectively. Pooled data projected the range for total number of seeds per fruit from 44.43 (JOL-08-12 x GO-2) to 50.81 (JOL-08-7 x Parbhani Kranti).

Among the parents, line JDNOL-11-11 (44.31) manifested the minimum number of seeds while, JOL-08-12 (48.26) exhibited the maximum value in pooled data for number of seeds per fruit. Among testers, Parbhani Kranti (49.06) recorded the maximum number of seeds per fruit, whereas GO-2 (44.11) recorded minimum value in pooled environment.

Among hybrids in pooled, cross combination, JOL-08-12 x GO-2 (44.43) recorded the minimum number of seeds and cross combination, JOL-08-7 x Parbhani Kranti (50.81) recorded the maximum number of seeds in pooled.

4.1.11 Days to last picking (Appendix VII)

Data pertaining to days to last picking revealed that the range was 97.95 days (JDNOL-11-1 x VRO-6) to 118.33 days (AOL-07-9 x Pusa Sawani), 102.76 days (JDNOL-11-3 x VRO-6) to 133.17 days (AOL-07-9 x Pusa Sawani), 111.87 days (AOL-07-9 x Parbhani Kranti) to 132.01 days (JOL-08-12 x Parbhani Kranti) and 112.88 days (JDNOL-11-11 x GO-2) to 130.92 days (JDNOL-11-14 x GO-2) in E_1, E_2, E_3 and E_4, respectively.

In respect to parents, line JDNOL-11-14 (126.18 days) recorded the maximum days to last picking, while among testers, Parbhani Kranti (122.25 days) recorded the maximum days to last picking.

Looking to the pooled analysis of hybrids, range for days to last picking was 112.79 days (JDNOL-11-3 x VRO-6) to 125.48 days (JOL-08-12 x Parbhani Kranti).

4.1.12 Crude protein content (%) (Appendix VII)

Among parents, maximum protein content was recorded by female, JDNOL-11-3 over E_3 (28.40 %) and E_4 (28.09 %), while female parent, JOL-08-7 recorded minimum protein content in E_1 (23.64 %). Pooled analysis of mean values of this trait revealed that, minimum and maximum protein content was recorded by female parent, GO-2 (25.92 %) and VRO-6 (27.57 %), respectively.

The hybrids possessing maximum protein content were JOL-08-7 x GO-2 (28.44 %), JDNOL-11-14 x GO-2 (28.39 %), JOL-08-12 x Parbhani Kranti (28.73 %), AOL-08-5 x GO-2 (28.16 %) and JDNOL-11-14 x GO-2 (27.39 %) in E_1, E_2, E_3, E_4 and pooled, respectively.

4.1.13 Crude fiber content (%) (Appendix VIII)

Minimum fiber content was recorded by female parent, JDNOL-11-12 over (4.39 %) in E_2, (4.10 %) in E_3 and (4.38 %) in E_4 while female parent, JDNOL-11-1 recorded minimum fiber content in E_1 (4.66 %). On the contrary, male parent, GO-2 recorded minimum fiber content over E_1 (4.67 %), E_2 (4.38 %), E_3 (4.52 %) and E_4 (4.86 %). Pooled analysis of mean values of this trait revealed that, minimum and maximum fiber content was recorded by male parent, GO-2 (4.61 %) and Pusa Sawani (5.13 %), respectively.

The hybrids possessing minimum fiber content were JDNOL-11-12 x Pusa Sawani (4.23 %), JDNOL-11-12 x Parbhani Kranti (3.84 %), JOL-08-7 x VRO-6 (3.87 %), JDNOL-11-12 x GO-2 (4.17 %) and JDNOL-11-12 x Parbhani Kranti (4.20 %) in E_1, E_2, E_3, E_4 and pooled, respectively.

4.1.14 Vitamin 'C' (mg/100 g pulp) (Appendix VIII)

The range for vitamin 'C' content in parental lines varied from 12.44 per cent (JOL-08-7) to 15.22 per cent (JDNOL-11-3) and in hybrids, it varied from 12.89 per cent (JDNOL-11-12 x VRO-6) to 15.42 per cent (JDNOL-11-3 x Parbhani Kranti) in pooled analysis. The highest and the poorest vitamin 'C' content of hybrids were recorded in E_4 and E_1in that order.

4.2 Analysis of variance for the experimental design (Table 4.2.1 to 4.2.7)

The analysis of variance depicting mean squares for fourteen traits under individual environments (E_1, E_2, E_3 and E_4) as well as pooled over environments are presented in Tables 4.2.1 to 4.2.7.

Pooled analysis of variance over four environments revealed highly significant differences among the environments for all the traits indicated variable environmental conditions. The differences among genotypes were highly significant for all the traits in individual and across the environments. This indicated the presence of considerable amount of genetic variability among the genotypes for various traits studied. Highly significant differences due to genotypes x environments were observed for all the traits, which emphasized that the genotypes studied, had reacted differentially to the environments.

Significant differences for all the traits (except days to first picking, fruit length, number of branches per plant, internodal length, total number of seeds per fruit, days to last picking and crude protein content) existed for parents over environments signifying appreciable amount of variability among the parents for traits studied. The variance due to parents was further partitioned into variance due to females, males and females vs. males. The results followed the same trend as it was for parents. The results revealed that mean squares due to males and females were highly significant for all traits in individual as well as pooled over environments (except days to first picking, internodal length, in case of males, while, days to first picking in case of females) indicated significant variability among males and females. Pooled analysis of variance due to females vs. males was highly significant for traits like fruit girth, number of branches per plant, internodal length, fruit yield per plant, total number of fruits per plant, total number of seeds per fruit, crude fiber content suggesting considerable variation between males and females for these traits.

Table 4.2.1 Analysis of variance (mean squares) for parents and hybrids for days to 50 % flowering, days to first picking and fruit length (cm) under individual environments

Source of variation	d.f.	Days to 50 % flowering				Days to first picking				Fruit length (cm)			
		E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4
Replication	2	7.13	4.12	2.11	1.92	4.64	0.56	9.50	0.17	0.21	0.16	0.07	0.81
Genotypes	64	26.91**	26.33**	13.71**	30.17**	11.86**	12.09*	21.55**	13.95*	0.75*	0.90*	0.94**	1.26**
Parents	14	25.22**	24.14*	7.37	14.71**	2.53	9.52	8.25	7.56	1.01*	0.49	0.38	1.06**
Females	9	27.90**	19.56	5.85	13.67**	2.26	9.19	9.14	9.49	1.14*	0.49	0.39	1.17**
Males	4	25.48	40.27*	11.63*	19.74**	3.26	10.25	6.76	5.10	0.97	0.51	0.46	0.73
Females vs. Males	1	0.03	0.86	4.01	3.98	2.08	9.61	6.17	0.04	0.02	0.36	0.02	1.36*
Parents vs. Hybrids	1	1.74	14.15	4.85	0.96	69.68**	39.76*	119.54**	5.44	2.07*	2.22	1.97*	4.70**
Hybrids	49	27.91**	27.20**	15.70**	35.19**	13.34**	12.26	23.35**	15.96*	0.65	0.99*	1.07**	1.24**
Error	128	10.85	11.38	4.45	3.67	6.56	8.55	7.97	9.71	0.50	0.62	0.31	0.32

Table 4.2.2: Analysis of variance (mean squares) for parents and hybrids for fruit girth (cm), number of branches per plant and internodal length (cm) under individual environments

Source of variation	d.f.	Fruit girth (cm)				Number of branches per plant				Internodal length (cm)			
		E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4
Replication	2	0.48	0.07	0.02	0.22	0.02	0.02	0.01	0.01	0.05	0.51	0.65	0.82
Genotypes	64	0.69**	1.35**	1.54**	1.62**	0.10**	0.10**	0.18**	0.13**	0.62**	1.84**	2.94**	1.43*
Parents	14	0.49**	1.15**	1.47**	1.17**	0.05	0.06	0.11**	0.11**	0.34	2.16**	0.63	0.27
Females	9	0.61**	1.17**	1.07**	1.03**	0.05	0.09*	0.13**	0.10**	0.33	1.88**	0.60	0.21
Males	4	0.21	1.06**	2.73**	1.38**	0.05	0.005	0.05	0.12**	0.03	2.52**	0.40	0.39
Females vs. Males	1	0.50	1.37**	0.00	1.63**	0.00	0.002	0.17*	0.23**	1.62*	3.29**	1.88	0.28
Parents vs. Hybrids	1	0.59	2.05**	0.03	5.68**	0.07	0.69**	0.08	0.49**	0.02	0.02	29.91**	12.74**
Hybrids	49	0.75**	1.39**	1.59**	1.67**	0.12**	0.10**	0.21**	0.13**	0.71**	1.78**	3.05**	1.53*
Error	128	0.18	0.19	0.16	0.10	0.04	0.04	0.02	0.03	0.24	0.27	0.96	0.94

* and ** are significant at P = 0.05 and P = 0.01 levels, respectively.

Table 4.2.3: Analysis of variance (mean squares) for parents and hybrids for plant height (cm) and fruit yield per plant (g) under individual environments

Source of variation	d.f.	Plant height (cm)				Fruit yield per plant (g)			
		E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4
Replication	2	5.61	16.36	28.63	27.71	380.43	210.68	574.26	143.95
Genotypes	64	116.98**	180.86**	852.40**	424.32**	1007.65**	1357.14**	2066.95**	1326.74**
Parents	14	247.66**	167.27**	1394.09**	630.97**	2390.15**	2969.07**	2163.19**	1120.66**
Females	9	265.26**	158.67**	1504.70**	547.08**	3567.38**	4254.80**	1790.37**	1342.80**
Males	4	132.26	70.46	1020.12**	918.41**	74.92	339.48	3235.46**	365.21
Females vs. Males	1	550.81**	631.91**	1894.56**	236.16	1056.03*	1915.91**	1229.51	2143.10*
Parents vs. Hybrids	1	114.71	1.94	1463.45**	81.59	3728.38**	3623.71**	8099.13**	6.11
Hybrids	49	79.69	188.39**	685.16**	372.27**	557.13**	850.33**	1916.34**	1412.57**
Error	128	60.72	35.87	114.87	118.18	212.02	152.01	450.18	334.22

Table 4.2.4: Analysis of variance (mean squares) for parents and hybrids for total number of fruits per plant, total number of seed per fruit and days to last picking under individual environments

Source of variation	d.f.	Total number of fruits per plant				Total number of seed per fruit				Days to last picking			
		E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4
Replication	2	3.32	7.267*	0.94	3.04	5.126	4.45	9.59	0.96	1.70	9.82	32.53	43.13
Genotypes	64	8.32**	7.098***	9.93**	4.42*	20.19**	14.93**	14.78*	20.11**	82.47*	172.94**	67.45*	67.60*
Parents	14	9.11**	12.57**	7.52**	3.96	7.34	11.77**	15.25	14.13*	93.65*	237.71**	82.04*	48.91
Females	9	8.50**	15.48**	6.09*	4.29	7.51	12.70*	9.09	9.02	71.85	186.46**	111.17*	56.95
Males	4	6.14*	8.35**	11.18**	4.16	8.54	11.55	30.65*	17.34	146.88*	412.10**	35.65	34.15
Females vs. Males	1	26.49**	3.29	5.80	0.19	1.02	4.31	9.10	47.21*	76.85	1.42	5.35	35.60
Parents vs. Hybrids	1	47.26**	9.32	1.09	15.97*	29.66	55.55**	0.01	11.15	49.84	364.12**	232.42*	35.01
Hybrids	49	7.29*	5.48**	10.79**	4.32*	23.67**	15.01**	14.95*	22.00**	79.95*	150.53**	59.92	73.61**

Error	128	2.37	2.29	2.86	2.84	8.37	5.23	9.21	7.75	52.62	41.36	45.56	42.28

* and ** are significant at P = 0.05 and P = 0.01 levels, respectively.

Table 4.2.5: Analysis of variance (mean squares) for parents and hybrids for crude protein content (%), crude fiber content (%) and vitamin 'C' (mg/100 g pulp) under individual environments

Source of variation	d.f.	Crude protein content (%)				Crude fiber content (%)				Vitamin 'C' (mg/100 g pulp)			
		E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4
Replication	2	2.71	2.64	2.00	0.23	0.08	0.03	0.12	0.01	0.77	1.31	0.62	0.87
Genotypes	64	3.74**	2.28*	2.95**	1.92*	0.30**	0.64**	0.43**	0.32**	2.43**	2.03**	1.99**	3.20**
Parents	14	2.88	1.97	1.90	2.71*	0.06	0.21**	0.35**	0.28**	5.66**	2.48**	2.63**	2.31**
Females	9	2.36	1.64	2.17	3.56**	0.06	0.25**	0.29**	0.28**	6.99**	1.38**	2.59**	2.96**
Males	4	4.75	0.46	1.70	1.27	0.06	0.17**	0.27**	0.11	3.23**	5.40**	3.07**	1.42*
Females vs. Males	1	0.12	10.97**	0.26	0.83	0.001	0.01	1.19**	0.96**	3.41*	0.70	1.22	0.01
Parents vs. Hybrids	1	2.74	0.65	3.52	0.23	0.04	0.62**	0.59**	0.21*	0.34	11.95**	0.64	0.82
Hybrids	49	4.01**	2.41*	3.24**	1.73	0.37**	0.76**	0.44**	0.34**	1.55**	1.70**	1.84**	3.50**
Error	128	2.20	1.50	1.49	1.29	0.04	0.02	0.04	0.04	0.57	0.51	0.34	0.45

* and ** are significant at P = 0.05 and P = 0.01 levels, respectively.

Table 4.2.6: Analysis of variance (mean squares) for parents and hybrids for days to 50 % flowering, days to first picking, fruit length (cm), fruit girth (cm), number of branches per plant, internodal length (cm) and plant height (cm) pooled over the environments

Source of variation	d.f.	Days to 50 % flowering	Days to first picking	Fruit length (cm)	Fruit girth (cm)	Number of branches per plant	Internodal length (cm)	Plant height (cm)
Replication in Environment	2	4.00	4.37	0.10	0.12	0.01	0.48	24.26
Environments (Env.)	3	1138.31**	58.26**	5.81**	7.49**	0.45**	1581.39**	129029.99**
Genotypes (Gen.)	64	36.30**	18.03**	1.57**	2.18**	0.26**	2.45**	767.92**
Parents (P)	14	29.36**	7.92	1.82**	2.82**	0.20**	1.73**	1220.07**
Females (F)	9	23.10**	5.49	1.79**	2.52**	0.22**	1.40*	1334.00**
Males (M)	4	50.76**	12.11	2.14**	3.58**	0.16**	1.36	1262.15**
Females vs. Males (F x M)	1	0.13	13.09	0.77	2.50**	0.20*	6.25**	26.45
Hybrids (H)	49	38.82**	17.31**	1.31**	1.95**	0.27**	2.29**	647.05**
Parents vs. Hybrids (P x H)	1	9.94	194.89**	10.58**	4.86**	0.12	20.46**	360.46*
Genotype x Environment	192	20.27**	13.81**	0.76**	1.01**	0.09**	1.46**	268.88**
Parents x Environments	42	14.03**	6.65	0.37	0.49**	0.04	0.56	406.64**
Females x Environments	27	14.63**	8.20	0.47	0.45**	0.05	0.54	380.57**
Males x Environments	12	15.45*	4.42	0.18	0.60**	0.02	0.66	293.03**
(F x M) x Environment	3	2.91	1.60	0.33	0.33	0.07	0.28	1095.66**
(P vs. H) x Environment	3	3.92	13.18	0.13	1.16**	0.41**	7.41**	433.74**
Hybrids x Environment	147	22.39**	15.87**	0.88**	1.15**	0.09**	1.60**	226.16**
Error	512	7.59	8.20	0.44	0.16	0.03	0.60	82.41

* and ** are significant at P = 0.05 and P = 0.01 levels, respectively.

Table 4.2.7: Analysis of variance (mean squares) for parents and hybrids for fruit yield per plant (g), total number of fruits per plant, total number of seed per fruit, days to last picking, crude protein content (%), crude fiber content (%) and vitamin 'C' (mg/100 g pulp) pooled over the environments

Source of variation	d.f.	Fruit yield per plant (g)	Total number of fruits per plant	Total number of seed per fruit	Days to last picking	Crude protein content (%)	Crude fiber content (%)	Vitamin 'C' (mg/100 g pulp)
Replication in Environment	2	192.54	4.81	2.05	13.55	2.16	0.01	0.88
Environments (Env.)	3	496824.83**	99.31**	2174.77**	9189.92**	102.83**	0.31**	0.55
Genotypes (Gen.)	64	3669.58**	14.30**	34.24**	168.51**	4.29**	0.91**	5.54**
Parents (P)	14	6033.19**	18.84**	27.61**	277.81**	4.27**	0.55**	9.90**
Females (F)	9	8450.22**	19.08**	19.05**	265.50**	4.38**	0.55**	10.33**
Males (M)	4	1624.66**	18.03**	46.27**	359.24**	4.38*	0.44**	11.09**
Females vs. Males (F x M)	1	1913.93*	19.95**	30.00*	62.84	2.83	0.91**	1.25
Hybrids (H)	49	2836.1**	12.15**	35.47**	138.40**	4.33**	1.00**	4.33**
Parents vs. Hybrids (P x H)	1	11419.72**	56.02**	66.93**	113.95	2.57	1.25**	3.86**
Genotype x Environment	192	696.30**	5.15**	11.92**	73.99**	2.20**	0.26**	1.37**
Parents x Environment	42	869.96**	4.77**	6.96	61.50	1.73	0.12**	1.06**
Females x Environment	27	835.04**	5.09**	6.42	53.64	1.78	0.11**	1.20**
Males x Environment	12	796.80**	3.93	7.27	89.85*	1.27	0.06	0.68
(F x M) x Environment	3	1476.87**	5.27	10.55	18.80	3.11	0.41**	1.36*
(P vs. H) x Environment	3	1345.87**	5.87	9.81	189.14**	1.52	0.07	3.29**
Hybrids x Environment	147	633.42**	5.25**	13.38**	75.20**	2.35**	0.30**	1.42**
Error	512	287.11	2.59	7.64	45.46	1.62	0.04	0.47

* and ** are significant at P = 0.05 and P = 0.01 levels, respectively.

The variance due to hybrids was highly significant for all the traits under individual environments as well as in pooled analysis signifying substantial variation among hybrids. A perusal of mean squares due to parents vs. hybrids revealed that the same were significant for all the traits in individual environments except days to 50 per cent flowering for all environment as well as pooled, fruit girth (E_1 and E_2), number of branches per plant (E_1 and E_3), internodal length (E_1 and E_2), fruit yield per plant (E_4), total number of fruits per plant (E_2 and E_3), total number of seed per fruits (E_1, E_3 and E_4), and vitamin 'C' (E_1, E_3 and E_4). These results suggested that the differences in the performance of the parents and hybrids were genuine for all the traits in all individual as well as in pooled environment indicated the presence of average heterosis for these traits. These contrasting results indicated that the diverse environments exerted variable influences on the expression of these traits.

The mean squares due to G x E interactions were significant for all the traits. The significant G x E interactions indicated that the performance of genotypes was not consistent over the environments with respect to traits under study. Further, break-up of genotype x environment interactions revealed that significant mean squares due to parents x environments, females x environments and males x environments were apparent for days to 50 per cent flowering, fruit girth, plant height, fruit yield per plant, total number of fruits per plant, crude fiber content, vitamin 'C'.

The interactions of hybrids x environments were significant for all the traits revealed that the hybrids were sensitive to the environments. The parents vs. hybrids x environments interactions were non-significant for seven traits (days to 50 % flowering, days to first picking, fruit length, total number of fruits per plant, total number of seed per fruit, crude protein content, crude fiber content) which pointed out that environment had less influence on these traits for parent vs. hybrids in pooled analysis, while for rest of the traits for the same were significant.

4.3 Magnitude of heterosis

The heterosis was estimated as per cent increase or decrease in F_1 value over mid parental value (relative heterosis), over better parental value (heterobeltiosis) and over standard check ‘GJOH-3’ variety (standard heterosis or economic heterosis) for fourteen characters in different environments mentioned in Table 4.3.1 to 4.3.28.

The magnitude of heterosis was subjected to parents for different characters and varied from cross to cross. The appropriateness of the parent was again subjected as per characters. Better performed parents was considered for calculation of relative heterosis, heterobeltiosis and standard heterosis for days to 50 per cent flowering, days to first picking, internodal length and plant height as well as both positive and negative traits. The result of each character is narrated in the following paragraphs.

4.3.1 Days to 50 per cent flowering (Table 4.3.1 to 4.3.2)

The relative heterosis range from -14.20 per cent (JDNOL-11-11 x Arka Anamika) to 26.05 per cent (JDNOL-11-12 x VRO-6) in E_1, -11.40 per cent (AOL-08-5 x VRO-6) to 20.92 per cent (JOL-6k-2 x Arka Anamika) in E_2, -12.68 per cent (JOL-08-7 x GO-2) to 16.02 per cent (JDNOL-11-1 x VRO-6) in E_3 and 13.50 per cent (AOL-08-5 x GO-2) to 18.51 per cent (AOL-07-9 x Arka Anamika) in E_4. Three, two, three and fourteen hybrids expressed the negative and significant relative heterosis in E_1, E_2, E_3 and E_4, respectively.

The ranged of heterobeltiosis was -14.90 per cent (JDNOL-11-11 x Arka Anamika) to 26.02 per cent (JDNOL-11-12 x VRO-6) in E_1, -14.10 per cent (AOL-08-5 x VRO-6) to 14.17 per cent (JOL-6k-2 x Arka Anamika) in E_2, -12.86 per cent (JOL-08-7 x GO-2) to 14.25 per cent (JDNOL-11-1 x VRO-6) in E_3 and -16.70 per cent (AOL-08-5 x GO-2) to 17.16 per cent (AOL-07-9 x Arka Anamika) in E_4. The number of crosses, which recorded significant negative heterobeltiosis were Six, five, five and sixteen crosses in E_1, E_2, E_3 and E_4, respectively.

The estimates of standard heterosis varied from -10.83 per cent (JDNOL-11-11 x Arka Anamika) to 17.27 per cent (JOL-08-12 x Pusa Sawani) in E_1, -13.45 per cent (JOL-08-7 x Arka Anamika) to 14.20 per cent (AOL-08-5 x Arka Anamika) in E_2, -9.14 per cent (JOL-08-12 x Pusa Sawani) to 17.01 per cent (JDNOL-11-1 x VRO-6) in E_3 and -7.43 per cent (AOL-08-5 x GO-2) to 17.59 per cent (AOL-07-9 x Arka Anamika) in E_4. The number of crosses, which exhibited significant negative standard heterosis were one (E_1, E_2 and E_3) and two (E_4).

The low stature of genotypes was considered as desirable trait to decide the better parent. The less number of significantly negative crosses found for this trait. The significant reduction observed in days to 50 per cent flowering, indicated that the behavior of hybrids varied with

Table 4.3.1: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for days to 50 % flowering under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
JDNOL-11-1 x Arka Anamika	-1.96	-5.60	-0.99	6.52	-0.32	-0.32	-0.88	-3.78	4.67	-3.09	-5.61	-2.35
JDNOL-11-1 x Pusa Sawani	-0.48	-1.49	-2.38	15.69**	12.51*	12.51*	0.93	0.34	2.76	14.54**	11.71**	15.57**
JDNOL-11-1 x Parbhani Kranti	2.47	2.18	-0.23	0.29	0.22	0.34	-2.38	-2.59	-0.23	-1.98	-4.57	-1.27
JDNOL-11-1 x GO-2	3.02	-1.77	5.15	-2.54	-5.53	0.63	-2.25	-5.12	3.23	-5.70 *	-8.99**	1.22
JDNOL-11-1 x VRO-6	0.25	-2.18	-5.03	1.06	0.93	0.92	16.02**	14.25**	17.01**	-6.12 *	-7.42 *	-4.22
JDNOL-11-3 x Arka Anamika	-4.72	-8.07	-3.58	19.20**	13.26*	9.63	0.55	-4.31	4.1	13.50**	13.44**	11.38**
JDNOL-11-3 x Pusa Sawani	5.11	4.27	3.33	2.94	1.72	-1.54	4.08	2.57	3.81	-1.49	-1.58	-3.20
JDNOL-11-3 x Parbhani Kranti	0.30	0.23	-2.13	-6.94	-8.48	-8.37	0.31	-1.51	0.43	-3.40	-3.49	-5.25
JDNOL-11-3 x GO-2	-9.63*	-13.6**	-7.58	-1.04	-5.56	0.60	-1.47	-6.24	2.01	8.17**	1.82	13.25**
JDNOL-11-3 x VRO-6	5.31	2.53	-0.02	-2.03	-3.47	-3.74	3.50	2.97	2.23	-5.57	-6.70	-6.16
JDNOL-11-11 x Arka Anamika	-14.2**	-14.9**	-10.83*	-3.74	-11.90*	-7.54	2.13	0.96	9.83*	-1.41	-1.69	-3.03
JDNOL-11-11 x Pusa Sawani	-5.37	-7.18	-4.36	2.67	-2.44	2.38	-0.50	-2.88	3.23	2.75	2.60	1.20
JDNOL-11-11 x Parbhani Kranti	-3.46	-5.99	-3.13	3.73	1.34	6.35	-1.04	-3.05	3.05	16.48**	16.10**	14.52**
JDNOL-11-11 x GO-2	-3.61	-5.42	1.24	-5.84	-6.53	-0.44	-2.48	-3.60	4.88	-7.15*	-12.4**	-2.57
JDNOL-11-11 x VRO-6	-5.59	-10.47*	-7.76	-8.83	-11.10*	-6.70	-3.02	-6.21	-0.31	-2.61	-3.56	-2.99
JDNOL-11-12 x Arka Anamika	10.12*	3.58	8.64	8.73	1.01	2.61	0.60	-3.47	5.01	6.74 *	6.34	5.10
JDNOL-11-12 x Pusa Sawani	5.53	1.98	1.06	-3.71	-7.07	-5.60	10.22**	9.56*	10.89**	-3.05	-3.28	-4.41
JDNOL-11-12 x Parbhani Kranti	1.76	-0.96	-3.30	-9.51*	-10.16	-8.74	3.23	2.23	4.25	13.18**	12.70**	11.39**
JDNOL-11-12 x GO-2	0.71	-6.16	0.44	-1.19	-3.48	2.82	-2.46	-6.41	1.83	2.84	-2.89	8.01 *
JDNOL-11-12 x VRO-6	26.05**	26.02**	16.47**	-8.78	-9.61	-8.18	6.09	5.72	5.71	0.21	-0.66	-0.08
JDNOL-11-14 x Arka Anamika	-0.72	-2.40	2.36	14.57**	10.57	3.60	5.03	1.18	10.06*	1.04	-1.64	1.87
JDNOL-11-14 x Pusa Sawani	-2.45	-3.53	-2.24	3.88	3.44	-2.25	0.00	-0.21	1.00	-3.34	-5.78	-2.41
JDNOL-11-14 x Parbhani Kranti	-5.87	-7.58	-6.35	-2.59	-5.71	-5.60	1.79	1.20	3.20	-4.03	-6.62	-3.28
JDNOL-11-14 x GO-2	-4.77	-7.31	-0.79	-1.43	-7.36	-1.32	-6.72*	-10.1**	-2.24	-7.96 **	-11.1**	-1.15
JDNOL-11-14 x VRO-6	3.10	-1.46	-0.14	1.54	-1.52	-1.80	2.21	1.44	2.25	-8.46 **	-9.78 **	-6.56
AOL-07-9 x Arka Anamika	13.12**	4.65	9.75	8.82	3.89	-0.44	10.09**	7.26*	16.68**	18.51**	17.16**	17.59**
AOL-07-9 x Pusa Sawani	7.36	1.98	1.06	13.92**	13.13 *	8.41	-2.62	-3.55	-0.48	-6.06*	-7.00*	-6.67
AOL-07-9 x Parbhani Kranti	3.22	-1.26	-3.58	1.17	-1.00	-0.88	4.47	3.86	7.16	11.46**	10.14**	10.54**
AOL-07-9 x GO-2	4.94	-3.82	2.95	-8.49	-13.08*	-7.41	-1.70	-4.24	4.19	-6.76*	-11.3**	-1.36
AOL-07-9 x VRO-6	23.10**	20.97**	11.74*	-3.22	-5.11	-5.37	-1.17	-3.04	0.05	-2.37	-2.48	-1.91
AOL-08-5 x Arka Anamika	-4.32	-6.03	2.22	18.03**	7.37	14.20*	-3.76	-7.29*	0.85	7.39*	4.85	7.94*
AOL-08-5 x Pusa Sawani	-2.51	-6.85	1.34	0.67	-4.94	1.11	0.22	0.02	1.23	-2.01	-4.20	-1.37

Table 4.3.1 Continue…

Table 4.3.1 Continue…

Cross		E1 MP	E1 BP	E1 SC	E2 MP	E2 BP	E2 SC	E3 MP	E3 BP	E3 SC	E4 MP	E4 BP	E4 SC
AOL-08-5 x Parbhani Kranti		-8.44	-13.1**	-5.50	-4.76	-7.55	-1.67	0.09	-0.48	1.48	-7.00*	-9.24**	-6.56
AOL-08-5 x GO-2		-10.84*	-11.55*	-3.78	-6.12	-6.19	-0.07	-7.29*	-10.7**	-2.84	-13.5**	-16.7**	-7.43*
AOL-08-5 x VRO-6		-4.80	-11.99*	-4.25	-11.40*	-14.1**	-8.70	-0.45	-1.20	-0.41	-3.79	-4.90	-2.10
JOL-6k-2 x Arka Anamika		2.99	2.5	7.5	20.92**	14.17*	12.01*	3.45	0.61	9.45*	9.74**	2.05	16.40**
JOL-6k-2 x Pusa Sawani		2.52	0.16	4.05	-5.79	-7.52	-9.27	3.68	2.87	5.76	-3.01	-9.69**	3.00
JOL-6k-2 x Parbhani Kranti		11.50*	8.15	12.36*	3.00	1.97	2.09	-2.71	-3.11	-0.39	-8.54 **	-14.9**	-3.02
JOL-6k-2 x GO-2		-5.4	-6.79	-0.23	1.36	-2.64	3.70	9.05**	6.05	15.38**	2.15	0.88	15.06**
JOL-6k-2 x VRO-6		0.99	-4.61	-0.90	-0.11	-0.92	-1.19	2.98	1.22	4.06	-6.97*	-12.4**	-0.15
JOL-08-7 x Arka Anamika		7.04	6.09	13.27*	-2.81	-4.84	-13.45*	4.09	3.87	13.48**	14.17**	10.06**	16.32**
JOL-08-7 x Pusa Sawani		-6.55	-9.91	-3.81	5.95	3.96	-1.76	0.26	-3.43	5.50	-4.48	-7.80*	-2.55
JOL-08-7 x Parbhani Kranti		-1.60	-5.81	0.57	-0.78	-5.32	-5.21	-0.89	-4.19	4.67	-7.68 *	-11.04**	-5.98
JOL-08-7 x GO-2		-4.46	-4.58	2.14	-7.06	-13.85**	-8.24	-12.68**	-12.86**	-4.80	-6.63*	-8.95**	1.27
JOL-08-7 x VRO-6		-1.28	-7.94	-1.70	5.14	0.51	0.24	0.03	-4.53	4.29	10.38**	7.71 *	13.85**
JOL-08-12 x Arka Anamika		-3.26	-5.10	-0.47	16.59**	12.59*	5.35	1.92	-1.28	7.39	-0.87	-2.15	-1.48
JOL-08-12 x Pusa Sawani		17.28**	16.24**	17.27**	5.17	4.66	-1.10	-10.55**	-10.87**	-9.14*	-2.8	-3.93	-3.28
JOL-08-12 x Parbhani Kranti		-5.88	-7.40	-6.57	-0.68	-3.93	-3.82	-3.54	-3.56	-1.65	-2.28	-3.58	-2.93
JOL-08-12 x GO-2		-4.74	-7.47	-0.96	4.29	-2.04	4.34	4.55	1.25	10.17*	1.77	-3.06	7.82*
JOL-08-12 x VRO-6		0.09	-4.14	-3.28	2.93	-0.24	-0.52	-0.17	-1.47	0.45	-7.75*	-7.80*	-7.17*
Range	**Min.**	-14.20	-14.90	-10.83	-11.40	-14.10	-13.45	-12.68	-12.86	-9.14	-13.50	-16.17	-7.43
	Max.	26.05	26.02	17.27	20.92	14.17	14.20	16.02	14.25	17.01	18.51	17.16	17.59
S. E. ±		2.32	2.69	2.69	2.38	2.75	2.75	1.49	1.72	1.72	1.35	1.56	1.56
Positive significant crosses		6	3	5	7	5	3	4	3	9	12	8	14
Negative significant crosses		3	6	1	2	5	1	3	5	1	14	16	2
Positive value		24	15	21	26	18	20	28	20	40	18	14	20
Negative value		26	35	29	24	32	30	22	30	10	32	36	30

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.2: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for days to 50 % flowering under pooled environments

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		0.16	-0.44	0.18
JDNOL-11-1 x Pusa Sawani		7.72**	6.41**	7.07**
JDNOL-11-1 x Parbhani Kranti		-0.33	-0.94	-0.33
JDNOL-11-1 x GO-2		-1.82	-5.31*	2.56
JDNOL-11-1 x VRO-6		2.63	1.24	1.87
JDNOL-11-3 x Arka Anamika		6.86**	5.91*	5.30*
JDNOL-11-3 x Pusa Sawani		2.72	2.44	0.58
JDNOL-11-3 x Parbhani Kranti		-2.51	-3.36	-3.95
JDNOL-11-3 x GO-2		-1.15	-6.01**	1.80
JDNOL-11-3 x VRO-6		0.28	0.15	-1.95
JDNOL-11-11 x Arka Anamika		-4.57*	-6.34**	-3.29
JDNOL-11-11 x Pusa Sawani		-0.19	-2.64	0.53
JDNOL-11-11 x Parbhani Kranti		3.67	1.74	5.05*
JDNOL-11-11 x GO-2		-4.78*	-7.00**	0.73
JDNOL-11-11 x VRO-6		-5.16*	-7.61**	-4.61
JDNOL-11-12 x Arka Anamika		6.63**	5.95*	5.34*
JDNOL-11-12 x Pusa Sawani		2.13	2.12	0.26
JDNOL-11-12 x Parbhani Kranti		1.75	1.11	0.50
JDNOL-11-12 x GO-2		-0.03	-4.71*	3.20
JDNOL-11-12 x VRO-6		5.51**	5.38*	3.43
JDNOL-11-14 x Arka Anamika		4.82*	4.68	4.36
JDNOL-11-14 x Pusa Sawani		-0.48	-1.24	-1.53
JDNOL-11-14 x Parbhani Kranti		-2.76	-2.91	-3.20
JDNOL-11-14 x GO-2		-5.15*	-8.92**	-1.35
JDNOL-11-14 x VRO-6		-0.36	-1.26	-1.56
AOL-07-9 x Arka Anamika		12.59**	11.14**	10.50**
AOL-07-9 x Pusa Sawani		3.38	2.69	0.82
AOL-07-9 x Parbhani Kranti		4.96*	3.63	3.00
AOL-07-9 x GO-2		-3.07	-8.19**	-0.56
AOL-07-9 x VRO-6		3.91	3.37	1.20
AOL-08-5 x Arka Anamika		4.22*	1.50	6.47**
AOL-08-5 x Pusa Sawani		-0.92	-4.09	0.60
AOL-08-5 x Parbhani Kranti		-5.14*	-7.62**	-3.11
AOL-08-5 x GO-2		-9.42**	-10.85**	-3.44
AOL-08-5 x VRO-6		-5.36**	-8.51**	-4.04
JOL-6k-2 x Arka Anamika		9.13**	6.47**	11.28**
JOL-6k-2 x Pusa Sawani		-0.70	-3.71	0.64
JOL-6k-2 x Parbhani Kranti		1.01	-1.47	2.99
JOL-6k-2 x GO-2		1.58	-0.20	8.09**
JOL-6k-2 x VRO-6		-0.85	-3.99	0.35
JOL-08-7 x Arka Anamika		5.70**	3.93	6.90**
JOL-08-7 x Pusa Sawani		-1.31	-3.56	-0.80
JOL-08-7 x Parbhani Kranti		-2.68	-4.32	-1.58
JOL-08-7 x GO-2		-7.61**	-9.93**	-2.45
JOL-08-7 x VRO-6		3.52	1.03	3.91
JOL-08-12 x Arka Anamika		3.42	3.26	2.67
JOL-08-12 x Pusa Sawani		2.71	2.22	1.33
JOL-08-12 x Parbhani Kranti		-3.11	-3.24	-3.82
JOL-08-12 x GO-2		1.37	-2.93	5.13*
JOL-08-12 x VRO-6		-1.14	-1.75	-2.60
Range	**Min.**	-9.42	-10.85	-4.61
	Max.	12.59	11.14	11.28
S. E. ±		0.98	1.13	1.13
Positive significant crosses		10	6	10
Negative significant crosses		8	12	0
Positive value		25	21	32
Negative value		25	29	18

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

changes in environmental conditions.

In pooled analysis, 10 crosses registered significant and negative standard heterosis. The range of standard heterosis was -4.61 per cent (JDNOL-11-11 x VRO-6) to 11.28 per cent (JOL-6k-2 x Arka Anamika). None of hybrid exhibited with significant and positive standard heterosis.

4.3.2 Days to first picking (Table 4.3.3 to 4.3.4)

The relative heterosis in E_1 ranged from -10.58 per cent (JDNOL-11-11 x VRO-6) to 6.37 per cent (AOL-08-5 x GO-2). Likewise, relative heterosis -12.50 per cent (JOL-6k-2 x GO-2) to 6.58 per cent (JDNOL-11-12 x VRO-6) in E_2, -12.61 per cent (JOL-08-12 x Arka Anamika) to 7.11 per cent (AOL-07-9 x Pusa Sawani) in E_3 and -8.25 per cent (JDNOL-11-14 x GO-2) to 14.47 per cent (JDNOL-11-12 x VRO-6) in E_4. The number of crosses, which recorded significant negative relative heterosis were eight, five, 12 and zero in E_1, E_2, E_3 and E_4, respectively.

The better parent ranged from -11.47 per cent (JDNOL-11-11 x VRO-6) to 5.85 per cent (AOL-08-5 x GO-2) in E_1, -13.23 per cent (JOL-6k-2 x GO-2) to 6.37 per cent (AOL-07-9 x Parbhani Kranti) in E_2, -14.09 per cent (AOL-08-5 x VRO-6) to 10.03 per cent (JOL-6k-2 x Pusa Sawani) in E_3 and -9.50 per cent (JDNOL-11-3 x Parbhani Kranti) to 13.23 per cent (JDNOL-11-12 x VRO-6) in E_4. The number of crosses, which recorded significant negative heterobeltiosis were six, six, sixteen and zero in E_1, E_2, E_3 and E_4, respectively.

The standard heterosis ranged from -13.85 per cent (JDNOL-11-11 x VRO-6) to 3.83 per cent (AOL-08-5 x GO-2) in E_1, -17.00 per cent (JDNOL-11-14 x Pusa Sawani) to -1.10 per cent (JDNOL-11-11 x GO-2) in E_2, -7.71 per cent (JDNOL-11-14 x GO-2) to 12.39 per cent (AOL-07-9 x Pusa Sawani) in E_3 and -6.90 per cent (AOL-08-5 x VRO-6) to 16.27 per cent (JDNOL-11-12 x VRO-6) in E_4. Nineteen in E_1, fifteen in E_2, and zero in E_3 and E_4 crosses manifested standard heterosis in desirable direction.

The range of standard heterosis in pooled analysis was -7.83 per cent to 1.51 per cent. Out of fifty hybrids, desirable (significant and negative) standard heterosis was recorded by six hybrids. JDNOL-11-11 x VRO-6 (-7.83 %), JOL-08-7 x Pusa Sawani (-7.40 %) and AOL-08-5 x VRO-6 (-7.06 %) were the top three hybrids with significant and negative standard heterosis.

Table 4.3.3: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for days to first picking under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	-5.48	-5.56	-6.99	-2.26	-4.57	-6.44	1.00	-0.60	10.61*	-1.51	-1.78	3.49
JDNOL-11-1 x Pusa Sawani	-1.53	-3.70	-5.32	-2.24	-3.96	-5.83	-7.78*	-12.18**	-2.28	-1.59	-2.79	1.86
JDNOL-11-1 x Parbhani Kranti	-8.19*	-10.21*	-11.72**	-0.10	-2.87	-4.77	-4.03	-5.21	5.47	4.62	2.32	7.21
JDNOL-11-1 x GO-2	-3.96	-4.54	-6.14	-5.81	-6.59	-8.42	-10.13**	-12.10**	-2.20	-3.00	-3.45	2.12
JDNOL-11-1 x VRO-6	-6.04	-7.45	-9.01*	-7.76	-12.86**	-14.56**	-0.19	-2.86	8.09	-4.81	-6.77	-2.31
JDNOL-11-3 x Arka Anamika	-5.79	-6.73	-8.14*	-3.31	-6.03	-12.23**	2.98	2.03	12.01*	4.42	3.45	11.07*
JDNOL-11-3 x Pusa Sawani	-5.78	-7.03	-10.26*	0.28	-3.14	-8.37	-6.63	-10.52*	-1.77	2.04	-0.40	6.93
JDNOL-11-3 x Parbhani Kranti	2.07	0.72	-2.78	-3.18	-5.51	-12.50**	-2.17	-2.73	6.79	-6.37	-9.5	-2.84
JDNOL-11-3 x GO-2	-7.29*	-7.58	-10.23*	-0.60	-4.86	-8.28	0.80	-0.75	8.95	-4.06	-4.77	2.24
JDNOL-11-3 x VRO-6	2.24	1.63	-1.90	6.48	5.90	-6.65	-3.05	-5.02	4.27	2.28	-1.00	6.29
JDNOL-11-11 x Arka Anamika	-10.11**	-10.65**	-12.00**	-0.45	-2.06	-5.47	-6.84	-8.03	1.70	-2.59	-2.73	2.49
JDNOL-11-11 x Pusa Sawani	-3.06	-4.73	-7.28	1.52	0.50	-2.99	2.26	-2.34	8.00	-2.88	-4.19	0.67
JDNOL-11-11 x Parbhani Kranti	-2.12	-3.79	-6.37	-9.05*	-10.91*	-14.00**	-7.61*	-8.47	1.22	2.76	0.37	5.46
JDNOL-11-11 x GO-2	-1.87	-1.96	-4.59	2.52	2.46	-1.10	-3.92	-5.74	4.24	-5.34	-5.65	-0.2
JDNOL-11-11 x VRO-6	-10.58**	-11.47**	-13.85**	-4.99	-9.58*	-12.72**	-11.50**	-13.61**	-4.47	-2.16	-4.30	0.55
JDNOL-11-12 x Arka Anamika	-1.50	-3.19	-4.65	-4.38	-5.19	-9.91*	5.59	2.86	10.83*	-7.57	-8.75	-3.85
JDNOL-11-12 x Pusa Sawani	-6.00	-6.56	-11.12**	-3.26	-3.47	-8.28	0.91	0.15	2.33	1.48	1.26	3.98
JDNOL-11-12 x Parbhani Kranti	2.31	1.70	-3.26	0.27	-1.01	-5.93	1.87	-1.11	7.32	1.45	0.22	2.91
JDNOL-11-12 x GO-2	3.12	2.05	-0.88	-8.01	-8.67	-11.95**	2.87	0.83	7.27	5.10	3.57	9.55
JDNOL-11-12 x VRO-6	-4.57	-4.70	-9.11*	6.58	2.20	-2.89	-3.57	-5.01	0.04	14.47**	13.23**	16.27**
JDNOL-11-14 x Arka Anamika	-2.93	-3.93	-5.39	-2.11	-3.34	-9.72*	-2.46	-3.86	3.59	-5.66	-5.71	-0.65
JDNOL-11-14 x Pusa Sawani	-6.61	-7.82	-11.08**	-10.58*	-12.26*	-17.00**	-7.66	-9.44*	-5.22	4.70	3.20	8.62
JDNOL-11-14 x Parbhani Kranti	-7.51*	-8.70*	-11.94**	-0.56	-1.39	-8.69	-7.34	-8.99*	-1.23	2.98	0.49	5.77
JDNOL-11-14 x GO-2	-1.83	-2.17	-4.98	-0.70	-3.46	-6.93	-12.54**	-13.25**	-7.71	-8.25	-8.48	-3.19
JDNOL-11-14 x VRO-6	0.06	-0.51	-4.03	4.29	2.09	-7.05	2.32	2.01	7.43	-1.00	-3.24	1.84
AOL-07-9 x Arka Anamika	-9.47**	-9.98*	-10.33*	-3.68	-4.20	-10.52*	-1.49	-2.16	6.87	1.18	-1.21	4.09
AOL-07-9 x Pusa Sawani	0.58	-2.26	-2.65	2.96	1.76	-3.73	7.11	2.89	12.39*	-3.12	-3.99	-1.85
AOL-07-9 x Parbhani Kranti	-0.43	-3.24	-3.62	6.48	6.37	-1.51	-6.36	-6.67	1.95	-4.24	-4.34	-3.97
AOL-07-9 x GO-2	-0.95	-2.18	-2.57	-1.29	-3.34	-6.82	-5.92	-7.15	1.42	-3.00	-5.47	-0.01
AOL-07-9 x VRO-6	-2.49	-4.57	-4.94	2.66	-0.23	-7.82	-0.11	-1.90	7.16	-2.16	-2.20	-1.74
AOL-08-5 x Arka Anamika	-4.06	-4.26	-5.70	1.14	-0.94	-3.50	1.59	0.69	10.44*	-3.04	-7.76	-2.81
AOL-08-5 x Pusa Sawani	-4.98	-6.98	-8.75*	-3.73	-5.12	-7.57	-3.42	-7.40	1.56	5.67	1.98	4.25

Table 4.3.3 Continue…

Table 4.3.3 Continue…

Cross		E1			E2			E3			E4		
		MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
AOL-08-5 x Parbhani Kranti		-4.15	-6.16	-7.95*	0.35	-2.14	-4.66	-8.94*	-9.42*	-0.65	-3.02	-5.48	-5.31
AOL-08-5 x GO-2		6.37	5.85	3.83	-1.90	-2.40	-4.92	-3.27	-4.72	4.50	0.51	-4.56	0.95
AOL-08-5 x VRO-6		-5.49	-6.80	-8.58*	0.87	-4.42	-6.88	-12.34**	-14.09**	-5.77	-4.78	-7.33	-6.90
JOL-6k-2 x Arka Anamika		4.37	2.85	1.30	-5.15	-7.40	-9.20*	6.30	2.92	10.89*	-3.30	-3.39	1.80
JOL-6k-2 x Pusa Sawani		-1.70	-2.54	-6.81	1.51	-0.28	-2.22	10.18*	10.03*	11.03*	-2.07	-3.45	1.55
JOL-6k-2 x Parbhani Kranti		6.14	5.23	0.62	-3.68	-6.36	-8.18	-7.56	-10.81*	-3.21	-6.20	-8.43	-3.68
JOL-6k-2 x GO-2		-9.87**	-10.57*	-13.14**	-12.50**	-13.23**	-14.92**	7.02	4.26	10.92*	1.93	1.64	7.51
JOL-6k-2 x VRO-6		3.22	3.08	-1.43	-0.32	-5.84	-7.67	-3.46	-5.48	-0.46	1.75	-0.53	4.62
JOL-08-7 x Arka Anamika		-4.53	-6.41	-7.83	-2.12	-2.49	-8.22	-11.66**	-11.78**	-4.69	1.07	0.35	5.73
JOL-08-7 x Pusa Sawani		-3.56	-3.89	-9.06*	-8.84*	-9.07	-13.98**	-8.28*	-11.43*	-4.31	-4.47	-5.22	-1.56
JOL-08-7 x Parbhani Kranti		-7.84*	-8.14	-13.09**	4.46	3.61	-2.48	-11.29**	-11.49*	-3.95	0.72	-1.07	2.75
JOL-08-7 x GO-2		1.23	-0.09	-2.95	-0.79	-1.97	-5.49	-8.78*	-9.47*	-2.20	1.19	0.27	6.06
JOL-08-7 x VRO-6		-1.21	-1.61	-6.16	3.39	-0.41	-6.27	-4.52	-5.73	1.85	-0.51	-2.13	1.65
JOL-08-12 x Arka Anamika		-4.45	-6.19	-7.6	-2.75	-4.07	-7.90	-12.61**	-12.87**	-6.12	5.88	3.05	8.58
JOL-08-12 x Pusa Sawani		1.17	0.67	-4.45	-6.64	-7.33	-11.03*	-7.55	-10.35*	-3.97	-2.77	-3.96	-1.82
JOL-08-12 x Parbhani Kranti		4.11	3.60	-1.66	-9.51*	-11.11*	-14.66**	-7.14	-7.74	0.12	-2.39	-2.61	-2.43
JOL-08-12 x GO-2		1.83	0.67	-2.22	-1.76	-1.96	-5.49	3.29	2.94	10.27*	1.64	-1.27	4.44
JOL-08-12 x VRO-6		-3.27	-3.50	-7.97*	-0.44	-5.01	-8.80	0.73	-0.12	6.99	-3.75	-4.10	-3.65
Range	**Min.**	-10.58	-11.47	-13.85	-12.50	-13.23	-17.00	-12.61	-14.09	-7.71	-8.25	-9.50	-6.90
	Max.	6.37	5.85	3.83	6.58	6.37	-1.10	7.11	10.03	12.39	14.47	13.23	16.27
S. E. ±		1.81	2.09	2.09	2.06	2.38	2.38	1.99	2.30	2.30	2.20	2.54	2.54
Positive significant crosses		0	0	0	0	0	0	1	1	9	1	1	2
Negative significant crosses		8	6	19	5	6	15	12	16	0	0	0	0
Positive value		14	11	3	16	8	0	16	11	33	21	14	32
Negative value		36	39	47	34	42	50	34	39	17	29	36	18

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.4: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for days to first picking under pooled environments

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		-2.04	-2.93	-0.12
JDNOL-11-1 x Pusa Sawani		-3.29	-5.72*	-2.99
JDNOL-11-1 x Parbhani Kranti		-1.95	-4.00	-1.22
JDNOL-11-1 x GO-2		-5.70**	-6.50**	-3.80
JDNOL-11-1 x VRO-6		-4.64*	-7.45**	-4.77
JDNOL-11-3 x Arka Anamika		-0.33	-0.78	0.24
JDNOL-11-3 x Pusa Sawani		-2.52	-3.68	-3.58
JDNOL-11-3 x Parbhani Kranti		-2.43	-3.17	-3.07
JDNOL-11-3 x GO-2		-2.79	-3.33	-2.14
JDNOL-11-3 x VRO-6		1.87	0.20	0.31
JDNOL-11-11 x Arka Anamika		-5.02*	-5.54*	-3.52
JDNOL-11-11 x Pusa Sawani		-0.53	-2.68	-0.59
JDNOL-11-11 x Parbhani Kranti		-4.05	-5.72*	-3.70
JDNOL-11-11 x GO-2		-2.17	-2.60	-0.51
JDNOL-11-11 x VRO-6		-7.36**	-9.77**	-7.83**
JDNOL-11-12 x Arka Anamika		-1.97	-3.15	-2.15
JDNOL-11-12 x Pusa Sawani		-1.71	-2.15	-3.52
JDNOL-11-12 x Parbhani Kranti		1.48	1.47	0.05
JDNOL-11-12 x GO-2		0.76	-0.55	0.68
JDNOL-11-12 x VRO-6		3.20	2.27	0.84
JDNOL-11-14 x Arka Anamika		-3.31	-4.22	-3.24
JDNOL-11-14 x Pusa Sawani		-4.97*	-5.64*	-6.47**
JDNOL-11-14 x Parbhani Kranti		-3.14	-3.4	-4.25
JDNOL-11-14 x GO-2		-5.88**	-6.86**	-5.71*
JDNOL-11-14 x VRO-6		1.38	0.20	-0.68
AOL-07-9 x Arka Anamika		-3.39	-3.78	-2.80
AOL-07-9 x Pusa Sawani		1.90	0.64	0.84
AOL-07-9 x Parbhani Kranti		-1.22	-2.02	-1.83
AOL-07-9 x GO-2		-2.81	-3.31	-2.11
AOL-07-9 x VRO-6		-0.56	-2.23	-2.04
AOL-08-5 x Arka Anamika		-1.07	-1.59	-0.58
AOL-08-5 x Pusa Sawani		-1.69	-2.79	-2.84
AOL-08-5 x Parbhani Kranti		-4.00	-4.66	-4.71
AOL-08-5 x GO-2		0.40	-0.24	1.00
AOL-08-5 x VRO-6		-5.54*	-7.01**	-7.06**
JOL-6k-2 x Arka Anamika		0.52	-0.07	0.95
JOL-6k-2 x Pusa Sawani		1.91	0.83	0.66
JOL-6k-2 x Parbhani Kranti		-2.87	-3.48	-3.64
JOL-6k-2 x GO-2		-3.40	-4.07	-2.88
JOL-6k-2 x VRO-6		0.31	-1.20	-1.37
JOL-08-7 x Arka Anamika		-4.35*	-4.87*	-3.90
JOL-08-7 x Pusa Sawani		-6.30**	-7.33**	-7.40**
JOL-08-7 x Parbhani Kranti		-3.57	-4.22	-4.30
JOL-08-7 x GO-2		-1.82	-2.46	-1.25
JOL-08-7 x VRO-6		-0.78	-2.31	-2.39
JOL-08-12 x Arka Anamika		-3.55	-4.39	-3.41
JOL-08-12 x Pusa Sawani		-3.98	-4.73	-5.42*
JOL-08-12 x Parbhani Kranti		-3.80	-4.13	-4.83
JOL-08-12 x GO-2		1.25	0.27	1.51
JOL-08-12 x VRO-6		-1.67	-2.88	-3.58
Range	**Min.**	-7.36	-9.77	-7.83
	Max.	3.20	2.27	1.51
S. E. ±		1.08	1.25	1.25
Positive significant crosses		0	0	0
Negative significant crosses		9	11	6
Positive value		11	7	10
Negative value		39	43	40

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

4.3.3 Fruit length (Table 4.3.5 to 4.3.6)

The range of relative heterosis was -10.06 per cent (JDNOL-11-1 x VRO-6) to 12.83 per cent (JOL-08-7 x GO-2) in E_1, -13.21 per cent (JDNOL-11-14 x Arka Anamika) to 13.61 per cent (AOL-08-5 x GO-2) in E_2, -9.44 per cent (AOL-07-9 x VRO-6) to 9.32 per cent (JOL-08-7 x Pusa Sawani) in E_3 and -14.53 per cent (JOL-6k-2 x Pusa Sawani) to 14.98 per cent (JOL-08-7 x Parbhani Kranti) in E_4. Significant and positive relative heterosis was recorded by five, four, eight and ten hybrids in E_1, E_2, E_3 and E_4, respectively.

The heterobeltiosis ranged from -10.63 per cent (JDNOL-11-11 x Parbhani Kranti) to 10.87 per cent (JOL-08-7 x GO-2) in E_1, -14.11 per cent (JDNOL-11-14 x Arka Anamika) to 11.59 per cent (AOL-08-5 x GO-2) in E_2, -11.24 per cent (JOL-08-12 x Arka Anamika) to 7.17 per cent (JOL-08-7 x Pusa Sawani) in E_3 and -16.89 per cent (JDNOL-11-12 x Pusa Sawani) to 12.13 per cent (JDNOL-11-14 x VRO-6) in E_4. The significant positive heterobeltiosis were recorded by one, one and six crosses in E_1, E_2 and E_4, respectively.

The range of standard heterosis varied from -14.03 per cent (JDNOL-11-1 x VRO-6) to 3.35 per cent (JDNOL-11-3 x Parbhani Kranti) in E_1, -15.65 per cent (JDNOL-11-14 x Arka Anamika) to 7.62 per cent (JDNOL-11-14 x VRO-6) in E_2, -16.53 per cent (JOL-6k-2 x Arka Anamika) to 5.24 per cent (JOL-08-7 x Pusa Sawani) in E_3 and -14.98 per cent (JDNOL-11-12 x Pusa Sawani) to 10.47 per cent (JDNOL-11-14 x VRO-6) E_4. The significant positive standard heterosis was recorded by only four crosses in E_4.

The extent of standard heterosis ranged from -6.69 per cent (JOL-6k-2 x Arka Anamika) to 4.50 per cent (JDNOL-11-11 x VRO-6) in pooled analysis. Only one cross combination exhibited significant and positive standard heterosis in this trait. JDNOL-11-11 x VRO-6 (4.50 %) was the hybrid with significant and positive standard heterosis.

4.3.4 Fruit girth (Table 4.3.7 to 4.3.8)

The relative heterosis ranged from -24.16 per cent (JDNOL-11-12 x VRO-6) to 19.74 per cent (JDNOL-11-3 x VRO-6) in E_1, -22.90 per cent (JDNOL-11-14 x Pusa Sawani) to 27.27 per cent (JOL-6k-2 x VRO-6) in E_2, -28.94 per cent (JDNOL-11-14 x VRO-6) to 24.76 per cent (AOL-08-5 x GO-2) in E_3 and -28.67 per cent (JOL-6k-2 x Pusa Sawani) to 53.47 per cent

Table 4.3.5: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for fruit length (cm) under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	1.50	1.28	-3.73	6.96	3.34	-0.63	1.41	0.70	-5.08	6.37	2.35	-2.49
JDNOL-11-1 x Pusa Sawani	4.29	3.98	-1.16	2.49	-2.02	-3.68	2.71	0.65	-1.17	4.51	-2.75	-0.52
JDNOL-11-1 x Parbhani Kranti	2.54	1.85	-1.87	2.06	-3.52	-2.89	2.47	2.04	-3.00	-0.10	-6.23	-5.85
JDNOL-11-1 x GO-2	7.48	1.93	-3.11	2.87	1.81	-6.81	-0.01	-0.93	-6.62	12.44**	9.97*	1.31
JDNOL-11-1 x VRO-6	-10.06*	-10.55*	-14.03**	6.91	2.48	0.19	3.50	0.72	0.32	2.81	-2.64	-4.07
JDNOL-11-3 x Arka Anamika	0.51	-3.03	-1.27	0.68	0.03	-2.56	-0.13	-2.81	-4.52	3.11	1.05	0.27
JDNOL-11-3 x Pusa Sawani	-2.30	-5.82	-4.11	-7.91	-8.34	-9.88	-2.57	-2.60	-4.31	0.24	-1.26	1.01
JDNOL-11-3 x Parbhani Kranti	4.31	1.51	3.35	1.97	0.32	0.98	6.68*	4.95	3.11	8.78**	8.14*	8.58*
JDNOL-11-3 x GO-2	8.89*	0.03	1.84	4.12	0.98	-1.63	-0.40	-3.30	-5.00	-4.00	-7.44	-8.15*
JDNOL-11-3 x VRO-6	-0.86	-3.64	-1.89	0.32	0.14	-2.10	-2.22	-2.88	-3.27	-0.55	-0.91	-1.67
JDNOL-11-11 x Arka Anamika	-6.27	-8.19	-9.38	-4.41	-5.41	-9.04	6.58	6.19	-0.56	3.20	2.31	-0.82
JDNOL-11-11 x Pusa Sawani	-1.23	-3.34	-4.60	5.62	3.38	1.63	-0.82	-3.11	-4.86	1.70	-0.96	1.31
JDNOL-11-11 x Parbhani Kranti	-9.55*	-10.63*	-11.79*	0.80	-2.46	-1.82	4.30	3.52	-1.59	0.18	-1.55	-1.15
JDNOL-11-11 x GO-2	-1.26	-8.00	-9.19	6.42	4.95	-1.20	3.48	2.87	-3.67	-2.98	-5.39	-8.28*
JDNOL-11-11 x VRO-6	1.17	-0.16	-1.46	10.91*	8.86	6.43	8.75**	5.50	5.08	10.52**	9.63*	8.01*
JDNOL-11-12 x Arka Anamika	1.84	-1.14	-6.44	1.06	-1.81	-5.58	5.92	4.51	-0.19	5.57	4.90	1.23
JDNOL-11-12 x Pusa Sawani	2.11	-0.80	-6.27	8.59	4.38	2.61	-0.81	-2.17	-3.93	-14.47**	-16.89**	-14.98**
JDNOL-11-12 x Parbhani Kranti	0.03	-3.73	-7.25	2.33	-2.73	-2.10	4.39	4.15	-0.53	-0.37	-2.31	-1.91
JDNOL-11-12 x GO-2	11.37*	8.95	-2.92	2.32	1.84	-6.78	-9.38**	-10.80**	-14.80**	4.55	2.18	-1.39
JDNOL-11-12 x VRO-6	6.18	2.31	-1.68	2.63	-1.09	-3.29	1.91	-0.19	-0.58	1.79	0.75	-0.74
JDNOL-11-14 x Arka Anamika	-1.74	-2.6	-7.82	-13.21**	-14.11*	-15.65**	4.88	2.71	-0.40	5.39	4.15	1.61
JDNOL-11-14 x Pusa Sawani	2.78	1.97	-3.65	1.08	1.02	-0.68	6.29	5.63	3.72	-2.28	-4.54	-2.35
JDNOL-11-14 x Parbhani Kranti	5.80	3.96	0.16	-3.07	-4.25	-3.62	4.12	3.10	-0.03	5.66	4.17	4.59
JDNOL-11-14 x GO-2	10.94*	6.31	-1.14	6.67	3.05	1.20	5.71	3.29	0.16	4.31	1.40	-1.07
JDNOL-11-14 x VRO-6	-5.59	-7.12	-10.74*	9.84*	9.59	7.62	6.61*	5.20	4.78	12.67**	12.13**	10.47**
AOL-07-9 x Arka Anamika	-2.86	-3.63	-7.33	3.42	2.80	0.05	8.60*	6.42	3.06	7.40*	5.14	0.16
AOL-07-9 x Pusa Sawani	1.33	0.45	-3.41	2.42	1.91	0.19	3.23	2.52	0.66	-5.25	-10.37**	-8.31*
AOL-07-9 x Parbhani Kranti	-0.94	-1.04	-4.65	-4.98	-6.55	-5.94	-0.62	-1.54	-4.65	4.41	-0.35	0.05
AOL-07-9 x GO-2	1.82	-3.97	-7.65	-1.95	-4.87	-7.41	2.78	0.49	-2.68	1.97	1.48	-6.51
AOL-07-9 x VRO-6	0.20	0.17	-3.68	-7.68	-7.88	-9.94	-9.44**	-10.70**	-11.06**	7.92*	3.94	2.41
AOL-08-5 x Arka Anamika	4.75	1.97	-3.49	-3.88	-4.50	-8.17	3.03	2.22	-3.45	6.64	2.27	-2.57
AOL-08-5 x Pusa Sawani	6.11	3.38	-2.33	8.61	6.73	4.93	1.45	-0.49	-2.29	5.95	-1.74	0.52

Table 4.3.5 Continue…

Table 4.3.5 Continue…

Cross		E1			E2			E3			E4		
		MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
AOL-08-5 x Parbhani Kranti		8.56	4.77	0.95	1.91	-1.00	-0.35	6.86*	6.51	1.25	5.79	-1.03	-0.63
AOL-08-5 x GO-2		10.15*	7.45	-3.7	13.61**	11.59*	5.91	6.40	5.32	-0.53	1.93	-0.65	-8.47*
AOL-08-5 x VRO-6		6.38	2.79	-1.22	5.02	3.48	1.17	1.62	-1.01	-1.41	9.60**	3.44	1.91
JOL-6k-2 x Arka Anamika		2.23	-1.60	-6.87	-0.69	-1.42	-3.78	-8.33*	-10.21*	-16.53**	4.88	4.10	0.68
JOL-6k-2 x Pusa Sawani		4.66	0.83	-4.73	1.64	1.27	-0.44	4.62	-0.19	-1.99	-14.53**	-16.86**	-14.95**
JOL-6k-2 x Parbhani Kranti		-5.22	-9.54	-12.84**	-3.02	-4.49	-3.87	-1.73	-4.78	-9.49*	5.73	3.78	4.21
JOL-6k-2 x GO-2		3.94	2.56	-10.19*	3.35	0.14	-2.26	8.70*	6.72	-1.25	0.32	-2.06	-5.28
JOL-6k-2 x VRO-6		-0.65	-5.06	-8.76	3.09	3.01	0.71	0.75	-4.54	-4.92	3.47	2.52	1.01
JOL-08-7 x Arka Anamika		5.81	2.26	-3.22	1.18	-0.14	-3.97	-2.19	-2.90	-8.40*	8.32*	5.48	0.49
JOL-08-7 x Pusa Sawani		7.94	4.41	-1.35	9.06	6.48	4.68	9.32**	7.17	5.24	-6.90*	-12.37**	-10.36**
JOL-08-7 x Parbhani Kranti		3.05	-1.26	-4.87	1.78	-1.76	-1.12	4.31	3.91	-1.22	14.98**	9.18*	9.62*
JOL-08-7 x GO-2		12.83**	10.87*	-2.11	10.88*	9.62	2.67	3.07	2.08	-3.69	10.34**	9.23*	0.63
JOL-08-7 x VRO-6		5.26	0.98	-2.95	-2.15	-4.20	-6.34	7.65*	4.80	4.38	2.58	-1.72	-3.17
JOL-08-12 x Arka Anamika		1.62	-0.33	-1.89	-6.79	-8.42	-8.74	-8.20*	-11.24**	-11.64**	0.84	-2.92	-0.05
JOL-08-12 x Pusa Sawani		-1.23	-3.21	-4.73	-2.24	-2.90	-3.24	-1.89	-2.56	-3.00	-4.40	-4.70	-1.89
JOL-08-12 x Parbhani Kranti		1.74	0.66	-0.92	-5.72	-6.19	-5.58	-0.37	-2.62	-3.06	-1.95	-3.16	-0.30
JOL-08-12 x GO-2		1.18	-5.60	-7.08	6.66	2.32	1.96	-7.03*	-10.30**	-10.71**	-5.04	-10.04**	-7.38
JOL-08-12 x VRO-6		3.00	1.79	0.19	5.28	4.29	3.92	1.01	0.99	0.58	0.95	-1.22	1.69
Range	**Min.**	-10.06	-10.63	-14.03	-13.21	-14.11	-15.65	-9.44	-11.24	-16.53	-14.53	-16.89	-14.98
	Max.	12.83	10.87	3.35	13.61	11.59	7.62	9.32	7.17	5.24	14.98	12.13	10.47
S. E. ±		0.50	0.58	0.58	0.56	0.64	0.64	0.39	0.45	0.45	0.40	0.46	0.46
Positive significant crosses		5	1	0	4	1	0	8	0	0	10	6	4
Negative significant crosses		2	2	5	1	1	1	5	5	7	3	5	7
Positive value		36	26	5	36	27	17	33	28	12	37	24	22
Negative value		14	24	45	14	23	33	17	22	38	13	26	28

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.6: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for fruit length (cm) under pooled environments

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		4.01	2.38	-2.99
JDNOL-11-1 x Pusa Sawani		3.50	0.06	-1.63
JDNOL-11-1 x Parbhani Kranti		1.76	-1.52	-3.39
JDNOL-11-1 x GO-2		5.60**	4.78	-3.83
JDNOL-11-1 x VRO-6		0.76	-2.44	-4.39
JDNOL-11-3 x Arka Anamika		1.04	-1.22	-2.03
JDNOL-11-3 x Pusa Sawani		-3.11	-3.53	-4.33
JDNOL-11-3 x Parbhani Kranti		5.44**	4.86*	4.00
JDNOL-11-3 x GO-2		2.11	-2.43	-3.23
JDNOL-11-3 x VRO-6		-0.84	-1.42	-2.24
JDNOL-11-11 x Arka Anamika		-0.24	-0.82	-4.94*
JDNOL-11-11 x Pusa Sawani		1.30	0.03	-1.66
JDNOL-11-11 x Parbhani Kranti		-1.09	-2.23	-4.09
JDNOL-11-11 x GO-2		1.42	-1.49	-5.58*
JDNOL-11-11 x VRO-6		7.82**	6.63**	4.50*
JDNOL-11-12 x Arka Anamika		3.63	2.65	-2.74
JDNOL-11-12 x Pusa Sawani		-1.31	-4.00	-5.62*
JDNOL-11-12 x Parbhani Kranti		1.61	-1.05	-2.94
JDNOL-11-12 x GO-2		1.98	0.56	-6.52**
JDNOL-11-12 x VRO-6		3.09	0.43	-1.57
JDNOL-11-14 x Arka Anamika		-1.18	-2.05	-5.54*
JDNOL-11-14 x Pusa Sawani		1.96	0.99	-0.72
JDNOL-11-14 x Parbhani Kranti		3.09	2.22	0.27
JDNOL-11-14 x GO-2		6.85**	3.48	-0.21
JDNOL-11-14 x VRO-6		5.96**	5.11*	3.02
AOL-07-9 x Arka Anamika		4.12*	3.76	-1.00
AOL-07-9 x Pusa Sawani		0.46	-1.02	-2.69
AOL-07-9 x Parbhani Kranti		-0.58	-1.94	-3.81
AOL-07-9 x GO-2		1.15	-1.52	-6.04**
AOL-07-9 x VRO-6		-2.39	-3.68	-5.60*
AOL-08-5 x Arka Anamika		2.58	0.88	-4.41*
AOL-08-5 x Pusa Sawani		5.50**	1.91	0.19
AOL-08-5 x Parbhani Kranti		5.75**	2.26	0.31
AOL-08-5 x GO-2		8.04**	7.30**	-1.69
AOL-08-5 x VRO-6		5.58**	2.14	0.10
JOL-6k-2 x Arka Anamika		-0.46	-1.52	-6.69**
JOL-6k-2 x Pusa Sawani		-1.06	-3.87	-5.50*
JOL-6k-2 x Parbhani Kranti		-1.00	-3.71	-5.54*
JOL-6k-2 x GO-2		4.07	2.74	-4.73*
JOL-6k-2 x VRO-6		1.7	-1.04	-3.02
JOL-08-7 x Arka Anamika		3.21	1.53	-3.81
JOL-08-7 x Pusa Sawani		4.86*	1.31	-0.41
JOL-08-7 x Parbhani Kranti		6.01**	2.53	0.57
JOL-08-7 x GO-2		9.17**	8.40**	-0.65
JOL-08-7 x VRO-6		3.36	0.01	-1.98
JOL-08-12 x Arka Anamika		-3.14	-5.75*	-5.62*
JOL-08-12 x Pusa Sawani		-2.46	-3.35	-3.22
JOL-08-12 x Parbhani Kranti		-1.6	-2.6	-2.47
JOL-08-12 x GO-2		-1.14	-5.96**	-5.83**
JOL-08-12 x VRO-6		2.54	1.45	1.59
Range	**Min.**	-3.14	-5.96	-6.69
	Max.	9.17	8.40	4.50
S. E. ±		0.23	0.27	0.27
Positive significant crosses		13	5	1
Negative significant crosses		0	2	14
Positive value		34	26	9
Negative value		16	24	41

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.7: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for fruit girth (cm) under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
JDNOL-11-1 x Arka Anamika	-1.03	-4.76	-23.22**	6.85	6.35	-28.44**	12.02*	8.83	-10.44*	10.27*	9.08	-11.40**
JDNOL-11-1 x Pusa Sawani	8.29	4.22	-15.98**	-5.07	-14.58*	-28.12**	14.35**	5.97	-3.63	-4.55	-14.19**	-14.54**
JDNOL-11-1 x Parbhani Kranti	2.02	-4.90	-17.97**	-18.92**	-26.81**	-38.85**	-2.03	-9.86	-16.74**	0.74	-7.31	-12.33**
JDNOL-11-1 x GO-2	4.89	0.54	-18.26**	-0.45	-4.97	-29.67**	12.70*	1.48	-21.24**	11.01*	6.62	-15.27**
JDNOL-11-1 x VRO-6	11.82*	2.73	-8.55	10.04	-1.55	-16.08**	-24.38**	-30.92**	-35.17**	17.04**	10.92*	-1.55
JDNOL-11-3 x Arka Anamika	5.39	-1.63	-20.69**	25.56**	20.20**	-12.40*	4.54	1.85	-11.63*	13.02**	12.95*	-8.25
JDNOL-11-3 x Pusa Sawani	5.20	-1.81	-20.84**	-0.87	-7.51	-22.17**	-5.87	-8.04	-16.37**	-3.14	-12.12**	-12.48**
JDNOL-11-3 x Parbhani Kranti	-8.12	-16.84**	-28.27**	9.50	2.50	-14.36**	10.01*	6.67	-1.47	13.12**	5.07	-0.62
JDNOL-11-3 x GO-2	4.47	-2.87	-21.03**	6.34	5.52	-21.90**	17.20**	0.58	-12.74**	10.43*	5.02	-14.80**
JDNOL-11-3 x VRO-6	19.74**	6.87	-4.86	-14.94**	-21.11**	-32.76**	2.60	-1.27	-7.36	-6.92	-10.92*	-20.94**
JDNOL-11-11 x Arka Anamika	-0.59	-3.49	-22.20**	17.16*	11.72	-25.53**	24.73**	18.49**	-2.48	10.23*	3.30	-16.09**
JDNOL-11-11 x Pusa Sawani	16.41**	13.01*	-8.89	3.05	-11.45	-25.49**	-11.28*	-19.51**	-26.80**	-5.50	-19.06**	-19.39**
JDNOL-11-11 x Parbhani Kranti	13.51*	6.70	-7.97	7.76	-7.12	-22.40**	-10.55*	-19.41**	-25.56**	-11.93**	-22.90**	-27.08**
JDNOL-11-11 x GO-2	3.12	-0.30	-18.94**	-2.30	-11.23	-34.30**	0.37	-7.70	-31.63**	-4.29	-5.71	-31.00**
JDNOL-11-11 x VRO-6	6.42	-1.42	-12.24*	21.17**	3.57	-11.72*	18.35**	5.88	-0.64	19.75**	7.79	-4.33
JDNOL-11-12 x Arka Anamika	-8.39	-13.00*	-22.00**	9.29	4.34	-23.53**	-10.71*	-10.84	-26.62**	-2.06	-3.63	-19.13**
JDNOL-11-12 x Pusa Sawani	-18.25**	-22.37**	-30.40**	-8.28	-14.20*	-27.81**	6.30	1.11	-8.05	-12.76**	-19.63**	-19.96**
JDNOL-11-12 x Parbhani Kranti	-19.05**	-20.59**	-28.80**	-8.40	-14.03*	-28.17**	9.54*	3.43	-4.46	-12.16**	-17.12**	-21.61**
JDNOL-11-12 x GO-2	8.07	3.03	-7.63	-12.77*	-13.20*	-35.76**	6.15	-6.72	-23.45**	24.43**	16.47**	-2.27
JDNOL-11-12 x VRO-6	-24.16**	-24.43**	-32.25**	-1.92	-8.80	-22.26**	-10.66*	-16.27**	-21.43**	24.19**	20.80**	7.22
JDNOL-11-14 x Arka Anamika	2.65	-0.68	-14.38**	-4.68	-14.39*	-28.35**	-6.19	-12.88**	-16.37**	-3.20	-9.23*	-15.78**
JDNOL-11-14 x Pusa Sawani	5.56	2.14	-11.95*	-22.90**	-23.11**	-35.30**	6.44	3.64	-0.51	-8.47*	-11.60**	-11.96**
JDNOL-11-14 x Parbhani Kranti	-0.20	-0.23	-13.94**	-9.70	-9.77	-24.49**	-3.34	-5.17	-8.97	1.46	0.49	-4.95
JDNOL-11-14 x GO-2	10.47	7.32	-7.48	11.44*	4.99	-12.13*	14.65**	-5.56	-9.33*	17.53**	5.11	-2.48
JDNOL-11-14 x VRO-6	-15.41**	-16.75**	-25.89**	-18.07**	-18.82**	-30.80**	-28.94**	-29.74**	-32.55**	-21.02**	-22.73**	-28.31**
AOL-07-9 x Arka Anamika	-0.90	-3.67	-22.34**	-8.49	-19.17**	-29.71**	-20.79**	-20.95**	-34.94**	-16.17**	-22.78**	-25.53**
AOL-07-9 x Pusa Sawani	2.08	-0.78	-20.01**	-1.49	-3.08	-15.72**	-12.04*	-16.38**	-23.95**	-5.13	-6.63	-7.01
AOL-07-9 x Parbhani Kranti	10.08	3.60	-10.64 *	-1.57	-3.50	-16.08**	-21.36**	-25.78**	-31.45**	19.82**	18.66**	14.44**
AOL-07-9 x GO-2	-7.56	-10.51	-27.25**	19.16**	10.29	-4.09	11.13*	-2.30	-19.91**	27.15**	11.82**	7.84
AOL-07-9 x VRO-6	5.47	-2.18	-12.92*	9.29	8.20	-5.91	3.87	-2.69	-8.69	20.13**	15.35**	11.24**
AOL-08-5 x Arka Anamika	2.12	1.43	-17.10**	-0.07	-0.07	-33.39**	-14.08**	-17.81**	-25.93**	7.02	-0.32	-19.03**
AOL-08-5 x Pusa Sawani	-2.24	-2.91	-20.64**	2.38	-8.26	-22.81**	4.98	4.50	-4.97	9.48*	-6.73	-7.12

Table 4.3.7 Continue…

Table 4.3.7 Continue…

Cross	E1			E2			E3			E4		
	MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
AOL-08-5 x Parbhani Kranti	-16.33**	-18.52**	-29.72**	13.73*	2.23	-14.58**	1.94	0.70	-6.99	24.02**	7.96	2.11
AOL-08-5 x GO-2	7.06	6.77	-12.72*	11.69	6.14	-21.44**	24.76**	5.41	-5.01	34.41**	31.57**	-3.71
AOL-08-5 x VRO-6	5.12	0.82	-10.25*	25.93**	12.21*	-4.36	-7.72	-9.55	-15.13**	18.38**	5.93	-5.98
JOL-6k-2 x Arka Anamika	6.82	3.86	-16.27**	4.54	3.83	-29.85**	7.57	1.56	-16.41**	14.90 **	6.98	-13.10**
JOL-6k-2 x Pusa Sawani	18.28**	15.00*	-7.29	-16.80**	-25.00**	-36.89**	-3.70	-13.14*	-21.01**	-28.67**	-39.25**	-39.50**
JOL-6k-2 x Parbhani Kranti	-1.14	-6.93	-19.72**	9.38	-1.09	-17.36**	0.08	-10.35*	-17.20**	-4.07	-16.52**	-21.04**
JOL-6k-2 x GO-2	13.26*	9.68	-10.83*	21.25**	15.96*	-14.18**	2.58	-5.09	-30.62**	53.47**	50.18**	9.90*
JOL-6k-2 x VRO-6	3.03	-4.42	-14.91**	27.27**	14.07*	-2.77	2.84	-8.53	-14.16**	34.26**	20.10**	6.60
JOL-08-7 x Arka Anamika	-2.56	-5.89	-18.55**	9.26	2.76	-22.26**	-0.22	-1.79	-16.55**	8.68	6.95	-10.26*
JOL-08-7 x Pusa Sawani	-4.18	-7.46	-19.91**	-5.09	-9.88	-24.17**	2.04	-1.31	-10.25*	8.38*	-0.16	-0.57
JOL-08-7 x Parbhani Kranti	12.03*	11.84*	-3.21	-0.97	-5.66	-21.17**	10.76*	6.32	-1.79	-0.32	-5.94	-11.04**
JOL-08-7 x GO-2	8.51	5.22	-8.94	9.05	7.87	-18.40**	2.88	-10.93*	-24.32**	12.67**	5.47	-11.50**
JOL-08-7 x VRO-6	-7.44	-8.73	-18.75**	18.78**	12.10*	-4.45	-7.12	-11.51*	-16.97**	-10.63*	-13.07**	-22.85**
JOL-08-12 x Arka Anamika	-3.5	-6.55	-19.57**	20.17**	8.78	-10.54*	-22.93**	-28.62**	-31.08**	14.01**	12.56*	-6.19
JOL-08-12 x Pusa Sawani	-2.74	-5.81	-18.94**	-1.31	-2.43	-17.90**	-16.58**	-19.00**	-21.79**	2.79	-5.59	-5.98
JOL-08-12 x Parbhani Kranti	0.45	0.34	-13.45**	8.74	7.88	-9.86*	-11.46**	-13.38**	-16.37**	-14.14**	-19.25**	-23.62**
JOL-08-12 x GO-2	0.46	-2.31	-15.93**	4.68	-0.55	-18.22**	10.72*	-9.00	-12.14**	14.20**	7.24	-10.62*
JOL-08-12 x VRO-6	12.79*	10.91	-1.26	-1.68	-3.41	-17.67**	3.69	2.24	-1.29	16.39**	12.84**	0.15
Range **Min.**	-24.16	-24.43	-32.25	-22.90	-26.81	-38.85	-28.94	-30.92	-35.17	-28.67	-39.25	-39.50
Range **Max.**	19.74	15.00	-1.26	27.27	20.20	-2.77	24.76	18.49	-0.51	53.47	50.18	14.44
S. E. ±	0.30	0.35	0.35	0.31	0.35	0.35	0.28	0.33	0.33	0.23	0.27	0.27
Positive significant crosses	8	3	0	11	5	0	13	1	0	26	12	03
Negative significant crosses	5	7	40	6	11	45	13	17	35	9	15	28
Positive value	31	20	0	27	21	0	29	17	0	31	26	08
Negative value	19	30	50	23	29	50	21	33	50	19	24	42

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.8: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for fruit girth (cm) under pooled environments

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		7.12*	5.08	-18.53**
JDNOL-11-1 x Pusa Sawani		3.40	-4.80	-15.63**
JDNOL-11-1 x Parbhani Kranti		-4.46	-12.23**	-21.83**
JDNOL-11-1 x GO-2		6.94*	5.48	-21.34**
JDNOL-11-1 x VRO-6		2.79	-5.65*	-15.82**
JDNOL-11-3 x Arka Anamika		11.77**	11.67**	-13.28**
JDNOL-11-3 x Pusa Sawani		-1.48	-7.57**	-18.09**
JDNOL-11-3 x Parbhani Kranti		6.47*	-0.35	-11.25**
JDNOL-11-3 x GO-2		9.64**	6.03	-17.66**
JDNOL-11-3 x VRO-6		0.00	-6.48*	-16.56**
JDNOL-11-11 x Arka Anamika		12.96**	7.66*	-16.54**
JDNOL-11-11 x Pusa Sawani		0.29	-10.11**	-20.34**
JDNOL-11-11 x Parbhani Kranti		-0.51	-11.02**	-20.75**
JDNOL-11-11 x GO-2		-0.64	-2.21	-29.07**
JDNOL-11-11 x VRO-6		16.32**	3.95	-7.26**
JDNOL-11-12 x Arka Anamika		-3.42	-6.08*	-22.94**
JDNOL-11-12 x Pusa Sawani		-8.00**	-11.41**	-21.50**
JDNOL-11-12 x Parbhani Kranti		-7.25**	-10.90**	-20.65**
JDNOL-11-12 x GO-2		6.23*	0.07	-17.89**
JDNOL-11-12 x VRO-6		-3.86	-7.72**	-17.67**
JDNOL-11-14 x Arka Anamika		-2.94	-9.49**	-18.89**
JDNOL-11-14 x Pusa Sawani		-4.75*	-5.28	-15.12**
JDNOL-11-14 x Parbhani Kranti		-2.99	-3.29	-13.34**
JDNOL-11-14 x GO-2		13.45**	2.64	-8.02**
JDNOL-11-14 x VRO-6		-21.12**	-21.30**	-29.47**
AOL-07-9 x Arka Anamika		-11.86**	-15.83**	-28.29**
AOL-07-9 x Pusa Sawani		-4.38	-6.23*	-16.90**
AOL-07-9 x Parbhani Kranti		1.38	-0.82	-11.67**
AOL-07-9 x GO-2		12.69**	4.32	-11.13**
AOL-07-9 x VRO-6		9.65**	7.17**	-4.38
AOL-08-5 x Arka Anamika		-1.95	-2.13	-24.12**
AOL-08-5 x Pusa Sawani		3.69	-2.96	-14.01 **
AOL-08-5 x Parbhani Kranti		5.26*	-1.72	-12.47**
AOL-08-5 x GO-2		18.93**	15.30**	-10.93**
AOL-08-5 x VRO-6		9.35**	2.02	-8.98**
JOL-6k-2 x Arka Anamika		8.38**	4.30	-19.14**
JOL-6k-2 x Pusa Sawani		-7.79**	-16.60**	-26.09**
JOL-6k-2 x Parbhani Kranti		1.09	-8.77**	-18.75**
JOL-6k-2 x GO-2		21.97**	21.25**	-12.05**
JOL-6k-2 x VRO-6		16.16**	4.75	-6.54**
JOL-08-7 x Arka Anamika		3.52	0.30	-17.09**
JOL-08-7 x Pusa Sawani		0.37	-3.00	-14.04**
JOL-08-7 x Parbhani Kranti		5.55*	1.76	-9.37**
JOL-08-7 x GO-2		8.23**	1.60	-16.01**
JOL-08-7 x VRO-6		-1.65	-5.26	-15.48**
JOL-08-12 x Arka Anamika		0.70	-4.86	-17.09**
JOL-08-12 x Pusa Sawani		-4.88*	-5.67*	-16.41**
JOL-08-12 x Parbhani Kranti		-4.23	-5.26	-15.62**
JOL-08-12 x GO-2		7.31**	-1.69	-14.32**
JOL-08-12 x VRO-6		7.44**	6.20*	-5.25*
Range	**Min.**	-21.12	-21.30	-29.47
	Max.	21.97	21.25	-4.38
S. E. ±		0.14	0.16	0.16
Positive significant crosses		21	7	0
Negative significant crosses		6	17	49
Positive value		31	19	0
Negative value		19	31	50

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

(JOL-6k-2 x GO-2) in E_4. Significant and positive relative heterosis was recorded by eight, eleven, thirteen and twenty six crosses in E_1, E_2, E_3 and E_4, respectively.

The value of heterobeltiosis in E_1 varied from -24.43 per cent (JDNOL-11-12 x VRO-6) to 15.00 per cent (JOL-6k-2 x Pusa Sawani). Further, it ranged from -26.81 per cent (JDNOL-11-1 x Parbhani Kranti) to 20.20 per cent (JDNOL-11-3 x Arka Anamika), -30.92 per cent (JDNOL-11-1 x VRO-6) to 18.49 per cent (JDNOL-11-11 x Arka Anamika) and -39.25 per cent (JOL-6k-2 x Pusa Sawani) to 50.18 per cent (JOL-6k-2 x GO-2) in E_2, E_3 and E_4, respectively. Three, five, one and twelve crosses registered significant positive heterobeltiosis in E_1, E_2, E_3 and E_4, respectively.

The estimates of standard heterosis ranged from -32.25 per cent (JDNOL-11-12 x VRO-6) to -1.26 per cent (JOL-08-12 x VRO-6) in E_1, -38.85 per cent (JDNOL-11-1 x Parbhani Kranti) to -2.77 per cent (JOL-6k-2 x VRO-6) in E_2, -35.17 per cent (JDNOL-11-1 x VRO-6) to -0.51 per cent (JDNOL-11-14 x Pusa Sawani) in E_3 and -39.50 per cent (JOL-6k-2 x Pusa Sawani) to 14.44 per cent (AOL-07-9 x Parbhani Kranti) in E_4. Three crosses recorded significant positive standard heterosis in E_4.

The extent of standard heterosis ranged from -29.47 per cent (JDNOL-11-14 x VRO-6) to -4.38 per cent (AOL-07-9 x VRO-6) in pooled analysis. None of the hybrids exhibited positive significant standard heterosis in desired direction for this trait.

The result of the present study revealed that the estimates of relative heterosis were in both directions in E_4. While majority of the crosses was manifested negative heterobeltiosis and economics heterosis. The genotype behaves differently in each environment as evident from the significant heterotic variations.

4.3.5 Number of branches per plant (Table 4.3.9 to 4.3.10)

The range of relative heterosis was from -13.52 per cent (JDNOL-11-3 x Pusa Sawani) to 24.24 per cent (JOL-08-7 x Pusa Sawani) in E_1, -9.53 per cent (JDNOL-11-3 x Arka Anamika) to 23.31 per cent (JDNOL-11-11 x VRO-6) in E_2, -19.00 per cent (AOL-07-9 x Parbhani Kranti) to 33.38 per cent (JOL-08-12 x GO-2) in E_3 and -27.55 per cent (AOL-08-5 x Arka Anamika) to 30.06 per cent (JDNOL-11-11 x VRO-6) in E_4, respectively. The number of crosses,

Table 4.3.9: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for number of branches per plant under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
JDNOL-11-1 x Arka Anamika	6.11	4.22	-9.92	5.76	-0.85	-13.61*	3.92	-1.65	-22.11**	-6.14	-15.21**	-17.83**
JDNOL-11-1 x Pusa Sawani	-6.04	-8.76	-19.27**	12.74	5.20	-7.43	-5.57	-12.99*	-27.02**	-8.15	-16.00**	-20.80**
JDNOL-11-1 x Parbhani Kranti	4.17	0.82	-15.96*	5.00	-0.15	-15.59*	-9.17	-13.31*	-32.57**	-0.57	-3.19	-20.11**
JDNOL-11-1 x GO-2	4.35	1.64	-15.28*	5.21	-0.29	-15.10*	0.68	-0.90	-27.67**	-7.73	-9.66	-26.29**
JDNOL-11-1 x VRO-6	13.09*	12.86	-5.93	4.16	-2.55	-14.73*	-3.99	-10.73	-26.58**	-3.29	-7.13	-21.14**
JDNOL-11-3 x Arka Anamika	-6.75	-9.03	-17.33**	-9.53	-9.66	-21.29**	1.78	1.22	-18.95**	-20.95**	-25.71**	-28.00**
JDNOL-11-3 x Pusa Sawani	-13.54*	-14.68*	-22.46**	-2.76	-3.38	-14.98*	-11.76*	-13.77*	-27.67**	-4.14	-8.73	-13.94**
JDNOL-11-3 x Parbhani Kranti	-11.41	-17.69*	-25.20**	16.39*	14.81*	-0.25	24.50**	22.72**	-1.74	4.63	2.95	-12.23*
JDNOL-11-3 x GO-2	-11.41	-17.19 *	-24.74**	-6.04	-6.98	-19.18**	-0.21	-4.63	-23.64**	-4.38	-6.43	-20.23**
JDNOL-11-3 x VRO-6	-0.33	-4.64	-13.34*	5.32	4.95	-8.17	-15.84**	-16.95**	-31.70**	-10.01	-10.19	-23.43**
JDNOL-11-11 x Arka Anamika	-5.1	-5.41	-18.24**	13.01	9.23	-4.83	2.87	-3.99	-23.97**	-16.89**	-26.89**	-29.14**
JDNOL-11-11 x Pusa Sawani	-1.5	-2.96	-14.14*	7.46	3.38	-9.03	-3.86	-12.60*	-26.69**	-8.37	-18.42**	-23.09**
JDNOL-11-11 x Parbhani Kranti	-1.04	-5.58	-18.93**	-1.49	-3.37	-18.32**	-5.65	-11.2	-30.94**	0.88	-4.57	-21.26**
JDNOL-11-11 x GO-2	0.00	-3.98	-17.56**	4.54	2.18	-13.00*	-5.54	-8.36	-33.12**	-1.33	-6.16	-23.43**
JDNOL-11-11 x VRO-6	11.01	9.16	-6.27	23.31**	18.95*	4.08	18.99**	9.14	-10.24*	30.06**	21.40**	3.09
JDNOL-11-12 x Arka Anamika	-6.08	-9.37	-21.66**	1.96	-0.43	-13.24*	-7.64	-10.18	-28.87**	-4.08	-14.15**	-16.80**
JDNOL-11-12 x Pusa Sawani	-3.17	-7.60	-18.24**	-0.29	-3.09	-14.73*	-6.11	-11.17*	-25.49**	-7.16	-15.88**	-20.69**
JDNOL-11-12 x Parbhani Kranti	-0.5	-1.99	-21.21**	8.42	7.47	-9.16	11.92*	9.80	-14.60**	1.15	-2.49	-19.54**
JDNOL-11-12 x GO-2	-6.72	-7.52	-25.66**	4.64	3.34	-12.00	0.81	-0.44	-25.49**	-9.83	-12.61*	-28.69**
JDNOL-11-12 x VRO-6	-9.84	-11.26	-26.34**	2.90	0.28	-12.25	-7.07	-11.26*	-27.02**	-5.17	-9.83	-23.43**
JDNOL-11-14 x Arka Anamika	2.68	1.19	-12.54*	2.60	-3.27	-4.83	2.08	-3.21	-14.49**	-25.42**	-28.54**	-30.74**
JDNOL-11-14 x Pusa Sawani	-3.04	-5.54	-16.42**	22.84**	16.35*	14.48*	2.34	-0.25	-11.87*	-5.62	-8.36	-13.60**
JDNOL-11-14 x Parbhani Kranti	5.21	1.49	-14.82*	-4.60	-11.32	-12.75*	-4.39	-10.11	-20.59**	-3.00	-6.44	-16.91**
JDNOL-11-14 x GO-2	13.93*	10.6	-7.18	-0.88	-7.55	-9.03	-12.09*	-19.73**	-29.08**	-11.33*	-14.93**	-24.46**
JDNOL-11-14 x VRO-6	2.05	1.49	-14.82*	8.26	2.26	0.62	9.83*	6.04	-6.32	-1.45	-3.6	-14.40**
AOL-07-9 x Arka Anamika	-4.20	-4.58	-16.88**	3.74	-0.39	-5.69	-18.10**	-20.39**	-33.22**	-19.78**	-22.52**	-24.91**
AOL-07-9 x Pusa Sawani	0.13	-0.64	-12.09	7.32	3.53	-1.98	-12.73**	-12.73*	-26.80**	-23.10**	-24.73**	-29.03**
AOL-07-9 x Parbhani Kranti	10.08	4.32	-9.12	-1.93	-7.19	-12.13	-19.00**	-21.95**	-34.53**	-7.28	-11.27*	-19.89**
AOL-07-9 x GO-2	3.91	-0.92	-13.68*	0.62	-4.44	-9.53	-7.50	-13.51*	-27.45**	-10.11*	-14.43*	-22.74**
AOL-07-9 x VRO-6	-3.35	-5.63	-17.79**	-4.76	-8.37	-13.24*	-5.57	-6.49	-21.57**	-13.24**	-15.82**	-24.00**
AOL-08-5 x Arka Anamika	5.96	-0.26	-13.80*	9.70	9.31	-4.08	0.30	-7.15	-26.47**	-27.55**	-29.13**	-31.31**
AOL-08-5 x Pusa Sawani	14.46*	6.57	-5.70	20.99**	20.82**	6.31	-1.22	-10.91*	-25.27**	-0.24	-1.09	-6.74

Table 4.3.9 Continue…

Table 4.3.9 Continue…

Cross		E1			E2			E3			E4		
		MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
AOL-08-5 x Parbhani Kranti		5.40	4.24	-18.70**	12.5	10.44	-3.09	29.18**	20.59**	-6.21	-4.24	-9.49	-16.11**
AOL-08-5 x GO-2		2.79	1.01	-20.18**	5.23	3.67	-9.03	8.92	4.78	-23.53**	-6.89	-12.45*	-18.86**
AOL-08-5 x VRO-6		2.51	-1.65	-18.36**	10.03	9.87	-3.59	5.82	-3.71	-20.81**	-5.41	-9.37	-16.00**
JOL-6k-2 x Arka Anamika		4.27	3.03	-10.95	12.24	6.82	-6.93	-7.73	-10.45	-29.08**	-10.85*	-18.16**	-20.69**
JOL-6k-2 x Pusa Sawani		-9.23	-11.34	-21.55**	3.19	-2.25	-13.99*	-3.03	-8.44	-23.20**	-18.64**	-24.36**	-28.69**
JOL-6k-2 x Parbhani Kranti		-9.69	-13.11	-26.68**	13.12	9.22	-7.67	4.72	2.52	-20.26**	-4.96	-5.82	-22.29**
JOL-6k-2 x GO-2		13.47*	9.86	-7.30	7.10	3.05	-12.25	14.33**	13.16*	-15.69**	1.34	0.98	-17.60**
JOL-6k-2 x VRO-6		3.00	2.16	-13.80*	4.10	-1.13	-13.49*	-5.91	-10.33	-26.25**	-8.40	-10.5	-24.00**
JOL-08-7 x Arka Anamika		-6.31	-11.87	-23.83**	10.16	9.38	-4.70	-6.04	-11.14	-29.63**	-15.23**	-23.23**	-25.60**
JOL-08-7 x Pusa Sawani		24.24**	15.59*	2.28	12.6	11.25	-2.10	19.32**	9.87	-7.84	-4.43	-12.36*	-17.37**
JOL-08-7 x Parbhani Kranti		17.31*	15.94*	-9.58	9.37	8.50	-6.81	23.79**	18.07**	-8.17	8.79	6.23	-12.34*
JOL-08-7 x GO-2		5.22	3.32	-18.36**	4.78	4.32	-10.4	6.22	4.48	-23.75**	-1.85	-3.64	-21.37**
JOL-08-7 x VRO-6		9.03	4.53	-13.23*	12.49	11.46	-2.48	6.63	-0.93	-18.52**	6.08	2.15	-13.26**
JOL-08-12 x Arka Anamika		-0.85	-1.43	-13.80*	6.59	5.68	-7.92	-12.34*	-17.47**	-34.64**	12.40*	4.25	1.03
JOL-08-12 x Pusa Sawani		19.90**	19.20**	5.47	13.33*	11.81	-1.61	12.89*	3.51	-13.18**	6.97	0.48	-5.26
JOL-08-12 x Parbhani Kranti		8.06	2.22	-10.6	-0.95	-1.59	-15.72*	-0.15	-5.18	-26.25**	1.45	1.24	-16.11**
JOL-08-12 x GO-2		2.19	-2.74	-14.94*	-7.54	-7.80	-21.04**	33.38**	30.60**	-4.68	-8.27	-8.97	-24.57**
JOL-08-12 x VRO-6		14.65*	11.73	-2.28	7.51	6.36	-6.93	21.55**	12.45*	-7.52	2.59	1.35	-13.94**
Range	**Min.**	-13.54	-17.69	-26.68	-9.53	-11.32	-21.29	-19.00	-21.95	-34.64	-27.55	-29.13	-31.31
	Max.	24.24	19.20	5.47	23.31	20.82	14.48	33.38	30.60	-1.74	30.06	21.40	3.09
S. E. ±		0.15	0.17	0.17	0.14	0.17	0.17	0.12	0.14	0.14	0.12	0.14	0.14
Positive significant crosses		8	3	0	5	4	1	11	6	0	2	1	0
Negative significant crosses		1	3	36	0	0	17	7	14	43	12	21	46
Positive value		29	23	2	39	29	4	24	15	0	11	9	2
Negative value		21	27	48	11	21	46	26	35	50	39	41	48

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.10: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for number of branches per plant under pooled environments.

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		2.22	-3.79	-15.99**
JDNOL-11-1 x Pusa Sawani		-2.15	-8.53**	-18.95**
JDNOL-11-1 x Parbhani Kranti		-0.16	-2.35	-21.31**
JDNOL-11-1 x GO-2		0.57	-0.98	-21.28**
JDNOL-11-1 x VRO-6		2.55	-1.88	-17.25**
JDNOL-11-3 x Arka Anamika		-9.09**	-9.94**	-21.36**
JDNOL-11-3 x Pusa Sawani		-8.15**	-9.67**	-19.95**
JDNOL-11-3 x Parbhani Kranti		8.32**	5.10	-9.95**
JDNOL-11-3 x GO-2		-5.59	-8.99**	-22.02**
JDNOL-11-3 x VRO-6		-5.33	-6.07	-19.52**
JDNOL-11-11 x Arka Anamika		-1.98	-7.67*	-19.38**
JDNOL-11-11 x Pusa Sawani		-1.70	-8.05*	-18.52**
JDNOL-11-11 x Parbhani Kranti		-1.80	-3.89	-22.54**
JDNOL-11-11 x GO-2		-0.53	-1.99	-22.08**
JDNOL-11-11 x VRO-6		20.67**	15.55**	-2.56
JDNOL-11-12 x Arka Anamika		-4.02	-8.82**	-20.39 **
JDNOL-11-12 x Pusa Sawani		-4.25	-9.67**	-19.95**
JDNOL-11-12 x Parbhani Kranti		5.24	3.92	-16.24**
JDNOL-11-12 x GO-2		-2.84	-3.40	-23.20**
JDNOL-11-12 x VRO-6		-4.87	-8.11*	-22.51**
JDNOL-11-14 x Arka Anamika		-4.91	-6.16	-15.84**
JDNOL-11-14 x Pusa Sawani		3.95	3.33	-7.33*
JDNOL-11-14 x Parbhani Kranti		-1.79	-6.76*	-16.39**
JDNOL-11-14 x GO-2		-2.75	-8.27**	-17.74**
JDNOL-11-14 x VRO-6		4.73	1.60	-8.88**
AOL-07-9 x Arka Anamika		-9.86**	-10.62**	-20.62**
AOL-07-9 x Pusa Sawani		-7.44**	-7.54*	-17.88**
AOL-07-9 x Parbhani Kranti		-4.65	-9.06**	-19.24**
AOL-07-9 x GO-2		-3.31	-8.38**	-18.63**
AOL-07-9 x VRO-6		-6.78*	-9.13**	-19.29**
AOL-08-5 x Arka Anamika		-3.95	-7.57*	-19.29**
AOL-08-5 x Pusa Sawani		8.25**	3.44	-8.34**
AOL-08-5 x Parbhani Kranti		10.18**	10.08**	-11.13**
AOL-08-5 x GO-2		2.17	1.39	-18.14**
AOL-08-5 x VRO-6		3.01	0.82	-14.98**
JOL-6k-2 x Arka Anamika		-0.86	-5.24	-17.25**
JOL-6k-2 x Pusa Sawani		-7.30*	-12.01**	-22.02**
JOL-6k-2 x Parbhani Kranti		0.54	-0.07	-19.47**
JOL-6k-2 x GO-2		9.04**	8.96*	-13.25**
JOL-6k-2 x VRO-6		-1.89	-4.64	-19.58**
JOL-08-7 x Arka Anamika		-4.62	-9.94**	-21.36**
JOL-08-7 x Pusa Sawani		12.70**	5.68	-6.35*
JOL-08-7 x Parbhani Kranti		14.74**	12.59**	-9.26**
JOL-08-7 x GO-2		3.53	2.28	-18.69**
JOL-08-7 x VRO-6		8.54**	4.19	-12.13**
JOL-08-12 x Arka Anamika		1.79	-1.75	-14.20**
JOL-08-12 x Pusa Sawani		13.27**	8.57**	-3.80
JOL-08-12 x Parbhani Kranti		2.19	1.77	-17.31**
JOL-08-12 x GO-2		4.42	3.29	-16.07**
JOL-08-12 x VRO-6		11.51**	9.48**	-7.68**
Range	**Min.**	-8.15	-12.01	-23.20
	Max.	20.67	15.55	-2.56
S. E. ±		0.07	0.08	0.08
Positive significant crosses		10	6	0
Negative significant crosses		6	20	48
Positive value		23	17	0
Negative value		27	33	50

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

which displayed desired relative heterosis were eight, five, eleven and two in E_1, E_2, E_3 and E_4, respectively.

The heterobeltiosis for this trait ranged from -17.69 per cent (JDNOL-11-3 x Parbhani Kranti) to 19.20 per cent (JOL-08-12 x Pusa Sawani) in E_1, -11.32 per cent (JDNOL-11-14 x Parbhani Kranti) to 20.82 per cent (AOL-08-5 x Pusa Sawani) in E_2, -21.95 per cent (AOL-07-9 x Parbhani Kranti) to 30.60 per cent (JOL-08-12 x GO-2) in E_3 and -29.13 per cent (AOL-08-5 x Arka Anamika) to 21.40 per cent (JDNOL-11-11 x VRO-6) in E_4. The number of crosses, which registered significant heterobeltiosis were three, four, six and one in E_1, E_2, E_3 and E_4, respectively.

The standard heterosis ranged from -26.68 per cent (JOL-6k-2 x Parbhani Kranti) to 5.47 per cent (JOL-08-12 x Arka Anamika) in E_1, -21.29 per cent (JDNOL-11-3 x Arka Anamika) to 14.48 per cent (JDNOL-11-14 x Pusa Sawani) in E_2, -34.64 per cent (JOL-08-12 x Arka Anamika) to -1.74 per cent (JDNOL-11-3 x Parbhani Kranti) in E_3, -31.31 per cent (AOL-08-5 x Arka Anamika) to 3.09 per cent (JDNOL-11-11 x VRO-6) in E_4, respectively. Only one cross in E_2 registered for significant and positive standard heterosis.

The range of standard heterosis in pooled analysis was -23.20 per cent (JDNOL-11-12 x GO-2) to -2.56 per cent (JDNOL-11-11 x VRO-6). None of crosses registered positive standard heterosis in desired direction for this trait.

4.3.6 Internodal length (Table 4.3.11 to 4.3.12)

The range of relative heterosis was -24.17 per cent (JDNOL-11-12 x VRO-6) to 9.01 per cent (AOL-08-5 x Arka Anamika) in E_1, -26.95 per cent (JDNOL-11-3 x VRO-6) to 22.07 per cent (AOL-08-5 x Pusa Sawani) in E_2, -4.02 per cent (JDNOL-11-11 x Parbhani Kranti) to 33.94 per cent (JDNOL-11-11 x VRO-6) in E_3 and -7.10 per cent (JDNOL-11-1 x Pusa Sawani) to 21.13 per cent (JOL-6k-2 x VRO-6) in E_4. Significant and negative relative heterosis was recorded by seven and nine hybrids in E_1 and E_2.

The heterobeltiosis ranged from -26.42 per cent (JDNOL-11-12 x VRO-6) to 4.65 per cent (JDNOL-11-1 x GO-2) in E_1, -31.34 per cent (JDNOL-11-3 x Arka Anamika) to 16.13 per cent (AOL-08-5 x Arka Anamika) in E_2, -6.35 per cent (JDNOL-11-11 x Parbhani Kranti) to

Table 4.3.11: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for internodal length (cm) under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	5.84	1.59	0.18	11.62*	-1.32	-3.78	22.13**	21.71**	12.71	-2.69	-2.88	-13.64*
JDNOL-11-1 x Pusa Sawani	7.72	2.49	2.95	0.58	-1.95	0.67	2.80	-0.19	-2.54	-7.10	-10.21	-14.76*
JDNOL-11-1 x Parbhani Kranti	-2.25	-6.68	-6.93	-14.63**	-17.21**	-14.08*	6.28	5.75	-1.76	-4.27	-4.97	-14.58*
JDNOL-11-1 x GO-2	8.72	4.65	2.59	-4.15	-5.65	-5.02	-0.47	-1.80	-9.69	5.93	5.28	-6.74
JDNOL-11-1 x VRO-6	-1.05	-6.42	-4.79	2.70	0.79	2.09	1.71	1.59	-6.35	2.96	2.45	-8.33
JDNOL-11-3 x Arka Anamika	-9.51*	-10.07	-11.31*	-21.65**	-31.34**	-31.67**	5.28	4.89	-2.14	-2.85	-2.94	-13.69*
JDNOL-11-3 x Pusa Sawani	0.59	-0.93	-0.49	-19.36**	-20.60**	-18.48**	-2.78	-4.95	-7.18	-0.06	-3.30	-8.20
JDNOL-11-3 x Parbhani Kranti	4.58	3.36	3.09	5.51	3.34	7.24	7.07	6.84	-0.32	12.15*	11.45	0.18
JDNOL-11-3 x GO-2	-9.57*	-9.85	-11.63*	-19.49**	-19.95**	-19.41**	-3.36	-5.32	-11.67	-2.06	-2.77	-13.69*
JDNOL-11-3 x VRO-6	-0.70	-2.81	-1.12	-26.95**	-27.59**	-26.65**	-3.68	-4.26	-10.68	4.29	3.88	-7.05
JDNOL-11-11 x Arka Anamika	-3.18	-8.12	-9.39	3.31	0.34	-20.26**	7.79	5.33	-2.46	4.74	2.97	-8.44
JDNOL-11-11 x Pusa Sawani	5.73	-0.53	-0.09	-1.71	-12.81*	-10.48	23.55**	17.69**	14.92*	-0.56	-5.28	-10.08
JDNOL-11-11 x Parbhani Kranti	6.89	0.90	0.63	0.41	-11.34*	-8.00	-4.02	-6.35	-13.00*	6.24	3.89	-6.61
JDNOL-11-11 x GO-2	2.25	-2.69	-4.61	0.42	-10.15	-9.55	15.61*	14.88*	2.83	8.38	7.41	-6.03
JDNOL-11-11 x VRO-6	4.77	-2.02	-0.31	4.94	-6.36	-5.15	33.94**	31.19**	20.93**	16.56**	14.25*	2.22
JDNOL-11-12 x Arka Anamika	-0.76	-2.22	-3.58	-12.62*	-20.01**	-27.90**	0.56	-2.19	-9.42	-1.73	-2.64	-13.43*
JDNOL-11-12 x Pusa Sawani	-5.43	-7.66	-7.25	-9.82	-15.32**	-13.06*	1.97	-3.31	-5.58	-0.87	-4.87	-9.69
JDNOL-11-12 x Parbhani Kranti	-0.92	-2.91	-3.18	-9.83	-15.75**	-12.57*	8.74	5.60	-1.90	9.50	7.90	-3.00
JDNOL-11-12 x GO-2	-8.96	-10.04	-11.81*	3.14	-2.25	-1.60	6.24	5.07	-5.95	10.85	10.72	-3.13
JDNOL-11-12 x VRO-6	-24.17**	-26.42**	-25.13**	-20.96**	-25.31**	-24.34**	3.06	0.46	-7.39	0.65	-0.58	-11.05
JDNOL-11-14 x Arka Anamika	1.92	1.58	0.85	13.04*	0.09	-2.75	6.21	6.17	-1.68	10.31	8.36	-0.10
JDNOL-11-14 x Pusa Sawani	-8.11	-8.64	-8.23	2.98	0.22	2.89	22.35**	19.14**	16.34*	3.00	1.51	-3.63
JDNOL-11-14 x Parbhani Kranti	-9.75*	-9.96	-10.2	-0.29	-3.47	0.18	7.17	6.95	-0.64	9.81	8.44	-0.03
JDNOL-11-14 x GO-2	-1.86	-2.48	-3.18	-17.36**	-18.80**	-18.26**	23.80**	21.78**	12.68	-2.79	-5.27	-12.67*
JDNOL-11-14 x VRO-6	-1.00	-2.20	-0.49	-5.31	-7.24	-6.04	3.28	3.09	-4.62	7.45	5.87	-2.4
AOL-07-9 x Arka Anamika	4.38	3.43	3.89	10.82	-2.05	-4.44	3.30	2.85	-4.75	11.42	9.37	0.97
AOL-07-9 x Pusa Sawani	-11.13*	-11.13*	-10.73*	-19.81**	-21.81**	-19.72**	3.51	0.41	-1.95	5.41	3.96	-1.31
AOL-07-9 x Parbhani Kranti	2.46	2.09	2.55	-4.68	-7.53	-4.04	3.28	2.67	-4.62	-3.80	-5.07	-12.36
AOL-07-9 x GO-2	-7.57	-8.68	-8.27	-2.64	-4.15	-3.51	-2.03	-3.26	-11.19	0.68	-1.95	-9.48
AOL-07-9 x VRO-6	-13.47**	-14.02**	-12.52*	4.87	2.94	4.26	7.02	6.81	-1.55	11.34	9.62	1.20
AOL-08-5 x Arka Anamika	9.01	2.90	1.48	20.86**	16.13*	-13.02*	-2.48	-3.20	-10.36	6.48	5.96	-4.86
AOL-08-5 x Pusa Sawani	6.33	-0.49	-0.04	22.07**	2.08	4.80	5.29	1.83	-0.56	-4.06	-6.66	-11.39

Table 4.3.11 Continue…

Table 4.3.11 Continue…

Cross		E1			E2			E3			E4		
		MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
AOL-08-5 x Parbhani Kranti		6.11	-0.36	-0.63	20.10**	0.00	3.78	14.27*	13.25	5.21	6.31	6.25	-4.49
AOL-08-5 x GO-2		-4.92	-9.99	-11.76*	20.89**	1.90	2.58	10.06	9.01	-0.53	0.80	-0.49	-10.66
AOL-08-5 x VRO-6		-5.88	-12.44*	-10.91*	14.87*	-3.42	-2.18	7.55	7.01	-1.36	10.32	10.13	-1.12
JOL-6k-2 x Arka Anamika		2.52	0.63	-0.76	11.08	0.63	-7.15	5.69	-0.4	-7.77	0.21	0.06	-11.02
JOL-6k-2 x Pusa Sawani		-3.98	-6.59	-6.17	7.98	2.51	5.24	5.96	-2.57	-4.86	10.05	6.41	1.02
JOL-6k-2 x Parbhani Kranti		6.71	4.17	3.89	6.19	0.30	4.09	3.68	-2.44	-9.37	13.09*	12.32	0.97
JOL-6k-2 x GO-2		-3.43	-4.93	-6.80	7.99	3.49	4.18	1.40	-2.89	-13.08*	6.87	6.16	-5.88
JOL-6k-2 x VRO-6		2.84	-0.57	1.16	-0.71	-5.13	-3.91	4.45	-1.36	-9.08	21.13**	20.58**	7.89
JOL-08-7 x Arka Anamika		6.92	2.95	1.52	-4.72	-5.28	-28.21**	4.67	3.46	-4.19	5.24	4.47	-7.11
JOL-08-7 x Pusa Sawani		-0.16	-4.72	-4.29	-4.71	-17.18**	-14.97*	2.20	-1.56	-3.87	10.16	5.92	0.55
JOL-08-7 x Parbhani Kranti		6.25	1.75	1.48	-4.70	-17.55**	-14.44*	-3.25	-4.51	-11.29	9.14	7.76	-3.13
JOL-08-7 x GO-2		5.88	2.24	0.22	-3.88	-15.75**	-15.19**	11.12	10.53	0.00	1.81	1.73	-10.87
JOL-08-7 x VRO-6		-8.29	-13.01*	-11.49*	-9.73	-21.10**	-20.08**	26.83**	25.66**	15.83*	1.96	0.91	-9.72
JOL-08-12 x Arka Anamika		-21.96**	-22.54**	-23.61**	2.00	-7.32	-15.06**	22.56**	18.02*	9.29	7.35	6.17	-5.59
JOL-08-12 x Pusa Sawani		3.76	2.05	2.50	1.97	-3.50	-0.93	6.52	0.03	-2.32	15.38*	10.54	4.94
JOL-08-12 x Parbhani Kranti		-0.36	-1.66	-1.92	8.21	1.88	5.73	16.68**	12.18	4.22	1.60	-0.06	-10.16
JOL-08-12 x GO-2		-4.77	-5.20	-7.07	1.96	-2.60	-1.95	12.26	9.90	-1.63	5.03	4.72	-8.39
JOL-08-12 x VRO-6		1.19	-1.10	0.63	-0.90	-5.61	-4.40	11.39	7.50	-0.91	12.20*	10.63	-1.02
Range	**Min.**	-24.17	-26.42	-25.13	-26.95	-31.34	-31.67	-4.02	-6.35	-13.08	-7.10	-10.21	-14.76
	Max.	9.01	4.65	3.89	22.07	16.13	7.24	33.94	31.19	20.93	21.13	20.58	7.89
S. E. ±		0.34	0.40	0.40	0.37	0.42	0.42	0.69	0.80	0.80	0.68	0.79	0.79
Positive significant crosses		0	0	0	7	1	0	10	8	4	6	2	0
Negative significant crosses		7	6	1	9	17	19	0	0	2	0	0	7
Positive value		23	15	16	26	15	12	42	33	11	12	34	9
Negative value		27	35	34	24	35	48	8	17	39	38	16	41

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.12: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for internodal length (cm) under pooled environments

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		9.37**	7.91*	-1.05
JDNOL-11-1 x Pusa Sawani		0.24	-3.10	-4.80
JDNOL-11-1 x Parbhani Kranti		-2.73	-4.54	-9.09**
JDNOL-11-1 x GO-2		2.48	2.02	-5.60
JDNOL-11-1 x VRO-6		1.76	0.10	-5.12
JDNOL-11-3 x Arka Anamika		-4.95	-7.25	-13.02**
JDNOL-11-3 x Pusa Sawani		-4.57	-6.73	-8.37*
JDNOL-11-3 x Parbhani Kranti		7.80*	6.97	1.88
JDNOL-11-3 x GO-2		-7.41*	-8.03*	-13.75**
JDNOL-11-3 x VRO-6		-5.33	-5.83	-10.74**
JDNOL-11-11 x Arka Anamika		3.91	2.01	-8.96**
JDNOL-11-11 x Pusa Sawani		7.98*	1.24	-0.54
JDNOL-11-11 x Parbhani Kranti		2.08	-2.89	-7.51*
JDNOL-11-11 x GO-2		7.93*	4.10	-3.67
JDNOL-11-11 x VRO-6		17.48**	12.02**	6.19
JDNOL-11-12 x Arka Anamika		-2.70	-2.81	-13.06**
JDNOL-11-12 x Pusa Sawani		-2.60	-6.95*	-8.59*
JDNOL-11-12 x Parbhani Kranti		3.44	0.30	-4.48
JDNOL-11-12 x GO-2		4.04	2.31	-5.33
JDNOL-11-12 x VRO-6		-7.74*	-10.34**	-15.01**
JDNOL-11-14 x Arka Anamika		7.83*	4.81	-0.91
JDNOL-11-14 x Pusa Sawani		6.79*	4.78	2.94
JDNOL-11-14 x Parbhani Kranti		3.21	2.83	-2.06
JDNOL-11-14 x GO-2		2.55	1.46	-4.08
JDNOL-11-14 x VRO-6		2.03	1.89	-3.42
AOL-07-9 x Arka Anamika		7.37*	4.31	-1.28
AOL-07-9 x Pusa Sawani		-3.25	-5.02	-6.69
AOL-07-9 x Parbhani Kranti		-0.61	-0.92	-5.64
AOL-07-9 x GO-2		-2.41	-3.50	-8.67*
AOL-07-9 x VRO-6		3.86	3.78	-1.63
AOL-08-5 x Arka Anamika		6.26	4.30	-6.91*
AOL-08-5 x Pusa Sawani		5.43	-1.16	-2.90
AOL-08-5 x Parbhani Kranti		11.24**	5.82	0.78
AOL-08-5 x GO-2		6.17	2.40	-5.25
AOL-08-5 x VRO-6		7.10*	2.11	-3.21
JOL-6k-2 x Arka Anamika		4.26	3.77	-7.39*
JOL-6k-2 x Pusa Sawani		5.70	0.41	-1.35
JOL-6k-2 x Parbhani Kranti		7.68*	3.82	-1.12
JOL-6k-2 x GO-2		3.45	1.15	-6.41
JOL-6k-2 x VRO-6		8.26*	4.62	-0.83
JOL-08-7 x Arka Anamika		3.80	2.48	-8.54*
JOL-08-7 x Pusa Sawani		2.99	-2.91	-4.62
JOL-08-7 x Parbhani Kranti		2.16	-2.27	-6.92*
JOL-08-7 x GO-2		4.46	1.33	-6.24
JOL-08-7 x VRO-6		5.58	1.22	-4.05
JOL-08-12 x Arka Anamika		5.18	5.12	-6.08
JOL-08-12 x Pusa Sawani		7.83*	2.95	1.14
JOL-08-12 x Parbhani Kranti		7.05*	3.73	-1.20
JOL-08-12 x GO-2		4.64	2.84	-4.84
JOL-08-12 x VRO-6		7.19*	4.11	-1.31
Range	**Min.**	-7.74	-10.34	-15.01
	Max.	17.48	12.02	6.19
S. E. ±		0.30	0.34	0.34
Positive significant crosses		14	2	0
Negative significant crosses		2	3	15
Positive value		39	35	5
Negative value		11	15	45

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

31.19 per cent (JDNOL-11-11 x VRO-6) in E_3 and -10.21 per cent (JDNOL-11-1 x Pusa Sawani) to 20.58 per cent (JOL-6k-2 x VRO-6) in E_4. The significant negative heterobeltiosis were recorded by six and seventeen crosses in E_1 and E_2.

The range of standard heterosis in the environments E_1, E_2, E_3 and E_4 varied from -25.13 per cent (JDNOL-11-12 x VRO-6) to 3.89 per cent (JOL-6k-2 x Parbhani Kranti), -31.67 per cent (JDNOL-11-3 x Arka Anamika) to 7.24 per cent (JDNOL-11-3 x Parbhani Kranti), -13.08 per cent (JOL-6k-2 x GO-2) to 20.93 per cent (JDNOL-11-11 x VRO-6) and -14.76 per cent (JDNOL-11-1 x Pusa Sawani) to 7.89 per cent (JOL-6k-2 x VRO-6), respectively. The significant negative crosses one, nineteen, two and seven for this character found in E_1, E_2, E_3 and E_4, respectively.

In pooled analysis, the range of standard heterosis was -15.01 per cent (JDNOL-11-12 x VRO-6) to 6.19 per cent (JDNOL-11-11 x VRO-6). The best three hybrids having significant and negative and standard heterosis in desirable direction were JDNOL-11-12 x VRO-6 (-15.01 %), JDNOL-11-3 x GO-2 (-13.75 %) and JDNOL-11-12 x Arka Anamika (-13.06 %).

4.3.7 Plant height (Table 4.3.13 to 4.3.14)

The range of relative heterosis was -13.54 per cent (JDNOL-11-3 x Pusa Sawani) to 9.63 per cent (JOL-08-12 x Arka Anamika) in E_1, -20.13 per cent (JDNOL-11-1 x VRO-6) to 17.86 per cent (JDNOL-11-11 x GO-2) in E_2, -22.26 per cent (JDNOL-11-3 x Pusa Sawani) to 34.75 per cent (AOL-08-5 x GO-2) in E_3 and -20.96 per cent (JDNOL-11-3 x Pusa Sawani) to 24.38 per cent (JOL-6k-2 x GO-2) was in E_4. Significant and negative relative heterosis was recorded by eight, seven, seven and five hybrids in E_1, E_2, E_3 and E_4, respectively.

The heterobeltiosis ranged from -18.26 per cent (JOL-6k-2 x VRO-6) to 6.65 per cent (JDNOL-11-12 x Arka Anamika) in E_1, -22.71 per cent (JDNOL-11-1 x VRO-6) to 8.51 per cent (JDNOL-11-11 x GO-2) in E_2, -28.48 per cent (JDNOL-11-1 x VRO-6) to 33.95 per cent (AOL-08-5 x GO-2) in E_3 and -22.52 per cent (JDNOL-11-1 x VRO-6) to 21.95 per cent (JOL-6k-2 x GO-2) in E_4. The significant negative heterobeltiosis were recorded by fourteen, thirteen, twelve and six crosses in E_1, E_2, E_3 and E_4, respectively.

Table 4.3.13: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for plant height (cm) under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	2.33	-1.02	-5.87	-0.06	-1.30	-5.20	9.53*	-2.72	-0.09	-2.28	-2.48	-3.70
JDNOL-11-1 x Pusa Sawani	-0.60	-8.33	-3.54	-0.46	-5.87	-1.09	-5.89	-6.18	-3.65	-3.14	-3.26	-4.47
JDNOL-11-1 x Parbhani Kranti	-2.43	-7.00	-8.8	-5.17	-8.71*	-7.59	-6.76	-11.46*	-9.07	-5.74	-9.15	-10.29*
JDNOL-11-1 x GO-2	6.99	3.83	-1.93	2.95	1.70	-2.38	9.25	-5.15	-2.59	10.40*	-3.18	-4.39
JDNOL-11-1 x VRO-6	-3.16	-10.55*	-6.19	-20.13**	-22.71**	-22.60**	-21.05**	-28.48**	-26.55**	-20.47**	-22.52**	-23.49**
JDNOL-11-3 x Arka Anamika	0.41	-2.14	-1.94	1.23	-0.09	-1.47	-0.16	-10.76*	-9.67	-7.45	-8.15	-8.28
JDNOL-11-3 x Pusa Sawani	-13.54**	-15.60**	-11.19*	-4.33	-7.27	-2.56	-22.26**	-22.58**	-20.98**	-20.96**	-21.50**	-21.61**
JDNOL-11-3 x Parbhani Kranti	-9.74*	-10.70*	-10.52*	2.32	1.00	2.25	11.72*	6.83	8.13	7.80	3.35	3.21
JDNOL-11-3 x GO-2	-7.18	-9.85	-9.66	-7.93*	-9.16*	-10.42**	-9.39	-20.84**	-19.88**	-10.96*	-22.28**	-22.39**
JDNOL-11-3 x VRO-6	-5.56	-7.66	-3.16	1.77	0.99	1.14	10.19*	0.47	1.70	1.40	-1.75	-1.89
JDNOL-11-11 x Arka Anamika	8.4	2.58	-2.45	11.82**	2.92	-1.15	20.33**	9.86	6.04	-2.03	-3.49	-5.09
JDNOL-11-11 x Pusa Sawani	0.39	-9.31	-4.57	1.95	-9.85**	-5.27	4.32	1.48	3.58	1.86	0.27	-1.24
JDNOL-11-11 x Parbhani Kranti	1.51	-5.31	-7.14	-2.08	-11.98**	-10.90**	7.59	5.27	1.61	3.74	1.67	-2.99
JDNOL-11-11 x GO-2	-3.59	-8.47	-13.55**	17.86**	8.51*	4.16	-0.98	-11.70*	-14.77**	2.69	-8.59	-12.77*
JDNOL-11-11 x VRO-6	3.07	-6.75	-2.21	15.35**	4.19	4.34	15.35**	7.50	3.76	3.96	2.99	-1.73
JDNOL-11-12 x Arka Anamika	7.18	6.65	1.43	0.34	-0.29	-4.23	-9.61*	-19.90**	-17.32**	-13.76**	-13.95**	-15.37**
JDNOL-11-12 x Pusa Sawani	-1.82	-6.98	-2.11	-4.87	-9.50*	-4.91	-12.70**	-13.19**	-10.39*	-7.71	-7.98	-9.36
JDNOL-11-12 x Parbhani Kranti	-9.07*	-10.87*	-12.60*	-2.33	-5.41	-4.25	-1.89	-7.05	-4.06	3.16	-0.17	-2.24
JDNOL-11-12 x GO-2	6.78	6.62	0.71	-16.22**	-16.72**	-20.06**	19.37**	3.42	6.75	8.82	-4.22	-6.21
JDNOL-11-12 x VRO-6	-9.29*	-13.92**	-9.73	-1.42	-4.03	-3.89	10.67*	0.03	3.26	0.61	-1.59	-3.63
JDNOL-11-14 x Arka Anamika	-4.14	-6.48	-6.51	2.05	-0.01	0.08	-3.56	-16.49**	-9.03	-7.18	-7.83	-9.35
JDNOL-11-14 x Pusa Sawani	-7.99	-10.29*	-5.60	-0.51	-2.87	2.06	-17.46**	-20.06**	-12.92*	4.41	3.60	2.04
JDNOL-11-14 x Parbhani Kranti	-7.19	-8.08	-8.10	1.93	1.36	2.61	3.30	-4.55	3.98	4.01	1.13	-1.93
JDNOL-11-14 x GO-2	-4.32	-6.96	-6.98	-4.28	-6.24	-6.16	8.41	-8.16	0.04	12.23*	-0.79	-3.80
JDNOL-11-14 x VRO-6	-4.70	-6.93	-2.40	-3.30	-3.33	-3.18	4.74	-7.55	0.71	1.21	-0.53	-3.54
AOL-07-9 x Arka Anamika	-3.53	-8.52	-2.97	-1.55	-2.54	-4.47	8.02	-4.53	-0.85	-4.47	-5.48	-5.04
AOL-07-9 x Pusa Sawani	-12.92**	-13.26**	-8.00	-8.60*	-11.67**	-7.19	-20.99**	-21.67**	-18.65**	-17.91**	-18.71**	-18.33**
AOL-07-9 x Parbhani Kranti	-10.95*	-14.30**	-9.11	0.21	-1.37	-0.16	-1.46	-6.92	-3.32	-5.67	-9.83	-9.41
AOL-07-9 x GO-2	1.51	-4.05	1.77	-7.07*	-8.04*	-9.86*	-11.04*	-23.13**	-20.16**	-0.77	-13.61**	-13.21**
AOL-07-9 x VRO-6	-10.16*	-10.66*	-5.25	-0.97	-2.02	-1.88	1.84	-8.20	-4.66	2.31	-1.17	-0.71
AOL-08-5 x Arka Anamika	-1.42	-2.79	-4.90	-12.13**	-15.29**	-18.63**	24.60**	22.11**	-2.64	6.23	-1.60	-3.23
AOL-08-5 x Pusa Sawani	-7.41	-10.66*	-5.99	1.66	-6.04	-1.28	19.42**	4.49	6.64	7.32	-0.66	-2.15

Table 4.3.13 Continue…

Table 4.3.13 Continue…

Cross		E1			E2			E3			E4		
		MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
AOL-08-5 x Parbhani Kranti		-1.54	-1.65	-3.56	4.88	-1.38	-0.17	24.23**	13.59*	4.91	15.07**	10.2	0.95
AOL-08-5 x GO-2		-8.33	-9.91	-11.87*	7.28*	3.46	-0.69	34.75**	33.95**	2.53	23.99**	17.05**	-1.85
AOL-08-5 x VRO-6		-7.03	-10.15*	-5.77	-4.20	-9.47*	-9.34*	10.76	6.22	-11.44*	4.32	-1.13	-7.42
JOL-6k-2 x Arka Anamika		8.35	3.69	-1.39	6.65	5.26	1.10	28.31**	22.90**	-2.01	9.71	-1.93	-3.55
JOL-6k-2 x Pusa Sawani		-3.16	-11.58*	-6.96	-0.75	-6.2	-1.44	16.18**	-0.36	1.70	1.92	-8.96	-10.33*
JOL-6k-2 x Parbhani Kranti		-2.43	-7.97	-9.76	-3.43	-7.10	-5.96	16.37**	4.18	-3.77	2.82	-5.11	-13.07*
JOL-6k-2 x GO-2		9.25	4.90	-0.92	0.70	-0.59	-4.57	11.24	9.31	-17.32**	24.38**	21.95**	-5.51
JOL-6k-2 x VRO-6		-10.62 *	-18.26**	-14.28**	-14.66**	-17.48**	-17.36**	14.05*	6.96	-10.82*	3.54	-5.40	-11.41*
JOL-08-7 x Arka Anamika		-4.70	-5.19	-9.83	4.60	4.56	0.51	21.79**	21.30**	-2.51	1.64	-1.81	-3.43
JOL-08-7 x Pusa Sawani		-3.64	-8.73	-3.96	0.41	-3.86	1.02	11.94*	0.05	2.11	7.75	4.02	2.45
JOL-08-7 x Parbhani Kranti		-6.94	-8.81	-10.58*	-0.81	-3.31	-2.12	19.02**	11.29*	2.79	5.95	5.91	-2.91
JOL-08-7 x GO-2		0.69	0.51	-5.06	-6.84	-6.9	-10.51**	7.20	4.04	-16.39**	16.23**	5.32	-3.45
JOL-08-7 x VRO-6		-2.05	-7.07	-2.55	1.96	-0.09	0.06	14.90**	12.83*	-5.93	7.60	6.47	-0.30
JOL-08-12 x Arka Anamika		9.63*	3.32	-1.74	-7.18*	-10.37*	-13.91**	9.63	-1.11	-1.95	-1.41	-1.51	-3.14
JOL-08-12 x Pusa Sawani		-5.26	-14.74**	-10.29*	6.13	-1.76	3.22	-4.28	-5.65	-3.70	4.73	4.55	2.98
JOL-08-12 x Parbhani Kranti		6.10	-1.41	-3.33	1.11	-4.78	-3.60	7.49	3.81	2.93	2.09	-1.32	-3.13
JOL-08-12 x GO-2		2.43	-3.15	-8.52	-2.07	-5.41	-9.20*	16.18**	2.40	1.53	8.93	-4.22	-5.98
JOL-08-12 x VRO-6		6.95	-3.61	1.09	7.89*	2.12	2.28	15.12**	5.96	5.07	0.19	-2.11	-3.91
Range	**Min.**	-13.54	-18.26	-13.55	-20.13	-22.71	-22.60	-22.26	-28.48	-26.55	-20.96	-22.52	23.49
	Max.	9.63	6.65	1.77	17.86	8.51	4.34	34.75	33.95	8.13	24.38	21.95	3.21
S. E. ±		5.51	6.36	6.36	4.23	4.89	4.89	7.57	8.75	8.75	7.68	8.87	8.87
Positive significant crosses		1	0	0	5	1	0	21	7	0	6	2	0
Negative significant crosses		8	14	8	7	13	11	7	12	13	5	6	11
Positive value		17	8	4	23	11	13	34	25	20	34	14	5
Negative value		33	42	46	27	39	37	16	25	30	16	36	45

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.14 : Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for plant height (cm) under pooled environments

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		2.42	-0.18	-3.44
JDNOL-11-1 x Pusa Sawani		-2.87	-5.52*	-3.33
JDNOL-11-1 x Parbhani Kranti		-5.24*	-5.99*	-9.06**
JDNOL-11-1 x GO-2		7.70**	0.34	-2.93
JDNOL-11-1 x VRO-6		-16.86**	-17.86**	-20.5**
JDNOL-11-3 x Arka Anamika		-1.95	-5.98**	-5.92**
JDNOL-11-3 x Pusa Sawani		-16.24**	-17.17 **	-15.25**
JDNOL-11-3 x Parbhani Kranti		3.99*	1.46	1.53
JDNOL-11-3 x GO-2		-9.01**	-16.53**	-16.48**
JDNOL-11-3 x VRO-6		2.33	-0.55	-0.49
JDNOL-11-11 x Arka Anamika		9.16**	8.34**	-0.51
JDNOL-11-11 x Pusa Sawani		2.30	-3.64	-1.40
JDNOL-11-11 x Parbhani Kranti		3.21	0.63	-4.20
JDNOL-11-11 x GO-2		3.51	-0.45	-9.96**
JDNOL-11-11 x VRO-6		9.29**	6.99**	1.02
JDNOL-11-12 x Arka Anamika		-5.24*	-8.23**	-10.06**
JDNOL-11-12 x Pusa Sawani		-7.35**	-9.30**	-7.20**
JDNOL-11-12 x Parbhani Kranti		-2.04	-3.44	-5.37*
JDNOL-11-12 x GO-2		5.84**	-1.98	-3.93
JDNOL-11-12 x VRO-6		0.82	-1.02	-2.99
JDNOL-11-14 x Arka Anamika		-3.56	-8.24**	-6.68**
JDNOL-11-14 x Pusa Sawani		-5.75**	-6.04**	-3.86
JDNOL-11-14 x Parbhani Kranti		0.98	-2.24	-0.59
JDNOL-11-14 x GO-2		3.82	-5.46*	-3.86
JDNOL-11-14 x VRO-6		-0.06	-3.64	-2.00
AOL-07-9 x Arka Anamika		-0.26	-5.28*	-3.28
AOL-07-9 x Pusa Sawani		-15.78**	-15.86**	-13.91**
AOL-07-9 x Parbhani Kranti		-4.37*	-7.61**	-5.66*
AOL-07-9 x GO-2		-4.49*	-13.18**	-11.35**
AOL-07-9 x VRO-6		-1.33	-5.05*	-3.04
AOL-08-5 x Arka Anamika		5.11*	1.66	-6.64**
AOL-08-5 x Pusa Sawani		6.05**	-2.51	-0.25
AOL-08-5 x Parbhani Kranti		11.49**	5.99*	0.90
AOL-08-5 x GO-2		15.21**	13.68**	-2.46
AOL-08-5 x VRO-6		1.40	-3.23	-8.63**
JOL-6k-2 x Arka Anamika		13.41**	7.06**	-1.68
JOL-6k-2 x Pusa Sawani		4.1	-6.47**	-4.3
JOL-6k-2 x Parbhani Kranti		3.86	-3.58	-8.21**
JOL-6k-2 x GO-2		11.78**	10.46**	-7.74**
JOL-6k-2 x VRO-6		-1.22	-7.96**	-13.09**
JOL-08-7 x Arka Anamika		6.01**	4.87*	-3.69
JOL-08-7 x Pusa Sawani		4.80*	-1.58	0.70
JOL-08-7 x Parbhani Kranti		5.12*	2.18	-2.72
JOL-08-7 x GO-2		4.98*	1.27	-8.99**
JOL-08-7 x VRO-6		6.01**	3.45	-2.32
JOL-08-12 x Arka Anamika		2.68	1.68	-4.76*
JOL-08-12 x Pusa Sawani		0.33	-3.91	-1.68
JOL-08-12 x Parbhani Kranti		4.27*	3.44	-1.53
JOL-08-12 x GO-2		7.19**	1.38	-5.03*
JOL-08-12 x VRO-6		7.41**	6.98**	1.02
Range	**Min.**	-16.86	-17.86	-16.48
	Max.	15.21	13.68	1.53
S. E. ±		2.96	3.42	3.42
Positive significant crosses		18	8	0
Negative significant crosses		10	18	21
Positive value		32	18	5
Negative value		18	32	45

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

The range of standard heterosis in the environments E_1, E_2, E_3 and E_4 varied from -13.55 per cent (JDNOL-11-11 x GO-2) to 1.77 per cent (AOL-07-9 x GO-2), -22.60 per cent (JDNOL-11-1 x VRO-6) to 4.34 per cent (JDNOL-11-11 x VRO-6), -26.55 per cent (JDNOL-11-1 x VRO-6) to 8.13 per cent (JDNOL-11-3 x Parbhani Kranti) and -23.49 per cent (JDNOL-11-1 x VRO-6) to 3.21 per cent (JDNOL-11-3 x Parbhani Kranti), respectively. The significant negative standard heterosis was recorded by eight, eleven, thirteen and eleven crosses in E_1, E_2, E_3 and E_4, respectively.

In pooled analysis, the range of standard heterosis was -16.48 per cent (JDNOL-11-3 x GO-2) to 1.53 per cent (JDNOL-11-3 x Parbhani Kranti). The best three hybrids having significant and negative and standard heterosis in desirable direction were JDNOL-11-3 x GO-2 (-16.48 %), JDNOL-11-3 x Pusa Sawani (-15.25 %) and AOL-07-9 x Pusa Sawani (-13.91 %) in pooled analysis.

4.3.8 Fruit yield per plant (Table 4.3.15 to 4.3.16)

Fruit yield per plant in all attributes of economics importance, which the breeder attempt to improve by evolving high yielding varieties. The estimates of relative, heterobeltiosis and standard heterosis are useful indictors for improving this character.

The relative heterosis ranged from -16.10 per cent (JOL-08-12 x Arka Anamika) to 46.90 per cent (JOL-6k-2 x GO-2) in E_1, -18.17 per cent (JOL-08-12 x Arka Anamika) to 46.90 per cent (JOL-6k-2 x GO-2) in E_2, -18.28 per cent (JDNOL-11-11 x Pusa Sawani) to 33.77 per cent (JOL-08-7 x GO-2) in E_3 and -19.64 per cent (AOL-07-9 x VRO-6) to 13.92 per cent (JOL-6k-2 x Arka Anamika) in E_4. Significant positive relative heterosis was expressed by eleven, fourteen, eighteen and five in E_1, E_2, E_3 and E_4, respectively.

The estimated heterobeltiosis varied from -17.00 per cent (JDNOL-11-14 x Arka Anamika) to 14.48 per cent (JOL-08-7 x Parbhani Kranti) in E_1, -21.89 per cent (JDNOL-11-14 x Arka Anamika) to 17.11 per cent (AOL-08-5 x Parbhani Kranti) in E_2, -25.90 per cent (JDNOL-11-11 x Pusa Sawani) to 32.74 per cent (JOL-08-7 x GO-2) in E_3 and -20.14 per cent (AOL-07-9 x VRO-6) to 11.17 per cent (JOL-08-7 x GO-2) in E_4, respectively. The number of crosses, which registered significant positive heterobeltiosis were two, five, nine and one in E_1, E_2, E_3 and E_4, respectively.

Table 4.3.15: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for fruit yield per plant (g) under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	4.04	1.10	-8.31	1.67	1.10	-15.80**	2.35	-0.10	-20.60**	1.52	-0.75	-5.49
JDNOL-11-1 x Pusa Sawani	-2.16	-2.91	-15.63**	-10.07*	-13.86**	-22.52**	17.03**	15.70*	-5.90	-10.26*	-11.73*	-13.10**
JDNOL-11-1 x Parbhani Kranti	0.58	-0.08	-13.37*	-3.50	-3.61	-20.44**	-1.67	-9.71	-14.20*	-6.89	-9.00	-9.23
JDNOL-11-1 x GO-2	2.60	2.32	-12.44*	0.18	-2.37	-19.60**	14.44*	13.58	-9.73	-19.22**	-19.37**	-23.21**
JDNOL-11-1 x VRO-6	-2.99	-5.12	-15.08**	7.44	4.89	-9.32*	-14.26*	-23.01**	-23.13**	-5.92	-7.43	-8.92
JDNOL-11-3 x Arka Anamika	0.41	0.34	-9.00	-4.12	-6.75	-17.83**	14.40*	1.63	-0.99	-7.43	-10.04*	-13.28**
JDNOL-11-3 x Pusa Sawani	1.35	-0.71	-10.07	-7.24	-8.19	-17.41**	5.12	-3.56	-6.05	-1.00	-2.03	-3.56
JDNOL-11-3 x Parbhani Kranti	9.24	6.91	-3.17	4.22	0.92	-11.08**	4.89	3.60	0.93	3.98	2.24	1.98
JDNOL-11-3 x GO-2	7.73	4.48	-5.37	4.53	-1.38	-13.10**	-10.63	-19.41**	-21.49**	-0.70	-1.48	-5.03
JDNOL-11-3 x VRO-6	-7.01	-7.56	-16.28**	2.38	1.41	-10.64*	-2.68	-3.86	-4.01	-4.99	-5.96	-7.47
JDNOL-11-11 x Arka Anamika	-1.22	-3.92	-12.87*	-1.22	-3.92	-19.99**	4.05	-8.60	-8.62	9.31	6.40	-3.21
JDNOL-11-11 x Pusa Sawani	-12.99*	-13.58*	-24.89**	-7.87	-13.63**	-22.31**	-18.28**	-25.90**	-25.92**	-6.18	-12.05*	-13.43**
JDNOL-11-11 x Parbhani Kranti	-1.09	-1.65	-14.73**	-2.88	-5.13	-21.70**	-2.56	-4.97	-4.99	-9.05*	-15.26**	-15.48**
JDNOL-11-11 x GO-2	4.71	4.33	-10.56	4.71	4.33	-17.87**	-3.26	-13.76*	-13.77*	2.19	-2.53	-7.52
JDNOL-11-11 x VRO-6	15.54**	13.10*	1.22	8.97*	4.10	-10.01*	0.59	0.52	0.50	4.95	-1.60	-3.18
JDNOL-11-12 x Arka Anamika	6.88	3.49	-6.14	6.88	3.49	-13.81**	21.17**	12.14	-0.30	-1.54	-4.21	-12.86**
JDNOL-11-12 x Pusa Sawani	3.89	2.71	-10.74*	-2.39	-8.88	-18.04**	2.79	-1.59	-12.51*	1.14	-5.24	-6.72
JDNOL-11-12 x Parbhani Kranti	-12.83*	-13.72*	-25.19**	1.71	-1.09	-18.37**	-3.32	-6.43	-11.09	1.06	-5.89	-6.13
JDNOL-11-12 x GO-2	-2.34	-2.44	-16.96**	-2.34	-2.44	-23.75**	8.86	2.36	-9.00	-15.20**	-19.16**	-23.30**
JDNOL-11-12 x VRO-6	-3.99	-6.43	-16.26**	-4.28	-8.96	-21.30**	6.05	0.25	0.09	0.53	-5.79	-7.30
JDNOL-11-14 x Arka Anamika	-14.85**	-17.00**	-20.73**	-17.50**	-21.89**	-27.20**	-6.87	-16.52**	-20.32**	-12.35**	-14.58**	-18.13**
JDNOL-11-14 x Pusa Sawani	0.19	-4.33	-8.62	-8.22*	-9.81*	-15.95**	6.56	-1.32	-5.81	2.14	0.79	-0.78
JDNOL-11-14 x Parbhani Kranti	-4.52	-8.92	-13.01*	11.47**	5.09	-2.06	13.88**	13.63*	8.45	6.51	4.43	4.16
JDNOL-11-14 x GO-2	7.07	1.24	-3.30	3.64	-4.72	-11.20**	14.96**	4.62	-0.14	4.21	3.68	-0.62
JDNOL-11-14 x VRO-6	5.08	1.77	-2.8	-0.63	-4.22	-10.74*	-4.91	-7.00	-7.15	6.54	5.16	3.47
AOL-07-9 x Arka Anamika	-2.52	-6.4	-7.76	-3.3	-7.84	-15.30**	11.73*	-1.08	-2.88	-1.61	-5.89	-6.24
AOL-07-9 x Pusa Sawani	-6.51	-12.03*	-13.31*	-12.45**	-13.38**	-20.39**	3.53	-5.35	-7.08	-12.04**	-12.57*	-12.89**
AOL-07-9 x Parbhani Kranti	-10.40*	-15.79**	-17.01**	-12.63**	-17.08**	-23.79**	-7.43	-8.92	-10.58	-6.78	-6.84	-7.08
AOL-07-9 x GO-2	-2.17	-8.84	-10.17	-2.99	-10.24*	-17.51**	5.96	-4.78	-6.51	2.06	-0.37	-0.74
AOL-07-9 x VRO-6	-12.84*	-16.84**	-18.05**	-15.62**	-18.12**	-24.75**	-14.74**	-15.45**	-15.59**	-19.64**	-20.14**	-20.44**
AOL-08-5 x Arka Anamika	-1.43	-5.04	-13.88*	-1.43	-5.04	-20.92**	18.43**	8.52	-1.39	-2.67	-2.72	-11.42*
AOL-08-5 x Pusa Sawani	8.38	6.59	-7.37	1.80	-5.43	-14.94**	14.91*	8.89	-1.06	4.18	0.27	-1.30

Table 4.3.15 Continue…

Table 4.3.15 Continue…

Cross		E1			E2			E3			E4		
		MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
AOL-08-5 x Parbhani Kranti		12.69*	10.96	-3.79	21.04**	17.11**	-3.34	3.50	1.24	-3.80	2.21	-2.24	-2.49
AOL-08-5 x GO-2		8.75	8.07	-8.02	8.75	8.07	-15.53**	20.48**	12.14	1.90	9.15*	6.94	1.47
AOL-08-5 x VRO-6		11.03*	7.65	-3.65	8.14	2.34	-11.53**	-3.33	-7.67	-7.82	-9.23*	-12.62*	-14.02**
JOL-6k-2 x Arka Anamika		25.13**	-7.25	-15.89**	25.13**	-7.25	-22.76**	0.91	-2.28	-21.08**	13.92**	5.50	-4.03
JOL-6k-2 x Pusa Sawani		31.43**	-1.20	-14.14**	21.18**	-12.35**	-21.16**	6.70	6.32	-13.52*	0.57	-10.12*	-11.52*
JOL-6k-2 x Parbhani Kranti		37.77**	3.65	-10.14	34.50**	-0.02	-17.48**	6.89	-1.13	-6.05	12.41*	-0.12	-0.37
JOL-6k-2 x GO-2		46.90**	11.21	-5.35	46.90**	11.21*	-13.08**	19.67**	17.82*	-4.84	5.72	-3.96	-8.88
JOL-6k-2 x VRO-6		37.85**	2.61	-8.16	33.21**	-2.44	-15.66**	-6.09	-15.06**	-15.19**	9.23	-2.36	-3.93
JOL-08-7 x Arka Anamika		17.95**	5.87	-3.99	17.95**	5.87	-11.83**	23.53**	20.55**	-4.16	3.24	3.03	-5.89
JOL-08-7 x Pusa Sawani		14.82*	5.05	-8.71	26.38**	9.71*	-1.31	26.81**	25.38**	1.97	-0.16	-3.76	-5.26
JOL-08-7 x Parbhani Kranti		24.99**	14.48*	-0.75	9.80**	16.98**	-3.46	26.30**	15.98**	10.21	11.80**	7.09	6.82
JOL-08-7 x GO-2		9.64	1.27	-13.81*	9.64	1.27	-20.85**	33.77**	32.74**	5.53	13.28**	11.17*	5.47
JOL-08-7 x VRO-6		11.4	0.58	-9.98	13.38**	0.12	-13.45**	4.73	-5.94	-6.09	-9.47*	-12.72*	-14.12**
JOL-08-12 x Arka Anamika		-16.10**	-16.15**	-23.96**	-18.17**	-20.09**	-30.17**	17.15**	10.11	-5.31	0.16	-3.56	-5.23
JOL-08-12 x Pusa Sawani		6.35	4.20	-5.63	16.41**	14.75**	3.22	28.15**	24.67**	7.22	-0.95	-1.03	-2.58
JOL-08-12 x Parbhani Kranti		9.07	6.75	-3.33	6.82	3.86	-9.25*	1.78	-3.05	-7.87	1.98	1.23	0.97
JOL-08-12 x GO-2		7.07	3.85	-5.95	4.34	-1.16	-13.63**	21.58**	16.12*	-0.14	-3.83	-5.49	-7.12
JOL-08-12 x VRO-6		6.6	5.97	-4.02	9.85*	9.26	-4.53	10.01	2.38	2.22	3.83	3.77	2.10
Range	**Min.**	-16.10	-17.00	-25.19	-18.17	-21.90	-30.17	-18.28	-25.90	-25.92	-19.64	-20.14	-23.21
	Max.	46.90	14.48	1.22	46.90	17.11	3.22	33.77	32.74	10.21	13.92	11.17	6.82
S. E. ±		10.29	11.88	11.88	8.71	10.06	10.06	15.00	17.32	17.32	12.92	14.92	14.92
Positive significant crosses		11	2	0	14	5	0	18	9	0	5	1	0
Negative significant crosses		6	7	22	7	10	44	3	7	12	9	12	14
Positive value		32	27	1	30	20	1	36	18	10	27	14	8
Negative value		18	23	49	20	30	49	14	32	40	23	36	42

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.16 : Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for fruit yield per plant (g) under pooled environments

Cross		Pooled		
		MP	**BP**	**SC**
JDNOL-11-1 x Arka Anamika		2.30	1.68	-12.67**
JDNOL-11-1 x Pusa Sawani		-1.46	-3.35	-13.68**
JDNOL-11-1 x Parbhani Kranti		-3.24	-6.40*	-14.00**
JDNOL-11-1 x GO-2		-1.78	-2.62	-16.36**
JDNOL-11-1 x VRO-6		-4.90*	-9.14**	-14.31**
JDNOL-11-3 x Arka Anamika		0.93	-3.81	-9.93**
JDNOL-11-3 x Pusa Sawani		-0.19	-2.5	-8.70**
JDNOL-11-3 x Parbhani Kranti		5.33*	4.34	-2.30
JDNOL-11-3 x GO-2		-0.69	-5.58*	-11.58**
JDNOL-11-3 x VRO-6		-3.17	-3.51	-9.01**
JDNOL-11-11 x Arka Anamika		3.39	1.35	-10.49**
JDNOL-11-11 x Pusa Sawani		-11.41**	-11.90**	-21.32**
JDNOL-11-11 x Parbhani Kranti		-4.26	-6.11*	-13.74**
JDNOL-11-11 x GO-2		1.61	-0.63	-12.24**
JDNOL-11-11 x VRO-6		6.49**	3.11	-2.76
JDNOL-11-12 x Arka Anamika		8.30**	8.29**	-8.13**
JDNOL-11-12 x Pusa Sawani		1.39	-1.15	-11.72**
JDNOL-11-12 x Parbhani Kranti		-2.88	-6.60*	-14.19**
JDNOL-11-12 x GO-2		-3.14	-3.37	-18.03**
JDNOL-11-12 x VRO-6		0.29	-4.75	-10.17**
JDNOL-11-14 x Arka Anamika		-12.53**	-17.23**	-21.31**
JDNOL-11-14 x Pusa Sawani		0.65	-2.40	-7.21**
JDNOL-11-14 x Parbhani Kranti		7.48**	5.67*	0.46
JDNOL-11-14 x GO-2		7.63**	1.60	-3.40
JDNOL-11-14 x VRO-6		1.37	0.96	-4.01
AOL-07-9 x Arka Anamika		1.45	-5.03	-7.62**
AOL-07-9 x Pusa Sawani		-6.74**	-10.56**	-13.00**
AOL-07-9 x Parbhani Kranti		-8.90**	-11.43**	-13.85**
AOL-07-9 x GO-2		1.2	-5.48*	-8.07**
AOL-07-9 x VRO-6		-15.99**	-17.27**	-19.53**
AOL-08-5 x Arka Anamika		3.68	2.71	-11.20**
AOL-08-5 x Pusa Sawani		7.50**	5.78*	-5.53*
AOL-08-5 x Parbhani Kranti		8.43**	5.23	-3.32
AOL-08-5 x GO-2		12.18**	10.85**	-4.16
AOL-08-5 x VRO-6		0.05	-4.11	-9.57**
JOL-6k-2 x Arka Anamika		14.19**	-0.40	-15.50**
JOL-6k-2 x Pusa Sawani		11.79**	-4.58	-14.78**
JOL-6k-2 x Parbhani Kranti		18.93**	0.34	-7.82**
JOL-6k-2 x GO-2		24.76**	9.05**	-7.94**
JOL-6k-2 x VRO-6		13.52**	-5.23	-10.62**
JOL-08-7 x Arka Anamika		14.75**	10.40**	-6.34*
JOL-08-7 x Pusa Sawani		15.63**	8.58**	-3.03
JOL-08-7 x Parbhani Kranti		22.07**	13.12**	3.93
JOL-08-7 x GO-2		17.48**	13.30**	-4.36
JOL-08-7 x VRO-6		3.25	-5.46*	-10.84**
JOL-08-12 x Arka Anamika		-2.83	-6.00*	-14.68**
JOL-08-12 x Pusa Sawani		12.04**	11.14**	0.88
JOL-08-12 x Parbhani Kranti		4.35	3.72	-4.71
JOL-08-12 x GO-2		6.92**	3.18	-6.35*
JOL-08-12 x VRO-6		7.41**	5.39*	-0.61
Range	**Min.**	-15.99	-17.23	-21.32
	Max.	24.76	13.30	3.93
S. E. ±		5.94	6.87	6.87
Positive significant crosses		20	11	0
Negative significant crosses		6	13	37
Positive value		34	22	3
Negative value		16	28	47

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

The standard heterosis varied from -25.19 per cent (JDNOL-11-12 x Parbhani Kranti) to 1.22 per cent (JDNOL-11-11 x VRO-6) in E_1, -30.17 per cent (JOL-08-12 x Arka Anamika) to 3.22 per cent (JOL-08-12 x Pusa Sawani) in E_2, -25.92 per cent (JDNOL-11-11 x Pusa Sawani) to 10.21 per cent (JOL-08-7 x Parbhani Kranti) in E_3 and -23.21 per cent (JDNOL-11-1 x GO-2) to 6.82 per cent (JOL-08-7 x Parbhani Kranti) in E_4, respectively. None of the hybrid recorded significant positive standard heterosis in all four environments.

The variation in the number of heterotic crosses observed in different environmental conditions indicated that the environment played considerable role in the expression of the trait. The present result also revealed that the estimates of relative heterosis, heterobeltiosis and standard heterosis was lowest to highest in both the directions shows bidirectional relationship.

4.3.9 Total number of fruits per plant (Table 4.3.17 to 4.3.18)

The relative heterosis in E_1 ranged from -15.20 per cent (-07-9 x Pusa Sawani) to 22.42 per cent (JOL-6k-2 x Pusa Sawani). Likewise, it was -20.36 per cent (JOL-08-12 x Arka Anamika) to 26.43 per cent (JOL-08-7 x GO-2) in E_2, -18.31 per cent (JOL-6k-2 x Parbhani Kranti) to 23.34 per cent (JOL-08-7 x GO-2) in E_3 and -12.43 per cent (JOL-6k-2 x Pusa Sawani) to 19.41 per cent (JOL-08-7 x GO-2) in E_4. The number of crosses, which recorded significant positive relative heterosis were fourteen, nine, eight and seven in E_1, E_2, E_3 and E_4, respectively.

The better parent ranged from -21.04 per cent (AOL-08-5 x Arka Anamika) to 17.58 per cent (AOL-08-5 x GO-2) in E_1, -24.64 per cent (JOL-08-12 x GO-2) to 22.71 per cent (JOL-08-7 x GO-2) in E_2, -21.67 per cent (JDNOL-11-12 x VRO-6) to 12.77 per cent (JDNOL-11-12 x GO-2) in E_3 and -16.83 per cent (AOL-07-9 x GO-2) to 16.34 per cent (JDNOL-11-12 x GO-2) in E_4. The number of crosses, which recorded significant positive heterobeltiosis were two, two, one and two in E_1, E_2, E_3 and E_4, respectively.

The standard heterosis ranged from -31.45 per cent (AOL-08-5 x Arka Anamika) to 1.65 per cent (JDNOL-11-14 x VRO-6) in E_1, -28.41 per cent (JOL-08-7 x Arka Anamika) to -4.84 per cent (AOL-08-5 x Pusa Sawani) in E_2, -24.77 per cent (JOL-6k-2 x Parbhani Kranti) to 10.24 per cent (JDNOL-11-14 x VRO-6) in E_3 and -17.23 per cent (JOL-6k-2 x Pusa Sawani) to 4.36

Table 4.3.17: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for total number of fruits per plant under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	8.26	-4.88	-17.42**	-0.01	-3.46	-16.68**	8.03	3.60	-6.45	0.10	-1.08	-4.24
JDNOL-11-1 x Pusa Sawani	3.89	-6.80	-22.85**	-0.51	-6.26	-14.84*	-2.15	-8.06	-5.59	-2.42	-2.6	-5.72
JDNOL-11-1 x Parbhani Kranti	14.20*	3.74	-16.51**	-2.43	-2.53	-21.51**	0.25	-0.59	-8.71	5.53	3.43	0.12
JDNOL-11-1 x GO-2	16.29*	7.95	-17.15**	8.17	1.31	-18.59**	-4.05	-4.62	-13.88*	11.42	3.83	0.51
JDNOL-11-1 x VRO-6	14.97*	-2.46	-7.96	3.85	2.73	-15.63**	2.27	-2.79	-2.58	-2.84	-3.23	-6.33
JDNOL-11-3 x Arka Anamika	0.24	-0.27	-13.42*	-6.30	-6.38	-19.06**	0.25	-8.46	-8.16	6.54	6.41	0.58
JDNOL-11-3 x Pusa Sawani	-8.99	-10.66	-23.22**	-10.63	-12.79*	-20.77**	-7.59	-8.66	-6.20	-3.87	-4.94	-8.33
JDNOL-11-3 x Parbhani Kranti	11.45	7.91	-7.27	7.24	3.56	-10.46	10.57*	5.89	6.23	10.68	9.89	3.62
JDNOL-11-3 x GO-2	-5.07	-10.15	-22.78**	-8.10	-16.77*	-28.04**	-11.69*	-16.58**	-16.31**	7.04	0.98	-4.78
JDNOL-11-3 x VRO-6	-6.69	-10.86	-15.88**	-1.74	-4.20	-17.17**	-9.81	-9.85	-9.56	4.45	3.52	-0.61
JDNOL-11-11 x Arka Anamika	-5.55	-11.71	-23.35**	-1.17	-11.68	-23.77**	9.68	6.89	-6.65	5.21	2.65	-2.98
JDNOL-11-11 x Pusa Sawani	0.64	-3.79	-20.35**	0.92	-11.79	-19.86**	13.46*	4.98	7.80	-7.62	-10.75	-13.93*
JDNOL-11-11 x Parbhani Kranti	3.70	0.49	-19.13**	4.47	-3.69	-22.44**	5.77	3.17	-5.25	-3.45	-5.02	-11.72
JDNOL-11-11 x GO-2	-7.09	-7.85	-29.28**	20.84**	18.95*	-16.55**	-4.59	-5.60	-15.78**	16.23**	12.16	0.85
JDNOL-11-11 x VRO-6	15.73*	4.16	-1.71	23.53**	12.87	-7.30	10.64	3.52	3.75	2.59	-0.67	-4.63
JDNOL-11-12 x Arka Anamika	-3.83	-9.27	-21.23**	-5.76	-12.91	-24.84**	-1.80	-3.94	-16.75**	6.14	1.12	-4.42
JDNOL-11-12 x Pusa Sawani	3.82	0.19	-17.06**	-3.38	-12.76*	-20.74**	-4.16	-11.63*	-9.26	12.43*	6.10	2.32
JDNOL-11-12 x Parbhani Kranti	-11.8	-13.71	-30.55**	0.49	-4.07	-22.75**	10.31	7.21	-1.54	2.29	-1.76	-8.70
JDNOL-11-12 x GO-2	5.55	5.38	-18.86**	17.16*	14.71	-16.01**	14.41*	12.77	0.62	17.69**	16.34*	-0.43
JDNOL-11-12 x VRO-6	-5.47	-14.17*	-19.00**	1.22	-4.27	-21.38**	-15.99**	-21.67**	-21.49**	3.97	-1.68	-5.60
JDNOL-11-14 x Arka Anamika	11.29	7.21	-6.92	8.01	7.34	-6.20	-7.01	-10.27	-20.01**	0.55	0.13	-4.56
JDNOL-11-14 x Pusa Sawani	10.6	9.04	-9.73	-3.97	-5.80	-14.42*	-6.24	-12.42*	-10.07	-7.01	-7.55	-10.84
JDNOL-11-14 x Parbhani Kranti	6.24	6.22	-14.51*	3.50	-0.57	-13.11*	-0.11	-1.57	-9.61	9.43	8.06	3.01
JDNOL-11-14 x GO-2	14.81*	12.17	-9.76	13.80*	2.58	-10.36	11.48*	11.44	-0.57	2.20	-4.08	-8.56
JDNOL-11-14 x VRO-6	16.29**	7.72	1.65	6.87	3.66	-9.41	16.42**	9.99	10.24	1.79	1.43	-2.62
AOL-07-9 x Arka Anamika	-7.19	-7.43	-19.22**	0.36	-1.77	-11.47*	1.66	-5.91	-8.36	1.96	-1.25	-0.39
AOL-07-9 x Pusa Sawani	-15.20*	-17.37*	-27.90**	-10.12	-10.48	-18.67**	-12.08*	-14.34*	-12.04*	3.91	1.62	2.52
AOL-07-9 x Parbhani Kranti	4.75	0.68	-12.14*	-1.28	-6.53	-15.77**	1.04	-1.84	-4.40	-6.89	-10.56	-9.77
AOL-07-9 x GO-2	-4.69	-10.43	-21.84**	7.81	-4.13	-13.60 *	-18.19**	-21.62**	-23.66**	-9.05	-16.83**	-16.10*
AOL-07-9 x VRO-6	-4.81	-8.40	-13.56*	-14.24*	-18.04**	-26.14**	2.11	0.67	0.90	-4.20	-6.51	-5.69
AOL-08-5 x Arka Anamika	-14.49*	-21.04**	-31.45**	-6.55	-9.65	-22.02**	8.48	2.85	-4.87	-3.40	-6.58	-5.48
AOL-08-5 x Pusa Sawani	16.50*	9.99	-8.94	11.03	4.75	-4.84	0.32	-4.66	-2.10	0.14	-2.21	-1.06

Table 4.3.17 Continue…

Table 4.3.17 Continue…

Cross		E1 MP	E1 BP	E1 SC	E2 MP	E2 BP	E2 SC	E3 MP	E3 BP	E3 SC	E4 MP	E4 BP	E4 SC
AOL-08-5 x Parbhani Kranti		12.46	7.60	-13.40*	8.13	8.10	-12.91*	-12.92*	-13.23*	-19.74**	3.14	-1.06	0.10
AOL-08-5 x GO-2		20.10**	17.58*	-9.76	21.99**	14.1	-8.07	2.08	0.27	-7.25	11.53*	1.85	3.05
AOL-08-5 x VRO-6		4.62	-6.93	-12.18*	5.92	4.91	-13.83*	-6.79	-10.38	-10.18	0.49	-2.08	-0.92
JOL-6k-2 x Arka Anamika		10.66	-4.70	-17.26**	0.76	-11.00	-23.18**	3.84	-1.47	-9.02	-0.96	-1.97	-7.34
JOL-6k-2 x Pusa Sawani		22.42**	7.58	-10.94	-8.24	-20.70**	-27.96**	-17.04**	-21.22**	-19.10**	-12.43*	-14.18*	-17.23**
JOL-6k-2 x Parbhani Kranti		22.05**	8.58	-12.62*	8.48	-1.19	-20.43**	-18.31**	-18.53**	-24.77**	7.34	7.13	-0.43
JOL-6k-2 x GO-2		21.35**	10.26	-15.38*	14.17	10.93	-22.18**	-5.92	-7.51	-14.59*	9.62	4.31	-3.43
JOL-6k-2 x VRO-6		15.01*	-4.27	-9.67	13.23	2.22	-16.04**	-1.61	-5.48	-5.26	3.49	1.64	-2.41
JOL-08-7 x Arka Anamika		-4.93	-10.97	-22.71**	-6.01	-17.05*	-28.41**	13.41*	10.79	-8.16	-0.90	-4.18	-9.43
JOL-08-7 x Pusa Sawani		3.36	-1.00	-18.04**	19.03**	2.77	-6.63	2.90	-8.93	-6.48	9.06	4.43	0.71
JOL-08-7 x Parbhani Kranti		17.64**	14.21	-8.08	19.34**	8.60	-12.55*	14.80*	6.82	-1.90	15.19*	12.29	4.36
JOL-08-7 x GO-2		16.76*	16.03*	-10.95	26.43**	22.71**	-13.91*	23.34**	16.32*	3.78	19.41**	16.27*	2.62
JOL-08-7 x VRO-6		8.95	-1.78	-7.31	21.64**	9.71	-9.89	-8.30	-17.98**	-17.80**	-3.73	-7.62	-11.3
JOL-08-12 x Arka Anamika		2.87	-0.07	-13.24*	-20.36**	-24.02**	-27.79**	3.30	1.07	-12.43*	7.86	4.38	-1.34
JOL-08-12 x Pusa Sawani		8.80	8.19	-10.43	-9.52	-11.51	-15.90**	4.72	-3.46	-0.87	-4.25	-8.23	-11.5
JOL-08-12 x Parbhani Kranti		10.23	9.30	-10.53	-6.58	-13.71*	-17.99**	4.92	1.95	-6.37	6.09	3.51	-3.80
JOL-08-12 x GO-2		-4.45	-7.44	-24.23**	-13.29*	-24.64**	-28.38**	-2.56	-3.97	-14.32*	11.32	8.29	-4.24
JOL-08-12 x VRO-6		10.82	3.48	-2.35	-7.76	-14.02*	-18.28**	0.57	-6.24	-6.03	12.95*	8.49	4.16
Range	**Min.**	-15.20	-21.04	-31.45	-20.36	-24.64	-28.41	-18.31	-21.67	-24.77	-12.43	-16.83	-17.23
	Max.	22.42	17.58	1.65	26.43	22.71	-4.84	23.34	12.77	10.24	19.41	16.34	4.36
S. E. ±		1.08	1.25	1.25	1.07	1.23	1.23	1.19	1.38	1.38	1.19	1.37	1.37
Positive significant crosses		14	2	0	9	2	0	8	1	0	7	2	0
Negative significant crosses		2	3	33	3	10	41	7	10	15	1	2	3
Positive value		35	24	1	28	19	0	28	18	7	45	26	14
Negative value		15	26	49	22	31	50	22	32	43	15	24	36

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.18: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for total number of fruits per plant under pooled environments

Cross		Pooled		
		MP	**BP**	**SC**
JDNOL-11-1 x Arka Anamika		3.95	1.63	-10.99**
JDNOL-11-1 x Pusa Sawani		-0.63	-5.86	-11.98**
JDNOL-11-1 x Parbhani Kranti		3.97	2.17	-11.45**
JDNOL-11-1 x GO-2		7.17*	4.96	-12.18**
JDNOL-11-1 x VRO-6		3.97	-1.44	-7.97**
JDNOL-11-3 x Arka Anamika		0.38	-2.04	-9.86**
JDNOL-11-3 x Pusa Sawani		-7.64**	-8.37**	-14.33**
JDNOL-11-3 x Parbhani Kranti		10.04**	6.84*	-1.69
JDNOL-11-3 x GO-2		-4.54	-10.66**	-17.80**
JDNOL-11-3 x VRO-6		-3.63	-4.33	-10.66**
JDNOL-11-11 x Arka Anamika		2.52	-1.65	-13.86**
JDNOL-11-11 x Pusa Sawani		2.22	-4.9	-11.09**
JDNOL-11-11 x Parbhani Kranti		2.49	-1.18	-14.36**
JDNOL-11-11 x GO-2		5.80	5.63	-15.01**
JDNOL-11-11 x VRO-6		12.36**	4.58	-2.34
JDNOL-11-12 x Arka Anamika		-1.05	-4.86	-16.68**
JDNOL-11-12 x Pusa Sawani		2.12	-4.8	-10.99**
JDNOL-11-12 x Parbhani Kranti		1.02	-2.39	-15.41**
JDNOL-11-12 x GO-2		13.85**	13.42**	-8.33**
JDNOL-11-12 x VRO-6		-4.57	-10.98**	-16.87**
JDNOL-11-14 x Arka Anamika		2.80	2.44	-9.65**
JDNOL-11-14 x Pusa Sawani		-2.29	-5.06	-11.24**
JDNOL-11-14 x Parbhani Kranti		4.71	3.80	-8.45**
JDNOL-11-14 x GO-2		10.27**	5.28	-7.15*
JDNOL-11-14 x VRO-6		10.35**	7.29*	0.19
AOL-07-9 x Arka Anamika		-0.59	-4.03	-9.70**
AOL-07-9 x Pusa Sawani		-8.07**	-8.36**	-13.77**
AOL-07-9 x Parbhani Kranti		-0.81	-4.72	-10.35**
AOL-07-9 x GO-2		-6.93*	-13.79**	-18.89**
AOL-07-9 x VRO-6		-4.80	-5.16	-10.76**
AOL-08-5 x Arka Anamika		-3.37	-3.55	-15.52**
AOL-08-5 x Pusa Sawani		6.07*	2.53	-4.13
AOL-08-5 x Parbhani Kranti		1.68	1.33	-11.58**
AOL-08-5 x GO-2		12.90**	8.34*	-5.46
AOL-08-5 x VRO-6		0.51	-2.78	-9.21**
JOL-6k-2 x Arka Anamika		3.26	-1.8	-14.00**
JOL-6k-2 x Pusa Sawani		-5.88*	-13.18**	-18.83**
JOL-6k-2 x Parbhani Kranti		2.99	-1.57	-14.70**
JOL-6k-2 x GO-2		8.28*	7.45*	-13.81**
JOL-6k-2 x VRO-6		6.50*	-1.70	-8.21**
JOL-08-7 x Arka Anamika		0.77	-5.07	-16.86**
JOL-08-7 x Pusa Sawani		8.27**	-1.03	-7.47*
JOL-08-7 x Parbhani Kranti		16.54**	10.33**	-4.38
JOL-08-7 x GO-2		21.39**	19.29**	-4.31
JOL-08-7 x VRO-6		3.33	-5.49	-11.75**
JOL-08-12 x Arka Anamika		-1.53	-1.75	-13.56**
JOL-08-12 x Pusa Sawani		-0.23	-3.17	-9.47**
JOL-08-12 x Parbhani Kranti		3.60	2.82	-9.53**
JOL-08-12 x GO-2		-1.97	-6.30	-17.56**
JOL-08-12 x VRO-6		4.14	1.13	-5.56
Range	**Min.**	-7.64	-13.79	-18.89
	Max.	21.39	19.29	0.19
S. E. ±		0.57	0.65	0.65
Positive significant crosses		13	5	0
Negative significant crosses		4	6	42
Positive value		33	19	1
Negative value		17	31	49

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

per cent (JOL-08-7 x Parbhani Kranti) in E_4. None of hybrid manifested significant positive standard heterosis in any of the four environments.

The extent of heterosis ranged from -18.89 per cent (AOL-07-9 x GO-2) to 0.19 per cent (JDNOL-11-14 x VRO-6) in pooled analysis. None of hybrids exhibited significant and positive standard heterosis.

The difference in number of crosses displaying relative heterosis, heterobeltiosis and standard heterosis under the different environmental situation indicated the role of environment in expression of this trait.

4.3.10 Total number of seeds per fruit (Table 4.3.19 to 4.3.20)

The relative heterosis ranged from -7.23 per cent (JOL-08-7 x Arka Anamika) to 19.79 per cent (AOL-08-5 x GO-2) in E_1, -8.50 per cent (JDNOL-11-12 x Pusa Sawani) to 18.83 per cent (JOL-6k-2 x GO-2) in E_2, -10.97 per cent (AOL-07-9 x Pusa Sawani) to 10.28 per cent (JDNOL-11-11 x VRO-6) in E_3 and -12.36 per cent (JDNOL-11-3 x Arka Anamika) to 17.74 per cent (JDNOL-11-12 x VRO-6) in E_4. Two, two and six hybrids expressed the negative and significant relative heterosis in E_2, E_3 and E_4, respectively.

The ranged of heterobeltiosis was -10.90 per cent (JDNOL-11-12 x Arka Anamika) to 19.51 per cent (AOL-08-5 x GO-2) in E_1, -9.40 per cent (JDNOL-11-12 x Pusa Sawani) to 16.78 per cent (JOL-6k-2 x GO-2) in E_2, -13.36 per cent (JDNOL-11-11 x Pusa Sawani) to 6.62 per cent (AOL-08-5 x GO-2) in E_3 and -14.80 per cent (JDNOL-11-3 x Arka Anamika) to 12.66 per cent (JDNOL-11-12 x VRO-6) in E_4. The number of crosses, which recorded significant negative heterobeltiosis were one, three, six and eleven in E_1, E_2, E_3 and E_4, respectively.

The estimates of standard heterosis varied from -16.38 per cent (JOL-08-7 x Arka Anamika) to 11.56 per cent (JDNOL-11-12 x GO-2) in E_1, -11.26 per cent (JDNOL-11-1 x VRO-6) to 11.42 per cent (JOL-08-12 x VRO-6) in E_2, -13.16 per cent (JDNOL-11-11 x Pusa Sawani) to 3.42 per cent (AOL-08-5 x Pusa Sawani) in E_3 and -13.79 per cent (JDNOL-11-3 x VRO-6) to 4.54 per cent (AOL-08-5 x Parbhani Kranti) in E_4. The number of crosses, which exhibited significant negative standard heterosis were six, five, eighteen and nine in E_1, E_2, E_3 and E_4, respectively.

Table 4.3.19: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for total number of seed per fruit under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	-3.17	-4.90	-12.08*	-1.53	-2.41	-7.25	-2.05	-2.30	-10.34*	-3.41	-7.89	-5.13
JDNOL-11-1 x Pusa Sawani	-0.56	-1.81	-6.89	2.87	1.55	-0.95	-7.77	-11.67*	-11.46*	-7.59	-10.45*	-10.79*
JDNOL-11-1 x Parbhani Kranti	-4.51	-7.44	-8.84	-5.13	-7.54	-7.43	-6.83	-9.44*	-11.96*	-5.56	-9.29*	-7.97
JDNOL-11-1 x GO-2	1.61	1.09	-6.55	6.67	3.32	-1.80	1.94	-1.48	-9.58*	0.92	-0.28	-6.82
JDNOL-11-1 x VRO-6	0.66	-0.68	-5.68	-7.85*	-9.04*	-11.26**	-2.40	-5.31	-7.58	5.10	3.54	-0.29
JDNOL-11-3 x Arka Anamika	-3.33	-7.71	-9.54	4.41	3.79	-1.94	4.04	3.29	-4.32	-12.36**	-14.80**	-12.24**
JDNOL-11-3 x Pusa Sawani	-0.53	-2.15	-4.09	-0.74	-2.30	-4.71	-8.29*	-11.76*	-11.56*	-1.34	-2.50	-2.87
JDNOL-11-3 x Parbhani Kranti	0.98	0.73	-0.79	1.43	-1.42	-1.31	4.12	1.66	-1.17	2.99	0.87	2.34
JDNOL-11-3 x GO-2	-1.33	-4.61	-6.5	6.05	3.01	-2.67	-3.29	-6.95	-13.81**	0.64	-2.49	-5.15
JDNOL-11-3 x VRO-6	1.00	-0.57	-2.54	0.27	-1.31	-3.72	-4.44	-6.88	-9.11*	-10.93**	-11.37*	-13.79**
JDNOL-11-11 x Arka Anamika	6.28	5.22	-4.29	8.01*	5.27	-1.74	5.43	3.73	-5.30	-2.60	-8.37	-5.62
JDNOL-11-11 x Pusa Sawani	14.84**	12.50*	6.68	-4.57	-8.93*	-11.18**	-7.90	-13.36**	-13.16**	-5.54	-9.73*	-10.07*
JDNOL-11-11 x Parbhani Kranti	9.67*	5.48	3.89	-1.34	-7.01	-6.90	4.44	-0.32	-3.10	-8.94*	-13.73**	-12.47**
JDNOL-11-11 x GO-2	-0.19	-0.48	-8.95	12.14**	11.85*	-0.37	2.35	0.77	-10.97*	12.44**	12.18*	2.33
JDNOL-11-11 x VRO-6	10.79*	8.46	3.00	10.89**	5.80	3.22	10.28*	5.05	2.53	5.81	2.78	-1.01
JDNOL-11-12 x Arka Anamika	-6.63	-10.90*	-12.59*	0.45	-2.64	-3.16	-1.20	-1.48	-9.54*	-7.24	-13.99**	-11.41*
JDNOL-11-12 x Pusa Sawani	-5.31	-6.89	-8.66	-8.50*	-9.40*	-9.87*	-3.38	-7.43	-7.22	-1.16	-6.92	-7.27
JDNOL-11-12 x Parbhani Kranti	-2.61	-2.80	-4.27	0.74	0.42	0.54	-2.45	-5.15	-7.80	3.98	-2.92	-1.50
JDNOL-11-12 x GO-2	17.69**	13.73**	11.56*	-2.34	-7.45	-7.94	6.86	3.25	-5.20	6.89	5.00	-4.22
JDNOL-11-12 x VRO-6	-0.73	-2.32	-4.18	-6.85	-7.75	-8.23*	-3.31	-6.17	-8.42	17.74**	12.66**	8.50
JDNOL-11-14 x Arka Anamika	0.68	-3.16	-6.54	2.24	-0.65	-1.71	-5.10	-7.31	-11.25*	-0.45	-4.31	-1.44
JDNOL-11-14 x Pusa Sawani	6.55	5.62	1.93	3.88	3.14	2.04	2.06	-0.22	0.01	3.05	0.67	0.29
JDNOL-11-14 x Parbhani Kranti	-4.02	-4.99	-6.42	-4.12	-4.69	-4.57	1.00	0.24	-2.55	4.21	0.90	2.37
JDNOL-11-14 x GO-2	6.84	4.07	0.42	2.44	-2.67	-3.71	0.06	-5.24	-9.27*	11.97**	9.73*	4.26
JDNOL-11-14 x VRO-6	0.52	-0.28	-3.77	6.46	5.73	4.60	-3.37	-4.28	-6.58	-0.99	-1.65	-5.28
AOL-07-9 x Arka Anamika	10.86*	10.03	-0.42	0.11	0.02	-6.47	-1.01	-4.22	-6.49	0.55	-1.39	1.57
AOL-07-9 x Pusa Sawani	-6.26	-8.40	-13.14*	-3.62	-5.61	-7.94	-10.97**	-12.13**	-11.92*	-6.30	-6.58	-6.93
AOL-07-9 x Parbhani Kranti	-0.84	-4.86	-6.30	-1.37	-4.62	-4.51	-5.83	-6.03	-8.26	-8.87*	-9.96*	-8.65
AOL-07-9 x GO-2	5.13	4.56	-4.33	3.92	1.45	-5.13	1.09	-5.13	-7.38	4.80	0.66	-0.31
AOL-07-9 x VRO-6	6.06	3.57	-1.64	2.03	-0.08	-2.52	-7.67	-7.68	-9.87*	5.21	3.76	2.76
AOL-08-5 x Arka Anamika	-1.72	-3.21	-11.02*	0.60	0.08	-6.58	0.13	-0.46	-9.13*	-4.43	-8.77*	-6.03
AOL-08-5 x Pusa Sawani	3.96	2.38	-2.93	3.54	0.80	-1.68	8.61*	3.18	3.42	3.37	0.27	-0.10

Table 4.3.19 Continue…

Table 4.3.19 Continue…

Cross		E1			E2			E3			E4		
		MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
AOL-08-5 x Parbhani Kranti		7.82	4.23	2.66	0.43	-3.46	-3.35	4.38	0.62	-2.18	7.16	3.04	4.54
AOL-08-5 x GO-2		19.79**	19.51**	9.86	14.08**	12.04**	3.49	9.41*	6.62	-3.81	6.44	5.05	-1.61
AOL-08-5 x VRO-6		8.52	6.79	1.41	-4.02	-6.57	-8.85*	1.79	-2.07	-4.41	1.95	0.55	-3.16
JOL-6k-2 x Arka Anamika		-1.73	-5.30	-8.97	7.52	3.29	-3.58	0.84	-0.45	-6.74	-4.27	-7.33	-4.55
JOL-6k-2 x Pusa Sawani		-2.83	-3.49	-7.23	6.24	-0.04	-2.50	-7.94	-10.95*	-10.74*	-3.49	-5.04	-5.40
JOL-6k-2 x Parbhani Kranti		-3.31	-4.47	-5.91	7.02	-0.52	-0.41	-3.12	-4.88	-7.53	-8.33*	-10.61*	-9.31*
JOL-6k-2 x GO-2		5.46	2.92	-1.08	18.83**	16.78**	4.02	2.72	-1.70	-7.91	1.49	-1.25	-4.78
JOL-6k-2 x VRO-6		-4.69	-5.26	-8.94	9.68*	3.18	0.67	-4.40	-6.32	-8.56	3.09	3.03	-0.66
JOL-08-7 x Arka Anamika		-7.23	-8.25	-16.38**	2.35	1.87	-4.91	3.39	1.69	-7.16	0.77	-5.08	-2.23
JOL-08-7 x Pusa Sawani		8.31	6.21	0.72	11.90**	9.00*	6.31	2.57	-3.55	-3.32	7.85	3.20	2.81
JOL-08-7 x Parbhani Kranti		12.63**	8.43	6.79	10.99**	6.75	6.88	6.19	1.32	-1.51	4.07	-1.27	0.17
JOL-08-7 x GO-2		9.47*	9.26	-0.04	3.00	1.10	-6.51	7.65	6.02	-6.40	11.84**	11.74*	1.92
JOL-08-7 x VRO-6		0.07	-1.94	-6.88	13.66**	10.69*	8.00	8.32	3.16	0.68	-1.26	-3.96	-7.50
JOL-08-12 x Arka Anamika		-3.65	-8.41	-9.41	-0.23	-3.46	-3.66	2.78	0.17	-3.66	-9.66*	-12.66**	-10.04*
JOL-08-12 x Pusa Sawani		6.38	4.18	3.04	-1.15	-2.27	-2.47	-3.28	-5.24	-5.02	3.55	1.75	1.37
JOL-08-12 x Parbhani Kranti		-1.82	-2.03	-3.10	-1.34	-1.5	-1.38	-7.22	-7.72	-10.29*	4.49	1.76	3.24
JOL-08-12 x GO-2		-5.54	-9.07	-10.07*	-2.77	-7.99	-8.18	-1.15	-6.58	-10.14*	-5.79	-8.21	-11.73**
JOL-08-12 x VRO-6		2.29	0.26	-0.84	12.92**	11.65**	11.42**	3.07	2.32	-0.13	3.94	3.86	0.03
Range	**Min.**	-7.23	-10.90	-16.38	-8.50	-9.40	-11.26	-10.97	-13.36	-13.16	-12.36	-14.80	-13.79
	Max.	19.79	19.51	11.56	18.83	16.78	11.42	10.28	6.62	3.42	17.74	12.66	4.54
S. E. ±		2.04	2.36	2.36	1.61	1.86	1	2	2.47	2.47	1.96	2.27	2.27
Positive significant crosses		8	3	1	10	6	1	3	0	0	4	4	0
Negative significant crosses		0	1	6	2	3	5	2	6	18	6	11	9
Positive value		27	22	12	33	24	11	26	16	4	28	21	15
Negative value		23	28	38	17	26	39	24	34	46	22	29	35

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.20: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for total number of seeds per fruit under pooled environments

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		-2.56	-3.17	-8.70**
JDNOL-11-1 x Pusa Sawani		-3.60	-6.08*	-7.80**
JDNOL-11-1 x Parbhani Kranti		-5.55**	-8.49**	-9.15**
JDNOL-11-1 x GO-2		2.68	0.56	-6.37**
JDNOL-11-1 x VRO-6		-1.00	-2.80	-6.08**
JDNOL-11-3 x Arka Anamika		-2.10	-2.74	-7.08**
JDNOL-11-3 x Pusa Sawani		-2.91	-4.21	-5.96*
JDNOL-11-3 x Parbhani Kranti		2.45	0.52	-0.20
JDNOL-11-3 x GO-2		0.35	-2.95	-7.28**
JDNOL-11-3 x VRO-6		-3.76	-4.30	-7.53**
JDNOL-11-11 x Arka Anamika		4.02	1.47	-4.33
JDNOL-11-11 x Pusa Sawani		-1.17	-5.45*	-7.18**
JDNOL-11-11 x Parbhani Kranti		0.84	-4.05	-4.74*
JDNOL-11-11 x GO-2		6.62**	6.37*	-4.62*
JDNOL-11-11 x VRO-6		9.37**	5.43*	1.88
JDNOL-11-12 x Arka Anamika		-3.69	-3.80	-9.29**
JDNOL-11-12 x Pusa Sawani		-4.48*	-6.47**	-8.18**
JDNOL-11-12 x Parbhani Kranti		-0.10	-2.72	-3.42
JDNOL-11-12 x GO-2		7.37**	4.62	-1.58
JDNOL-11-12 x VRO-6		1.75	0.41	-2.98
JDNOL-11-14 x Arka Anamika		-0.82	-1.94	-5.41*
JDNOL-11-14 x Pusa Sawani		3.79	2.89	1.00
JDNOL-11-14 x Parbhani Kranti		-0.54	-1.95	-2.66
JDNOL-11-14 x GO-2		5.34*	1.40	-2.18
JDNOL-11-14 x VRO-6		0.44	0.36	-3.02
AOL-07-9 x Arka Anamika		2.35	1.78	-2.95
AOL-07-9 x Pusa Sawani		-7.00**	-8.33**	-10.01**
AOL-07-9 x Parbhani Kranti		-4.48*	-6.36**	-7.04**
AOL-07-9 x GO-2		3.67	0.35	-4.31
AOL-07-9 x VRO-6		1.09	0.43	-2.96
AOL-08-5 x Arka Anamika		-1.44	-2.63	-8.19**
AOL-08-5 x Pusa Sawani		4.99*	1.69	-0.17
AOL-08-5 x Parbhani Kranti		5.02*	1.18	0.45
AOL-08-5 x GO-2		12.19**	10.51**	1.68
AOL-08-5 x VRO-6		2.09	-0.36	-3.71
JOL-6k-2 x Arka Anamika		0.28	-0.29	-5.98*
JOL-6k-2 x Pusa Sawani		-2.44	-4.90*	-6.64**
JOL-6k-2 x Parbhani Kranti		-2.32	-5.30*	-5.98*
JOL-6k-2 x GO-2		6.59**	4.32	-2.75
JOL-6k-2 x VRO-6		0.61	-1.17	-4.50
JOL-08-7 x Arka Anamika		-0.03	-1.96	-7.56**
JOL-08-7 x Pusa Sawani		7.44**	3.32	1.43
JOL-08-7 x Parbhani Kranti		8.28**	3.56	2.82
JOL-08-7 x GO-2		8.12**	7.30**	-2.75
JOL-08-7 x VRO-6		5.12*	1.86	-1.57
JOL-08-12 x Arka Anamika		-2.76	-4.43	-6.68**
JOL-08-12 x Pusa Sawani		1.26	0.99	-0.86
JOL-08-12 x Parbhani Kranti		-1.52	-2.33	-3.03
JOL-08-12 x GO-2		-3.79	-7.92**	-10.09**
JOL-08-12 x VRO-6		5.39*	4.84*	2.38
Range	**Min.**	-5.55	-8.83	-10.09
	Max.	12.19	10.51	2.82
S. E. ±		1.00	1.15	1.15
Positive significant crosses		13	5	0
Negative significant crosses		4	9	24
Positive value		28	23	7
Negative value		22	27	43

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

The extent of heterosis ranged from -10.09 per cent (JOL-08-12 x GO-2) to 2.82 per cent (JOL-08-7 x Parbhani Kranti) in pooled analysis. Twenty four hybrids exhibited significant and negative standard heterosis. JOL-08-12 x GO-2 (-10.09 %), AOL-07-9 x Pusa Sawani (-10.01 %) and JDNOL-11-12 x Arka Anamika (-9.29 %) were the top three hybrids with significant and negative standard heterosis.

4.3.11 Days to last picking (Table 4.3.21 to 4.3.22)

The minimum and maximum value of relative heterosis ranged from -11.57 per cent (JDNOL-11-1 x VRO-6) to 6.57 per cent (JOL-08-12 x Pusa Sawani) in E_1, -15.57 per cent (JOL-08-12 x Arka Anamika) to 26.52 per cent (JOL-08-7 x GO-2) in E_2, -9.46 per cent (AOL-07-9 x Parbhani Kranti) to 11.87 per cent (AOL-08-5 x GO-2) in E_3 and -10.40 per cent (JDNOL-11-14 x Arka Anamika) to 7.20 per cent (AOL-08-5 x Pusa Sawani) in E_4. However, the number of crosses, which registered significant and positive heterosis were fifteen and four in E_2 and E_3, respectively.

The range of heterobeltiosis varied from -16.15 per cent (JDNOL-11-1 x VRO-6) to 2.67 per cent (AOL-07-9 x Pusa Sawani) in E_1, -17.18 per cent (JOL-08-12 x Arka Anamika) to 22.85 per cent (JOL-08-7 x GO-2) in E_2, -12.45 per cent (AOL-07-9 x Parbhani Kranti) to 9.38 per cent (AOL-08-5 x GO-2) in E_3 and -13.18 per cent (JDNOL-11-14 x Arka Anamika) to 5.56 per cent (AOL-08-5 x GO-2) in E_4, respectively. Significant and positive heterobeltiosis was exhibited by six and one hybrids in E_2 and E_3.

The range of standard heterosis was -15.37 per cent (JDNOL-11-1 x VRO-6) to 2.23 per cent (AOL-07-9 x Pusa Sawani) in E_1, -18.29 per cent (JDNOL-11-3 x VRO-6) to 5.89 per cent (AOL-07-9 x Pusa Sawani) in E_2, -13.52 per cent (AOL-07-9 x Parbhani Kranti) to 2.05 per cent (JOL-08-12 x Parbhani Kranti) in E_3 and in E_4, -13.66 per cent (JDNOL-11-11 x GO-2) to 0.14 per cent (JDNOL-11-14 x GO-2). None of hybrids showed positive significant heterosis over standard check in any environments under study.

The extent of standard heterosis over environments ranged from -10.06 per cent (JDNOL-11-3 x VRO-6) to 0.07 per cent (JOL-08-12 x Parbhani Kranti). Among 50 hybrids, none of hybrid exhibited significant and positive heterosis over standard check.

Table 4.3.21: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for days to last picking under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	-4.07	-7.72	-9.63	3.35	-0.02	0.89	-2.54	-4.00	-8.85*	5.07	4.20	-1.46
JDNOL-11-1 x Pusa Sawani	-1.35	-5.86	-6.26	-3.01	-5.12	-10.50*	2.72	0.20	-2.93	-7.45*	-8.25	-13.17**
JDNOL-11-1 x Parbhani Kranti	-1.66	-7.05	-5.56	6.53	3.98	-1.91	-2.19	-5.49	-6.64	-5.53	-8.81*	-8.87*
JDNOL-11-1 x GO-2	0.35	-1.66	-11.02*	15.98**	4.95	-1.00	3.49	3.22	-4.92	-0.83	-1.17	-7.45
JDNOL-11-1 x VRO-6	-11.57*	-16.15**	-15.37**	-12.24**	-13.37**	-16.12**	3.77	2.34	-3.06	2.88	0.6	-2.11
JDNOL-11-3 x Arka Anamika	-4.33	-4.38	-6.36	-12.45**	-15.36**	-14.60**	0.58	-2.2	-1.71	-0.98	-1.89	-5.49
JDNOL-11-3 x Pusa Sawani	-4.75	-5.59	-5.99	1.40	-0.74	-6.50	-5.91	-7.60	-7.14	-3.28	-4.13	-7.65
JDNOL-11-3 x Parbhani Kranti	0.87	-1.01	0.57	-9.65*	-11.74**	-16.86**	0.42	-0.44	0.06	0.35	-1.46	-1.52
JDNOL-11-3 x GO-2	1.14	-4.53	-6.61	9.49*	-0.86	-6.62	1.56	-2.91	-2.43	-2.17	-3.54	-7.08
JDNOL-11-3 x VRO-6	-9.26*	-10.66*	-9.83	-14.44**	-15.60**	-18.29**	-1.48	-4.31	-3.84	-5.49	-5.97	-8.50*
JDNOL-11-11 x Arka Anamika	-0.05	-0.26	-1.90	6.54	0.39	1.30	9.49*	7.14	1.73	-5.53	-7.58	-12.60**
JDNOL-11-11 x Pusa Sawani	0.92	0.30	-0.13	4.08	3.53	-6.59	5.20	1.94	-1.24	4.96	2.65	-2.86
JDNOL-11-11 x Parbhani Kranti	-5.16	-6.67	-5.18	0.38	0.06	-10.11*	0.89	-3.14	-4.32	-5.52	-10.00*	-10.06*
JDNOL-11-11 x GO-2	1.76	-4.18	-5.76	13.76**	5.55	-5.78	6.66	6.22	-2.66	-6.21	-7.8	-13.66**
JDNOL-11-11 x VRO-6	1.45	0.15	1.08	5.99	1.86	-1.38	8.63*	6.43	0.81	6.11	2.37	-0.38
JDNOL-11-12 x Arka Anamika	-0.27	-0.59	-2.02	-2.04	-6.83	-5.99	3.59	1.52	0.4	2.07	1.95	-3.36
JDNOL-11-12 x Pusa Sawani	-0.21	-0.72	-1.14	0.23	-0.22	-9.17*	1.58	0.54	-0.56	1.85	1.77	-3.53
JDNOL-11-12 x Parbhani Kranti	-8.42	-9.79	-8.34	1.61	0.94	-8.11	-2.50	-2.55	-3.63	0.03	-2.54	-2.61
JDNOL-11-12 x GO-2	-0.04	-5.98	-7.33	11.78**	2.79	-6.43	3.49	-0.31	-1.41	3.57	2.94	-2.41
JDNOL-11-12 x VRO-6	-7.82	-8.90	-8.05	-1.49	-4.43	-7.47	-0.90	-2.99	-4.06	2.30	0.98	-1.73
JDNOL-11-14 x Arka Anamika	-4.15	-5.40	-4.88	-13.96**	-14.85**	-14.08**	-0.44	-3.98	-1.84	-10.40**	-13.18**	-12.45**
JDNOL-11-14 x Pusa Sawani	-0.70	-1.18	-0.64	4.40	-0.14	-1.32	0.27	-2.36	-0.18	-0.82	-3.87	-3.06
JDNOL-11-14 x Parbhani Kranti	-2.03	-2.54	-0.98	3.33	-1.37	-2.54	-2.99	-4.63	-2.50	-7.96*	-8.37*	-7.6
JDNOL-11-14 x GO-2	5.71	-1.48	-0.94	10.90**	-1.69	-2.85	3.39	-1.97	0.22	2.98	-0.70	0.14
JDNOL-11-14 x VRO-6	-9.77*	-9.94	-9.10	-11.74**	-12.64**	-13.67**	-2.45	-6.04	-3.94	-4.29	-5.96	-5.17
AOL-07-9 x Arka Anamika	-7.87	-8.17	-9.49	-5.42	-7.36	-6.52	6.79	5.28	-0.04	-0.92	-3.11	-4.14
AOL-07-9 x Pusa Sawani	3.20	2.67	2.23	13.26**	9.43*	5.89	4.63	2.13	-1.06	-10.01**	-11.96**	-12.90**
AOL-07-9 x Parbhani Kranti	0.05	-1.45	0.13	-7.00	-10.33*	-13.23**	-9.46*	-12.45**	-13.52**	-4.42	-4.90	-4.96
AOL-07-9 x GO-2	1.96	-4.09	-5.47	8.78*	-2.67	-5.82	-3.28	-3.60	-11.06*	-9.72**	-12.14**	-13.08**
AOL-07-9 x VRO-6	-3.69	-4.82	-3.93	6.61	6.58	3.20	-1.69	-2.97	-8.09	-0.71	-1.52	-2.57
AOL-08-5 x Arka Anamika	-8.58	-10.23	-12.08*	-3.41	-10.11*	-9.30*	7.55	3.37	-1.85	1.29	-0.57	-5.96
AOL-08-5 x Pusa Sawani	-4.94	-7.41	-7.81	12.55**	10.48*	-0.32	8.95*	3.72	0.48	7.20	5.19	-0.45

Table 4.3.21 Continue…

Table 4.3.21 Continue…

Cross		E1			E2			E3			E4		
		MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
AOL-08-5 x Parbhani Kranti		3.00	-0.66	0.94	6.71	4.97	-5.70	7.23	1.14	-0.09	-1.00	-5.38	-5.44
AOL-08-5 x GO-2		-3.83	-7.67	-12.84*	16.80**	9.73*	-4.63	11.87**	9.38*	0.23	7.01	5.56	-1.15
AOL-08-5 x VRO-6		2.73	-0.60	0.33	-1.82	-6.85	-9.81*	6.82	2.78	-2.64	-0.24	-3.43	-6.02
JOL-6k-2 x Arka Anamika		-0.06	-4.13	-6.11	4.65	-5.23	-4.37	5.04	3.29	-1.92	-1.67	-2.68	-7.96
JOL-6k-2 x Pusa Sawani		-3.27	-7.94	-8.33	-1.56	-6.12	-15.30**	1.94	-0.74	-3.84	-0.40	-1.46	-6.74
JOL-6k-2 x Parbhani Kranti		-5.28	-10.71*	-9.28	13.46**	8.43	-2.60	-5.55	-8.89*	-10.00*	-0.61	-4.24	-4.30
JOL-6k-2 x GO-2		0.41	-1.32	-11.22*	22.97**	18.85**	-2.71	2.99	2.91	-5.54	0.87	0.32	-6.06
JOL-6k-2 x VRO-6		-5.72	-10.85*	-10.02	4.86	-3.24	-6.32	5.21	3.58	-1.89	-2.69	-5.03	-7.58
JOL-08-7 x Arka Anamika		-1.48	-4.93	-6.90	0.35	-9.50*	-8.68*	-3.82	-3.94	-8.56*	-2.83	-3.75	-8.97*
JOL-08-7 x Pusa Sawani		4.64	0.18	-0.25	12.65**	6.95	-3.50	4.67	3.76	0.52	0.52	-0.47	-5.80
JOL-08-7 x Parbhani Kranti		2.76	-2.56	-1.00	15.70**	10.08*	-1.12	0.73	-1.10	-2.30	1.24	-2.38	-2.44
JOL-08-7 x GO-2		4.24	1.82	-7.26	26.52**	22.85**	-0.37	7.11	5.11	0.06	2.24	1.78	-4.70
JOL-08-7 x VRO-6		2.99	-2.03	-1.12	5.19	-3.36	-6.43	4.95	4.69	-0.34	-3.78	-6.02	-8.55*
JOL-08-12 x Arka Anamika		-2.74	-6.63	-8.57	-15.57**	-17.18**	-16.43**	-1.13	-2.10	-5.18	-0.82	-0.99	-6.04
JOL-08-12 x Pusa Sawani		6.57	1.49	1.06	-3.47	-6.87	-9.61*	-0.17	-0.18	-3.3	1.12	0.99	-4.17
JOL-08-12 x Parbhani Kranti		1.37	-4.37	-2.84	8.15*	4.12	1.06	4.32	3.30	2.05	2.37	-0.21	-0.28
JOL-08-12 x GO-2		0.02	-1.78	-11.51*	3.82	-7.23	-9.96*	-1.05	-3.72	-6.74	-3.50	-4.14	-9.03*
JOL-08-12 x VRO-6		4.72	-0.9	0.02	2.01	1.89	-1.11	4.68	3.53	0.27	2.35	1.08	-1.63
Range	**Min.**	-11.57	-16.15	-15.37	-15.57	-17.18	-18.29	-9.46	-12.45	-13.52	-10.40	-13.18	-13.66
	Max.	6.57	2.67	2.23	26.52	22.85	5.89	11.87	9.38	2.05	7.20	5.56	0.14
S. E. ±		5.12	5.92	5.92	4.54	5.25	5.25	4.77	5.51	5.51	4.59	5.30	5.30
Positive significant crosses		0	0	0	15	6	0	4	1	0	0	0	0
Negative significant crosses		3	4	6	6	10	17	1	2	5	5	6	12
Positive value		21	6	8	34	21	5	33	24	11	21	14	1
Negative value		29	44	42	16	29	45	17	26	39	29	36	49

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.22: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for days to last picking under pooled environments

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		0.59	-1.74	-4.66*
JDNOL-11-1 x Pusa Sawani		-2.29	-3.69	-8.26**
JDNOL-11-1 x Parbhani Kranti		-0.83	-3.36	-5.78**
JDNOL-11-1 x GO-2		4.58*	1.59	-6.01**
JDNOL-11-1 x VRO-6		-4.07*	-6.45**	-8.93**
JDNOL-11-3 x Arka Anamika		-4.24*	-4.33*	-7.00**
JDNOL-11-3 x Pusa Sawani		-3.20	-4.18	-6.85**
JDNOL-11-3 x Parbhani Kranti		-1.88	-2.02	-4.48*
JDNOL-11-3 x GO-2		2.30	-2.95	-5.66**
JDNOL-11-3 x VRO-6		-7.55**	-7.61**	-10.06**
JDNOL-11-11 x Arka Anamika		2.63	0.02	-2.95
JDNOL-11-11 x Pusa Sawani		3.82	2.10	-2.75
JDNOL-11-11 x Parbhani Kranti		-2.38	-5.08*	-7.47**
JDNOL-11-11 x GO-2		3.69	0.96	-7.02**
JDNOL-11-11 x VRO-6		5.59**	2.73	0.01
JDNOL-11-12 x Arka Anamika		0.89	0.24	-2.74
JDNOL-11-12 x Pusa Sawani		0.90	0.62	-3.63
JDNOL-11-12 x Parbhani Kranti		-2.28	-3.14	-5.57**
JDNOL-11-12 x GO-2		4.59*	-0.08	-4.29*
JDNOL-11-12 x VRO-6		-1.86	-2.66	-5.23*
JDNOL-11-14 x Arka Anamika		-7.29**	-8.95**	-8.38**
JDNOL-11-14 x Pusa Sawani		0.76	-1.93	-1.32
JDNOL-11-14 x Parbhani Kranti		-2.57	-4.09	-3.49
JDNOL-11-14 x GO-2		5.57**	-1.46	-0.84
JDNOL-11-14 x VRO-6		-6.95**	-8.46**	-7.89**
AOL-07-9 x Arka Anamika		-1.78	-2.01	-4.91*
AOL-07-9 x Pusa Sawani		2.55	1.84	-1.64
AOL-07-9 x Parbhani Kranti		-5.26**	-5.70**	-8.07**
AOL-07-9 x GO-2		-0.97	-5.76**	-8.98**
AOL-07-9 x VRO-6		0.17	-0.23	-2.86
AOL-08-5 x Arka Anamika		-0.66	-4.31*	-7.15**
AOL-08-5 x Pusa Sawani		6.00**	3.02	-1.87
AOL-08-5 x Parbhani Kranti		3.90*	-0.15	-2.66
AOL-08-5 x GO-2		7.98**	6.38**	-4.37*
AOL-08-5 x VRO-6		1.86	-2.04	-4.63*
JOL-6k-2 x Arka Anamika		2.00	-2.18	-5.08*
JOL-6k-2 x Pusa Sawani		-0.74	-3.94	-8.51**
JOL-6k-2 x Parbhani Kranti		0.23	-4.09	-6.49**
JOL-6k-2 x GO-2		6.30**	5.19*	-6.28**
JOL-6k-2 x VRO-6		0.45	-3.82	-6.36**
JOL-08-7 x Arka Anamika		-2.00	-5.51*	-8.31**
JOL-08-7 x Pusa Sawani		5.42**	2.56	-2.31
JOL-08-7 x Parbhani Kranti		4.77*	0.79	-1.74
JOL-08-7 x GO-2		9.43**	7.70**	-2.98
JOL-08-7 x VRO-6		2.24	-1.58	-4.19*
JOL-08-12 x Arka Anamika		-5.15**	-6.22**	-9.00**
JOL-08-12 x Pusa Sawani		0.90	0.68	-4.10
JOL-08-12 x Parbhani Kranti		4.06*	2.64	0.07
JOL-08-12 x GO-2		-0.31	-4.31	-9.25**
JOL-08-12 x VRO-6		3.41	2.07	-0.63
Range	**Min.**	-7.55	-8.95	-10.06
	Max.	9.43	7.70	0.07
S. E. ±		2.29	2.65	2.65
Positive significant crosses		13	3	0
Negative significant crosses		7	11	32
Positive value		29	17	2
Negative value		21	33	48

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

In the present investigations, the estimates of various heterotic effects were low to moderate in both the directions.

4.3.12 Crude protein content (Table 4.3.23 to 4.3.24)

The value of relative heterosis varied from -12.01 per cent (JDNOL-11-11 x Arka Anamika) to 18.77 per cent (JOL-08-7 x GO-2) in E_1, -10.25 per cent (AOL-08-5 x Arka Anamika) to 9.73 per cent (JDNOL-11-14 x GO-2) in E_2 , -9.94 per cent (JDNOL-11-3 x VRO-6) to 9.98 per cent (JOL-08-7 x Parbhani Kranti) in E_3 and -7.04 per cent (JDNOL-11-3 x GO-2) to 8.32 per cent (JOL-08-7 x Pusa Sawani) in E_4. The number of crosses, which recorded significant positive relative heterosis were one in each in E_1 and E_2, two and three crosses in E_3 and E_4, respectively.

The estimated of heterobeltiosis ranged from -12.63 per cent (JDNOL-11-11 x Arka Anamika) to 17.29 per cent (JOL-08-7 x GO-2) in E_1, -10.75 per cent (JOL-08-12 x GO 2) to 6.88 per cent (JDNOL-11-14 x GO-2) in E_2, -11.49 per cent (JDNOL-11-3 x GO-2) to 9.86 per cent (JOL-08-7 x Parbhani Kranti) in E_3 and -9.78 per cent (JDNOL-11-3 x GO-2) to 6.54 per cent (AOL-08-5 x GO-2) in E_4. Only shows significantly positive heterobeltiosis in E_1 and E_3.

The magnitude of standard heterosis ranged from -13.79 per cent (JDNOL-11-11 x Arka Anamika) to 10.23 per cent (JOL-08-7 x GO-2) in E_1, -11.85 per cent (AOL-08-5 x Arka Anamika) to 4.30 per cent (JDNOL-11-14 x GO-2) in E_2, -17.27 per cent (JDNOL-11-11 x Arka Anamika) to -2.72 per cent (JOL-08-12 x Parbhani Kranti) in E_3 and -9.84 per cent (JOL-6k-2 x Arka Anamika) to 1.76 per cent (AOL-08-5 x GO-2) in E_4. Only one cross JDNOL-11-14 x GO-2 was recorded significant positive standard heterosis in E_1.

The magnitude of standard heterosis in pooled analysis ranged from -9.93 per cent (JDNOL-11-11 x Arka Anamika) to -0.60 per cent (JDNOL-11-14 x GO-2). None of hybrids exhibited significant and positive heterosis for crude protein content over commercial check.

In the present investigation, the estimates of relative heterosis and heterobeltiosis were lowest to highest in both the directions.

Table 4.3.23: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for crude protein content (%) under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	1.93	-0.01	1.14	0.96	-0.66	-2.38	-0.39	-0.44	-7.39*	-0.46	-2.5	-5.71
JDNOL-11-1 x Pusa Sawani	-4.76	-7.52	-6.46	3.68	0.54	1.81	-0.58	-0.83	-7.37*	1.02	0.01	-5.36
JDNOL-11-1 x Parbhani Kranti	0.50	-0.38	0.76	-1.21	-2.98	-4.27	0.37	-2.10	-9.02**	1.55	-0.88	-3.44
JDNOL-11-1 x GO-2	-3.49	-6.91	-5.84	3.49	2.18	-0.28	1.95	0.11	-6.96*	-1.04	-2.47	-6.85*
JDNOL-11-1 x VRO-6	-3.36	-5.73	0.28	-2.01	-4.30	-4.51	-1.13	-1.74	-7.55*	2.73	-1.35	-0.6
JDNOL-11-3 x Arka Anamika	2.19	-1.46	3.23	-2.47	-4.37	-6.02	-8.68**	-10.19**	-13.61**	0.67	-1.70	-0.23
JDNOL-11-3 x Pusa Sawani	-4.43	-8.76	-4.42	-2.20	-5.50	-4.31	-7.03*	-8.37*	-11.86**	-1.45	-4.78	-3.36
JDNOL-11-3 x Parbhani Kranti	-2.20	-4.71	-0.18	2.83	0.62	-0.72	1.38	-2.75	-6.46	0.95	-1.08	0.40
JDNOL-11-3 x GO-2	-5.29	-10.16*	-5.89	3.90	2.22	-0.24	-8.34**	-11.49**	-14.87**	-7.04*	-9.78**	-8.43*
JDNOL-11-3 x VRO-6	-9.57*	-10.26*	-4.53	0.52	-2.17	-2.39	-9.94**	-10.93**	-14.32**	-4.08	-4.43	-3.00
JDNOL-11-11 x Arka Anamika	-12.01**	-12.63**	-13.79**	0.98	-2.49	-4.18	-8.95**	-11.06**	-17.27**	-1.00	-1.11	-4.16
JDNOL-11-11 x Pusa Sawani	-6.71	-8.33	-9.53*	3.34	-1.63	-0.39	1.24	-1.31	-7.81*	-3.36	-4.5	-7.44*
JDNOL-11-11 x Parbhani Kranti	-1.11	-1.46	-2.07	-4.71	-8.17*	-9.39*	7.65*	7.43	-4.70	2.30	2.04	-0.60
JDNOL-11-11 x GO-2	-0.50	-2.87	-4.15	1.84	-1.33	-3.71	3.01	2.52	-8.17*	3.70	2.95	-0.23
JDNOL-11-11 x VRO-6	0.34	-3.29	2.88	2.21	-2.02	-2.24	3.10	0.16	-5.77	1.42	-0.51	0.24
JDNOL-11-12 x Arka Anamika	1.10	0.57	-1.12	-0.76	-3.51	-5.18	-5.32	-6.94	-13.44**	-1.36	-2.72	-3.24
JDNOL-11-12 x Pusa Sawani	-4.66	-6.14	-7.71	-2.98	-7.03	-5.85	-3.32	-5.17	-11.42**	-5.65	-7.94*	-8.43*
JDNOL-11-12 x Parbhani Kranti	-2.69	-3.21	-3.81	1.04	-1.96	-3.27	0.98	0.15	-10.03**	-1.45	-2.47	-2.99
JDNOL-11-12 x GO-2	7.09	4.73	2.97	3.11	0.59	-1.84	-3.53	-3.67	-13.47**	-0.57	-2.55	-3.07
JDNOL-11-12 x VRO-6	-6.79	-10.32*	-4.60	-4.42	-7.76*	-7.96*	2.84	0.52	-5.43	-2.63	-3.25	-2.52
JDNOL-11-14 x Arka Anamika	6.36	4.98	4.84	-0.98	-3.89	-5.55	-6.00	-6.90	-11.71**	-3.67	-5.47	-5.03
JDNOL-11-14 x Pusa Sawani	-3.54	-5.76	-5.88	4.45	-0.06	1.20	-4.85	-5.57	-10.44**	2.15	-0.82	-0.36
JDNOL-11-14 x Parbhani Kranti	-0.62	-0.87	-0.99	6.54	3.21	1.84	-4.54	-7.81*	-12.56**	1.53	-0.01	0.45
JDNOL-11-14 x GO-2	3.01	-0.03	-0.16	9.73**	6.88	4.30	4.71	1.80	-3.45	-0.78	-3.23	-2.78
JDNOL-11-14 x VRO-6	-1.40	-4.42	1.68	0.84	-2.83	-3.05	-1.18	-1.57	-6.65	-3.55	-3.69	-2.96
AOL-07-9 x Arka Anamika	2.27	2.06	-0.31	2.86	0.51	-1.22	-2.43	-2.79	-8.91**	-2.44	-3.20	-6.38
AOL-07-9 x Pusa Sawani	-4.33	-5.50	-7.70	1.81	-1.95	-0.71	-8.39**	-8.54*	-14.29**	0.01	-0.29	-5.08
AOL-07-9 x Parbhani Kranti	-3.21	-4.04	-4.64	2.57	0.04	-1.30	2.56	-0.37	-6.64	0.25	-0.89	-3.46
AOL-07-9 x GO-2	-5.66	-7.45	-9.60*	-2.32	-4.22	-6.53	-5.29	-7.38*	-13.21**	-3.12	-3.28	-7.62*
AOL-07-9 x VRO-6	-0.28	-4.36	1.74	1.06	-1.98	-2.19	-4.32	-4.51	-10.16**	-4.12	-6.77*	-6.06
AOL-08-5 x Arka Anamika	1.25	0.58	-0.84	-10.25**	-10.30**	-11.85**	-2.92	-3.37	-10.13**	-1.02	-3.03	-6.21
AOL-08-5 x Pusa Sawani	2.98	1.24	-0.18	-2.53	-4.03	-2.82	2.38	1.69	-5.01	5.49	4.47	-1.14

Table 4.3.23 Continue…

Table 4.3.23 Continue…

Cross		E1			E2			E3			E4		
		MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
AOL-08-5 x Parbhani Kranti		-2.6	-2.99	-3.59	3.33	3.07	1.69	3.14	1.02	-6.92*	0.97	-1.42	-3.97
AOL-08-5 x GO-2		5.52	3.05	1.60	-1.76	-2.05	-3.86	-2.66	-4.02	-11.56**	8.08*	6.54	1.76
AOL-08-5 x VRO-6		-3.49	-7.02	-1.09	0.32	-0.50	-0.72	-0.47	-1.50	-7.33*	-3.55	-7.36*	-6.66
JOL-6k-2 x Arka Anamika		-6.25	-6.53	-9.07	1.11	0.61	-1.13	-3.02	-4.47	-11.14**	-6.03*	-6.77	-9.84**
JOL-6k-2 x Pusa Sawani		0.47	-0.27	-3.57	-4.43	-6.3	-5.12	0.12	-1.57	-8.06*	0.59	0.30	-4.54
JOL-6k-2 x Parbhani Kranti		-0.51	-1.86	-2.47	2.62	1.91	0.55	2.29	1.21	-8.66*	-0.74	-1.88	-4.42
JOL-6k-2 x GO-2		-3.37	-4.73	-7.88	1.80	1.66	-0.8	0.35	-0.03	-9.78**	-0.95	-1.12	-5.56
JOL-6k-2 x VRO-6		-3.59	-7.98	-2.11	0.81	-0.44	-0.66	0.77	-1.28	-7.12*	-1.81	-4.53	-3.81
JOL-08-7 x Arka Anamika		3.66	0.65	-2.08	-2.42	-2.88	-4.55	-4.77	-7.25*	-13.73**	-0.25	-4.41	-7.55*
JOL-08-7 x Pusa Sawani		7.43	5.38	0.40	-0.80	-2.71	-1.48	3.83	0.92	-5.73	8.32*	4.90	-0.73
JOL-08-7 x Parbhani Kranti		6.84	2.68	2.04	-2.50	-3.15	-4.44	9.98**	9.86*	-2.93	6.51*	1.72	-0.92
JOL-08-7 x GO-2		18.77**	17.29**	10.23*	2.91	2.79	0.31	3.16	2.36	-8.32*	1.98	-1.68	-6.09
JOL-08-7 x VRO-6		0.36	-6.59	-0.63	-2.34	-3.52	-3.73	-4.88	-7.87*	-13.32**	0.65	-5.39	-4.67
JOL-08-12 x Arka Anamika		-4.90	-6.86	-5.49	-7.55*	-8.20*	-8.51*	-0.20	-1.52	-5.90	-1.56	-1.57	-4.81
JOL-08-12 x Pusa Sawani		0.87	-2.22	-0.78	-4.81	-5.56	-4.37	2.04	0.90	-3.59	0.41	-0.66	-3.95
JOL-08-12 x Parbhani Kranti		-5.45	-6.43	-5.05	-2.74	-3.22	-3.55	5.79	1.81	-2.72	-0.86	-1.22	-3.78
JOL-08-12 x GO-2		-5.87	-9.35*	-8.01	-9.81**	-10.75**	-11.06**	-2.71	-5.75	-9.94**	-3.76	-4.35	-7.52*
JOL-08-12 x VRO-6		0.99	-1.34	4.96	-0.39	-0.45	-0.67	0.54	-0.24	-4.67	-5.56	-7.47*	-6.77*
Range	**Min.**	-12.01	-12.63	-13.79	-10.25	-10.75	-11.85	-9.94	-11.49	-17.27	-7.04	-9.78	-9.84
	Max.	18.77	17.29	10.23	9.73	6.88	4.30	9.98	9.86	-2.72	8.32	6.54	1.76
S. E. ±		1.05	1.21	1.21	0.86	1.00	1.00	0.86	0.99	0.99	0.80	0.92	0.92
Positive significant crosses		1	1	1	1	0	0	2	1	0	3	0	0
Negative significant crosses		2	9	3	3	5	5	6	10	36	2	5	9
Positive value		20	11	14	27	14	7	23	15	0	21	8	4
Negative value		30	39	36	23	36	43	27	35	50	29	42	46

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.24: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for crude protein content (%) under pooled environments

Cross		Pooled		
		MP	BP	SC
JDNOL-11-1 x Arka Anamika		0.49	0.03	-3.73
JDNOL-11-1 x Pusa Sawani		-0.11	-0.49	-4.38*
JDNOL-11-1 x Parbhani Kranti		0.30	0.09	-4.16*
JDNOL-11-1 x GO-2		0.28	-0.39	-5.02*
JDNOL-11-1 x VRO-6		-0.94	-3.26	-3.22
JDNOL-11-3 x Arka Anamika		-2.15	-3.56	-4.44*
JDNOL-11-3 x Pusa Sawani		-3.80*	-5.26**	-6.12**
JDNOL-11-3 x Parbhani Kranti		0.75	-0.95	-1.85
JDNOL-11-3 x GO-2		-4.27*	-6.69**	-7.54**
JDNOL-11-3 x VRO-6		-5.83**	-6.28**	-6.24**
JDNOL-11-11 x Arka Anamika		-5.21**	-6.41**	-9.93**
JDNOL-11-11 x Pusa Sawani		-1.30	-2.48	-6.29**
JDNOL-11-11 x Parbhani Kranti		1.07	0.03	-4.21*
JDNOL-11-11 x GO-2		2.06	1.91	-4.13*
JDNOL-11-11 x VRO-6		1.77	-1.41	-1.36
JDNOL-11-12 x Arka Anamika		-1.64	-2.28	-5.96**
JDNOL-11-12 x Pusa Sawani		-4.15*	-4.70*	-8.43**
JDNOL-11-12 x Parbhani Kranti		-0.53	-0.93	-5.14**
JDNOL-11-12 x GO-2		1.42	0.94	-4.14*
JDNOL-11-12 x VRO-6		-2.71	-5.17**	-5.13**
JDNOL-11-14 x Arka Anamika		-1.22	-1.54	-4.64*
JDNOL-11-14 x Pusa Sawani		-0.45	-0.85	-3.97*
JDNOL-11-14 x Parbhani Kranti		0.69	0.12	-3.03
JDNOL-11-14 x GO-2		4.13*	2.63	-0.60
JDNOL-11-14 x VRO-6		-1.35	-2.93	-2.88
AOL-07-9 x Arka Anamika		0.00	-0.63	-4.36*
AOL-07-9 x Pusa Sawani		-2.77	-3.30	-7.08**
AOL-07-9 x Parbhani Kranti		0.58	0.20	-4.05*
AOL-07-9 x GO-2		-4.09*	-4.57*	-9.31**
AOL-07-9 x VRO-6		-1.96	-4.42*	-4.38*
AOL-08-5 x Arka Anamika		-3.31	-3.78	-7.40**
AOL-08-5 x Pusa Sawani		2.02	1.60	-2.37
AOL-08-5 x Parbhani Kranti		1.25	1.01	-3.27
AOL-08-5 x GO-2		2.20	1.54	-3.23
AOL-08-5 x VRO-6		-1.78	-4.11*	-4.07*
JOL-6k-2 x Arka Anamika		-3.50*	-4.26*	-7.86**
JOL-6k-2 x Pusa Sawani		-0.85	-1.55	-5.40**
JOL-6k-2 x Parbhani Kranti		0.93	0.39	-3.87*
JOL-6k-2 x GO-2		-0.49	-0.84	-6.06**
JOL-6k-2 x VRO-6		-0.93	-3.56	-3.52
JOL-08-7 x Arka Anamika		-1.06	-3.56	-7.18**
JOL-08-7 x Pusa Sawani		4.56*	2.00	-1.99
JOL-08-7 x Parbhani Kranti		5.13**	2.73	-1.64
JOL-08-7 x GO-2		6.46**	4.93*	-1.29
JOL-08-7 x VRO-6		-1.59	-5.85**	-5.81**
JOL-08-12 x Arka Anamika		-3.51*	-4.49*	-6.17**
JOL-08-12 x Pusa Sawani		-0.39	-1.48	-3.21
JOL-08-12 x Parbhani Kranti		-0.76	-2.01	-3.74
JOL-08-12 x GO-2		-5.52**	-7.53**	-9.16**
JOL-08-12 x VRO-6		-1.11	-2.00	-1.96
Range	**Min.**	-5.83	-7.53	-9.93
	Max.	6.46	4.93	-0.60
S. E. ±		0.46	0.53	0.53
Positive significant crosses		4	1	0
Negative significant crosses		9	13	33
Positive value		19	15	0
Negative value		31	35	50

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

4.3.13 Crude Fibre content (Table 4.3.25 to 4.3.26)

The relative heterosis in E_1 ranged from -12.95 per cent (JDNOL-11-12 x Pusa Sawani) to 15.06 per cent (AOL-08-5 x Pusa Sawani). Likewise, relative heterosis it -22.47 per cent (JDNOL-11-3 x Pusa Sawani) to 26.14 per cent (AOL-08-5 x Parbhani Kranti) in E_2, -21.29 per cent (JOL-08-7 x VRO-6) to 26.47 per cent (JDNOL-11-14 x GO-2) in E_3 and -11.59 per cent (JOL-08-7 x VRO-6) to 17.01 per cent (JOL-08-7 x Parbhani Kranti) in E_4. The number of crosses, which recorded significant negative relative heterosis were seven, eleven, nine and nine in E_1, E_2, E_3 and E_4, respectively.

The better parent ranged from -16.06 per cent (JDNOL-11-12 x Pusa Sawani) to 12.10 per cent (JOL-08-12 x Pusa Sawani) in E_1, -23.87 per cent (JDNOL-11-3 x Pusa Sawani) to 23.61 per cent (AOL-08-5 x Parbhani Kranti) in E_2, -23.77 per cent (JOL-08-7 x VRO-6) to 25.07 per cent (JDNOL-11-14 x GO-2) in E_3 and -19.19 per cent (JOL-08-7 x VRO-6) to 15.14 per cent (JDNOL-11-14 x GO-2) in E_4. The number of crosses, which exhibited significant negative heterobeltiosis were eleven, fourteen, sixteen and seventeen in E_1, E_2, E_3 and E_4, respectively.

The standard heterosis ranged from -11.87 per cent (JDNOL-11-12 x Pusa Sawani) to 17.70 per cent (JOL-08-12 x Pusa Sawani) in E_1, -36.00 per cent (JDNOL-11-12 x Parbhani Kranti) to -2.72 per cent (AOL-08-5 x Parbhani Kranti) in E_2, -32.85 per cent (JOL-08-7 x VRO-6) to -1.91 per cent (JDNOL-11-14 x GO-2) in E_3 and -21.92 per cent (JDNOL-11-12 x GO-2) to 6.62 per cent (JDNOL-11-14 x Parbhani Kranti) in E_4. Four, 46, 46 and 31 crosses manifested significant negative standard heterosis under E_1, E_2, E_3 and E_4, respectively.

The magnitude of standard heterosis in pooled analysis ranged from -23.27 per cent (JDNOL-11-12 x Parbhani Kranti) to 0.21 per cent (AOL-08-5 x Parbhani Kranti). Three hybrids exhibited significant and negative heterosis for crude fiber over commercial check. JDNOL-11-12 x Parbhani Kranti (-23.27 %), JOL-08-7 x VRO-6 (-20.78 %) and JDNOL-11-3 x Pusa Sawani (-20.06 %) were the top three hybrids with significant and negative standard heterosis.

The results of present study revealed that the estimates of heterosis were of low to moderate in both the directions, but majority of the hybrids had negative effects. The difference in number of crosses displaying relative heterosis, heterobeltiosis and standard heterosis under the different environmental situation indicated the role of environment in expression of this quality trait.

4.3.14 Vitamin 'C' (mg/100 g pulp) (Table 4.3.27 to 4.3.28)

The estimates of relative ranged from -12.73 per cent (JOL-08-12 x Pusa Sawani) to 29.37 per cent (JOL-08-7 x GO-2) in E_1, -11.13 per cent (JDNOL-11-14 x Pusa Sawani) to 23.91 per cent (JDNOL-11-11 x GO-2) in E_2, -12.47 per cent (AOL-07-9 x VRO-6) to 11.77 per cent (JDNOL-11-1 x GO-2) in E_3 and -16.45 per cent (JDNOL-11-12 x VRO-6) to 15.27 per cent (AOL-08-5 x Parbhani Kranti) in E_4. Out of 60 cross combinations, seven, fifteen, fifteen and five crosses displayed significant positive relative heterosis for this quality trait in E_1, E_2, E_3 and E_4, respectively.

The magnitude of heterobeltiosis range from -14.28 per cent (JOL-08-12 x Pusa Sawani) to 16.11 per cent (JOL-08-7 x GO-2) in E_1, -12.23 per cent (JDNOL-11-14 x Pusa Sawani) to 15.66 per cent (JOL-08-7 x GO-2) in E_2, -15.16 per cent (JDNOL-11-1 x Pusa Sawani) to 10.81 per cent (JOL-08-7 x GO-2) in E_3 and -22.43 per cent (JDNOL-11-12 x VRO-6) to 12.72 per cent (AOL-08-5 x GO-2) in E_4. The number of crosses, which exhibited significant positive heterobeltiosis were three, five, four and two in E_1, E_2, E_3 and E_4, respectively.

The standard heterosis varied from -21.95 per cent (JDNOL-11-12 x GO-2) to -0.59 per cent (JDNOL-11-14 x Pusa Sawani) in E_1, -10.00 per cent (JDNOL-11-12 x VRO-6) to 10.64 per cent (JDNOL-11-11 x Arka Anamika) in E_2, -19.42 per cent (JOL-08-7 x VRO-6) to -1.33 per cent (JDNOL-11-1 x VRO-6) in E_3 and -24.14 per cent (JDNOL-11-12 x VRO-6) to 5.84 per cent (AOL-08-5 x Parbhani Kranti) in E_4. Six cross combinations recorded significantly and positive standard heterosis in E_2.

Pooled basis standard heterosis varied from -15.54 per cent (JDNOL-11-12 x VRO-6) to 1.00 per cent (JDNOL-11-3 x Parbhani Kranti). None hybrid registered significant and positive heterosis over standard check.

The result of the present study revealed that the estimates of relative heterosis, heterobeltiosis and standard heterosis were low to moderate in both the directions.

Table 4.3.25: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for crude fiber content (%) under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	-1.75	-1.99	-4.44	0.33	-2.48	-23.68**	1.42	-5.68	-17.41**	8.13*	3.17	-4.50
JDNOL-11-1 x Pusa Sawani	-4.71	-8.33*	-3.75	6.88**	0.33	-15.53**	-11.75**	-19.79**	-26.14**	2.57	-3.53	-7.93*
JDNOL-11-1 x Parbhani Kranti	2.04	0.14	0.90	5.42*	2.18	-19.58**	14.60**	9.18*	-9.20**	1.82	-3.59	-9.31**
JDNOL-11-1 x GO-2	8.08*	8.00*	4.93	14.71**	13.89**	-15.86**	6.02	3.91	-18.51**	8.05*	3.84	-5.31
JDNOL-11-1 x VRO-6	9.76**	8.53*	7.70*	1.09	-1.91	-22.96**	5.35	-2.30	-13.94**	0.34	-7.89*	-7.37*
JDNOL-11-3 x Arka Anamika	-6.10	-7.46*	-7.08	-10.05**	-14.73**	-25.51**	-17.53**	-18.43**	-28.57**	-4.8	-7.78*	-8.93**
JDNOL-11-3 x Pusa Sawani	-9.32**	-11.30**	-6.87	-22.47**	-23.87**	-33.50**	-15.52**	-18.47**	-24.93**	-8.91**	-10.44**	-11.56**
JDNOL-11-3 x Parbhani Kranti	5.42	5.23	6.04	10.69**	5.21	-8.10**	5.58	4.05	-10.87**	-0.87	-3.23	-4.43
JDNOL-11-3 x GO-2	-6.08	-7.60*	-7.22	-7.13**	-14.86**	-25.62**	5.32	0.88	-13.59**	-4.77	-8.41*	-9.56**
JDNOL-11-3 x VRO-6	-4.62	-5.18	-4.79	-16.08**	-20.32**	-30.39**	-9.92**	-11.16**	-21.75**	-11.06**	-11.86**	-11.37**
JDNOL-11-11 x Arka Anamika	1.24	0.49	-0.56	4.06	1.84	-20.30**	-6.15	-11.76**	-22.73**	0.55	-1.89	-9.18**
JDNOL-11-11 x Pusa Sawani	2.35	-0.59	4.37	0.45	-5.07	-20.08**	4.75	-3.77	-11.39**	-3.61	-7.33*	-11.56**
JDNOL-11-11 x Parbhani Kranti	1.11	0.21	0.97	-11.55**	-13.67**	-32.06**	6.60*	2.71	-14.57**	1.23	-1.99	-7.81*
JDNOL-11-11 x GO-2	1.2	0.28	-0.76	7.81**	6.29*	-20.35**	5.91	5.01	-17.64**	0.49	-1.23	-9.93**
JDNOL-11-11 x VRO-6	5.88	5.73	4.93	22.59**	19.77**	-5.93*	9.94**	3.09	-9.20**	8.41**	1.68	2.25
JDNOL-11-12 x Arka Anamika	-5.27	-5.27	-7.63*	-6.85*	-9.92**	-29.51**	7.40*	-2.71	-14.81**	-9.87**	-14.98**	-21.30**
JDNOL-11-12 x Pusa Sawani	-12.95**	-16.06**	-11.87**	-10.16**	-16.07**	-29.34**	3.93	-7.91*	-15.21**	8.02*	0.46	-4.12
JDNOL-11-12 x Parbhani Kranti	-9.91**	-11.36**	-10.69**	-15.67**	-18.68**	-36.00**	-0.79	-8.00*	-23.48**	-9.22**	-15.01**	-20.05**
JDNOL-11-12 x GO-2	7.95*	7.76*	5.07	-3.53	-3.72	-29.62**	8.01*	2.95	-19.26**	-9.88**	-14.38**	-21.92**
JDNOL-11-12 x VRO-6	-8.50**	-9.30*	-9.99**	-4.83	-8.12**	-27.84**	15.55**	4.40	-8.04**	5.61	-4.10	-3.56
JDNOL-11-14 x Arka Anamika	-2.97	-6.64	-1.53	3.69	1.85	-17.36**	6.13	-0.46	-12.84**	2.97	0.67	-6.81*
JDNOL-11-14 x Pusa Sawani	-0.56	-0.79	4.65	-8.96**	-10.61**	-24.74**	-1.51	-9.74**	-16.89**	0.88	-2.81	-7.25*
JDNOL-11-14 x Parbhani Kranti	-3.03	-5.20	0.00	20.89**	19.07**	-3.38	-6.51*	-10.15**	-25.27**	16.84**	13.35**	6.62*
JDNOL-11-14 x GO-2	2.47	-1.58	3.82	17.58**	11.55**	-9.48**	26.47**	25.07**	-1.91	16.90**	15.14**	5.00
JDNOL-11-14 x VRO-6	13.69**	10.33**	16.38**	19.83**	17.91**	-4.33	-5.02	-11.16**	-21.75**	-0.53	-6.52*	-6.00
AOL-07-9 x Arka Anamika	-7.82*	-11.05**	-6.73	-0.71	-4.63	-18.97**	0.21	-6.27	-17.93**	-2.08	-4.02	-7.50*
AOL-07-9 x Pusa Sawani	-7.41*	-7.47*	-2.85	-0.79	-1.24	-16.08**	12.85**	3.14	-5.03	-8.24**	-8.68*	-11.99**
AOL-07-9 x Parbhani Kranti	9.15**	7.02*	12.21**	-1.05	-4.70	-19.02**	-2.47	-6.54	-22.27**	-2.39	-3.56	-7.06*
AOL-07-9 x GO-2	-5.74	-9.20**	-4.79	2.99	-4.37	-18.75**	11.52**	9.96*	-13.77**	-1.83	-4.47	-7.93*
AOL-07-9 x VRO-6	-7.99*	-10.46**	-6.11	-5.43*	-9.01**	-22.68**	18.83**	10.83**	-2.37	-1.87	-3.91	-3.37
AOL-08-5 x Arka Anamika	0.77	-0.28	-0.69	6.38*	4.54	-18.19**	2.31	2.17	-10.29**	13.93**	10.66**	2.44
AOL-08-5 x Pusa Sawani	15.06**	12.10**	17.70**	-6.04*	-10.87**	-24.96**	-2.70	-4.96	-12.49**	-8.79**	-12.70**	-16.68**

Table 4.3.25 Continue…

Table 4.3.25 Continue…

Cross		**E_1**			**E_2**			**E_3**			**E_4**		
		MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
AOL-08-5 x Parbhani Kranti		11.88**	11.23**	12.07**	26.14**	23.61**	-2.72	9.20**	6.32	-6.65*	10.58**	6.57	0.25
AOL-08-5 x GO-2		6.17	4.88	4.44	15.89**	13.80**	-14.03**	2.99	-2.50	-14.40**	7.46*	5.14	-4.12
AOL-08-5 x VRO-6		-0.52	-0.70	-1.11	22.46**	20.13**	-5.66*	3.72	3.55	-8.79**	4.62	-2.30	-1.75
JOL-6k-2 x Arka Anamika		8.22*	7.68*	6.04	1.72	1.05	-19.86**	-4.27	-8.19*	-19.61**	-5.76	-8.91*	-15.68**
JOL-6k-2 x Pusa Sawani		-3.68	-6.68	-2.01	0.75	-2.17	-17.64**	-5.77	-11.75**	-18.74**	-0.10	-4.84	-9.18**
JOL-6k-2 x Parbhani Kranti		-0.73	-1.86	-1.11	10.99**	10.56**	-12.31**	5.45	3.69	-13.77**	-2.60	-6.57	-12.12**
JOL-6k-2 x GO-2		5.57	4.86	3.26	6.82*	2.45	-18.75**	-3.28	-4.46	-23.19**	5.38	2.60	-6.43
JOL-6k-2 x VRO-6		11.41**	10.98**	10.13**	3.30	2.80	-18.47**	-7.52*	-11.56**	-22.09**	-2.84	-9.69**	-9.18**
JOL-08-7 x Arka Anamika		-4.73	-4.77	-7.15	-4.75	-4.82	-25.51**	0.78	-2.11	-14.29**	-4.80	-9.58**	-16.30**
JOL-08-7 x Pusa Sawani		6.14	2.31	7.43*	15.20**	11.07**	-6.49**	-5.93*	-10.80**	-17.87**	12.34**	5.17	0.370
JOL-08-7 x Parbhani Kranti		11.13**	9.30*	10.13**	23.48**	23.04**	-3.16	1.78	1.39	-15.67**	17.01**	10.29**	3.75
JOL-08-7 x GO-2		-4.71	-4.84	-7.29*	10.07**	6.32*	-16.92**	5.28	2.66	-15.27**	6.34	1.71	-7.25*
JOL-08-7 x VRO-6		-3.25	-4.13	-4.86	-2.65	-2.9	-23.74**	-21.29**	-23.77**	-32.85**	-11.59**	-19.19**	-18.74**
JOL-08-12 x Arka Anamika		-2.67	-4.95	-2.78	-3.17	-5.83*	-22.02**	-9.56**	-10.37**	-21.52**	-0.67	-1.84	-6.93*
JOL-08-12 x Pusa Sawani		13.56**	12.10**	17.70**	0.56	-0.26	-16.03**	-0.49	-3.77	-11.39**	-0.79	-1.11	-5.62
JOL-08-12 x Parbhani Kranti		7.86*	7.06	9.51*	14.63**	11.79**	-7.43**	7.56*	5.78	-9.02**	1.59	1.19	-4.06
JOL-08-12 x GO-2		-2.64	-5.09	-2.91	0.07	-5.96*	-22.13**	-0.18	-4.57	-17.93**	-4.10	-5.93	-10.81**
JOL-08-12 x VRO-6		0.07	-1.42	0.83	-0.93	-3.48	-20.08**	9.10**	7.81*	-5.03	-7.54*	-10.19**	-9.68**
Range	**Min.**	-12.95	-16.06	-11.87	-22.47	-23.87	-36.00	-21.29	-23.77	-32.85	-11.59	-19.19	-21.92
	Max.	15.06	12.10	17.70	26.14	23.61	-2.72	26.47	25.07	-1.91	17.01	15.14	6.62
S. E. ±		0.15	0.17	0.17	0.12	0.14	0.14	0.15	0.17	0.17	0.15	0.17	0.17
Positive significant crosses		12	11	10	19	14	0	13	5	0	11	4	1
Negative significant crosses		7	11	4	11	14	46	9	16	46	9	17	31
Positive value		25	20	24	31	23	0	30	21	0	24	15	7
Negative value		25	30	26	19	27	50	20	29	50	26	35	43

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.26: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for crude fiber content (%) under pooled environments

Cross		Pooled		
		MP	**BP**	**SC**
JDNOL-11-1 x Arka Anamika		2.06	-1.75	-13.14**
JDNOL-11-1 x Pusa Sawani		-1.80	-7.97**	-13.89**
JDNOL-11-1 x Parbhani Kranti		5.89**	1.91	-9.86**
JDNOL-11-1 x GO-2		9.18**	7.69**	-9.43**
JDNOL-11-1 x VRO-6		4.11**	-1.12	-10.07**
JDNOL-11-3 x Arka Anamika		-9.63**	-11.65**	-18.24**
JDNOL-11-3 x Pusa Sawani		-14.10**	-14.57**	-20.06**
JDNOL-11-3 x Parbhani Kranti		5.15**	2.83	-4.84**
JDNOL-11-3 x GO-2		-3.21*	-7.63**	-14.51**
JDNOL-11-3 x VRO-6		-10.49**	-11.26**	-17.87**
JDNOL-11-11 x Arka Anamika		-0.11	-2.62	-13.90**
JDNOL-11-11 x Pusa Sawani		0.99	-4.19*	-10.36**
JDNOL-11-11 x Parbhani Kranti		-0.61	-3.13	-14.31**
JDNOL-11-11 x GO-2		3.76*	3.67*	-12.81**
JDNOL-11-11 x VRO-6		11.57**	7.29**	-2.42
JDNOL-11-12 x Arka Anamika		-3.68*	-8.21**	-18.85**
JDNOL-11-12 x Pusa Sawani		-2.86	-9.85**	-15.65**
JDNOL-11-12 x Parbhani Kranti		-8.96**	-13.26**	-23.27**
JDNOL-11-12 x GO-2		0.58	-1.81	-17.42**
JDNOL-11-12 x VRO-6		1.95	-4.13*	-12.81**
JDNOL-11-14 x Arka Anamika		2.42	1.65	-10.13**
JDNOL-11-14 x Pusa Sawani		-2.54	-5.92**	-11.97**
JDNOL-11-14 x Parbhani Kranti		7.14**	6.31**	-5.96**
JDNOL-11-14 x GO-2		15.60**	13.62**	-1.05
JDNOL-11-14 x VRO-6		6.97**	4.70**	-4.78**
AOL-07-9 x Arka Anamika		-2.61	-3.37*	-13.22**
AOL-07-9 x Pusa Sawani		-1.05	-3.04	-9.28**
AOL-07-9 x Parbhani Kranti		0.84	0.08	-10.12**
AOL-07-9 x GO-2		1.50	-1.73	-11.74**
AOL-07-9 x VRO-6		0.68	0.05	-9.01**
AOL-08-5 x Arka Anamika		5.81**	4.90**	-7.26**
AOL-08-5 x Pusa Sawani		-0.6	-4.15*	-10.31**
AOL-08-5 x Parbhani Kranti		14.31**	13.29**	0.21
AOL-08-5 x GO-2		8.00**	6.27**	-7.67**
AOL-08-5 x VRO-6		7.36**	4.97**	-4.53**
JOL-6k-2 x Arka Anamika		-0.07	-1.70	-13.10**
JOL-6k-2 x Pusa Sawani		-2.22	-6.42**	-12.44**
JOL-6k-2 x Parbhani Kranti		3.24*	1.53	-10.19**
JOL-6k-2 x GO-2		3.65*	2.79	-12.09**
JOL-6k-2 x VRO-6		0.99	-2.02	-10.89**
JOL-08-7 x Arka Anamika		-3.33*	-5.32**	-16.29**
JOL-08-7 x Pusa Sawani		6.81**	1.79	-4.76**
JOL-08-7 x Parbhani Kranti		13.31**	10.95**	-1.86
JOL-08-7 x GO-2		4.20**	3.79*	-12.02**
JOL-08-7 x VRO-6		-9.83**	-12.90**	-20.78**
JOL-08-12 x Arka Anamika		-4.04**	-5.32**	-13.99**
JOL-08-12 x Pusa Sawani		3.16*	1.66	-4.88**
JOL-08-12 x Parbhani Kranti		7.85**	6.43**	-3.32*
JOL-08-12 x GO-2		-1.75	-5.39**	-14.06**
JOL-08-12 x VRO-6		0.11	0.05	-9.01**
Range	**Min.**	-14.10	-13.26	-23.27
	Max.	15.60	13.62	0.21
S. E. ±		0.07	0.08	0.08
Positive significant crosses		20	13	0
Negative significant crosses		9	17	46
Positive value		29	23	1
Negative value		21	27	49

Where, E_1, E_2, E_3 and E_4 are four different environments.
* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.27: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for vitamin 'C' (mg/100 g pulp) under individual environments

Cross	E_1			E_2			E_3			E_4		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
JDNOL-11-1 x Arka Anamika	4.81	0.43	-5.81	-0.39	-1.98	1.22	1.88	0.49	-10.02**	2.72	2.55	-1.78
JDNOL-11-1 x Pusa Sawani	5.89	-1.28	-1.86	-1.07	-2.10	-0.05	-12.28**	-15.16**	-18.69**	-1.90	-3.86	-4.10
JDNOL-11-1 x Parbhani Kranti	2.94	0.000	-8.84*	2.47	1.93	2.99	-2.57	-5.46	-10.00**	6.31	5.55	2.56
JDNOL-11-1 x GO-2	14.53**	12.99**	-2.88	15.73**	4.59	4.57	11.77**	6.64*	-4.51	3.01	-1.2	-5.37
JDNOL-11-1 x VRO-6	-1.94	-8.64*	-9.05*	5.74	5.30	6.17	7.42**	4.79	-1.33	-2.48	-3.49	-5.62
JDNOL-11-3 x Arka Anamika	-5.91	-9.41*	-8.20*	4.56	3.81	7.20	1.81	-1.54	-8.21**	-5.58	-9.03*	-6.32
JDNOL-11-3 x Pusa Sawani	-6.26	-7.15	-5.91	5.07	4.91	7.11	-0.95	-2.30	-6.36*	-5.58	-7.06*	-4.30
JDNOL-11-3 x Parbhani Kranti	1.32	-3.76	-2.48	5.96	5.57	7.46	5.13	4.04	-0.96	0.59	-2.25	0.66
JDNOL-11-3 x GO-2	-1.50	-10.10*	-8.90*	16.05**	4.05	5.91	5.31	-1.40	-8.09**	2.47	-5.01	-2.18
JDNOL-11-3 x VRO-6	-9.45**	-10.25**	-9.05*	1.34	0.86	2.66	-11.11**	-11.55**	-16.72**	-11.88**	-14.10**	-11.54**
JDNOL-11-11 x Arka Anamika	-0.91	-2.37	-8.43*	11.24**	7.13	10.64*	-2.42	-4.52	-13.10**	3.93	2.16	0.97
JDNOL-11-11 x Pusa Sawani	-4.94	-8.95*	-9.49*	11.81**	8.28*	10.54*	-6.88*	-9.22**	-12.99**	-9.94**	-10.36**	-10.57**
JDNOL-11-11 x Parbhani Kranti	0.08	0.00	-8.84*	7.74*	4.87	5.95	-7.09*	-9.13**	-13.49**	-0.74	-1.58	-2.73
JDNOL-11-11 x GO-2	11.21**	6.71	-2.88	23.91**	14.25**	9.27*	7.79*	2.06	-7.11*	-1.65	-7.06	-8.15*
JDNOL-11-11 x VRO-6	-4.55	-8.64*	-9.05*	12.51**	9.62*	10.52*	4.57	2.83	-3.18	0.44	-0.09	-1.26
JDNOL-11-12 x Arka Anamika	5.80	0.81	-5.45	-6.71	-8.68*	-5.70	7.88*	6.09	-7.61*	-9.88**	-15.39**	-19.23**
JDNOL-11-12 x Pusa Sawani	-0.78	-7.99*	-8.54*	-6.25	-7.72	-5.79	-0.05	-6.12	-10.02**	-9.90**	-17.11**	-17.31**
JDNOL-11-12 x Parbhani Kranti	3.53	0.00	-8.84*	-9.88**	-10.83**	-9.91*	-6.13*	-11.55**	-15.80**	-14.42**	-20.31**	-22.58**
JDNOL-11-12 x GO-2	-7.42	-8.13	-21.95**	3.64	-5.88	-6.92	6.36*	4.54	-11.98**	-1.40	-3.73	-15.33**
JDNOL-11-12 x VRO-6	-1.41	-8.64*	-9.05*	-9.88**	-10.74*	-10.00*	-8.82**	-13.65**	-18.69**	-16.45**	-22.43**	-24.14**
JDNOL-11-14 x Arka Anamika	-11.57**	-12.84**	-15.83**	-0.18	-0.85	3.79	-2.11	-6.56*	-10.50**	1.40	-0.66	-1.15
JDNOL-11-14 x Pusa Sawani	1.45	0.00	-0.59	-11.13**	-12.23**	-8.12	-0.99	-1.02	-5.14	2.60	2.47	2.22
JDNOL-11-14 x Parbhani Kranti	2.90	0.02	-3.41	-3.42	-5.10	-0.66	-2.00	-2.30	-6.42*	2.72	1.51	1.01
JDNOL-11-14 x GO-2	7.78*	0.57	-2.88	13.58**	0.58	5.30	7.36*	-0.74	-4.93	1.14	-4.74	-5.20
JDNOL-11-14 x VRO-6	-7.25*	-8.64*	-9.05*	5.57	3.62	8.47*	-8.17**	-8.94**	-12.79**	0.49	-0.38	-0.86
AOL-07-9 x Arka Anamika	-3.11	-4.24	-8.05*	-1.48	-2.96	3.32	0.66	-1.86	-10.02**	-0.70	-2.43	-3.50
AOL-07-9 x Pusa Sawani	-2.88	-4.54	-5.11	-2.66	-4.66	1.51	-10.20**	-12.15**	-15.80**	3.36	2.91	2.67
AOL-07-9 x Parbhani Kranti	-2.59	-5.05	-8.84*	-3.50	-5.97	0.12	-6.77*	-8.50**	-12.89**	-10.95**	-11.74**	-12.71**
AOL-07-9 x GO-2	-1.25	-7.61	-11.29**	5.18	-7.54	-1.55	7.35*	1.29	-7.13*	5.65	-0.20	-1.30
AOL-07-9 x VRO-6	-6.99*	-8.64*	-9.05*	-4.38	-6.92	-0.89	-12.47**	-13.62**	-18.67**	-13.06**	-13.54**	-14.49**
AOL-08-5 x Arka Anamika	-7.20	-10.30*	-15.87**	-0.36	-4.44	-1.32	8.73**	3.32	-10.02**	6.51	1.50	-3.11
AOL-08-5 x Pusa Sawani	6.36	0.00	-0.59	9.54*	5.62	7.84	7.97**	-1.84	-5.93*	4.65	-2.32	-2.56

Table 4.3.27 Continue…

Table 4.3.27 Continue…

Cross		**E1**			**E2**			**E3**			**E4**		
		MP	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**	**MP**	**BP**	**SC**
AOL-08-5 x Parbhani Kranti		2.04	0.00	-8.84*	5.16	1.91	2.97	8.85**	-0.74	-5.51	15.27**	8.93*	5.84
AOL-08-5 x GO-2		13.48**	10.97*	-2.88	22.45**	13.36**	7.46	14.00**	11.96**	-8.94**	13.68**	12.72**	-0.86
AOL-08-5 x VRO-6		-2.76	-8.64*	-9.05*	2.79	-0.28	0.54	0.95	-7.49*	-12.89**	12.50**	5.99	3.66
JOL-6k-2 x Arka Anamika		-8.49*	-9.24*	-14.88**	-6.26	-6.72	-3.67	9.20**	8.43*	-4.22	-5.77	-5.93	-10.20**
JOL-6k-2 x Pusa Sawani		-3.34	-6.82	-7.37	0.15	0.07	2.33	-5.43	-9.13**	-12.91**	-8.02*	-10.16**	-10.37**
JOL-6k-2 x Parbhani Kranti		-5.19	-5.74	-13.05**	1.48	0.87	3.15	1.20	-2.45	-7.13*	0.66	-0.39	-3.22
JOL-6k-2 x GO-2		-0.05	-4.71	-12.10**	17.14**	4.81	7.18	2.66	-1.41	-12.91**	-10.39**	-13.78**	-17.97**
JOL-6k-2 x VRO-6		-5.8	-9.26*	-9.66*	3.53	2.81	5.13	-0.66	-3.73	-9.36**	2.57	1.17	-1.06
JOL-08-7 x Arka Anamika		6.32	-9.15*	-14.79**	8.48*	1.75	5.08	-2.77	-6.64	-18.69**	-4.75	-7.5	-11.70**
JOL-08-7 x Pusa Sawani		14.17**	-4.73	-5.30	11.17**	4.84	7.04	7.39*	-1.39	-5.49	6.84*	1.59	1.34
JOL-08-7 x Parbhani Kranti		21.56**	5.11	-4.17	13.48**	7.55	8.66 *	7.10*	-1.35	-6.09*	7.36*	3.38	0.44
JOL-08-7 x GO-2		29.37**	16.11**	-2.88	22.24**	15.66**	4.64	11.61**	10.81**	-9.88**	3.95	2.79	-7.53*
JOL-08-7 x VRO-6		9.55*	-8.64*	-9.05*	3.52	-1.80	-0.99	-7.55*	-14.42**	-19.42**	-11.45**	-15.00**	-16.87**
JOL-08-12 x Arka Anamika		-9.85**	-10.83**	-14.52**	5.60	3.78	7.18	-0.24	-3.44	-10.15**	-5.01	-8.15*	-6.12
JOL-08-12 x Pusa Sawani		-12.73**	-14.28**	-14.79**	6.12	4.89	7.08	1.17	-0.30	-4.45	-1.89	-3.06	-0.93
JOL-08-12 x Parbhani Kranti		-2.52	-4.91	-8.84*	5.56	4.87	5.95	-0.70	-1.81	-6.53*	0.23	-2.24	-0.09
JOL-08-12 x GO-2		-5.96	-11.96**	-15.60**	12.04**	1.37	1.08	-4.89	-10.88**	-17.07**	-0.66	-7.59*	-5.55
JOL-08-12 x VRO-6		-0.61	-2.45	-2.88	6.89	6.30	7.18	3.25	2.65	-3.35	-0.31	-2.46	-0.31
Range	**Min.**	-12.73	-14.28	-21.95	-11.13	-12.23	-10.00	-12.47	-15.16	-19.42	-16.45	-22.43	-24.14
	Max.	29.37	16.11	-0.59	23.91	15.66	10.64	11.77	10.81	-1.33	15.27	12.72	5.84
S. E. ±		0.53	0.62	0.62	0.50	0.58	0.58	0.41	0.47	0.47	0.47	0.54	0.54
Positive significant crosses		7	3	0	15	5	6	15	4	0	5	2	0
Negative significant crosses		7	20	32	3	4	2	11	15	39	11	15	16
Positive value		20	15	0	35	31	37	26	14	0	25	14	10
Negative value		30	35	50	15	19	19	24	36	50	25	36	40

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Table 4.3.28: Estimates of relative heterosis (MP), heterobeltiosis (BP) and standard check (GJOH-3) for vitamin-C (mg/100g pulp) under pooled environments

Cross		Pooled		
		MP	**BP**	**SC**
JDNOL-11-1 x Arka Anamika		2.25	1.13	-4.29*
JDNOL-11-1 x Pusa Sawani		-2.39	-5.64**	-6.41**
JDNOL-11-1 x Parbhani Kranti		2.26	0.44	-3.58*
JDNOL-11-1 x GO-2		11.13**	5.64**	-2.20
JDNOL-11-1 x VRO-6		2.17	-0.60	-2.64
JDNOL-11-3 x Arka Anamika		-1.38	-3.89 *	-4.17*
JDNOL-11-3 x Pusa Sawani		-2.07	-2.33	-2.61
JDNOL-11-3 x Parbhani Kranti		3.22*	1.29	1.00
JDNOL-11-3 x GO-2		5.29**	-3.31	-3.59*
JDNOL-11-3 x VRO-6		-7.91**	-8.70**	-8.96**
JDNOL-11-11 x Arka Anamika		2.93	2.59	-2.90
JDNOL-11-11 x Pusa Sawani		-2.73	-5.26**	-6.03**
JDNOL-11-11 x Parbhani Kranti		-0.14	-1.16	-5.12**
JDNOL-11-11 x GO-2		9.91**	3.72	-2.48
JDNOL-11-11 x VRO-6		3.07	0.99	-1.04
JDNOL-11-12 x Arka Anamika		-0.72	-4.37*	-9.49**
JDNOL-11-12 x Pusa Sawani		-4.18*	-9.73**	-10.47**
JDNOL-11-12 x Parbhani Kranti		-6.72**	-10.75**	-14.32**
JDNOL-11-12 x GO-2		0.27	-2.17	-14.20**
JDNOL-11-12 x VRO-6		-9.04**	-13.82**	-15.54**
JDNOL-11-14 x Arka Anamika		-3.15*	-5.27**	-6.24**
JDNOL-11-14 x Pusa Sawani		-1.93	-2.03	-2.83
JDNOL-11-14 x Parbhani Kranti		0.05	-1.46	-2.47
JDNOL-11-14 x GO-2		7.35**	-1.08	-2.10
JDNOL-11-14 x VRO-6		-2.46	-2.94	-3.94*
AOL-07-9 x Arka Anamika		-1.18	-2.88	-4.80**
AOL-07-9 x Pusa Sawani		-3.10*	-3.67*	-4.45*
AOL-07-9 x Parbhani Kranti		-5.97**	-6.94**	-8.78**
AOL-07-9 x GO-2		4.20*	-3.55	-5.46**
AOL-07-9 x VRO-6		-9.22**	-9.23**	-11.03**
AOL-08-5 x Arka Anamika		1.77	-2.58	-7.80**
AOL-08-5 x Pusa Sawani		7.11**	0.30	-0.52
AOL-08-5 x Parbhani Kranti		7.81**	2.51	-1.59
AOL-08-5 x GO-2		15.81**	13.71**	-1.57
AOL-08-5 x VRO-6		3.29	-2.74	-4.68**
JOL-6k-2 x Arka Anamika		-2.93	-3.13	-8.32**
JOL-6k-2 x Pusa Sawani		-4.18**	-6.56**	-7.32**
JOL-6k-2 x Parbhani Kranti		-0.45	-1.35	-5.30**
JOL-6k-2 x GO-2		2.10	-3.77*	-9.30**
JOL-6k-2 x VRO-6		-0.15	-2.06	-4.02*
JOL-08-7 x Arka Anamika		1.71	-5.37**	-10.44**
JOL-08-7 x Pusa Sawani		9.79**	-0.02	-0.84
JOL-08-7 x Parbhani Kranti		12.07**	3.59	-0.56
JOL-08-7 x GO-2		16.29**	14.92**	-4.13*
JOL-08-7 x VRO-6		-1.75	-10.04**	-11.84**
JOL-08-12 x Arka Anamika		-2.47	-3.94*	-6.26**
JOL-08-12 x Pusa Sawani		-1.98	-2.77	-3.56*
JOL-08-12 x Parbhani Kranti		0.59	-0.23	-2.63
JOL-08-12 x GO-2		-0.15	-7.39**	-9.62**
JOL-08-12 x VRO-6		2.22	2.01	-0.03
Range	**Min.**	-9.22	-13.82	-15.54
	Max.	16.29	14.92	1.00
S. E. ±		0.23	0.27	0.27
Positive significant crosses		12	3	0
Negative significant crosses		8	18	33
Positive value		25	13	1
Negative value		25	37	49

Where, E_1, E_2, E_3 and E_4 are four different environments.

* and ** Significant at 5 % and 1 % levels of probability, respectively.

4.4 Combining ability analysis

4.4.1 Analysis of variance for combining ability (Table 4.4.1 to 4.4.7)

In the present investigation, line x tester method was applied to develop 50 experimental hybrids from 10 lines (females) and 5 testers (males), which were evaluated under four different environments *viz.*, E_1-Timely summer, E_2-Late summer E_3-Timely *kharif* and E_4-Late *kharif* for fourteen traits.

The analysis of variance and variance components for combining ability for fourteen traits under four environments as well as pooled over environments are presented in Table 4.4.1 to 4.4.7.

Analysis of variance for combining ability over the environments revealed that mean squares due to environment were highly significant for all the traits indicated considerable differences among the environments under which the study was conducted. This was further recognised by significant estimates of variance due to environments (e).

The mean squares due to females were significant for fruit yield per plant and other traits like number of branches per plant, number of fruits per plant and vitamin 'C' under individual environments as well as across the environments. The mean square due to males was significant for days to 50 per cent flowering, fruit length and crude protein content signifying that both females and males had considerable general combining ability (gca) towards these traits. Highly significant mean squares due to females x males manifested by all the traits in pooled analysis, suggested its significant contribution in favour of specific combining ability (sca) variances.

Perusal of mean squares due to females, males and females x males in individual and across the environments revealed that mean squares due to females were of larger magnitude in comparison with those due to males or females x males indicated greater diversity among females. The mean squares due to females x males were with lower magnitude compared to both males and females indicated that the hybrids were more uniform. An assessment of gca of females (females) and gca of males (males) for their contribution towards gca (average gca) on the basis of pooled analysis revealed that for all the traits contributed largely towards gca.

Table 4.4.1: Analysis of variance (mean squares) and variance estimates for combining ability for days to 50 % flowering and days to first picking under individual and pooled over environments

Source	d.f.	Days to 50 % flowering					Days to first picking				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Environments	3	-	-	-	-	906.88**	-	-	-	-	52.09**
Replication/Environment	2	22.80	2.47	6.22	2.72	9.99	8.98	0.74	8.37	3.09	1.03
Hybrids	49	27.91**	27.20**	15.70**	35.19**	38.82**	13.34*	12.27	23.35**	15.96	17.31**
Females (F)	9	40.85	23.75	13.21	26.15	42.90	10.93	9.38	32.34	19.06	19.49
Males (M)	4	22.01	44.16	34.45	73.24	131.62**	12.21	1.07	20.19	7.33	18.06
Females x Males (F x M)	36	25.33**	26.17**	14.24**	33.21**	27.49**	14.07*	14.24	21.45**	16.14	16.68**
Hybrids x Environnements	147	-	-	-	-	22.39**	-	-	-	-	15.87**
Female x Environment	27	-	-	-	-	20.35	-	-	-	-	17.40
Male x Environment	12	-	-	-	-	14.08	-	-	-	-	7.58
(Female x Male) x Environments	108	-	-	-	-	23.82**	-	-	-	-	16.41**
Pooled Error	392					7.78					9.45
Estimates											
σ^2 Environment		-	-	-	-	4.61	-	-	-	-	0.21
σ^2 Females		2.00	0.82	0.58	1.49	0.58	0.29	0.05	1.62	0.62	0.16
σ^2 Males		0.37	1.09	1.00	2.31	1.03	0.18	-0.24	0.40	-0.07	0.07
σ^2 gca		0.91 *	1.00*	0.86**	2.04*	0.88	0.22	-0.14	0.81*	0.15	0.10
σ^2 sca		4.82 **	4.93**	3.26**	9.84**	1.64	2.50**	1.89*	4.49**	2.14*	0.60
σ^2 gca/ σ^2 sca		0.18	0.20	0.26	0.20	0.53	0.08	-0.07	0.18	0.07	0.17
σ^2 Females x Environments		-	-	-	-	0.83	-	-	-	-	0.53
σ^2 Males x Environments		-	-	-	-	0.21	-	-	-	-	-0.06
σ^2 gca x Environments		-	-	-	-	0.41	-	-	-	-	0.13
σ^2 sca x Environments		-	-	-	-	5.34	-	-	-	-	2.31

E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.
* and ** significant at 5 % and 1 % level of probability, respectively.

Table 4.4.2: Analysis of variance (mean squares) and variance estimates for combining ability for fruit length (cm) and fruit girth (cm) under individual and pooled over environments

Source	d.f.	Fruit length (cm)					Fruit Girth (cm)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Environments	3	-	-	-	-	4.50**	-	-	-	-	4.09**
Replication/Environment	2	0.27	0.46	0.14	0.72	1.30	0.29	0.07	0.15	0.17	0.53*
Hybrids	49	0.65	0.99*	1.07**	1.24**	1.31**	0.75**	1.39**	1.59**	1.67**	1.95**
Females (F)	9	1.37*	0.49	1.42	0.72	1.93	0.81	2.00	1.28	1.53	1.49
Males (M)	4	0.15	2.37	1.92	4.77**	3.14*	0.67	2.82	1.32	1.82	3.87
Females x Males (F x M)	36	0.53	0.96*	0.89**	0.98**	0.96**	0.75**	1.08**	1.70**	1.68**	1.85**
Hybrids x Environnements	147	-	-	-	-	0.88**	-	-	-	-	1.15**
Female x Environment	27	-	-	-	-	0.69	-	-	-	-	1.38
Male x Environment	12	-	-	-	-	2.02**	-	-	-	-	0.92
(Female x Male) x Environments	108	-	-	-	-	0.80**	-	-	-	-	1.12**
Pooled Error	392					0.45					0.17
Estimates											
σ^2 Environment		-	-	-	-	0.02	-	-	-	-	0.02
σ^2 Females		0.05*	-0.009	0.07	0.02	0.02	0.04	0.12	0.07	0.09	0.02
σ^2 Males		-0.01	0.05	0.05	0.14**	0.02	0.01	0.08	0.03	0.05	0.03
σ^2 gca		0.01**	0.03*	0.06**	0.10**	0.02	0.02	0.09**	0.05	0.06	0.02
σ^2 sca		0.005	0.11*	0.19**	0.22**	0.04	0.18**	0.29**	0.51**	0.52**	0.14
σ^2 gca/ σ^2 sca		2.17	0.31	0.31	0.48	0.55	0.13	0.33	0.09	0.13	0.19
σ^2 Females x Environments		-	-	-	-	0.01	-	-	-	-	0.08
σ^2 Males x Environments		-	-	-	-	0.05	-	-	-	-	0.02
σ^2 gca x Environments		-	-	-	-	0.04	-	-	-	-	0.04
σ^2 sca x Environments		-	-	-	-	0.11	-	-	-	-	0.31

E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.
* and ** significant at 5 % and 1 % level of probability, respectively.

Table 4.4.3: Analysis of variance (mean squares) and variance estimates for combining ability for number of branches per plant and internodal length (cm) under individual and pooled over environments

Source	d.f.	Number of branches per plant					Internodal length (cm)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Environments	3	-	-	-	-	0.62**	-	-	-	-	1305.95**
Replication/Environment	2	0.04	0.03	0.04	0.003	0.03	0.004	0.39	0.91	1.16	0.58
Hybrids	49	0.12**	0.10**	0.21**	0.13**	0.27**	0.71**	1.78**	3.05**	1.53	2.29**
Females (F)	9	0.23*	0.17*	0.25	0.14	0.46*	0.55	4.27**	4.97	2.04	4.13*
Males (M)	4	0.11	0.22*	0.21	0.19	0.50	0.82	3.48*	1.44	2.54	3.21
Females x Males (F x M)	36	0.09**	0.07	0.19**	0.12**	0.20**	0.74**	0.98**	2.75**	1.29	1.73**
Hybrids x Environments	147	-	-	-	-	0.09**	-	-	-	-	1.60**
Female x Environment	27	-	-	-	-	0.11	-	-	-	-	2.56*
Male x Environment	12	-	-	-	-	0.08	-	-	-	-	1.69
(Female x Male) x Environments	108	-	-	-	-	0.09**	-	-	-	-	1.34**
Pooled Error	392					0.04					0.72
Estimates											
σ^2 Environment		-	-	-	-	0.003	-	-	-	-	6.69
σ^2 Females		0.01*	0.008 *	0.01	0.007	0.007	0.02	0.26**	0.26	0.07	0.05
σ^2 Males		0.002	0.006*	0.006	0.005	0.003	0.01	0.10*	0.01	0.05	0.02
σ^2 gca		0.005**	0.007**	0.009*	0.006*	0.004	0.02	0.16**	0.09*	0.05**	0.03
σ^2 sca		0.01**	0.009 *	0.05**	0.03**	0.01	0.16**	0.23**	0.59**	0.11	0.08
σ^2 gca/ σ^2 sca		0.34	0.72	0.16	0.20	0.35	0.11	0.68	0.16	0.51	0.39
σ^2 Females x Environments		-	-	-	-	0.005	-	-	-	-	0.12
σ^2 Males x Environments		-	-	-	-	0.001	-	-	-	-	0.03
σ^2 gca x Environments		-	-	-	-	0.002	-	-	-	-	0.06
σ^2 sca x Environments		-	-	-	-	0.01	-	-	-	-	0.20

E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.
* and ** significant at 5 % and 1 % level of probability, respectively.

Table 4.4.4: Analysis of variance (mean squares) and variance estimates for combining ability for plant height (cm) and fruit yield per plant (g) under individual and pooled over environments

Source	d.f.	Plant height (cm)					Fruit yield per plant (g)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Environments	3	-	-	-	-	104237.15**	-	-	-	-	376504.80**
Replication/Environment	2	7.55	6.46	852.38**	33.07	174.34	296.20	127.44	1405.00*	691.98	440.57
Hybrids	49	79.69	188.39**	685.16**	372.27**	647.05**	557.13**	850.33**	1916.34**	1412.57**	2836.1**
Females (F)	9	23.16	143.45	641.07	520.56	650.10	525.28	1122.10	3667.24*	1868.84	5424.23*
Males (M)	4	146.93	194.06	860.04	168.66	515.16	297.98	1261.13	902.07	1443.66	2592.23
Females x Males (F x M)	36	86.36	198.99**	676.76**	357.82**	660.94**	593.88**	736.74**	1591.32**	1295.04**	2216.16**
Hybrids x Environments	147	-	-	-	-	226.16**	-	-	-	-	633.42**
Female x Environment	27	-	-	-	-	226.04	-	-	-	-	586.41
Male x Environment	12	-	-	-	-	284.84	-	-	-	-	437.54
(Female x Male) x Environments	108	-	-	-	-	219.66**	-	-	-	-	666.94**
Pooled Error	392					70.46					283.20
Estimates											
σ^2 Environment		-	-	-	-	534.18	-	-	-	-	1929.34
σ^2 Females		-2.50	7.17	35.07	26.82	9.66	20.88	64.67	214.47 *	102.30	85.68
σ^2 Males		2.87	5.27	24.83	1.68	3.70	2.86	36.97	15.06	36.98	19.24
σ^2 gca		1.08	5.90	28.25*	10.06	5.69	8.87	46.20 **	81.53 **	58.75 *	41.38
σ^2 sca		8.54	54.37**	187.29**	79.87**	49.20	127.28**	194.90**	80.37 **	320.27**	161.08
σ^2 gca/ σ^2 sca		0.12	0.10	0.15	0.12	0.11	0.06	0.23	0.21	0.18	0.25
σ^2 Females x Environments		-	-	-	-	10.37	-	-	-	-	20.21
σ^2 Males x Environments		-	-	-	-	7.14	-	-	-	-	5.14
σ^2 gca x Environments		-	-	-	-	8.22	-	-	-	-	10.16
σ^2 sca x Environments		-	-	-	-	49.73	-	-	-	-	127.91

E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

* and ** significant at 5 % and 1 % level of probability, respectively.

Table 4.4.5: Analysis of variance (mean squares) and variance estimates for combining ability for days to total number of fruits per plant and total number of seed per fruit under individual and pooled over environments

Source	d.f.	Total number of fruits per plant					Total number of seed per fruit				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Environments	3	-	-	-	-	729.82**	-	-	-	-	1557.96**
Replication/Environment	2	1.34	3.05	0.16	4.07	0.61	1.34	11.69	1.08	2.364	7.47
Hybrids	49	7.29**	5.48**	10.79**	4.32*	12.15**	23.67**	15.01**	14.95*	22.00**	35.47**
Females (F)	9	10.35	10.59*	7.62	2.71	13.20	21.41	20.63	22.27	20.28	52.90
Males (M)	4	21.65**	4.64	7.12	3.41	19.83	61.44*	10.17	15.94	16.78	63.58
Females x Males (F x M)	36	4.93**	4.30*	11.99**	4.82**	11.03**	20.04**	14.14**	13.01	23.01**	27.99**
Hybrids x Environments	147	-	-	-	-	5.25**	-	-	-	-	13.38**
Female x Environment	27	-	-	-	-	6.02	-	-	-	-	10.56
Male x Environment	12	-	-	-	-	5.66	-	-	-	-	13.59
(Female x Male) x Environments	108	-	-	-	-	5.01**	-	-	-	-	14.07**
Pooled Error	392					2.60					8.007
Estimates											
σ^2 Environment		-	-	-	-	3.72	-	-	-	-	7.94
σ^2 Females		0.53	0.55*	0.31	-0.009	0.17	0.86	1.02	0.87	0.83	0.74
σ^2 Males		0.64**	0.07	0.14	0.01	0.14	1.76*	0.16	0.22	0.30	0.46
σ^2 gca		0.60**	0.23**	0.20	0.009	0.15	1.46**	0.45*	0.43**	0.47	0.55
σ^2 sca		0.85**	0.66**	3.04**	0.66*	0.70	3.89**	2.96**	1.26	5.08**	1.66
σ^2 gca/ σ^2 sca		0.70	0.35	0.06	0.01	0.22	0.37	0.15	0.34	0.09	0.33
σ^2 Females x Environments		-	-	-	-	0.22	-	-	-	-	0.17
σ^2 Males x Environments		-	-	-	-	0.10	-	-	-	-	0.18
σ^2 gca x Environments		-	-	-	-	0.14	-	-	-	-	0.18
σ^2 sca x Environments		-	-	-	-	0.80	-	-	-	-	2.02

E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.
* and ** significant at 5 % and 1 % level of probability, respectively.

Table 4.4.6: Analysis of variance (mean squares) and variance estimates for combining ability for days to last picking and crude protein content (%) under individual and pooled over environments

Source	d.f.	Days to last picking					Crude Protein content (%)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Environments	3	-	-	-	-	7475.29**	-	-	-	-	81.19**
Replication/Environment	2	28.74	36.002	9.89	38.34	57.41	2.80	0.95	2.23	0.12	0.25
Hybrids	49	79.95*	150.53**	59.92	73.61**	138.40**	4.01*	2.41*	3.24**	1.73	4.33**
Females (F)	9	121.19*	157.08	96.22	70.14	132.06	5.09	2.85	4.64	1.95	4.14
Males (M)	4	209.21*	88.39	33.53	56.37	108.21	5.03	3.21	7.10*	3.00	10.21*
Females x Males (F x M)	36	55.27	155.79**	53.78	76.39**	143.34**	3.62*	2.21	2.46	1.53	3.73**
Hybrids x Environments	147	-	-	-	-	75.20**	-	-	-	-	2.35*
Female x Environment	27	-	-	-	-	104.19	-	-	-	-	3.46*
Male x Environment	12	-	-	-	-	93.10	-	-	-	-	2.71
(Female x Male) x Environments	108	-	-	-	-	65.97**	-	-	-	-	2.03
Pooled Error	392					42.13					1.73
Estimates											
σ^2 Environment		-	-	-	-	38.11	-	-	-	-	0.40
σ^2 Females		4.57*	7.71	3.37	1.85	1.49	0.19	0.09	0.20	0.04	0.04
σ^2 Males		5.21*	1.56	-0.40	0.46	0.55	0.09	0.05	0.18*	0.05	0.07
σ^2 gca		5.00**	3.61	0.85*	0.93	0.86	0.12**	0.06*	0.19**	0.05**	0.06
σ^2 sca		0.88	38.14**	2.74	11.36*	8.43	0.47*	0.23	0.32*	0.07	0.16
σ^2 gca/ σ^2 sca		5.66	0.09	0.31	0.08	0.10	0.26	0.28	0.60	0.65	0.36
σ^2 Females x Environments		-	-	-	-	4.13	-	-	-	-	0.11
σ^2 Males x Environments		-	-	-	-	1.69	-	-	-	-	0.03
σ^2 gca x Environments		-	-	-	-	2.51	-	-	-	-	0.06
σ^2 sca x Environments		-	-	-	-	7.94	-	-	-	-	0.10

E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.
* and ** significant at 5 % and 1 % level of probability, respectively.

Table 4.4.7: Analysis of variance (mean squares) and variance estimates for combining ability for crude fiber content (%) and vitamin 'C' (mg/100 g pulp) under individual and pooled over environments

Source	d.f.	Crude Fiber content (%)					Vitamin-C (mg/100g pulp)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
Environments	3	-	-	-	-	0.22**	-	-	-	-	2.23**
Replication/Environment	2	0.07	0.02	0.05	0.0005	0.09	1.36	2.11*	0.42	1.42*	0.96
Hybrids	49	0.37**	0.76**	0.44**	0.34**	1.00**	1.55**	1.70**	1.84**	3.50**	4.33**
Females (F)	9	0.61	1.61**	0.51	0.48	2.17**	1.63	6.11**	1.46	11.07**	12.03**
Males (M)	4	0.52	0.90	0.17	0.20	1.41	2.65	0.09	1.07	2.18	2.81
Females x Males (F x M)	36	0.30**	0.53**	0.46**	0.32**	0.66**	1.41**	0.77*	2.01**	1.76**	2.57**
Hybrids x Environments	147	-	-	-	-	0.30**	-	-	-	-	1.42**
Female x Environment	27	-	-	-	-	0.35	-	-	-	-	2.74**
Male x Environment	12	-	-	-	-	0.13	-	-	-	-	1.06
(Female x Male) x Environments	108	-	-	-	-	0.31**	-	-	-	-	1.13**
Pooled Error	392					0.04					0.44
Estimates											
σ^2 Environment		-	-	-	-	0.0009	-	-	-	-	0.009
σ^2 Females		0.03	0.10**	0.03	0.02	0.03	0.07	0.37**	0.07	0.70**	0.19
σ^2 Males		0.01	0.02	0.004	0.005	0.01	0.06	-0.01	0.02	0.05	0.01
σ^2 gca		0.023**	0.05**	0.01	0.01*	0.01	0.06**	0.11**	0.04	0.27**	0.07
σ^2 sca		0.08**	0.16**	0.14**	0.09**	0.05	0.27**	0.08	0.55**	0.43**	0.17
σ^2 gca/ σ^2 sca		0.27	0.32	0.09	0.14	0.37	0.25	1.33	0.07	0.62	0.43
σ^2 Females x Environments		-	-	-	-	0.02	-	-	-	-	0.15
σ^2 Males x Environments		-	-	-	-	0.003	-	-	-	-	0.02
σ^2 gca x Environments		-	-	-	-	0.008	-	-	-	-	0.06
σ^2 sca x Environments		-	-	-	-	0.09	-	-	-	-	0.22

E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.
* and ** significant at 5 % and 1 % level of probability, respectively.

The mean squares due to females with environment was significant for days to 50 per cent flowering, days to last picking, internodal length and crude protein, whereas males with environments were found significant for fruit length. These indicated the role of environment in the contribution to gca variance. The significant mean squares due to (females x males) with environment for all the characters indicated the estimates of sca variance were influenced by the environment except crude protein content.

The variance estimates, σ^2gca and σ^2sca were highly non-significant for all the traits over the environments, emphasized the importance of additive and non-additive gene actions in inheritance of these traits. However, scrutiny of σ^2gca/σ^2sca ratio in pooled analysis, revealed preponderance of non-additive gene action for all the traits except fruit length and days to last picking in E_1 and vitamin 'C' in E_2.

Perusal of variance components over the environments revealed that σ^2 females x environment and σ^2 males x environment were non-significant for all the traits indicated that the general combining ability of females and males were not influenced by environment and this was endorsed by non-significance of σ^2 gca x environments for all the traits. Moreover, it is seen from the non-significance interaction of σ^2 sca with environment for all the traits that specific combining ability was less sensitive to environments as evident from highly non-significant estimates due to σ^2 sca x environments.

4.4.2 General and specific combining ability effects (Table 4.4.8 to 4.4.14)

The estimates of general combining ability (gca) effects of parents (10 females and 5 males) and specific combining ability (sca) effects of 50 hybrids were estimated for each individual environment as well as pooled over environments. The results of gca effects (g_i and g_j) and the sca effects (s_{ij}) are presented trait wise in Table 4.4.8 to 4.4.14.

4.4.2.1 Days to 50 per cent flowering (Table 4.4.8)

In E_1, among lines, gca effects ranged from -2.75 (JDNOL-11-11) to 2.02 (JDNOL-11-12). JDNOL-11-11 (-2.75) was the best general combiner. The gca effects of testers ranged from -1.17 (Parbhani Kranti) to 1.09 (Arka Anamika). Parbhani Kranti (-1.17) was the best general combiner among testers. The sca effects ranged from -4.00 (JDNOL-11-1 x Parbhani Kranti) to 7.51

(JDNOL-11-12 x VRO-6). Only hybrid registered significant and negative sca effect. A hybrid with desirable significant and negative effects was JDNOL-11-1 x Parbhani Kranti (-4.00).

In E_2, among lines, gca effects ranged from -2.50 (JOL-08-7) to 1.80 (JDNOL-11-1). JOL-08-7 (-2.50) was the best general combiners. The gca effects of testers ranged from -1.39 (VRO-6) to 1.67 (Arka Anamika). VRO-6 (-1.39) was the best general combiner among testers. The sca effects ranged from -5.96 (JDNOL-11-12 x Parbhani Kranti) to 5.02 (JDNOL-11-3 x Pusa Sawani). Three hybrids registered significant and negative sca effect, were JDNOL-11-12 x Parbhani Kranti (-5.96), JDNOL-11-3 x GO-2 (-5.61) and JDNOL-11-1 x Parbhani Kranti (-4.89) were the three hybrids with desirable significant and negative effects.

In E_3, among lines, gca effects ranged from -1.69 (AOL-08-5) to 1.29 (JOL-6k-2). AOL-08-5 (-1.69) registered significant and negative gca effect, while among testers, gca effects ranged from 0.75 (Parbhani Kranti) to -1.87 (Arka Anamika). None of the tester had significant and negative gca effect. The sca effects ranged from -4.02 (JDNOL-11-12 x VRO-6) to 5.23 (JOL-08-7 x Arka Anamika). Three hybrid *viz.,* JDNOL-11-12 x VRO-6 (-4.02), JOL-6k-2 x GO-2 (-3.83) and AOL-07-9 x Parbhani Kranti (-2.43) were registered significant and negative sca effect.

In E_4, among lines, gca effects ranged from -1.85 (JDNOL-11-14) to 2.01 (JOL-6k-2). JDNOL-11-14 (-1.85), AOL-08-5 (-1.67), JOL-08-12 (-1.45) were the best general combiners. The gca effects of testers ranged from -1.60 (VRO-6) to 2.33 (Arka Anamika). VRO-6 (-1.60) was the best general combiner among testers. The sca effects ranged from -4.34 (JDNOL-11-1 x Parbhani Kranti) to 7.23 (JDNOL-11-11 x Arka Anamika). Thirteen hybrids registered significant and negative sca effect. JDNOL-11-1 x Parbhani Kranti (-4.34), AOL-07-9 x GO-2 (4.32) and JDNOL-11-1 x Arka Anamika (-4.20) were the top three hybrids with desirable significant and negative effects.

In pooled analysis, among lines, gca effects ranged from -0.94 (AOL-08-5) to 1.60 (JOL-6k-2). AOL-08-5 (-0.94), JDNOL-11-14 (-0.92) and JDNOL-11-11 (-0.76) registered significant and negative gca effect, while among testers, gca effects ranged from -0.82 (Parbhani Kranti) to 1.74 (Arka Anamika). Parbhani Kranti (-0.82) and GO-2 (-0.80) had significant and negative gca

Table 4.4.8: Estimates of general combining ability and specific combining ability effects in individual and pooled over environments for days to 50 % flowering and days to first picking

Sr. No.	Genotypes	Days to 50 % flowering					Days to first picking				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	-0.63	1.80*	0.69	-0.00	0.46	-0.78	-0.03	0.47	0.18	-0.04
2.	JDNOL-11-3	-1.28	0.03	-0.61	0.08	-0.44	-0.17	-0.88	1.49*	1.30	0.43
3.	JDNOL-11-11	-2.75**	-0.22	0.10	-0.17	-0.76*	-1.30	0.36	-0.40	-0.14	-0.37
4.	JDNOL-11-12	2.02*	-1.35	0.71	0.99*	0.59	0.27	0.07	1.25	1.81*	0.85*
5.	JDNOL-11-14	-0.99	-0.36	-0.46	-1.85**	-0.92*	-0.60	-1.03	-1.74*	0.19	-0.79*
6.	AOL-07-9	1.88*	-0.19	0.71	0.82	0.80*	0.79	0.99	1.44*	-1.37	0.46
7.	AOL-08-5	-1.28	0.87	-1.69**	-1.67**	-0.94**	0.47	1.30	-0.45	-1.99*	-0.17
8.	JOL-6k-2	1.97*	1.12	1.29*	2.01**	1.60 **	1.28	-0.26	1.38	0.13	0.63
9.	JOL-08-7	0.75	-2.50**	0.31	1.25*	-0.04	-0.77	0.35	-2.72**	0.41	-0.68
10.	JOL-08-12	0.30	0.81	-1.08*	-1.45**	-0.35	0.81	-0.87	-0.73	-0.52	-0.32
	S.E.g_i	1.68	1.72	1.08	0.98	0.70	1.31	1.49	1.44	1.59	0.78
MALES (TESTERS)											
11.	Arka Anamika	1.09	1.67**	1.87**	2.33**	1.74**	-0.20	-0.19	1.28*	0.44	0.33
12.	Pusa Sawani	0.47	0.52	-0.63	-1.00**	-0.16	-0.70	-0.08	-0.57	0.08	-0.32
13.	Parbhani Kranti	-1.17	-0.91	-0.75	-0.44	-0.82**	0.08	0.10	-0.76	-0.74	-0.32
14.	GO-2	-0.35	0.10	-0.31	0.72*	0.03	1.02*	0.27	0.28	0.42	0.49
15.	VRO-6	-0.03	-1.39*	-0.16	-1.60**	-0.80**	-0.19	-0.10	-0.22	-0.21	-0.18
	S.E.g_i	1.19	1.22	0.76	0.69	0.50	0.92	1.05	1.02	1.12	0.55
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	-1.24	-3.26	-2.23	-4.20**	-2.73**	0.65	1.03	1.94	0.05	0.92
17.	JDNOL-11-1 x Pusa Sawani	-1.88	3.54	-1.17	1.90	0.59	-0.56	-1.20	1.60	2.67	0.62
18.	JDNOL-11-1 x Parbhani Kranti	-4.00*	-4.89*	0.63	-4.34**	-3.15**	-1.46	1.15	-1.49	-0.10	-0.47
19.	JDNOL-11-1 x GO-2	0.87	1.37	-2.10	-1.83	-0.42	0.81	-0.93	1.27	-5.18**	-1.00
20.	JDNOL-11-1 x VRO-6	0.78	0.89	1.30	-0.44	0.63	1.31	0.28	0.76	-1.98	0.09
21.	JDNOL-11-3 x Arka Anamika	1.57	-1.32	3.04*	3.96**	1.81*	-2.68	-2.17	-0.84	1.91	-0.94
22.	JDNOL-11-3 x Pusa Sawani	0.99	5.02*	-1.52	2.11	1.65*	0.06	1.26	2.79	-0.86	0.81
23.	JDNOL-11-3 x Parbhani Kranti	0.36	3.66	-0.72	2.24*	1.38	2.93	-0.21	1.16	-0.72	0.79
24.	JDNOL-11-3 x GO-2	4.45*	-5.61**	2.02	2.97**	0.96	0.20	-0.30	-2.26	0.93	-0.35
25.	JDNOL-11-3 x VRO-6	-1.92	0.60	0.74	-2.36*	-0.73	-1.27	1.09	-4.95**	3.28	-0.46
26.	JDNOL-11-11 x Arka Anamika	-1.30	4.38*	-0.56	7.23**	2.43**	2.02	1.24	-2.43	-0.38	0.11
27.	JDNOL-11-11 x Pusa Sawani	2.17	-0.95	1.20	-1.34	0.26	-1.18	0.74	-3.21	0.99	-0.66
28.	JDNOL-11-11 x Parbhani Kranti	-0.17	1.28	0.24	0.90	0.56	1.51	2.36	3.41*	-0.64	1.66
29.	JDNOL-11-11 x GO-2	-2.26	-1.62	2.99*	-2.79*	-0.92	-2.08	-0.17	-0.98	-0.97	-1.05

Table 4.4.8 Continue...

Table 4.4.8 Continue...

Sr. No.	Genotypes	Days to 50 % flowering					Days to first picking				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
30.	JDNOL-11-11 x VRO-6	-0.87	-0.91	-0.17	0.95	-0.25	-1.18	-3.71*	-1.64	2.94	-0.90
31.	JDNOL-11-12 x Arka Anamika	-2.12	4.31*	-2.00	-3.65**	-0.86	1.84	1.33	3.69*	-0.65	1.55
32.	JDNOL-11-12 x Pusa Sawani	1.18	-0.45	1.15	1.24	0.78	-1.03	-1.01	0.35	2.98	0.32
33.	JDNOL-11-12 x Parbhani Kranti	-0.72	-5.96**	0.15	-0.46	-1.75*	-0.82	3.40*	3.09	-0.48	1.29
34.	JDNOL-11-12 x GO-2	-3.40	1.46	1.02	-2.22*	-0.78	0.05	-3.48*	-0.22	-2.29	-1.48
35.	JDNOL-11-12 x VRO-6	7.51**	-1.51	-4.02**	0.15	0.53	0.88	-0.69	-2.05	-1.48	-0.83
36.	JDNOL-11-14 x Arka Anamika	1.40	-0.34	-1.76	-0.93	-0.40	-2.12	1.61	1.51	3.07	1.02
37.	JDNOL-11-14 x Pusa Sawani	1.11	-2.98	-0.16	-2.83*	-1.21	1.95	-1.65	1.12	-2.99	-0.39
38.	JDNOL-11-14 x Parbhani Kranti	2.08	4.73*	0.27	6.36**	3.36**	1.20	-3.70*	0.32	2.55	0.09
39.	JDNOL-11-14 x GO-2	-2.77	-1.78	0.18	3.78**	-0.14	1.25	0.88	1.61	-0.67	0.77
40.	JDNOL-11-14 x VRO-6	-1.26	-1.17	0.90	0.007	-0.38	-2.41	0.52	0.47	2.36	0.23
41.	AOL-07-9 x Arka Anamika	-2.78	1.04	1.47	3.56**	0.82	0.54	2.33	-1.17	-0.87	0.20
42.	AOL-07-9 x Pusa Sawani	-0.56	-0.42	1.37	-1.65	-0.31	-1.40	0.34	-0.52	-0.90	-0.62
43.	AOL-07-9 x Parbhani Kranti	5.05**	1.22	-2.43*	-3.74**	0.02	2.28	0.03	-3.61*	-2.24	-0.88
44.	AOL-07-9 x GO-2	0.41	1.15	0.77	-4.32**	-0.49	-2.85	2.45	0.14	0.65	0.10
45.	AOL-07-9 x VRO-6	-2.68	-1.45	-0.61	-0.23	-1.24	1.55	-2.82	0.12	-0.96	-0.52
46.	AOL-08-5 x Arka Anamika	3.26	-1.21	-0.67	-0.98	0.09	-0.13	-0.49	-3.25*	-0.59	-1.11
47.	AOL-08-5 x Pusa Sawani	-2.41	0.54	0.09	4.35**	0.64	-2.89	0.43	1.12	-1.65	-0.74
48.	AOL-08-5 x Parbhani Kranti	3.44	0.27	0.64	-2.53*	0.45	1.19	3.01	0.73	-1.40	0.88
49.	AOL-08-5 x GO-2	-1.73	3.05	-1.31	1.08	0.27	1.56	-2.49	0.55	1.44	0.26
50.	AOL-08-5 x VRO-6	0.68	-0.02	-1.92	-0.20	-0.36	0.29	1.30	-3.71*	-3.21	-1.33
51.	JOL-6k-2 x Arka Anamika	-0.35	-3.28	-0.26	-2.98**	-1.72*	0.16	-0.66	-2.47	-0.08	-0.76
52.	JOL-6k-2 x Pusa Sawani	-0.53	-0.63	-0.96	-3.22**	-1.33	3.83*	0.03	0.92	1.01	1.45
53.	JOL-6k-2 x Parbhani Kranti	-2.01	1.02	4.07**	3.25**	1.58*	-5.87**	-3.73*	2.18	2.11	-1.32
54.	JOL-6k-2 x GO-2	0.38	-1.39	-3.83**	-2.22*	-1.76*	1.53	0.68	-0.05	1.12	0.82
55.	JOL-6k-2 x VRO-6	-0.71	1.66	4.15**	3.44**	2.13**	0.32	1.91	3.98*	1.26	1.86*
56.	JOL-08-7 x Arka Anamika	-2.11	0.43	5.23**	-1.10	0.61	-0.42	-3.39*	2.23	-2.14	-0.93
57.	JOL-08-7 x Pusa Sawani	1.01	-0.15	0.039	-2.08	-0.29	2.68	1.67	-0.64	0.97	1.17
58.	JOL-08-7 x Parbhani Kranti	-1.35	-1.39	-1.79	-0.38	-1.23	-2.44	-2.81	-2.97	-0.40	-2.16*
59.	JOL-08-7 x GO-2	5.89**	-1.017	0.23	-0.23	1.22	-1.54	2.71	-2.45	5.38**	1.02
60.	JOL-08-7 x VRO-6	0.67	1.23	-0.10	-0.31	0.37	2.00	1.60	4.12*	-0.10	1.90*
61.	JOL-08-12 x Arka Anamika	3.68	-0.74	-2.24	-0.9	-0.05	0.12	-0.82	0.80	-0.30	-0.05
62.	JOL-08-12 x Pusa Sawani	-1.08	-3.50	-0.04	1.52	-0.78	-1.46	-0.63	-3.55*	-2.22	-1.96*
63.	JOL-08-12 x Parbhani Kranti	-2.67	0.04	-1.06	-1.29	-1.24	1.48	0.51	-2.83	1.32	0.12
64.	JOL-08-12 x GO-2	-1.85	4.36*	0.01	5.79**	2.08**	1.06	0.64	2.40	-0.41	0.92
65.	JOL-08-12 x VRO-6	-2.19	0.70	-0.27	-0.99	-0.69	-1.48	0.51	2.90	-2.09	-0.04
	$S.E.s_{ij}$	3.77	3.86	2.41	2.19	1.58	2.93	3.35	3.23	3.57	1.74

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

effect. The sca effects ranged from -3.15 (JDNOL-11-1 x Parbhani Kranti) to 3.36 (JDNOL-11-14 x Parbhani Kranti). Five hybrids registered significant and negative sca effect. JDNOL-11-1 x Parbhani Kranti (-3.15), JDNOL-11-1 x Arka Anamika (-2.73) and JDNOL-11-12 x Parbhani Kranti (-1.75) were the top three hybrids with higher significant and negative effects.

However, scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.18), E_2 (0.20), E_3 (0.26), E_4 (0.20) and pooled analysis (0.53) revealed preponderance of non-additive gene action for this trait.

4.4.2.2 Days to first picking (Table 4.4.8)

Looking to the data in E_1, none of the parent recorded significant and negative gca effect. GCA effects for lines and testers was ranged from -1.30 (JDNOL-11-11) to 1.28 (JOL-6k-2) and -0.70 (Pusa Sawani) to 1.02 (GO-2), respectively. The values of sca effects varied from -5.87 (JOL-6k-2 x Parbhani Kranti) to JOL-6k-2 x Pusa Sawani (3.83). One hybrid exhibited significant and negative sca effect.

In E_2, none of the parent recorded significant and negative gca effect. GCA effects for lines and testers was ranged from -1.03 (JDNOL-11-14) to 1.30 (AOL-08-5) and -0.19 (Arka Anamika) to 0.27 (GO-2), respectively. The values of sca effects in hybrids varied from -3.73 (JOL-6k-2 x Parbhani Kranti) to 3.40 (JDNOL-11-12 x Parbhani Kranti). Five hybrids exhibited significant and negative sca effect of which JOL-6k-2 x Parbhani Kranti (-3.73), JDNOL-11-11 x VRO-6 (-3.71) and JDNOL-11-14 x Parbhani Kranti (-3.70) were the top three hybrids with higher significant and negative effects.

Whereas, in E_3, gca effects for lines and testers was ranged from -2.72 (JOL-08-7) to 1.49 (JDNOL-11-3) and -0.76 (Parbhani Kranti) to 1.28 (Arka Anamika), respectively. Among lines, JOL-08-7 (-2.72) and JDNOL-11-14 (-1.74) recorded significant and negative gca effect, while, none of the tester recorded significant and negative gca effect. In crosses, the values of sca effects varied from -4.95 (JDNOL-11-3 x VRO-6) to 4.12 (JOL-08-7 x VRO-6). Five hybrids registered significant and negative sca effect. JDNOL-11-3 x VRO-6 (-4.95), AOL-08-5 x VRO-6 (-3.71) and AOL-07-9 x Parbhani Kranti (-3.61) were the top three hybrids with higher significant and negative effects.

In E_4, gca effects for lines and testers was ranged from -1.99 (AOL-08-5) to 1.81 (JDNOL-11-12) and -0.74 (Parbhani Kranti) to 0.44 (Arka Anamika), respectively. Among lines, only AOL-08-5 (-1.99) recorded significant and negative gca effect, while, none of the tester recorded significant and negative gca effect. The values of sca effects in hybrids varied from -5.18 (JDNOL-11-1 x GO-2) to 5.38 (JOL-08-7 x GO-2). Only one hybrid JDNOL-11-1 x GO-2 (-5.18) found with significant and negative sca effects.

Looking to the data in pooled analysis, gca effects for lines and testers was ranged from -0.79 (JDNOL-11-14) to 0.85 (JDNOL-11-12) and -0.32 (Pusa Sawani) to 0.49 (GO-2), respectively. Among lines, only JDNOL-11-14 (-0.79) recorded significant and negative gca effect, while, none of the tester recorded significant and negative gca effect. The values of sca effects in hybrids varied from -2.16 (JOL-08-7 x Parbhani Kranti) to 1.90 (JOL-08-7 x VRO-6). JOL-08-7 x Parbhani Kranti (-2.16) and JOL-08-12 x Pusa Sawani (-1.96) hybrids possessed higher significant and negative sca effects.

However, scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.08), E_2 (-0.07), E_3 (0.18), E_4 (0.07) and pooled analysis (0.17) revealed preponderance of non-additive gene action for this particular trait.

4.4.2.3 Fruit length (Table 4.4.9)

In E_1, among lines, gca effects ranged from -0.53 (JOL-6k-2) to 0.48 (JDNOL-11-3). JDNOL-11-3 (0.48) registered significant and positive gca effect. Among testers, gca effects ranged from -0.09 (Arka Anamika) to 0.09 (Pusa Sawani). None of the tester had significant and positive gca effect. The sca effects ranged from -1.11 (JOL-08-7 x Arka Anamika) to 0.74 (JOL-08-7 x Parbhani Kranti). None of the hybrid found with significant and positive sca effects.

Whereas, in E_2, gca effects for lines and testers ranged from -0.30 (AOL-07-9) to 0.34 (AOL-08-5) and -0.45 (Arka Anamika) to 0.23 (VRO-6), respectively. The sca effects varied from -1.18 (JDNOL-11-1 x VRO-6) to 1.02 (JDNOL-11-3 x Arka Anamika). The crosses JDNOL-11-3 x Arka Anamika (1.02) and JOL-08-7 x VRO-6 (0.97) was recorded significant and positive sca effect.

Table 4.4.9: Estimates of general combining ability and specific combining ability effects in individual and pooled over environments for fruit length (cm) and fruit girth (cm)

Sr. No.	Genotypes	Fruit length (cm)					Fruit girth (cm)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	-0.04	-0.08	-0.05	-0.12	-0.07	-0.006	-0.50**	-0.09	-0.03	-0.16**
2.	JDNOL-11-3	0.48*	-0.11	-0.01	0.15	0.12	-0.16	0.04	0.44**	-0.06	0.06
3.	JDNOL-11-11	-0.35	0.15	0.19	0.13	0.03	0.18	-0.18	-0.09	-0.59**	-0.17**
4.	JDNOL-11-12	-0.06	-0.11	-0.16	-0.27	-0.15	-0.51**	-0.45**	-0.05	-0.04	-0.26**
5.	JDNOL-11-14	-0.03	-0.01	0.54**	0.47**	0.24**	0.13	-0.35**	0.18	-0.14	-0.04
6.	AOL-07-9	-0.11	-0.30	-0.03	-0.14	-0.15	-0.13	0.51**	-0.55**	0.68**	0.12*
7.	AOL-08-5	0.29	0.34	0.17	-0.07	0.18*	-0.09	0.14	0.32**	0.23**	0.15**
8.	JOL-6k-2	-0.53**	0.01	-0.52**	-0.19	-0.30**	0.2	0.08	-0.27*	-0.06	-0.01
9.	JOL-08-7	0.18	0.15	0.24	0.08	0.16	0.19	0.23*	0.15	-0.05	0.13*
10.	JOL-08-12	0.18	-0.03	-0.36*	-0.03	-0.06	0.19	0.47**	-0.03	0.07	0.18**
	S.E.g_i	0.36	0.40	0.28	0.29	0.17	0.22	0.22	0.20	0.16	0.10
MALES (TESTERS)											
11.	Arka Anamika	-0.09	-0.45**	-0.26*	0.13	-0.16**	-0.20*	-0.22**	-0.22**	-0.26**	-0.22**
12.	Pusa Sawani	0.09	0.20	0.18	-0.46**	0.006	-0.05	-0.31**	0.17*	-0.22**	-0.10**
13.	Parbhani Kranti	0.05	-0.06	0.09	0.36**	0.11	-0.04	0.04	0.21**	-0.009	0.05
14.	GO-2	-0.018	0.08	-0.27**	-0.38**	-0.15*	0.12	0.02	-0.21**	0.19**	0.03
15.	VRO-6	-0.03	0.23	0.25*	0.34**	0.20**	0.17*	0.47**	0.05	0.29**	0.24**
	S.E.g_i	0.26	0.28	0.20	0.20	0.12	0.15	0.15	0.14	0.12	0.07
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	0.22	0.71	0.01	-0.15	0.20	-0.24	0.21	0.73**	0.23	0.23
17.	JDNOL-11-1 x Pusa Sawani	-0.01	0.51	0.04	-0.10	0.11	0.09	0.83**	0.10	0.46*	0.37**
18.	JDNOL-11-1 x Parbhani Kranti	-0.16	-0.55	0.33	-0.21	-0.15	-0.35	0.10	1.31**	0.48*	0.38**
19.	JDNOL-11-1 x GO-2	-0.09	0.14	0.74*	0.44	0.31	0.35	0.51*	-0.48*	-0.25	0.03
20.	JDNOL-11-1 x VRO-6	-0.29	-1.18*	0.006	-0.26	-0.43*	0.22	0.06	0.02	0.06	0.09
21.	JDNOL-11-3 x Arka Anamika	-0.15	1.02*	1.01**	0.18	0.51**	-0.05	-0.90**	-0.58*	-1.40**	-0.73**
22.	JDNOL-11-3 x Pusa Sawani	-0.09	-0.63	-0.009	-0.22	-0.24	0.26	-0.80**	-0.81**	-0.53**	-0.47**
23.	JDNOL-11-3 x Parbhani Kranti	0.31	0.22	-0.95**	0.29	-0.02	0.03	-0.48	0.48*	0.15	0.04
24.	JDNOL-11-3 x GO-2	0.05	0.06	-0.69*	-0.009	-0.14	-0.12	-0.08	0.04	0.32	0.04
25.	JDNOL-11-3 x VRO-6	0.21	-0.32	-0.49	0.05	-0.14	-0.19	0.54*	-0.82**	0.45*	-0.005
26.	JDNOL-11-11 x Arka Anamika	0.35	-0.32	0.05	0.68*	0.19	0.10	0.32	0.83**	-0.007	0.31**
27.	JDNOL-11-11 x Pusa Sawani	-0.54	-1.04*	-0.37	0.58	-0.34	-0.06	0.20	-0.63**	0.15	-0.08
28.	JDNOL-11-11 x Parbhani Kranti	0.23	0.09	-0.65*	0.64	0.08	0.40	0.19	-0.85**	0.23	-0.003
29.	JDNOL-11-11 x GO-2	-0.26	0.48	-0.17	-0.93**	-0.22	-0.37	0.29	0.46	-0.34	0.009

Table 4.4.9 Continue...

Table 4.4.9 Continue...

Sr. No.	Genotypes	Fruit length (cm)					Fruit girth (cm)				
		E 1	E 2	E 3	E4	Pooled	E 1	E 2	E 3	E4	Pooled
30.	JDNOL-11-11 x VRO-6	0.02	-0.01	0.07	-0.14	-0.01	0.24	-0.35	0.77**	0.26	0.23
31.	JDNOL-11-12 x Arka Anamika	0.14	0.37	0.26	-0.25	0.13	-0.04	0.21	-0.18	-0.24	-0.06
32.	JDNOL-11-12 x Pusa Sawani	-0.13	0.31	-0.31	0.75*	0.15	-0.12	0.06	0.31	0.19	0.11
33.	JDNOL-11-12 x Parbhani Kranti	0.39	-0.02	0.42	-1.01**	-0.05	0.50*	-0.90**	-0.25	-1.59**	-0.56**
34.	JDNOL-11-12 x GO-2	0.09	0.46	0.56	-0.73*	0.09	-0.36	-0.13	0.09	0.91**	0.13
35.	JDNOL-11-12 x VRO-6	-0.31	-0.31	0.13	0.42	-0.01	-0.29	0.09	-0.55*	0.43*	-0.08
36.	JDNOL-11-14 x Arka Anamika	0.30	0.05	-0.08	-0.79*	-0.12	-0.03	-0.82**	-0.16	-0.07	-0.27*
37.	JDNOL-11-14 x Pusa Sawani	0.41	0.55	0.64*	0.68*	0.57**	-0.58*	0.42	0.39	0.70**	0.23
38.	JDNOL-11-14 x Parbhani Kranti	-0.60	-0.05	-0.15	-0.48	-0.32	0.46	0.06	-0.80**	-0.47*	-0.18
39.	JDNOL-11-14 x GO-2	-0.33	0.18	0.34	-0.16	0.005	-0.27	-0.09	0.67**	-0.66**	-0.08
40.	JDNOL-11-14 x VRO-6	0.54	-0.10	-0.30	-0.12	0.00	0.09	0.08	0.11	0.51**	0.20
41.	AOL-07-9 x Arka Anamika	0.03	-0.09	-0.31	-0.06	-0.10	0.59*	-0.17	-0.77**	0.93**	0.14
42.	AOL-07-9 x Pusa Sawani	0.30	-0.06	0.22	-0.21	0.06	-0.75**	0.30	0.11	0.58**	0.06
43.	AOL-07-9 x Parbhani Kranti	-0.56	-0.17	-0.42	0.49	-0.16	-0.36	0.16	-0.02	-0.61**	-0.20
44.	AOL-07-9 x GO-2	-0.29	0.03	-0.15	0.87**	0.11	0.77**	-0.27	0.66**	0.02	0.29*
45.	AOL-07-9 x VRO-6	0.19	-0.33	0.22	-0.20	-0.03	0.07	0.32	-0.20	-0.92**	-0.18
46.	AOL-08-5 x Arka Anamika	0.22	-0.57	-0.16	0.83*	0.07	-0.22	-0.12	-0.06	-0.47*	-0.22
47.	AOL-08-5 x Pusa Sawani	0.29	0.09	0.001	-0.60	-0.05	-0.25	-0.11	0.009	-0.41*	-0.19
48.	AOL-08-5 x Parbhani Kranti	-0.21	-0.12	-0.04	-0.59	-0.24	-0.46	-0.78**	-0.81**	-0.93**	-0.75**
49.	AOL-08-5 x GO-2	0.26	-0.53	-1.07**	0.65*	-0.17	1.01**	-0.62*	-0.26	0.37	0.12
50.	AOL-08-5 x VRO-6	0.44	0.34	0.09	-0.06	0.20	0.37	1.01**	0.51*	0.46*	0.59**
51.	JOL-6k-2 x Arka Anamika	-0.26	-0.42	0.30	-0.10	-0.12	-0.71**	0.72**	0.49*	0.29	0.20
52.	JOL-6k-2 x Pusa Sawani	-0.19	0.55	0.37	-0.41	0.07	0.24	-0.18	0.69**	-0.001	0.18
53.	JOL-6k-2 x Parbhani Kranti	-0.16	-0.12	0.97**	0.09	0.19	0.08	0.41	-0.56*	1.18**	0.27*
54.	JOL-6k-2 x GO-2	0.11	0.34	-0.09	0.53	0.22	0.21	-0.04	-0.53*	-0.21	-0.14
55.	JOL-6k-2 x VRO-6	-0.49	0.44	-0.36	-0.31	-0.18	-0.26	-0.27	0.53*	-0.28	-0.07
56.	JOL-08-7 x Arka Anamika	-1.11**	0.12	0.17	-0.56	-0.34	0.39	0.41	-1.34**	0.31	-0.05
57.	JOL-08-7 x Pusa Sawani	-0.15	-0.12	-0.31	-0.55	-0.28	0.80**	-1.35**	0.13	-0.91**	-0.33**
58.	JOL-08-7 x Parbhani Kranti	0.74	0.64	0.51	0.65*	0.64**	-0.04	0.41	1.16**	0.69**	0.55**
59.	JOL-08-7 x GO-2	0.42	-0.26	0.17	-0.004	0.08	-0.72**	-0.08	-0.39	0.89**	-0.07
60.	JOL-08-7 x VRO-6	-0.72	0.97*	0.13	0.60	0.24	-0.93**	-0.81**	-1.43**	-1.30**	-1.12**
61.	JOL-08-12 x Arka Anamika	0.23	-0.88	-1.27**	0.24	-0.42*	0.21	0.13	1.04**	0.41*	0.45**
62.	JOL-08-12 x Pusa Sawani	0.12	-0.17	-0.27	0.11	-0.05	0.36	0.62*	-0.31	-0.24	0.10
63.	JOL-08-12 x Parbhani Kranti	0.02	0.08	-0.01	0.12	0.05	-0.24	0.80**	0.36	0.87**	0.44**
64.	JOL-08-12 x GO-2	0.02	-0.91*	0.38	-0.66*	-0.29	-0.50*	0.52*	-0.27	-1.04**	-0.32**
65.	JOL-08-12 x VRO-6	0.40	0.53	0.51	0.05	0.37	0.68**	-0.68**	1.05**	0.31	0.34**
	S.E.s_{ij}	0.82	0.90	0.64	0.65	0.38	0.49	0.50	0.46	0.37	0.23

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

In E_3, gca effects for lines and testers ranged from -0.52 (JOL-6k-2) to 0.54 (JDNOL-11-14) and -0.27 (GO-2) to 0.25 (VRO-6), respectively. Among lines, JDNOL-11-14 (0.54), while, in testers, VRO-6 (0.25) recorded significant and positive gca effect. The sca effects of crosses varied from -1.27 (JOL-08-12 x Arka Anamika) to 1.01 (JDNOL-11-3 x Arka Anamika). Four hybrids registered positively significant sca effect. JDNOL-11-3 x Arka Anamika (1.01), JOL-6k-2 x Parbhani Kranti (0.97) and JDNOL-11-1 x GO-2 (0.74) were the top three hybrids with significant and positive sca effects.

Looking to the data in E_4, gca effects for lines and testers ranged from -0.27 (JDNOL-11-12) to 0.47 (JDNOL-11-14) and -0.46 (Pusa Sawani) to 0.36 (Parbhani Kranti), respectively. JDNOL-11-14 (0.47) and tester, Parbhani Kranti (0.36) and VRO-6 (0.34) identified as good general combiners for longer fruits. The sca effects for crosses varied from -1.01 (JDNOL-11-12 x Parbhani Kranti) to 0.87 (AOL-07-9 x GO-2). Seven crosses *viz.*, AOL-07-9 x GO-2 (0.87), AOL-08-5 x Arka Anamika (0.83) and JDNOL-11-11 x Arka Anamika (0.68) found promising among all studied.

Whereas, in pooled analysis, gca effects for lines and testers ranged from -0.30 (JOL-6k-2) to 0.24 (JDNOL-11-14) and -0.16 (Arka Anamika) to 0.20 (VRO-6), respectively. Among lines, JDNOL-11-14 (0.24) and AOL-08-5 (0.18) while, in testers, VRO-6 (0.20) recorded significant and positive gca effect. The sca effects varied from -0.43 (JDNOL-11-1 x VRO-6) to 0.64 (JOL-08-7 x Parbhani Kranti). Three crosses *viz.*, JOL-08-7 x Parbhani Kranti (0.64), JDNOL-11-14 x Pusa Sawani (0.57) and JDNOL-11-3 x Arka Anamika (0.51) exhibited positive sca effects across the environments.

However, scrutiny of σ^2gca/σ^2sca ratio in E_1 (2.17), E_2 (0.31), E_3 (0.31), E_4 (0.48) and pooled analysis (0.55) revealed preponderance of additive gene action (for E_1) and non-additive gene action (for E_2, E_3, E_4 and pooled), respectively.

4.4.2.4 Fruit girth (Table 4.4.9)

Looking to the data in E_1, gca effects for lines and testers ranged from -0.51 (JDNOL-11-12) to 0.19 (JOL-08-7) and -0.20 (Arka Anamika) to 0.17 (VRO-6), respectively. Among lines, JOL-08-7 (0.19) recorded significant and positive gca effect, while, among testers, only VRO-6 (0.17) recorded significant and positive gca effect. In case of hybrids, the sca effects varied from

-0.93 (JOL-08-7 x VRO-6) to AOL-08-5 x GO-2 (1.01). The top three crosses AOL-08-5 x GO-2 (1.01), JOL-08-7 x Pusa Sawani (0.80) and AOL-07-9 x GO-2 (0.77) exhibited positive sca effects.

In E_2, gca effects for lines and testers ranged from -0.50 (JDNOL-11-1) to 0.51 (AOL-07-9) and -0.31 (Pusa Sawani) to 0.47 (VRO-6), respectively. Among lines, AOL-07-9 (0.51), JOL-08-12 (0.47) and JOL-08-7 (0.23) recorded significant and positive gca effect, while, among testers, only VRO-6 (0.47) recorded significant and positive gca effect. The sca effects for crosses varied from -0.35 (JOL-08-7 x Pusa Sawani) to 1.01 (AOL-08-5 x GO-2). Seven hybrids recorded significant and positive sca effect. AOL-08-5 x GO-2 (1.01), JOL-08-7 x Pusa Sawani (0.80) and JOL-6k-2 x Arka Anamika (0.72) were the top three hybrids with higher significant and positive sca effects.

Whereas, in E_3, gca effects for lines and testers ranged from -0.55 (AOL-07-9) to 0.44 (JDNOL-11-3) and -0.22 (Arka Anamika) to 0.21 (Parbhani Kranti), respectively. Among lines, JDNOL-11-3 (0.44) and AOL-08-5 (0.32) recorded significant and positive gca effect, while, among testers, Parbhani Kranti (0.21) and Pusa Sawani (0.17) recorded significant and positive gca effect.The sca effects varied from -1.43 (JOL-08-7 x VRO-6) to 1.31 (JDNOL-11-1 x Parbhani Kranti). Thirteen hybrids recorded significant and positive sca effect. JDNOL-11-1 x Parbhani Kranti (1.31), JOL-08-12 x VRO-6 (1.05) and JOL-08-12 x Arka Anamika (1.04) were the top three hybrids.

In E_4, gca effects for lines and testers ranged from -0.59 (JDNOL-11-11) to 0.68 (AOL-07-9) and -0.26 (Arka Anamika) to 0.29 (VRO-6), respectively. Among lines, AOL-07-9 (0.68) and AOL-08-5 (0.23), while, among testers, VRO-6 (0.29) and GO-2 (0.19) recorded significant gca effect in desirable direction. The sca effects varied from -1.59 (JDNOL-11-12 x Parbhani Kranti) to 1.18 (JOL-6k-2 x Parbhani Kranti). Fourteen hybrids recorded significant and positive sca effect. JOL-6k-2 x Parbhani Kranti (1.18), AOL-07-9 x Arka Anamika (0.93) and JDNOL-11-12 x GO-2 (0.91) were the top three hybrids.

Looking to the data in pooled analysis, gca effects for lines and testers ranged from -0.26 (JDNOL-11-12) to 0.18 (JOL-08-12) and -0.22 (Arka Anamika) to 0.24 (VRO-6). Among lines, JOL-08-12 (0.18), AOL-08-5 (0.15) and JOL-08-7 (0.13) recorded significant and positive gca effect, while, among testers, only VRO-6 (0.24) recorded significant and positive gca effect. The sca effects varied from -1.12 (JOL-08-7 x VRO-6) to 0.59 (AOL-08-5 x VRO-6). Nine hybrids recorded significant and positive sca effect. AOL-08-5 x VRO-6 (0.59), JOL-08-7 x Parbhani Kranti (0.55), and JOL-08-12 x Arka Anamika (0.45) were the top three hybrids having significant and positive sca effect.

However, scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.13), E_2 (0.33), E_3 (0.09), E_4 (0.13) and pooled analysis (0.19) revealed preponderance of non-additive gene action for this particular trait.

4.4.2.5 Number of branches per plant (Table 4.4.10)

In E_1, among lines, gca effects ranged from -0.22 (JDNOL-11-12) to 0.22 (JOL-08-12). JOL-08-12 (0.22) registered significant and positive gca effect. Among testers, gca effects ranged from -0.06 (Parbhani Kranti) to 0.08 (Pusa Sawani). Pusa Sawani (0.08) was the only tester which had significant and positive gca effect. The sca effects ranged from -0.30 (JDNOL-11-3 x GO-2) to 0.35 (JDNOL-11-12 x GO-2). Three hybrids recorded the highest significant and positive sca effects *viz.*, JDNOL-11-12 x GO-2 (0.35), JOL-6k-2 x Parbhani Kranti (0.30) and JDNOL-11-12 x VRO-6 (0.29).

Whereas, in E_2, among lines, gca effects ranged from -0.12 (JDNOL-11-1) to 0.17 (JDNOL-11-14), while, among testers, gca effects ranged from -0.11(GO-2) to 0.11 (Pusa Sawani). Among lines JDNOL-11-14 (0.17) and testers, Pusa Sawani (0.11) possessed significant and positive gca effect. The sca effects ranged from -0.24 (JDNOL-11-14 x VRO-6) to 0.37 (JDNOL-11-14 x Pusa Sawani). Three hybrids recorded the highest significant and positive sca effects *viz.*, JDNOL-11-14 x Pusa Sawani (0.37), JDNOL-11-11 x VRO-6 (0.33) and JOL-08-7 x Parbhani Kranti (0.28).

However, in E_3, among lines, gca effects ranged from -0.20 (AOL-07-9) to 0.17 (JDNOL-11-14). JDNOL-11-14 (0.17) registered significant and positive gca effect followed by JOL-08-126 (0.14) and JOL-08-7 (0.13). Among testers, gca effects ranged from -0.12 (Arka Anamika) to 0.07 (VRO-6). VRO-6 (0.07) had significant and positive gca effect followed by Parbhani Kranti (0.07). The sca effects ranged from -0.40 (JDNOL-11-3 x VRO-6) to 0.50 (JDNOL-11-14 x Pusa Sawani). The hybrids *viz.*, JDNOL-11-14 x Pusa Sawani (0.50), JOL-6k-2 x VRO-6 (0.42) and

JOL-08-7 x Parbhani Kranti (0.37) recorded high significant and positive sca effects along with other eight hybrids.

In E_4, among lines, gca effects ranged from -0.13 (AOL-07-9) to 0.22 (JOL-08-12). Only one cross JOL-08-12 (0.22) registered significant and positive gca effect, while among testers, gca effects ranged from -0.09 (GO-2) to 0.07 (VRO-6). Only VRO-6 (0.07) had significant and positive gca effect. The sca effects ranged from -0.31 (JDNOL-11-3 x Pusa Sawani) to 0.56 (JOL-08-7 x Parbhani Kranti). Five hybrids recorded the highest significant and positive sca effects. JOL-08-7 x Parbhani Kranti (0.56), JDNOL-11-3 x VRO-6 (0.45) and JDNOL-11-12 x Pusa Sawani (0.27) were the top three hybrids with significant and positive effects.

Whereas, in pooled analysis, among lines, gca effects ranged from -0.11 (JDNOL-11-12) to 0.13 (JOL-08-12). JOL-08-12 (0.13) registered significant and positive gca effect followed by JDNOL-11-14 (0.09) and JOL-08-7 (0.08). While among testers, ranged from -0.07 (GO-2) to 0.06 (Pusa Sawani). Pusa Sawani (0.06) and VRO-6 (0.06) had significant and positive gca effect. The sca effects ranged from -0.17 (JDNOL-11-12 x Parbhani Kranti) to 0.35 (JOL-08-7 x Parbhani Kranti). Eight hybrids recorded significant and positive sca effect. The superior hybrids registering desired sca effects across the environments were JOL-08-7 x Parbhani Kranti (0.35), JDNOL-11-14 x Pusa Sawani (0.24) and JOL-6k-2 x Parbhani Kranti (0.22).

Looking to, scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.34), E_2 (0.72), E_3 (0.16), E_4 (0.20) and pooled analysis (0.35) revealed preponderance of non-additive gene action for this trait.

4.4.2.6 Internodal length (Table 4.4.10)

Looking to the data in E_1, among lines, gca effects ranged from -0.44 (JDNOL-11-12) to 0.22 (JDNOL-11-1). Only one hybrid JDNOL-11-12 (-0.44) registered significant and negative gca effect, while among testers, gca effects ranged from -0.17 (VRO-6) to 0.23 (Parbhani Kranti). None of hybrid had significant and negative gca effect. The sca effects ranged from -1.33 (JDNOL-11-3 x VRO-6) to 0.65 (JDNOL-11-14 x Arka Anamika). Four hybrids recorded the highest significant and negative sca effects *viz.*, JDNOL-11-3 x VRO-6 (-1.33), JOL-08-7 x GO-2 (-0.94), JDNOL-11-14 x VRO-6 (-0.67) and JDNOL-11-14 x Arka Anamika (-0.65).

Table 4.4.9: Estimates of general combining ability and specific combining ability effects in individual and pooled over environments for fruit length (cm) and fruit girth (cm)

Sr. No.	Genotypes	Fruit length (cm)					Fruit girth (cm)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	-0.04	-0.08	-0.05	-0.12	-0.07	-0.006	-0.50**	-0.09	-0.03	-0.16**
2.	JDNOL-11-3	0.48*	-0.11	-0.01	0.15	0.12	-0.16	0.04	0.44**	-0.06	0.06
3.	JDNOL-11-11	-0.35	0.15	0.19	0.13	0.03	0.18	-0.18	-0.09	-0.59**	-0.17**
4.	JDNOL-11-12	-0.06	-0.11	-0.16	-0.27	-0.15	-0.51**	-0.45**	-0.05	-0.04	-0.26**
5.	JDNOL-11-14	-0.03	-0.01	0.54**	0.47**	0.24**	0.13	-0.35**	0.18	-0.14	-0.04
6.	AOL-07-9	-0.11	-0.30	-0.03	-0.14	-0.15	-0.13	0.51**	-0.55**	0.68**	0.12*
7.	AOL-08-5	0.29	0.34	0.17	-0.07	0.18*	-0.09	0.14	0.32**	0.23**	0.15**
8.	JOL-6k-2	-0.53**	0.01	-0.52**	-0.19	-0.30**	0.2	0.08	-0.27*	-0.06	-0.01
9.	JOL-08-7	0.18	0.15	0.24	0.08	0.16	0.19	0.23*	0.15	-0.05	0.13*
10.	JOL-08-12	0.18	-0.03	-0.36*	-0.03	-0.06	0.19	0.47**	-0.03	0.07	0.18**
	S.E.g_i	0.36	0.40	0.28	0.29	0.17	0.22	0.22	0.20	0.16	0.10
MALES (TESTERS)											
11.	Arka Anamika	-0.09	-0.45**	-0.26*	0.13	-0.16**	-0.20*	-0.22**	-0.22**	-0.26**	-0.22**
12.	Pusa Sawani	0.09	0.20	0.18	-0.46**	0.006	-0.05	-0.31**	0.17*	-0.22**	-0.10**
13.	Parbhani Kranti	0.05	-0.06	0.09	0.36**	0.11	-0.04	0.04	0.21**	-0.009	0.05
14.	GO-2	-0.018	0.08	-0.27**	-0.38**	-0.15*	0.12	0.02	-0.21**	0.19**	0.03
15.	VRO-6	-0.03	0.23	0.25*	0.34**	0.20**	0.17*	0.47**	0.05	0.29**	0.24**
	S.E.g_i	0.26	0.28	0.20	0.20	0.12	0.15	0.15	0.14	0.12	0.07
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	0.22	0.71	0.01	-0.15	0.20	-0.24	0.21	0.73**	0.23	0.23
17.	JDNOL-11-1 x Pusa Sawani	-0.01	0.51	0.04	-0.10	0.11	0.09	0.83**	0.10	0.46*	0.37**
18.	JDNOL-11-1 x Parbhani Kranti	-0.16	-0.55	0.33	-0.21	-0.15	-0.35	0.10	1.31**	0.48*	0.38**
19.	JDNOL-11-1 x GO-2	-0.09	0.14	0.74*	0.44	0.31	0.35	0.51*	-0.48*	-0.25	0.03
20.	JDNOL-11-1 x VRO-6	-0.29	-1.18*	0.006	-0.26	-0.43*	0.22	0.06	0.02	0.06	0.09
21.	JDNOL-11-3 x Arka Anamika	-0.15	1.02*	1.01**	0.18	0.51**	-0.05	-0.90**	-0.58*	-1.40**	-0.73**
22.	JDNOL-11-3 x Pusa Sawani	-0.09	-0.63	-0.009	-0.22	-0.24	0.26	-0.80**	-0.81**	-0.53**	-0.47**
23.	JDNOL-11-3 x Parbhani Kranti	0.31	0.22	-0.95**	0.29	-0.02	0.03	-0.48	0.48*	0.15	0.04
24.	JDNOL-11-3 x GO-2	0.05	0.06	-0.69*	-0.009	-0.14	-0.12	-0.08	0.04	0.32	0.04
25.	JDNOL-11-3 x VRO-6	0.21	-0.32	-0.49	0.05	-0.14	-0.19	0.54*	-0.82**	0.45*	-0.005
26.	JDNOL-11-11 x Arka Anamika	0.35	-0.32	0.05	0.68*	0.19	0.10	0.32	0.83**	-0.007	0.31**
27.	JDNOL-11-11 x Pusa Sawani	-0.54	-1.04*	-0.37	0.58	-0.34	-0.06	0.20	-0.63**	0.15	-0.08
28.	JDNOL-11-11 x Parbhani Kranti	0.23	0.09	-0.65*	0.64	0.08	0.40	0.19	-0.85**	0.23	-0.003
29.	JDNOL-11-11 x GO-2	-0.26	0.48	-0.17	-0.93**	-0.22	-0.37	0.29	0.46	-0.34	0.009

Table 4.4.9 Continue...

Table 4.4.9 Continue...

Sr. No.	**Genotypes**	**Fruit length (cm)**					**Fruit girth (cm)**				
		E_1	**E_2**	**E_3**	**E_4**	**Pooled**	**E_1**	**E_2**	**E_3**	**E_4**	**Pooled**
30.	JDNOL-11-11 x VRO-6	0.02	-0.01	0.07	-0.14	-0.01	0.24	-0.35	0.77**	0.26	0.23
31.	JDNOL-11-12 x Arka Anamika	0.14	0.37	0.26	-0.25	0.13	-0.04	0.21	-0.18	-0.24	-0.06
32.	JDNOL-11-12 x Pusa Sawani	-0.13	0.31	-0.31	0.75*	0.15	-0.12	0.06	0.31	0.19	0.11
33.	JDNOL-11-12 x Parbhani Kranti	0.39	-0.02	0.42	-1.01**	-0.05	0.50*	-0.90**	-0.25	-1.59**	-0.56**
34.	JDNOL-11-12 x GO-2	0.09	0.46	0.56	-0.73*	0.09	-0.36	-0.13	0.09	0.91**	0.13
35.	JDNOL-11-12 x VRO-6	-0.31	-0.31	0.13	0.42	-0.01	-0.29	0.09	-0.55*	0.43*	-0.08
36.	JDNOL-11-14 x Arka Anamika	0.30	0.05	-0.08	-0.79*	-0.12	-0.03	-0.82**	-0.16	-0.07	-0.27*
37.	JDNOL-11-14 x Pusa Sawani	0.41	0.55	0.64*	0.68*	0.57**	-0.58*	0.42	0.39	0.70**	0.23
38.	JDNOL-11-14 x Parbhani Kranti	-0.60	-0.05	-0.15	-0.48	-0.32	0.46	0.06	-0.80**	-0.47*	-0.18
39.	JDNOL-11-14 x GO-2	-0.33	0.18	0.34	-0.16	0.005	-0.27	-0.09	0.67**	-0.66**	-0.08
40.	JDNOL-11-14 x VRO-6	0.54	-0.10	-0.30	-0.12	0.00	0.09	0.08	0.11	0.51**	0.20
41.	AOL-07-9 x Arka Anamika	0.03	-0.09	-0.31	-0.06	-0.10	0.59*	-0.17	-0.77**	0.93**	0.14
42.	AOL-07-9 x Pusa Sawani	0.30	-0.06	0.22	-0.21	0.06	-0.75**	0.30	0.11	0.58**	0.06
43.	AOL-07-9 x Parbhani Kranti	-0.56	-0.17	-0.42	0.49	-0.16	-0.36	0.16	-0.02	-0.61**	-0.20
44.	AOL-07-9 x GO-2	-0.29	0.03	-0.15	0.87**	0.11	0.77**	-0.27	0.66**	0.02	0.29*
45.	AOL-07-9 x VRO-6	0.19	-0.33	0.22	-0.20	-0.03	0.07	0.32	-0.20	-0.92**	-0.18
46.	AOL-08-5 x Arka Anamika	0.22	-0.57	-0.16	0.83*	0.07	-0.22	-0.12	-0.06	-0.47*	-0.22
47.	AOL-08-5 x Pusa Sawani	0.29	0.09	0.001	-0.60	-0.05	-0.25	-0.11	0.009	-0.41*	-0.19
48.	AOL-08-5 x Parbhani Kranti	-0.21	-0.12	-0.04	-0.59	-0.24	-0.46	-0.78**	-0.81**	-0.93**	-0.75**
49.	AOL-08-5 x GO-2	0.26	-0.53	-1.07**	0.65*	-0.17	1.01**	-0.62*	-0.26	0.37	0.12
50.	AOL-08-5 x VRO-6	0.44	0.34	0.09	-0.06	0.20	0.37	1.01**	0.51*	0.46*	0.59**
51.	JOL-6k-2 x Arka Anamika	-0.26	-0.42	0.30	-0.10	-0.12	-0.71**	0.72**	0.49*	0.29	0.20
52.	JOL-6k-2 x Pusa Sawani	-0.19	0.55	0.37	-0.41	0.07	0.24	-0.18	0.69**	-0.001	0.18
53.	JOL-6k-2 x Parbhani Kranti	-0.16	-0.12	0.97**	0.09	0.19	0.08	0.41	-0.56*	1.18**	0.27*
54.	JOL-6k-2 x GO-2	0.11	0.34	-0.09	0.53	0.22	0.21	-0.04	-0.53*	-0.21	-0.14
55.	JOL-6k-2 x VRO-6	-0.49	0.44	-0.36	-0.31	-0.18	-0.26	-0.27	0.53*	-0.28	-0.07
56.	JOL-08-7 x Arka Anamika	-1.11**	0.12	0.17	-0.56	-0.34	0.39	0.41	-1.34**	0.31	-0.05
57.	JOL-08-7 x Pusa Sawani	-0.15	-0.12	-0.31	-0.55	-0.28	0.80**	-1.35**	0.13	-0.91**	-0.33**
58.	JOL-08-7 x Parbhani Kranti	0.74	0.64	0.51	0.65*	0.64**	-0.04	0.41	1.16**	0.69**	0.55**
59.	JOL-08-7 x GO-2	0.42	-0.26	0.17	-0.004	0.08	-0.72**	-0.08	-0.39	0.89**	-0.07
60.	JOL-08-7 x VRO-6	-0.72	0.97*	0.13	0.60	0.24	-0.93**	-0.81**	-1.43**	-1.30**	-1.12**
61.	JOL-08-12 x Arka Anamika	0.23	-0.88	-1.27**	0.24	-0.42*	0.21	0.13	1.04**	0.41*	0.45**
62.	JOL-08-12 x Pusa Sawani	0.12	-0.17	-0.27	0.11	-0.05	0.36	0.62*	-0.31	-0.24	0.10
63.	JOL-08-12 x Parbhani Kranti	0.02	0.08	-0.01	0.12	0.05	-0.24	0.80**	0.36	0.87**	0.44**
64.	JOL-08-12 x GO-2	0.02	-0.91*	0.38	-0.66*	-0.29	-0.50*	0.52*	-0.27	-1.04**	-0.32**
65.	JOL-08-12 x VRO-6	0.40	0.53	0.51	0.05	0.37	0.68**	-0.68**	1.05**	0.31	0.34**
	S.E.s_{ij}	0.82	0.90	0.64	0.65	0.38	0.49	0.50	0.46	0.37	0.23

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

Table 4.4.10: Estimates of general combining ability and specific combining ability effects in individual and pooled over environments for number of branches per plant and internodal length (cm)

Sr. No.	Genotypes	Number of branches per plant					Internodal length (cm)				
		E 1	E 2	E 3	E4	Pooled	E 1	E 2	E 3	E4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	0.05	-0.12*	-0.15**	-0.04	-0.07**	0.22	0.30*	0.04	-0.71**	-0.03
2.	JDNOL-11-3	-0.16**	-0.11*	0.04	0.00	-0.05*	-0.005	-0.72**	-0.56*	-0.31	-0.40**
3.	JDNOL-11-11	-0.001	0.01	-0.09*	0.02	-0.01	0.10	-0.19	0.81**	0.02	0.19
4.	JDNOL-11-12	-0.22**	-0.09	-0.06	-0.06	-0.11**	-0.44**	-0.58**	-0.51*	-0.26	-0.45**
5.	JDNOL-11-14	0.05	0.17**	0.17**	-0.01	0.09**	-0.002	0.24	0.78**	0.28	0.33**
6.	AOL-07-9	0.031	0.005	-0.20**	-0.13**	-0.07**	-0.05	0.19	-0.36	0.22	0.001
7.	AOL-08-5	-0.01	0.16**	0.04	0.05	0.06*	-0.01	0.54**	0.04	-0.06	0.12
8.	JOL-6k-2	-0.03	-0.05	-0.02	-0.09	-0.05*	0.18	0.64**	-0.86**	0.58*	0.13
9.	JOL-08-7	0.07	0.09	0.13**	0.04	0.08**	0.12	-0.78**	0.15	-0.008	-0.12
10.	JOL-08-12	0.22**	-0.05	0.14**	0.22**	0.13**	-0.12	0.35**	0.45	0.24	0.23*
	S.E.g_i	0.11	0.10	0.08	0.09	0.05	0.25	0.26	0.50	0.49	0.21
MALES (TESTERS)											
11.	Arka Anamika	-0.027	-0.001	-0.12**	-0.08*	-0.05**	0.01	-0.55**	-0.02	-0.21	-0.19*
12.	Pusa Sawani	0.08*	0.11**	0.01	0.04	0.06**	0.07	0.12	0.26	0.09	0.14
13.	Parbhani Kranti	-0.06	-0.03	0.07*	0.05	0.008	0.23*	0.36**	-0.18	0.08	0.12
14.	GO-2	-0.04	-0.11**	-0.04	-0.09**	-0.07**	-0.15	0.09	-0.23	-0.35	-0.16*
15.	VRO-6	0.05	0.04	0.07*	0.07*	0.06**	-0.17	-0.04	0.17	0.39*	0.08
	S.E.g_i	0.07	0.07	0.06	0.06	0.03	0.17	0.19	0.35	0.35	0.15
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	0.12	-0.008	0.28**	0.18	0.14*	0.09	0.56	1.79**	-0.04	0.60*
17.	JDNOL-11-1 x Pusa Sawani	0.12	-0.22	0.18	-0.16	-0.02	-0.53	-0.49	0.55	-0.44	-0.23
18.	JDNOL-11-1 x Parbhani Kranti	-0.06	0.09	0.15	-0.22*	-0.01	-0.50	-0.16	-0.86	-0.12	-0.41
19.	JDNOL-11-1 x GO-2	0.05	-0.02	-0.01	0.22*	0.06	0.48	-0.35	-0.4	-0.46	-0.18
20.	JDNOL-11-1 x VRO-6	0.04	-0.06	0.18	-0.23*	-0.01	0.36	0.70*	-0.74	0.68	0.25
21.	JDNOL-11-3 x Arka Anamika	-0.06	0.07	-0.01	0.05	0.01	0.65*	0.62*	0.02	0.87	0.54*
22.	JDNOL-11-3 x Pusa Sawani	0.07	-0.03	-0.05	-0.31**	-0.08	0.42	-0.36	-1.08	0.42	-0.14
23.	JDNOL-11-3 x Parbhani Kranti	0.17	0.10	-0.06	0.14	0.09	0.06	-0.02	0.15	-1.01	-0.20
24.	JDNOL-11-3 x GO-2	-0.30*	0.01	-0.24*	-0.14	-0.16**	0.29	-0.17	-0.41	0.08	-0.05
25.	JDNOL-11-3 x VRO-6	-0.16	0.07	-0.40**	0.45**	-0.01	-1.33**	-0.33	0.96	0.01	-0.16
26.	JDNOL-11-11 x Arka Anamika	-0.25*	0.04	-0.01	-0.03	-0.06	0.23	0.22	-0.39	-0.49	-0.10
27.	JDNOL-11-11 x Pusa Sawani	-0.13	-0.17	-0.22*	0.11	-0.10	0.20	-0.17	-0.36	-0.05	-0.09
28.	JDNOL-11-11 x Parbhani Kranti	-0.05	-0.13	-0.06	-0.17	-0.10	0.12	-0.11	1.01	-0.64	0.09
29.	JDNOL-11-11 x GO-2	0.04	-0.17	-0.05	-0.01	-0.05	0.14	0.08	-0.20	-0.30	-0.07

Table 4.4.10 Continue...

Sr. No.	Genotypes	Number of branches per plant					Internodal length (cm)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
30.	JDNOL-11-11 x VRO-6	-0.17	0.33**	0.12	0.13	0.10	-0.37	0.45	1.22*	-0.07	0.30
31.	JDNOL-11-12 x Arka Anamika	-0.02	0.06	0.04	-0.19	-0.02	-0.50	-1.19**	0.08	0.27	-0.33
32.	JDNOL-11-12 x Pusa Sawani	0.20	0.13	-0.16	0.27**	0.11	0.24	0.29	-0.14	-0.71	-0.08
33.	JDNOL-11-12 x Parbhani Kranti	-0.24	-0.19	-0.02	-0.22*	-0.17**	-0.40	0.23	0.22	0.21	0.06
34.	JDNOL-11-12 x GO-2	0.35**	-0.02	0.28**	-0.03	0.14*	-0.21	0.14	-0.66	0.74	0.005
35.	JDNOL-11-12 x VRO-6	0.29*	0.13	0.10	0.14	0.16**	0.54	0.05	-0.77	1.05	0.22
36.	JDNOL-11-14 x Arka Anamika	-0.01	-0.02	-0.24*	-0.02	-0.07	-0.65*	-1.12**	0.15	-0.46	-0.52*
37.	JDNOL-11-14 x Pusa Sawani	-0.07	0.37**	0.50**	0.15	0.24**	0.31	1.51**	0.93	1.02	0.94**
38.	JDNOL-11-14 x Parbhani Kranti	-0.05	-0.23	-0.25*	-0.12	-0.16**	0.02	-0.16	-2.02**	-0.19	-0.58*
39.	JDNOL-11-14 x GO-2	0.10	0.12	0.22*	0.01	0.11*	0.29	-0.11	0.69	0.56	0.35
40.	JDNOL-11-14 x VRO-6	0.01	-0.24	-0.20 *	0.03	-0.09	-0.67*	0.007	-0.45	0.39	-0.18
41.	AOL-07-9 x Arka Anamika	0.20	-0.05	-0.25*	0.06	-0.01	0.33	-0.25	0.20	-1.12*	-0.21
42.	AOL-07-9 x Pusa Sawani	-0.03	0.02	0.36**	-0.006	0.08	0.04	-0.02	1.02	0.17	0.30
43.	AOL-07-9 x Parbhani Kranti	-0.24	0.12	0.005	-0.04	-0.04	0.18	-0.09	0.11	0.21	0.10
44.	AOL-07-9 x GO-2	0.14	-0.001	0.21*	0.10	0.11*	0.06	-0.05	-1.14*	0.28	-0.21
45.	AOL-07-9 x VRO-6	-0.03	-0.09	-0.35**	-0.18	-0.16**	0.06	0.31	0.49	-0.86	0.001
46.	AOL-08-5 x Arka Anamika	-0.01	0.06	0.02	-0.05	0.007	0.43	-0.17	-0.78	0.97	0.11
47.	AOL-08-5 x Pusa Sawani	-0.07	-0.05	-0.04	0.07	-0.02	-0.39	-0.22	-0.41	-0.31	-0.33
48.	AOL-08-5 x Parbhani Kranti	-0.03	-0.01	-0.20*	-0.04	-0.07	0.01	-0.01	0.01	0.32	0.08
49.	AOL-08-5 x GO-2	-0.04	0.12	0.005	-0.10	-0.005	0.02	0.97**	0.25	0.98	0.55*
50.	AOL-08-5 x VRO-6	0.21	-0.06	-0.34**	-0.03	-0.05	0.23	-1.10**	1.27*	-0.78	-0.09
51.	JOL-6k-2 x Arka Anamika	0.05	0.09	0.08	0.13	0.08	-0.09	0.05	-0.55	-0.32	-0.23
52.	JOL-6k-2 x Pusa Sawani	-0.09	-0.05	-0.05	0.06	-0.03	-0.40	0.15	0.36	-0.17	-0.01
53.	JOL-6k-2 x Parbhani Kranti	0.30*	0.08	0.26**	0.24*	0.22**	-0.22	0.17	-0.29	-0.21	-0.14
54.	JOL-6k-2 x GO-2	-0.12	-0.02	-0.14	-0.004	-0.07	0.35	0.15	0.32	-0.26	0.14
55.	JOL-6k-2 x VRO-6	-0.18	-0.16	0.42**	-0.27**	-0.04	0.06	0.004	-0.18	-0.20	-0.07
56.	JOL-08-7 x Arka Anamika	0.16	-0.08	-0.05	-0.07	-0.01	-0.09	0.5	-0.77	0.02	-0.08
57.	JOL-08-7 x Pusa Sawani	0.16	0.07	-0.40**	-0.18	-0.08	0.40	-0.62*	-0.70	-0.20	-0.28
58.	JOL-08-7 x Parbhani Kranti	0.20	0.28*	0.37**	0.56**	0.35**	0.35	0.45	1.86**	0.63	0.82**
59.	JOL-08-7 x GO-2	-0.16	-0.04	-0.15	-0.12	-0.12*	-0.94**	-0.59	-0.34	-0.77	-0.66**
60.	JOL-08-7 x VRO-6	-0.1	0.03	0.23*	0.09	0.06	0.45	-0.05	-1.30*	-0.21	-0.28
61.	JOL-08-12 x Arka Anamika	-0.16	-0.17	0.14	-0.07	-0.06	-0.39	0.77*	0.23	0.29	0.22
62.	JOL-08-12 x Pusa Sawani	-0.14	-0.06	-0.08	-0.02	-0.07	-0.31	-0.06	-0.15	0.29	-0.05
63.	JOL-08-12 x Parbhani Kranti	0.01	-0.11	-0.17	-0.11	-0.09	0.38	-0.28	-0.20	0.79	0.17
64.	JOL-08-12 x GO-2	-0.07	0.03	-0.10	0.06	-0.02	-0.5	-0.07	1.89**	-0.85	0.11
65.	JOL-08-12 x VRO-6	0.09	0.05	0.22*	-0.13	0.05	0.65*	-0.03	-0.50	-0.004	0.02
	S.E.s_{ij}	0.25	0.24	0.19	0.20	0.11	0.56	0.60	1.12	1.11	0.48

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

Whereas, in E_2, among lines, gca effects ranged from -0.78 (JOL-08-7) to 0.64 (JOL-6k-2). Only JOL-08-7 (-0.78) registered significant and negative gca effect, while among testers, its ranged from -0.55 (Arka Anamika) to 0.36 (Parbhani Kranti). Arka Anamika (-0.55) had significant and negative gca effect. The sca effects ranged from -1.19 (JDNOL-11-12 x Arka Anamika) to 1.51 (JDNOL-11-14 x Pusa Sawani). Four hybrids registered significant and negative sca effect *viz.,* JDNOL-11-12 x Arka Anamika (-1.19), JDNOL-11-14 x Arka Anamika (-1.12), AOL-08-5 x VRO-6 (-1.10) and JOL-08-7 x Pusa Sawani (-0.62).

In E_3, among lines, gca effects ranged from -0.86 (JOL-6k-2) to 0.81 (JDNOL-11-11). JOL-6k-2 (-0.86), JDNOL-11-3 (-0.56) and JDNOL-11-12 (-0.51) registered significant and negative gca effect, while among testers, gca effects ranged from -0.23 (GO-2) to 0.26 (Pusa Sawani). None of the tester recorded significant and negative gca effect. The sca effects ranged from -2.02 (JDNOL-11-14 x Parbhani Kranti) to 1.89 (JOL-08-12 x GO-2). Three hybrids recorded the highest significant and positive sca effects *viz.,* JDNOL-11-14 x Parbhani Kranti (2.02), JOL-08-7 x VRO-6 (1.30) and AOL-07-9 x GO-2 (1.14).

In E_4, among lines, gca effects ranged from -0.71 (JDNOL-11-1) to 0.58 (JOL-6k-2). Only JDNOL-11-1 (-0.71) registered significant and negative gca effect, while among testers, gca effects ranged from -0.35 (GO-2) to 0.39 (VRO-6). None of the tester recorded significant and negative gca effect. The sca effects ranged from -1.12 (AOL-07-9 x Arka Anamika) to 1.05 (JDNOL-11-12 x VRO-6). One hybrid AOL-07-9 x Arka Anamika (-1.12) was registered significant and negative sca effects.

Whereas, in pooled analysis, among lines, gca effects ranged from -0.45 (JDNOL-11-12) to 0.33 (JDNOL-11-14). JDNOL-11-12 (-0.45) and JDNOL-11-3 (-0.40) registered significant and negative gca effect. Among testers, gca effects ranged from -0.19 to 0.14. Arka Anamika (-0.19) had significant and negative gca effect followed by GO-2 (-0.16). The sca effects ranged from -0.66 (JOL-08-7 x GO-2) to 0.94 (JDNOL-11-14 x Pusa Sawani). Three hybrids registered significant and negative sca effect. JOL-08-7 x GO-2 (-0.66), JDNOL-11-14 x Parbhani Kranti (-0.58) and JDNOL-11-14 x Arka Anamika (0.52) were top three hybrids with higher significant and negative effects.

Looking to, scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.11), E_2 (0.68), E_3 (0.16), E_4 (0.51) and pooled analysis (0.39) revealed preponderance of non-additive gene action for this trait.

4.4.2.7 Plant height (Table 4.4.11)

Looking to the data in E_1, among lines, gca effects ranged from -1.94 (JDNOL-11-3) to 1.54 (JOL-08-12). None of the line recorded significant and negative gca effect, while among testers, gca effects ranged from -3.29 to 2.74. Only Parbhani Kranti (-3.29) had significant and negative gca effect. The sca effects ranged from -10.63 (JOL-08-12 x Parbhani Kranti) to 8.05 (JOL-6k-2 x Arka Anamika). Two hybrids recorded significant and negative sca effect. JOL-08-12 x Parbhani Kranti (-10.63) and AOL-08-5 x Parbhani Kranti (-9.85) were the hybrids with significant and negative sca effects.

In E_2, among lines, gca effects ranged from -4.40 (JDNOL-11-1) to 4.28 (JDNOL-11-14). Only JDNOL-11-1 (-4.40) and JDNOL-11-12 (-4.01) registered significant and negative gca effect, while among testers, gca effects ranged from -3.38 to 3.23. Only GO-2 (-3.38) had significant and negative gca effect. The sca effects ranged from -17.84 (JOL-08-7 x Arka Anamika) to 10.89 (AOL-08-5 x Parbhani Kranti). Nine hybrids recorded significant and negative sca effect. JOL-08-7 x Arka Anamika (-17.84), JDNOL-11-3 x Pusa Sawani (-15.42) and JOL-08-12 x Parbhani Kranti (-13.89) were the promising hybrids for the traits.

Whereas, in E_3, among lines, gca effects ranged from -9.00 to 8.90. The lines AOL-07-9 (-9.00), JDNOL-11-1 (-7.02) and JDNOL-11-3 (-6.59) registered significant and negative gca effect, while among testers, gca effects ranged from -6.39 (GO-2) to 8.27 (Parbhani Kranti). Only GO-2 (-6.39) recorded significant and negative gca effect. The sca effects ranged from -31.30 (JOL-08-7 x Arka Anamika) to 25.69 (AOL-08-5 x GO-2). Ten hybrids recorded significant and negative sca effect. JOL-08-7 x Arka Anamika (-31.30), JDNOL-11-1 x GO-2 (-23.13) and JDNOL-11-11 x Pusa Sawani (-20.09) were the top three promising hybrids.

In E_4, among lines, gca effects ranged from -7.43 to 7.90. JDNOL-11-3 (-7.43) and AOL-07-9 (-5.92) registered significant and negative gca effect, while among testers, gca effects ranged from -3.47 (GO-2) to 3.20 (Parbhani Kranti). None of testers recorded significant and negative gca effect. The sca effects ranged from -25.52 to 20.51. Five hybrids exhibited significant and negative sca effect. JOL-08-7 x Arka Anamika (-25.52), JDNOL-11-11 x Pusa Sawani (-20.20) and AOL-08-5 x Pusa Sawani (-18.11) were the top three hybrids with significant and negative sca effects.

While in pooled analysis, among lines, gca effects ranged from -4.14 to 3.18. JDNOL-11-1(-4.14), AOL-07-9 (-3.52) and JDNOL-11-3 (-3.33) registered significant and negative gca effect, while among testers, gca effects ranged from -3.26 to 2.46. Only GO-2 (-3.26) had significant and negative gca effect. The sca effects ranged from -19.19 to 10.92. Twelve hybrids recorded significant and negative sca effect. JOL-08-7 x Arka Anamika (-19.19), JDNOL-11-11 x Pusa Sawani (-12.09) and AOL-08-5 x Pusa Sawani (-10.58) were the top three promising hybrids across the environments for the traits.

Looking to, scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.12), E_2 (0.10), E_3 (0.15), E_4 (0.12) and pooled analysis (0.11) revealed preponderance of non-additive gene action for this trait.

4.4.2.8 Fruit yield per plant (Table 4.4.11)

In E_1, among lines, gca effects ranged from -9.80 (JDNOL-11-12) to 7.25 (AOL-08-5). None of lines recorded significant and positive gca effect, while among testers, gca effects ranged from -3.60 to 3.16. None of testers recorded significant and positive gca effect. In E_1, the sca effects ranged from -30.39 (JDNOL-11-3 x VRO-6) to 27.13 (JOL-08-7 x Parbhani Kranti). Promising hybrids with higher, significant and positive effects in E_1 were JOL-08-7 x Parbhani Kranti (27.13) and JDNOL-11-1 x GO-2 (23.31). In E_1 only two hybrids was revealed good (significant and positive) sca effects.

In E_2, among lines, gca effects ranged from -11.65 (AOL-07-9) to 12.82 (JOL-08-7). JOL-08-7 (12.82) and JOL-08-7 (11.16) were the general combiners which registered higher, significant and positive gca effects, while among testers, gca effects ranged from -9.75 to 5.80. Parbhani Kranti (5.80) registered higher positive gca effects followed by VRO-6 (5.57). The sca effects ranged from -36.70 (JDNOL-11-3 x VRO-6) to 32.88 (JDNOL-11-12 x VRO-6). Top three hybrids with higher, significant and positive effects were JDNOL-11-12 x VRO-6 (32.88), JDNOL-11-1 x GO-2 (22.37) and JDNOL-11-3 x Arka Anamika (21.90). Nine hybrids depicted good (significant and positive) sca effects.

Table 4.4.11: Estimates of general combining ability and specific combining ability effects in individual and pooled over environments for plant height (cm) and fruit yield per plant (g)

Sr. No.	Genotypes	Plant height (cm)					Fruit yield per plant (g)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	0.63	-4.40**	-7.02*	-5.80*	-4.14**	-5.18	-4.88	-24.95**	-16.81**	-12.95**
2.	JDNOL-11-3	-1.94	2.64	-6.59*	-7.43**	-3.33**	4.08	3.59	0.70	3.29	2.92
3.	JDNOL-11-11	-0.27	3.20*	7.62**	2.17	3.18**	-3.85	-6.89*	-12.25*	-6.24	-7.31**
4.	JDNOL-11-12	1.66	-4.01*	-0.006	-2.42	-1.19	-9.80*	-8.52**	-0.02	-14.56**	-8.23**
5.	JDNOL-11-14	-0.19	4.28**	1.57	4.73	2.59*	2.05	5.001	4.76	12.84**	6.16**
6.	AOL-07-9	1.34	-0.52	-9.00**	-5.92*	-3.52**	-5.83	-11.65**	-6.03	-9.06	-8.14**
7.	AOL-08-5	-0.83	-2.18	7.55**	5.76*	2.57*	7.25	5.43	12.59*	3.04	7.08**
8.	JOL-6k-2	-1.14	-1.71	-3.65	-4.92	-2.85**	-0.25	-6.06	-17.07**	2.45	-5.23*
9.	JOL-08-7	-0.80	2.64	0.62	7.90**	2.59*	7.02	12.82**	24.60**	12.17*	14.15**
10.	JOL-08-12	1.54	0.06	8.90**	5.94*	4.11**	4.52	11.16**	17.66**	12.87**	11.55**
	S.E.g_i	3.99	3.06	5.49	5.57	2.13	7.46	6.31	10.87	9.36	4.27
MALES (TESTERS)											
11.	Arka Anamika	2.74	-0.55	0.59	-0.04	0.68	-3.60	-9.75**	-6.15	-6.28	-6.45**
12.	Pusa Sawani	-0.57	3.23**	-2.22	-0.01	0.10	-2.85	1.03	-0.95	-1.76	-1.13
13.	Parbhani Kranti	-3.29*	1.65	8.27**	3.20	2.46**	0.38	5.80*	8.11*	11.89**	6.55**
14.	GO-2	0.21	-3.38**	-6.39**	-3.47	-3.26**	3.16	-2.65	2.24	-1.25	0.37
15.	VRO-6	0.92	-0.94	-0.25	0.33	0.01	2.90	5.57*	-3.25	-2.59	0.66
	S.E.g_i	2.82	2.17	3.88	3.93	1.50	5.27	4.46	7.68	6.62	3.02
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	-3.50	3.81	13.82*	9.89	6.00*	13.89	13.93	-11.86	26.36*	10.58*
17.	JDNOL-11-1 x Pusa Sawani	4.08	1.49	-3.25	3.43	1.43	3.10	0.56	22.45	-17.81	2.07
18.	JDNOL-11-1 x Parbhani Kranti	1.76	1.34	9.82	-0.52	3.10	2.49	5.86	12.08	22.80*	10.81*
19.	JDNOL-11-1 x GO-2	4.76	4.66	-23.13**	-14.13*	-6.95**	23.31**	22.37**	25.30*	1.34	18.08**
20.	JDNOL-11-1 x VRO-6	-3.49	1.82	-10.30	-10.64	-5.65*	-20.78*	-23.39**	-40.72**	-42.30**	-31.80**
21.	JDNOL-11-3 x Arka Anamika	-0.52	0.86	14.49*	7.65	5.62*	15.75	21.90**	23.42	16.27	19.34**
22.	JDNOL-11-3 x Pusa Sawani	-0.80	-15.42**	-5.19	-0.81	-5.56*	-10.84	-8.69	9.34	-11.83	-5.50
23.	JDNOL-11-3 x Parbhani Kranti	3.98	9.10**	7.10	9.29	7.37**	-7.78	-1.63	-21.19	11.57	-4.76
24.	JDNOL-11-3 x GO-2	-7.12	4.00	1.96	-3.32	-1.12	11.25	5.78	-11.13	-3.88	0.50
25.	JDNOL-11-3 x VRO-6	0.85	-11.69**	-5.33	-0.84	-4.25	-30.39**	-36.70**	-7.70	-2.53	-19.33**
26.	JDNOL-11-11 x Arka Anamika	2.78	5.23	10.46	8.51	6.74**	-3.03	-13.02	27.91*	-1.66	2.54
27.	JDNOL-11-11 x Pusa Sawani	-4.38	-3.68	-20.09**	-20.20**	-12.09**	-0.001	-9.21	1.79	7.67	0.06
28.	JDNOL-11-11 x Parbhani Kranti	2.37	-7.68*	8.36	6.25	2.33	-24.84**	-10.49	-46.01**	-13.24	-23.64**
29.	JDNOL-11-11 x GO-2	3.57	0.005	-8.27	-3.52	-2.05	12.39	1.41	-17.22	15.79	3.09

Table 4.4.11 Continue...

Table 4.4.11 Continue...

Sr. No.	Genotypes	Plant height (cm)					Fruit yield per plant (g)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
30.	JDNOL-11-11 x VRO-6	0.98	0.53	-14.24*	9.50	-0.80	5.21	-7.09	-1.55	6.70	0.81
31.	JDNOL-11-12 x Arka Anamika	-3.61	-6.37	-13.63*	-15.90*	-9.88**	2.74	-1.13	5.38	-8.77	-0.44
32.	JDNOL-11-12 x Pusa Sawani	1.12	2.77	13.77*	1.06	4.68	2.79	-5.08	5.16	14.90	4.44
33.	JDNOL-11-12 x Parbhani Kranti	0.19	2.10	16.38**	-2.73	3.98	-4.68	-8.56	-3.28	-16.05	-8.14
34.	JDNOL-11-12 x GO-2	3.68	0.85	12.82*	7.06	6.10*	0.05	20.31**	2.42	-6.45	4.08
35.	JDNOL-11-12 x VRO-6	-6.72	6.22	-5.55	9.95	0.97	9.36	32.88**	25.39*	1.12	17.19**
36.	JDNOL-11-14 x Arka Anamika	-1.21	-1.42	-9.45	-5.01	-4.27	-1.26	-12.80	-6.56	-3.38	-6.005
37.	JDNOL-11-14 x Pusa Sawani	-0.81	3.99	20.00**	20.51**	10.92**	12.01	1.25	14.06	11.09	9.60*
38.	JDNOL-11-14 x Parbhani Kranti	1.81	-13.23**	-5.55	-0.06	-4.25	-5.61	-13.80	8.91	-33.24**	-10.93*
39.	JDNOL-11-14 x GO-2	-7.08	2.42	-7.76	5.86	-1.63	-22.78**	-4.15	-21.95	3.93	-11.24*
40.	JDNOL-11-14 x VRO-6	0.50	2.81	4.62	-0.75	1.79	-7.71	21.57**	33.01**	8.28	13.79**
41.	AOL-07-9 x Arka Anamika	-2.31	4.10	2.51	-3.33	0.24	-8.67	-14.10	-14.38	-4.48	-10.41*
42.	AOL-07-9 x Pusa Sawani	6.93	5.76	0.26	3.32	4.07	7.46	18.04*	-12.25	-2.45	2.68
43.	AOL-07-9 x Parbhani Kranti	-0.65	-2.05	-3.62	-10.81	-4.28	0.93	-4.48	10.50	4.68	2.91
44.	AOL-07-9 x GO-2	-2.03	-1.54	3.50	-5.65	-1.43	14.42	10.37	18.53	17.15	15.12**
45.	AOL-07-9 x VRO-6	4.86	-0.84	-4.52	-4.08	-1.14	11.22	-1.89	-29.82*	-1.58	-5.52
46.	AOL-08-5 x Arka Anamika	4.04	10.22**	16.47**	12.11	10.71**	-2.00	-2.30	13.002	-33.38**	-6.17
47.	AOL-08-5 x Pusa Sawani	-3.22	-7.01*	-14.00*	-18.11**	-10.58**	4.37	4.85	-48.62**	2.61	-9.19
48.	AOL-08-5 x Parbhani Kranti	-9.85*	10.89**	-19.35**	-10.70	-7.25**	0.83	3.87	-12.07	4.47	-0.72
49.	AOL-08-5 x GO-2	6.37	-12.57**	25.69**	5.52	6.25*	-7.36	-8.64	-9.70	-35.88**	-15.39**
50.	AOL-08-5 x VRO-6	-1.57	-3.25	12.45*	2.62	2.56	10.95	8.01	12.59	6.67	9.56*
51.	JOL-6k-2 x Arka Anamika	8.05	-3.13	-12.09	-3.37	-2.63	3.67	9.49	3.91	28.21**	11.32*
52.	JOL-6k-2 x Pusa Sawani	-7.15	10.13**	10.78	5.05	4.70	-4.65	-2.83	10.99	22.92*	6.60
53.	JOL-6k-2 x Parbhani Kranti	7.10	4.744	-12.51*	9.25	2.14	8.75	14.56*	20.07	-8.4	8.74
54.	JOL-6k-2 x GO-2	1.49	-7.13*	-15.15*	0.06	-5.18*	-17.21*	-23.02**	10.10	26.16*	-0.99
55.	JOL-6k-2 x VRO-6	-5.26	-2.89	7.71	-2.44	-0.72	2.65	-3.99	-0.28	-13.39	-3.75
56.	JOL-08-7 x Arka Anamika	-2.10	-17.84**	-31.30**	-25.52**	-19.19**	-7.58	14.19*	-22.49	12.07	-0.95
57.	JOL-08-7 x Pusa Sawani	4.34	5.19	17.35**	14.36*	10.31**	-19.49*	2.54	10.31	-3.56	-2.55
58.	JOL-08-7 x Parbhani Kranti	3.89	8.68*	6.70	5.04	6.08*	27.13**	14.56*	37.08**	19.20	24.49**
59.	JOL-08-7 x GO-2	-7.63	5.47	13.47*	6.27	4.39	-5.55	-10.98	23.58	14.82	5.46
60.	JOL-08-7 x VRO-6	3.56	-1.92	7.47	-0.73	2.09	12.3	0.90	-3.33	20.64	7.63
61.	JOL-08-12 x Arka Anamika	-1.60	4.53	8.71	14.95*	6.65**	-13.49	-16.16*	-18.34	-31.22**	-19.80**
62.	JOL-08-12 x Pusa Sawani	-0.09	-3.25	-19.63 **	-8.62	-7.90 **	5.24	-1.42	-13.21	-23.53*	-8.23
63.	JOL-08-12 x Parbhani Kranti	-10.63*	-13.89**	-7.35	-5.00	-9.22**	2.78	0.11	-6.09	8.19	1.25
64.	JOL-08-12 x GO-2	3.98	3.81	-3.13	1.83	1.62	-8.51	-13.44	-19.92	-32.98**	-18.71**
65.	JOL-08-12 x VRO-6	6.27	9.20**	7.70	-2.59	5.14*	7.15	9.69	12.42	16.38	11.41*
	S.E.s_{ij}	8.92	6.86	12.27	12.45	4.76	16.68	14.12	24.30	20.94	9.55

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

Although in E_3, among lines, gca effects ranged from -24.95 to 24.60. JOL-08-7 (24.60) registered higher, significant and positive gca effects followed by JOL-08-12 (17.66) and AOL-08-5 (12.59), while among testers, gca effects ranged from -6.15 to 8.11. Only Parbhani Kranti (8.11) registered higher positive gca effects for this trait. The sca effects ranged from -48.62 (AOL-08-5 x Pusa Sawani) to 37.08 (JOL-08-7 x Parbhani Kranti). Top three hybrids with higher, significant and positive effects were JOL-08-7 x Parbhani Kranti (37.08), JDNOL-11-14 x VRO-6 (33.01) and JDNOL-11-11 x Arka Anamika (27.91). Five hybrids exhibited good (significant and positive) specific combining effects.

In E_4, among lines, gca effects ranged from -16.81 to 12.87. JOL-08-12 (12.87), JDNOL-11-14 (12.84) and JOL-08-7 (12.17) were the top three general combiners which registered higher, significant and positive gca effects, while among testers, gca effects ranged from -6.28 to 11.89. Only one tester Parbhani Kranti (11.89) registered higher positive gca effects. The sca effects ranged from -42.30 (JDNOL-11-1 x VRO-6) to 28.21 (JOL-6k-2 x Arka Anamika). Top three hybrids with higher, significant and positive effects were JOL-6k-2 x Arka Anamika (28.21), JDNOL-11-1 x Arka Anamika (26.36) and JOL-6k-2 x Pusa Sawani (22.92). Five hybrids were revealing good (significant and positive) specific combining effects.

Whereas, in pooled analysis, among lines, gca effects ranged from -12.95 (JDNOL-11-1) to 14.15 (JOL-08-7). Five lines proved to be good general combiners. JDNOL-11-1 (12.95), JOL-08-12 (11.55) and AOL-08-5 (7.08) were top three general combiners which registered higher, significant and positive gca effects, while among testers, Parbhani Kranti (6.55) registered higher positive significant gca effects for this trait. In pooled analysis, the sca effects ranged from -31.80 (JDNOL-11-1 x VRO-6) to 24.49 (JOL-08-7 x Parbhani Kranti). Top three hybrids with higher, significant and positive effects across the environments were JOL-08-7 x Parbhani Kranti (24.49), JDNOL-11-3 x Arka Anamika (19.34) and JDNOL-11-1 x GO-2 (18.08). Twelve hybrids were revealing good (significant and positive) sca effects.

While in scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.06), E_2 (0.23), E_3 (0.21), E_4 (0.18) and pooled analysis (0.25) revealed preponderance of non-additive gene action for this particular trait.

4.4.2.9 Total number of fruits per plant (Table 4.4.12)

Looking to the data in E_1, among lines, gca effects ranged from -1.26 (JDNOL-11-12) to 1.59 (JDNOL-11-14). Only JDNOL-11-14 (1.59) registered significant and positive gca effect, while among testers, gca effects ranged from -0.69 (Arka Anamika) to 1.39 (VRO-6). Only VRO-6 (1.39) had significant and positive gca effect. The sca effects ranged from -2.77 (JDNOL-11-3 x Pusa Sawani) to 2.22 (JOL-08-7 x Parbhani Kranti). Two hybrids *viz.,* JOL-08-7 x Parbhani Kranti (2.22) and JDNOL-11-14 x Pusa Sawani (1.77) recorded the highest, significant and positive sca effect.

In E_2, among lines, gca effects ranged from -0.98 to 1.44. JDNOL-11-14 (1.44) registered significant and positive gca effect followed by AOL-08-5 (1.08). Among testers, gca effects ranged from -0.64 (Arka Anamika) to 0.40 (VRO-6). None of testers depicted significant and positive gca effect. The sca effects ranged from -2.40 (JDNOL-11-3 x GO-2) to 1.90 (JOL-08-7 x Parbhani Kranti). Two hybrids recorded the highest significant and positive sca effects. JOL-08-7 x Parbhani Kranti (1.90) and JDNOL-11-14 x Pusa Sawani (1.78) were the hybrids with significant and positive sca effects.

Whereas, in E_3, among lines, gca effects ranged from -1.55 to 1.14. JDNOL-11-11 (1.14) was the only line which had significant and positive gca effects, while among testers, gca effects ranged from -0.51 (GO-2) to 0.52 (VRO-6). None of testers possessed significant and positive gca effect. The sca effects ranged from -3.33 (JOL-08-7 x GO-2) to 3.33 (JOL-08-7 x VRO-6). Six hybrids recorded the highest significant and positive sca effects. JOL-08-7 x VRO-6 (3.33), AOL-08-5 x GO-2 (2.97) and JOL-6k-2 x GO-2 (2.87) were top three hybrids with significant and positive sca effects.

In E_4, among lines, gca effects ranged from -0.59 (JDNOL-11-12) to 0.66 (AOL-08-5). None of line recorded significant and positive gca effect, while among testers, gca effects ranged from -0.55 (Pusa Sawani) to 0.34 (Parbhani Kranti). None of testers had significant and positive gca effect. The sca effects ranged from -2.46 (JOL-6k-2 x Arka Anamika) to 2.43 (JDNOL-11-12 x Arka Anamika). Only one cross JDNOL-11-12 x Arka Anamika (2.43) recorded the significant and positive sca effect.

Table 4.4.12: Estimates of general combining ability and specific combining ability effects in individual and pooled over environments for total number of fruits per plant and total number of seed per fruit

Sr. No.	Genotypes	Total number of fruits per plant					Total number of seed per fruit				
		E 1	E 2	E 3	E4	Pooled	E 1	E 2	E 3	E4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	-0.21	-0.01	0.13	0.16	0.01	-1.98**	-1.39*	-1.86*	-1.43*	-1.67**
2.	JDNOL-11-3	-0.24	-0.37	0.28	0.43	0.02	-0.42	-0.10	-0.67	-1.51*	-0.67
3.	JDNOL-11-11	-0.72	-0.13	1.14*	-0.59	-0.07	1.81*	-0.34	0.40	-1.01	0.21
4.	JDNOL-11-12	-1.26**	-0.81*	-0.39	0.10	-0.59**	0.07	-1.39*	-0.48	0.11	-0.42
5.	JDNOL-11-14	1.59**	1.44**	0.47	-0.19	0.83**	0.43	0.88	0.44	1.76*	0.88*
6.	AOL-07-9	-0.75	0.05	-0.35	-0.45	-0.37	-0.64	-1.20*	-1.10	0.55	-0.60
7.	AOL-08-5	0.04	1.08**	-0.19	0.66	0.40	1.78*	-0.34	1.90*	1.09	1.11**
8.	JOL-6k-2	0.46	-0.98*	-1.55**	-0.52	-0.64**	-1.23	1.02	-0.84	-0.79	-0.46
9.	JOL-08-7	0.41	0.66	0.45	0.27	0.45*	0.30	2.07**	1.73*	1.24	1.33**
10.	JOL-08-12	0.68	-0.92*	0.002	0.11	-0.03	-0.13	0.80	0.48	-0.01	0.28
	S.E.g_i	0.78	0.77	0.86	0.86	0.40	1.48	1.17	1.55	1.42	0.71
MALES (TESTERS)											
11.	Arka Anamika	-0.69*	-0.64*	-0.49	-0.02	-0.46**	-2.50**	-0.66	-0.35	-1.18*	-1.17**
12.	Pusa Sawani	-0.33	0.19	0.38	-0.55	-0.07	0.34	-0.29	-0.19	-0.25	-0.09
13.	Parbhani Kranti	0.19	0.08	0.09	0.34	0.17	0.73	0.17	0.60	0.34	0.46
14.	GO-2	-0.55*	-0.04	-0.51	0.17	-0.23	1.05*	-0.11	-0.92	0.40	0.10
15.	VRO-6	1.39**	0.40	0.52	0.05	0.59**	0.37	0.88*	0.86	0.69	0.70**
	S.E.g_i	0.55	0.54	0.61	0.61	0.28	1.04	0.82	1.09	1.00	0.50
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	0.47	0.80	0.72	-0.22	0.44	0.59	-0.02	0.26	1.73	0.64
17.	JDNOL-11-1 x Pusa Sawani	1.34	0.64	0.16	0.58	0.68	0.22	1.07	2.34	-1.83	0.45
18.	JDNOL-11-1 x Parbhani Kranti	-0.28	-0.60	-0.32	0.80	-0.10	0.45	1.40	0.73	1.05	0.91
19.	JDNOL-11-1 x GO-2	0.71	-0.15	-1.18	-0.21	-0.21	-1.71	1.82	-0.68	-3.03	-0.90
20.	JDNOL-11-1 x VRO-6	0.89	1.61	-2.84**	0.06	-0.07	0.78	0.19	-2.53	0.42	-0.28
21.	JDNOL-11-3 x Arka Anamika	0.63	1.86*	0.76	1.25	1.12*	4.73**	0.13	1.59	3.17	2.41**
22.	JDNOL-11-3 x Pusa Sawani	-2.77**	-1.45	1.43	-1.009	-0.94*	-2.67	-0.77	-2.85	-1.25	-1.88*
23.	JDNOL-11-3 x Parbhani Kranti	-0.17	0.37	1.81	-0.23	0.44	1.30	-0.79	1.19	1.38	0.77
24.	JDNOL-11-3 x GO-2	-1.28	-2.40**	0.005	-1.50	-1.29**	-3.71*	-2.43	-1.61	0.53	-1.80*
25.	JDNOL-11-3 x VRO-6	0.46	-0.68	-0.56	0.47	-0.07	-0.003	-0.60	1.53	-2.20	-0.31
26.	JDNOL-11-11 x Arka Anamika	-1.03	0.36	0.05	-0.02	-0.16	0.17	2.45	-0.5	-2.09	0.009
27.	JDNOL-11-11 x Pusa Sawani	-1.09	-0.55	-0.24	-0.88	-0.69	-0.06	-0.53	-1.74	2.03	-0.07
28.	JDNOL-11-11 x Parbhani Kranti	-0.002	-0.60	2.23*	-1.11	0.13	2.76	-3.21*	-3.69*	-2.15	-1.57
29.	JDNOL-11-11 x GO-2	1.24	-0.11	-0.28	1.82	0.66	-2.71	-1.57	0.41	-1.84	-1.42

Table 4.4.12 Continue...

Table 4.4.12 Continue...

Sr. No.	Genotypes	Total number of fruits per plant					Total number of seed per fruit				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
30.	JDNOL-11-11 x VRO-6	-0.06	-0.99	-1.35	-0.82	-0.80	1.91	1.52	3.41	0.38	1.80*
31.	JDNOL-11-12 x Arka Anamika	-1.56	-0.52	-0.98	2.43*	-0.16	-4.09*	-0.88	-1.51	-2.11	-2.15**
32.	JDNOL-11-12 x Pusa Sawani	1.65	1.42	1.21	0.50	1.19*	-1.72	1.06	3.79*	0.85	0.99
33.	JDNOL-11-12 x Parbhani Kranti	0.81	-1.49	-1.47	-1.92	-1.01*	-0.72	-0.67	-1.13	0.02	-0.62
34.	JDNOL-11-12 x GO-2	-0.64	1.45	-0.47	1.29	0.40	1.47	2.26	0.31	2.19	1.56
35.	JDNOL-11-12 x VRO-6	0.70	1.04	1.31	-1.27	0.44	3.001	-0.43	0.64	2.71	1.48
36.	JDNOL-11-14 x Arka Anamika	-0.21	-0.95	-0.4	0.38	-0.29	-1.12	-0.93	-1.56	-1.25	-1.22
37.	JDNOL-11-14 x Pusa Sawani	1.77*	1.78*	3.00**	0.89	1.86**	1.10	0.52	3.09	4.10*	2.20**
38.	JDNOL-11-14 x Parbhani Kranti	-0.26	-1.04	-0.58	-1.51	-0.85	1.06	-1.76	0.97	-3.98*	-0.92
39.	JDNOL-11-14 x GO-2	-2.14*	-0.42	1.84	-1.53	-0.56	-1.04	2.65*	-0.68	0.51	0.36
40.	JDNOL-11-14 x VRO-6	-1.60	-0.60	-0.95	1.38	-0.44	-2.40	-1.93	1.22	0.85	-0.56
41.	AOL-07-9 x Arka Anamika	1.25	0.21	1.12	-1.21	0.34	-1.26	0.18	-0.31	-3.59*	-1.24
42.	AOL-07-9 x Pusa Sawani	0.18	-0.20	-2.69**	-0.12	-0.71	0.51	-0.15	-0.03	2.63	0.73
43.	AOL-07-9 x Parbhani Kranti	-0.07	0.24	-2.53*	0.94	-0.35	-0.49	-0.19	-0.18	-2.58	-0.86
44.	AOL-07-9 x GO-2	0.94	0.29	0.90	1.21	0.83	3.94*	2.04	0.50	0.23	1.68*
45.	AOL-07-9 x VRO-6	0.15	0.71	0.29	-0.44	0.17	-0.27	-0.41	-3.008	3.07	-0.15
46.	AOL-08-5 x Arka Anamika	0.39	-0.20	-1.01	0.63	-0.04	-0.36	1.88	1.24	-0.72	0.51
47.	AOL-08-5 x Pusa Sawani	-0.77	-1.88*	-1.74	-0.82	-1.30**	-1.90	0.19	-2.22	0.20	-0.93
48.	AOL-08-5 x Parbhani Kranti	-1.67	0.35	-2.46*	1.46	-0.58	-5.29**	1.47	-1.77	3.54*	-0.51
49.	AOL-08-5 x GO-2	1.08	1.14	2.97**	0.47	1.42**	6.09**	-0.88	2.24	-0.93	1.63*
50.	AOL-08-5 x VRO-6	0.15	0.11	1.81	-1.03	0.26	0.50	-1.26	-0.88	1.76	0.03
51.	JOL-6k-2 x Arka Anamika	-0.05	0.80	-2.84**	-2.46*	-1.14*	-0.65	0.19	1.68	0.62	0.46
52.	JOL-6k-2 x Pusa Sawani	1.70	0.96	0.89	0.69	1.06*	3.59*	3.21*	0.60	-0.57	1.70*
53.	JOL-6k-2 x Parbhani Kranti	0.09	-0.005	0.50	0.43	0.25	1.46	2.08	1.13	-0.32	1.09
54.	JOL-6k-2 x GO-2	1.08	0.12	2.87**	0.99	1.26**	0.41	-3.70**	-0.62	1.07	-0.70
55.	JOL-6k-2 x VRO-6	-2.00*	-1.40	-0.98	-0.37	-1.19*	-3.87*	-3.19*	-1.40	-4.66**	-3.28**
56.	JOL-08-7 x Arka Anamika	0.39	-0.00	0.63	-0.77	0.06	0.72	-3.38*	0.54	2.33	0.05
57.	JOL-08-7 x Pusa Sawani	-1.26	0.01	-1.18	0.23	-0.55	0.64	-1.27	-1.47	-4.51**	-1.65*
58.	JOL-08-7 x Parbhani Kranti	2.22*	1.90*	1.13	0.35	1.40**	1.00	2.09	3.75*	1.53	2.10*
59.	JOL-08-7 x GO-2	-0.89	-0.45	-3.33**	-0.55	-1.31**	-0.63	-2.01	-1.29	5.29**	0.33
60.	JOL-08-7 x VRO-6	0.62	-0.12	3.33**	0.41	1.06*	-0.79	1.48	-1.22	-3.42*	-0.98
61.	JOL-08-12 x Arka Anamika	-0.25	-2.34**	1.95*	-0.01	-0.16	1.28	0.37	-1.45	1.90	0.52
62.	JOL-08-12 x Pusa Sawani	-0.76	-0.72	-0.84	-0.07	-0.60	0.29	-3.35*	-1.51	-1.66	-1.55
63.	JOL-08-12 x Parbhani Kranti	-0.65	0.87	1.68	0.78	0.67	-1.55	-0.42	-1.01	1.49	-0.37
64.	JOL-08-12 x GO-2	-0.09	0.54	-3.30**	-2.00*	-1.21**	-2.12	1.83	1.42	-4.04*	-0.72
65.	JOL-08-12 x VRO-6	0.68	0.32	-0.05	1.62	0.64	1.15	4.65**	2.23	1.07	2.27**
	S.E.s_{ij}	1.76	1.73	1.94	1.93	0.91	3.31	2.62	3.47	3.19	1.60

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

While in pooled analysis, among lines, gca effects ranged from -0.64 (JOL-6k-2) to 0.83 (JDNOL-11-14). JDNOL-11-14 (0.83) and JOL-08-7 (0.45) were the good general combiners which registered significant and positive gca effect, while among testers, gca effects ranged from -0.46 (Arka Anamika) to 0.59 (VRO-6). Only VRO-6 (0.59) had significant and positive gca effect. In case of hybrids, the sca effects ranged from -1.31 (JOL-08-7 x GO-2) to 1.86 (JDNOL-11-14 x Pusa Sawani). Seven hybrids recorded significant and positive sca effect. The superior hybrids registering good specific combining ability across the environments were JDNOL-11-14 x Pusa Sawani (1.86), AOL-08-5 x GO-2 (1.42) and JOL-08-7 x Parbhani Kranti (1.40).

Looking to the scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.70), E_2 (0.35), E_3 (0.06), E_4 (0.01) and pooled analysis (0.22) revealed preponderance of non-additive gene action for this trait.

4.4.2.10 Number of seeds per fruits (Table 4.4.12)

Where in E_1, gca effects for lines and testers ranged from -1.98 (JDNOL-11-1) to 1.81 (JDNOL-11-11) and -2.50 (Arka Anamika) to 1.05 (GO-2), respectively. Among lines, JDNOL-11-13 (-1.98) recorded significant and negative gca effect, while, among the testers Arka Anamika (-2.50) recorded significant and negative gca effect. The sca effects of crosses varied from -5.29 (AOL-08-5 x Parbhani Kranti) to 6.09 (AOL-08-5 x GO-2). Four crosses recorded significant and negative sca effect. AOL-08-5 x Parbhani Kranti (-5.29), JDNOL-11-12 x Arka Anamika (-4.09) and JOL-6k-2 x VRO-6 (-3.87) were top three crosses which recorded significant and negative sca effect.

In E_2, gca effects for lines and testers ranged from -1.39 (JDNOL-11-12) to 2.07 (JOL-08-7) and -0.66 (Arka Anamika) to 0.88 (VRO-6), respectively. Among lines, JDNOL-11-12 (-1.39) recorded significant and negative gca effect followed by AOL-07-9 (-1.20) and AOL-08-5 (-0.34) While, among testers, Arka Anamika (-0.66) recorded significant and negative gca effect. The sca effects varied from -3.70 (JOL-6k-2 x GO-2) to 4.65 (JOL-08-12 x VRO-6). Five crosses recorded significant and negative sca effect. JOL-6k-2 x GO-2 (-3.70), JOL-08-7 x Arka Anamika (-3.38) and JDNOL-11-11 x Parbhani Kranti (-3.21) were the top three crosses which recorded significant sca effect in desired direction.

Looking to the data in E_3, gca effects for lines and testers ranged from -1.86 (JDNOL-11-1) to 1.90 (AOL-08-5) and -0.92 (GO-2) to 0.86 (VRO-6), respectively. Among lines, only

JDNOL-11-1 (-1.86) recorded significant and negative gca effect, while, among testers, none of tester had significant and negative gca effect. The sca effects varied from -3.69 (JDNOL-11-11 x Parbhani Kranti) to 3.79 (JDNOL-11-12 x Pusa Sawani). Only one cross recorded significant and negative sca effect. Only one combination JDNOL-11-11 x Parbhani Kranti (-3.69) reported with significant and negative sca effect.

While in E_4, gca effects for lines and testers ranged from -1.51 (JDNOL-11-3) to 1.76 (JDNOL-11-14) and -1.18 (Arka Anamika) to 0.69 (VRO-6), respectively. Among lines, JDNOL-11-33 (-1.51) recorded significant and negative gca effect, while, among testers, Arka Anamika (-1.18) recorded significant and negative gca effect. The sca effects ranged from -4.66 (JOL-6k-2 x VRO-6) to 5.29 (JOL-08-7 x GO-2). Six crosses recorded significant and negative sca effect. The crosses JOL-6k-2 x VRO-6 (-4.66), JOL-08-7 x Pusa Sawani (-4.51) and JOL-08-12 x GO-2 (-4.04) were top three hybrids with significant and negative sca effect.

Whereas, in pooled analysis, gca effects for lines and testers ranged from -1.67 (JDNOL-11-1) to 1.33 (JOL-08-7) and -1.17 (Arka Anamika) to 0.70 (VRO-6), respectively. Among lines, JDNOL-11-1 (-1.67) recorded significant and negative gca effect, while, among testers, Arka Anamika (-1.17) recorded significant and negative gca effect. The sca effects varied from -3.28 (JOL-6k-2 x VRO-6) to 2.41 (JDNOL-11-3 x Arka Anamika). Five crosses showed significant and negative sca effect. The highest negative sca effect was noticed in cross *viz.*, JOL-6k-2 x VRO-6 (-3.28) followed by JDNOL-11-12 x Arka Anamika (-2.15) and JDNOL-11-3 x Pusa Sawani (-1.88).

However, scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.37), E_2 (0.15), E_3 (0.34), E_4 (0.09) and pooled analysis (0.33) revealed preponderance of non-additive gene action for this trait.

4.4.2.11 Days to last picking (Table 4.4.13)

Looking to the data in E_1, gca effects for lines and testers ranged from -4.99 (JDNOL-11-1) to 3.33 (JDNOL-11-11) and -3.17 (GO-2) to 2.92 (Pusa Sawani), respectively. Among lines, none of line had significant and positive gca effect, while among testers, only Pusa Sawani (2.92) depicted highly significant and positive gca effects. The values of sca effects varied from -5.86 (JDNOL-11-14 x GO-2) to 8.06 (JOL-08-12 x Pusa Sawani). None of the cross registered significant and positive sca effects for the trait.

In E_2, gca effects for lines and testers ranged from -7.77 (JDNOL-11-3) to 3.88 (AOL-07 9) and -1.74 (Arka Anamika) to 2.22 (GO-2), respectively. Among lines, only AOL-07-9 (3.88) depicted significant and positive gca effect, while, none of the tester recorded significant and positive gca effect. The values of sca effects of crosses varied from -12.84 (AOL-07-9 x Arka Anamika) to 10.67 (JDNOL-11-12 x Arka Anamika). Six hybrids recorded the highest significant and positive sca effects. The cross combinations, JDNOL-11-12 x Arka Anamika (10.67), JDNOL-11-1 x Arka Anamika (10.06) and AOL-07-9 x VRO-6 (10.05) were reported significant and positive effects which secured top three position.

However in E_3, gca effects for lines and testers was ranged from -4.88 (AOL-07-9) to 2.85 (AOL-08-5) and -1.43 (Parbhani Kranti) to 1.36 (Pusa Sawani), respectively. Among lines, none of line had significant and positive gca effect, while, among testers, none of tester had significant and positive gca effect. The values of sca effects varied from -8.57 (JDNOL-11-3 x GO-2) to 8.42 (JDNOL-11-3 x Arka Anamika). Only one cross JDNOL-11-3 x Arka Anamika (8.42) registered significant and positive sca effects for the trait.

In E_4, gca effects for lines and testers ranged from -2.87 (JDNOL-11-11) to 3.90 (JDNOL-11-12) and -1.48 (Arka Anamika) to 1.68 (VRO-6), respectively. Among lines, only JDNOL-11-12 (3.90) depicted significant and positive gca effect, while, none of the tester expressed significant and positive gca effect. The values of sca effects of crosses varied from -8.15 (JDNOL-11-11 x Arka Anamika) to 8.50 (AOL-08-5 x VRO-6). Three hybrids recorded the highest significant and positive sca effects. The crosses AOL-08-5 x VRO-6 (8.50), JDNOL-11-1 x Arka Anamika (8.21) and JOL-08-7 x Parbhani Kranti (8.16) were the top three hybrids with significant and positive sca effects.

While in pooled analysis, gca effects for lines and testers ranged from -2.17 (JDNOL-11-3) to 1.45 (JOL-08-7) and -1.18 (Arka Anamika) to 1.18 (Pusa Sawani), respectively. Among lines, none of line had significant and positive gca effect, while, among testers Pusa Sawani (1.18) recorded significant and negative gca effect. The values of sca effects of crosses varied from -5.22 (JOL-6k-2 x VRO-6) to 5.19 (AOL-07-9 x VRO-6). Six hybrids recorded the highest

Table 4.4.13: Estimates of general combining ability and specific combining ability effects in individual and pooled over environments for days to last picking and crude protein content (%)

Sr. No.	Genotypes	Days to last picking					Crude protein content (%)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	-4.99**	0.83	-2.97	-1.17	-2.07*	0.08	0.27	0.40	-0.11	0.16
2.	JDNOL-11-3	-0.45	-7.77**	-0.04	-0.43	-2.17**	-0.003	0.05	-0.94**	0.29	-0.14
3.	JDNOL-11-11	3.33	2.35	2.38	-2.87	1.29	-0.76*	-0.28	0.08	0.43	-0.13
4.	JDNOL-11-12	-0.14	-1.31	1.45	3.90*	0.97	-0.13	-0.51	-0.51	-0.01	-0.29
5.	JDNOL-11-14	2.25	-0.63	1.72	0.10	0.86	0.58	0.73*	0.02	0.51	0.46**
6.	AOL-07-9	2.25	3.88 *	-4.88 **	-2.37	-0.28	-0.45	0.15	-0.47	-0.47	-0.31
7.	AOL-08-5	-1.20	0.54	2.85	2.49	1.17	0.39	-0.15	0.24	0.20	0.17
8.	JOL-6k-2	-4.32*	0.16	-2.14	-1.07	-1.84*	-0.68	0.41	0.02	-0.45	-0.17
9.	JOL-08-7	2.25	2.97	1.10	-0.49	1.46	1.12**	0.04	0.06	-0.001	0.30
10.	JOL-08-12	1.02	-1.03	0.51	1.93	0.61	-0.135	-0.73*	1.08**	-0.38	-0.04
	S.E.g_i	3.71	3.29	3.45	3.33	1.64	0.76	0.62	0.62	0.58	0.33
MALES (TESTERS)											
11.	Arka Anamika	-1.78	-1.74	0.25	-1.48	-1.18*	0.00	-0.57*	-0.67**	-0.36	-0.40**
12.	Pusa Sawani	2.92*	0.87	1.36	-0.41	1.18*	-0.57*	0.20	0.13	-0.01	-0.06
13.	Parbhani Kranti	2.43	0.34	-1.43	1.18	0.63	0.09	0.17	0.58*	0.47*	0.33**
14.	GO-2	-3.17*	2.22	-0.57	-0.96	-0.62	-0.08	0.15	-0.27	-0.18	-0.09
15.	VRO-6	-0.39	-1.7	0.39	1.68	-0.00	0.57*	0.03	0.23	0.08	0.23
	S.E.g_i	2.62	2.33	2.44	2.35	1.16	0.53	0.44	0.44	0.41	0.23
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	1.71	10.06**	-4.87	8.21*	3.78*	0.81	0.45	0.75	0.003	0.50
17.	JDNOL-11-1 x Pusa Sawani	0.95	-0.79	1.42	2.21	0.94	1.44	-0.32	0.26	1.11	0.62
18.	JDNOL-11-1 x Parbhani Kranti	2.33	9.05*	3.45	-4.64	2.54	-2.18*	0.52	-1.84*	-0.10	-0.90*
19.	JDNOL-11-1 x GO-2	5.67	3.56	2.65	0.65	3.13	0.44	0.47	-0.11	0.59	0.35
20.	JDNOL-11-1 x VRO-6	-0.03	-7.29	-0.50	-7.44	-3.82*	1.27	-0.86	-0.13	-0.43	-0.04
21.	JDNOL-11-3 x Arka Anamika	-5.37	-2.30	8.42*	5.91	1.66	0.97	0.89	1.18	0.18	0.81*
22.	JDNOL-11-3 x Pusa Sawani	-4.91	-2.45	-1.64	-1.34	-2.59	-0.005	-1.69*	0.10	-0.45	-0.51
23.	JDNOL-11-3 x Parbhani Kranti	5.11	4.12	3.25	-0.39	3.02	-1.04	0.65	0.03	-0.79	-0.28
24.	JDNOL-11-3 x GO-2	-2.37	-4.11	-8.57*	-2.28	-4.33*	-1.05	0.09	-0.77	-0.61	-0.58
25.	JDNOL-11-3 x VRO-6	-3.07	-9.84**	-3.61	-0.88	-4.35*	-0.67	-0.20	0.51	0.52	0.03
26.	JDNOL-11-11 x Arka Anamika	0.90	-6.87	1.67	-8.15*	-3.11	-0.56	0.81	-0.05	-0.25	-0.01
27.	JDNOL-11-11 x Pusa Sawani	-3.32	6.76	-6.70	-1.67	-1.23	0.04	-0.63	-0.03	-0.10	-0.18
28.	JDNOL-11-11 x Parbhani Kranti	-0.32	-3.49	-1.50	7.02	0.42	-0.50	0.77	0.13	-1.37*	-0.24
29.	JDNOL-11-11 x GO-2	1.97	-3.05	0.30	-0.62	-0.35	-0.67	-0.48	-0.33	-1.19	-0.67

Table 4.4.13 Continue...

Table 4.4.13 Continue...

Sr. No.	Genotypes	Days to last picking					Crude protein content (%)				
		E 1	E 2	E 3	E4	Pooled	E 1	E 2	E 3	E4	Pooled
30.	JDNOL-11-11 x VRO-6	0.16	6.13	0.53	3.77	2.65	-0.91	0.19	-0.57	0.50	-0.19
31.	JDNOL-11-12 x Arka Anamika	3.48	10.67**	6.00	-6.6	3.39	-0.35	0.25	-1.21	0.19	-0.28
32.	JDNOL-11-12 x Pusa Sawani	-4.67	6.21	0.25	4.81	1.65	0.74	-0.01	0.79	0.59	0.53
33.	JDNOL-11-12 x Parbhani Kranti	-2.16	-12.24**	-0.32	0.13	-3.64	0.95	-1.20	0.12	0.31	0.04
34.	JDNOL-11-12 x GO-2	0.60	-0.22	2.05	0.79	0.80	0.16	0.15	0.76	0.91	0.50
35.	JDNOL-11-12 x VRO-6	3.35	-3.89	-2.29	0.50	-0.58	1.11	0.14	0.38	0.40	0.51
36.	JDNOL-11-14 x Arka Anamika	2.21	4.45	-0.32	-4.13	0.55	0.62	-0.81	-0.98	-0.21	-0.34
37.	JDNOL-11-14 x Pusa Sawani	4.76	-5.74	5.40	4.73	2.29	0.47	0.36	1.12	0.44	0.60
38.	JDNOL-11-14 x Parbhani Kranti	-5.67	-7.38*	-2.68	-3.98	-4.93**	0.75	-1.65*	0.61	0.03	-0.06
39.	JDNOL-11-14 x GO-2	-5.86	-1.2	-0.86	-1.02	-2.23	-0.33	0.24	-0.36	-0.18	-0.16
40.	JDNOL-11-14 x VRO-6	0.26	5.13	0.33	-3.75	0.49	-0.32	0.38	-1.64*	0.24	-0.33
41.	AOL-07-9 x Arka Anamika	1.54	-12.84**	-7.31	2.17	-4.10*	-0.22	0.11	0.60	0.15	0.16
42.	AOL-07-9 x Pusa Sawani	5.93	-0.03	2.31	-3.31	1.22	-0.80	1.23	-0.20	-0.67	-0.11
43.	AOL-07-9 x Parbhani Kranti	-2.76	4.25	-5.50	1.73	-0.56	0.56	0.36	-0.49	-0.13	0.07
44.	AOL-07-9 x GO-2	0.24	3.30	1.20	3.58	2.08	-0.07	-0.63	1.15	0.37	0.20
45.	AOL-07-9 x VRO-6	-0.66	10.05**	7.42	3.98	5.19**	-0.65	0.38	0.20	-0.03	-0.02
46.	AOL-08-5 x Arka Anamika	1.48	3.71	1.04	-0.14	1.52	-0.90	0.29	0.48	-0.50	-0.15
47.	AOL-08-5 x Pusa Sawani	2.05	5.26	1.32	-0.38	2.06	-0.82	0.52	-0.50	-1.34*	-0.53
48.	AOL-08-5 x Parbhani Kranti	-0.73	-3.81	-1.39	-6.55	-3.12	0.38	-0.08	0.44	0.79	0.38
49.	AOL-08-5 x GO-2	0.91	-0.96	1.15	1.37	0.62	1.58	0.65	-0.52	0.45	0.54
50.	AOL-08-5 x VRO-6	5.91	2.85	2.99	8.50*	5.06**	0.06	1.08	1.90**	0.002	0.76*
51.	JOL-6k-2 x Arka Anamika	0.67	-5.39	-4.99	-6.28	-4.00*	-1.33	-1.28	-0.48	-0.34	-0.86*
52.	JOL-6k-2 x Pusa Sawani	-4.40	-0.56	1.88	4.43	0.33	0.70	-0.25	-0.71	1.56*	0.32
53.	JOL-6k-2 x Parbhani Kranti	0.59	2.24	-0.59	1.58	0.95	-0.65	0.01	0.03	0.19	-0.10
54.	JOL-6k-2 x GO-2	-1.40	2.35	3.39	2.78	1.78	2.20*	0.68	0.42	-0.40	0.72
55.	JOL-6k-2 x VRO-6	-5.09	-5.68	-4.81	-5.31	-5.22**	-1.24	-1.63*	-1.07	-0.41	-1.09**
56.	JOL-08-7 x Arka Anamika	-6.31	-11.37**	2.47	4.20	-2.75	0.02	-0.73	-0.20	0.96	0.01
57.	JOL-08-7 x Pusa Sawani	-4.44	-5.48	-1.45	-4.88	-4.06*	-1.13	0.05	-0.85	-0.10	-0.50
58.	JOL-08-7 x Parbhani Kranti	4.40	5.64	2.13	8.16*	5.08**	1.54	0.43	0.64	0.65	0.82*
59.	JOL-08-7 x GO-2	-2.69	1.65	-3.24	-0.38	-1.16	-1.02	-0.89	1.33	0.33	-0.05
60.	JOL-08-7 x VRO-6	-6.30	-6.82	-3.35	-1.08	-4.39*	-0.11	-0.79	0.44	-0.31	-0.19
61.	JOL-08-12 x Arka Anamika	-0.32	9.86**	-2.11	4.79	3.05	0.93	0.01	-0.09	-0.17	0.17
62.	JOL-08-12 x Pusa Sawani	8.06	-3.14	-2.80	-4.58	-0.61	-0.63	0.72	0.01	-1.03	-0.23
63.	JOL-08-12 x Parbhani Kranti	-0.78	1.62	3.16	-3.05	0.23	0.18	0.17	0.30	0.42	0.27
64.	JOL-08-12 x GO-2	2.92	-1.32	1.91	-4.89	-0.34	-1.24	-0.29	-1.56*	-0.274	-0.84*
65.	JOL-08-12 x VRO-6	5.48	9.37*	3.29	1.71	4.96**	1.45	1.31	-0.03	-0.47	0.56
	S.E.s$_{ij}$	8.31	7.36	7.73	7.45	3.68	1.70	1.40	1.40	1.30	0.74

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

significant and positive sca effects. AOL-07-9 x VRO-6 (5.19), JOL-08-7 x Parbhani Kranti (5.08) and AOL-08-5 x VRO-6 (5.06) were top three hybrids with significant and positive effects.

Looking to the scrutiny of σ^2gca/σ^2sca ratio in E_1 (5.66), E_2 (0.09), E_3 (0.31), E_4 (0.08) and pooled analysis (0.10) revealed preponderance of additive gene action (for E_1) and non-additive gene action (E_2, E_3, E_4 and pooled).

4.4.2.12 Crude protein content (Table 4.4.13)

In E_1, gca effects for lines and testers ranged from -0.76 (JDNOL-11-11) to 1.12 (JOL-08-7) and -0.57 (Pusa Sawani) to 0.57 (VRO-6), respectively. Among lines, JOL-08-7 (1.12) recorded significant and positive gca effect, while, among testers, only VRO-6 (0.57) recorded significant and positive gca effect. The sca effects varied from -2.18 (JDNOL-11-1 x Parbhani Kranti) to 2.20 (JOL-6k-2 x GO-2). Only one cross JOL-6k-2 x GO-2 (2.20) was recorded highest significant and positive sca effect.

Whereas in E_2, gca effects for lines and testers ranged from -0.73 to 0.73 and -0.57 to 0.20, respectively. Among lines, JDNOL-11-14 (0.73) recorded significant and positive gca effect, while, among testers, none of tester recorded significant and positive gca effect. The sca effects of hybrids varied from -1.69 (JDNOL-11-3 x Pusa Sawani) to 1.31 (JOL-08-12 x VRO-6). None of hybrid depicted highest significant and positive sca effect.

In E_3, gca effects for lines and testers ranged from -0.94 (JDNOL-11-3) to 1.08 (JOL-08-12) and -0.67 (Arka Anamika) to 0.58 (Parbhani Kranti), respectively. Among lines, JOL-08-12 (1.08) recorded significant and positive gca effect, while, among testers, only Parbhani Kranti (0.58) recorded significant and positive gca effect. The sca effects varied from -1.84 (JDNOL-11-1 x Parbhani Kranti) to 1.90 (AOL-08-5 x VRO-6). Only AOL-08-5 x VRO-6 (1.90) was promising hybrid with significant and positive sca effects.

However in E_4, gca effects for lines and testers ranged from -0.47 (AOL-07-9) to 0.51 (JDNOL-11-14) and -0.36 (Arka Anamika) to 0.47 (Parbhani Kranti), respectively. Among lines, none of line had significant and positive gca effect, while, among testers, only Parbhani Kranti (0.47) recorded significant and positive gca effect. The sca effects varied from -1.37 (JDNOL-11-

11 x Parbhani Kranti) to 1.56 (JOL-6k-2 x Pusa Sawani). Only cross combination JOL-6k-2 x Pusa Sawani (1.56) recorded highest significant and positive sca effect.

Though in pooled analysis, gca effects for lines and testers ranged from -0.31 to 0.46 and -0.40 to 0.33, respectively. Among lines, only JDNOL-11-14 (0.46) recorded significant and positive gca effect, while, among testers, Parbhani Kranti (0.33) recorded significant and positive gca effect. The sca effects varied from -1.09 (JOL-6k-2 x VRO-6) to 0.82 (JOL-08-7 x Parbhani Kranti). Three crosses recorded highest significant and positive sca effect *viz.*, JOL-08-7 x Parbhani Kranti (0.82), JDNOL-11-3 x Arka Anamika (0.81) and AOL-08-5 x VRO-6 (0.76).

However, scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.26), E_2 (0.28), E_3 (0.60), E_4 (0.65) and pooled analysis (0.36) revealed preponderance of non-additive gene action for this trait.

4.4.2.13 Crude Fiber content (Table 4.4.14)

Looking to the data in E_1, gca effects for lines and testers ranged from -0.37 (JDNOL-11-12) to 0.26 (AOL-08-5) and -0.19 (Arka Anamika) to 0.15 (Parbhani Kranti), respectively. Among lines, JDNOL-11-12 (-0.37), JDNOL-11-3 (0.23) and AOL-07-9 (-0.12) recorded significant and negative gca effect, while, among testers, Arka Anamika (-0.19) recorded significant and negative gca effect. The sca effects varied from -0.38 (JOL-08-12 x Pusa Sawani) to 0.63 (AOL-08-5 x GO-2). Nine hybrids showed significant and negative sca effect. JOL-08-12 x Pusa Sawani (-0.38), JDNOL-11-14 x VRO-6 (-0.37) andAOL-07-9 x Parbhani Kranti (-0.36) were top three hybrids with significant and negative sca effect.

However in E_2, gca effects for lines and testers ranged from -0.69 (JDNOL-11-12) to 0.42 (JDNOL-11-14) and -0.19 (Arka Anamika) to 0.26 (Parbhani Kranti), respectively. Among lines, JDNOL-11-12(-0.69) and JDNOL-11-3 (-0.34) recorded significant and negative gca effect, while, among testers, Arka Anamika (-0.19) recorded significant and negative gca effect. The sca effects varied from -0.67 (JDNOL-11-11 x VRO-6) to 0.79 (JOL-08-7 x Parbhani Kranti). Thirteen hybrids showed significant and negative sca effect. JDNOL-11-11 x VRO-6 (-0.67), JDNOL-11-12 x Pusa Sawani (-0.61) and JDNOL-11-14 x GO-2 (-0.60) secured top three position.

In E_3, gca effects for lines and testers ranged from -0.23 (JDNOL-11-3) to 0.30 (AOL-08-58) and -0.12 (Arka Anamika) to 0.07 (VRO-6), respectively. Among lines, JDNOL-11-3 (-0.23), JOL-6k-2 (-0.21) and JOL-08-7 (-0.19) recorded significant and negative gca effect, while, among testers, Arka Anamika (-0.12) recorded significant and negative gca effect. The sca effects varied from -0.86 (JOL-08-12 x GO-2) to 0.78 (AOL-08-5 x VRO-6). Eleven hybrids showed significant and negative sca effect. JOL-08-12 x GO-2 (-0.86), AOL-07-9 x Arka Anamika (0.62) and JDNOL-11-14 x VRO-6 (0.59) were top three hybrids.

Although in E_4, gca effects for lines and testers ranged from -0.35 (JDNOL-11-12) to 0.31 (JDNOL-11-14) and -0.09 (Arka Anamika) to 0.11 (Parbhani Kranti), respectively. Among lines, JDNOL-11-12 (-0.35) and JOL-6k-2 (-0.15) recorded significant and negative gca effect, while, among testers, Arka Anamika (-0.09) recorded significant and negative gca effect. The sca effects varied from -0.63 (JOL-08-12 x GO-2) to 0.58 (JDNOL-11-11 x GO-2). Nine hybrids recorded significant and negative sca effect. JOL-08-12 x GO-2 (-0.63), JDNOL-11-12 x Pusa Sawani (-0.62) and JDNOL-11-14 x GO-2 (-0.43) were top three hybrids.

In pooled analysis, gca effects for lines and testers ranged from -0.36 (JDNOL-11-12) to 0.27 (AOL-08-5) and -0.15 (Arka Anamika) to 0.14 (Parbhani Kranti), respectively. Among lines, JDNOL-11-12 (-0.36) and JDNOL-11-3 (-0.22) recorded significant and negative gca effect, while, among testers, Arka Anamika (-0.15) recorded significant and negative gca effect. The sca effects varied from -0.57 (JOL-08-12 x GO-2) to 0.41 (JOL-08-7 x Parbhani Kranti). JOL-08-12 x GO-2 (-0.57), JDNOL-11-14 x GO-2 (-0.45) and JDNOL-11-14 x Parbhani Kranti (-0.34) were the top three hybrids with significant and negative sca effect.

Whereas, scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.27), E_2 (0.32), E_3 (0.09), E_3 (0.14) and pooled analysis (0.37) revealed preponderance of non-additive gene action for this trait.

4.4.2.14 Vitamin 'C' (mg/100 g pulp) (Table 4.4.14)

Looking to the data in E_1, gca effects for lines and testers ranged from -0.48 (JOL-6k-2) to 0.41 (JDNOL-11-1) and -0.44 (Arka Anamika) to 0.37 (Pusa Sawani), respectively. Among lines, only JDNOL-11-1 (0.37) recorded significant and positive gca effect, while, among testers, Pusa Sawani (0.37) recorded significant and positive gca effect. The sca effects varied from -1.74 (AOL-08-5 x GO-2) to 1.35 (JOL-08-12 x VRO-6). Two crosses showed significant and positive sca effect. JOL-08-12 x VRO-6 (1.35) and JDNOL-11-1 x GO-2 (1.28) were promising hybrids with significant and positive sca effect.

Table 4.4.14: Estimates of general combining ability and specific combining ability effects in individual and pooled over environments for crude fiber content (%) and vitamin 'C' (mg/100 g pulp)

Sr. No.	Genotypes	Crude fiber content (%)					Vitamin 'C' (mg/100 g pulp)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	0.009	-0.04	-0.06	0.04	-0.01	0.41*	-0.002	0.15	0.41*	0.24**
2.	JDNOL-11-3	-0.23**	-0.34**	-0.23**	-0.08	-0.22**	0.22	0.43*	0.29	0.12	0.26**
3.	JDNOL-11-11	0.04	-0.05	0.04	0.02	0.01	0.09	0.90**	-0.01	0.18	0.29***
4.	JDNOL-11-12	-0.37**	-0.69**	-0.01	-0.35**	-0.36**	-0.38	-1.50**	-0.47**	-2.14**	-1.12***
5.	JDNOL-11-14	0.18**	0.42**	0.006	0.31**	0.23**	0.31	-0.17	0.30*	0.72**	0.29**
6.	AOL-07-9	-0.12*	-0.01	0.20**	0.003	0.01	-0.02	-0.35	-0.48**	-0.04	-0.22**
7.	AOL-08-5	0.26**	0.34**	0.30**	0.19**	0.27**	0.14	0.07	0.19	0.93**	0.33**
8.	JOL-6k-2	0.11*	0.08	-0.21**	-0.15**	-0.04	-0.48*	-0.02	0.092	-0.45*	-0.21*
9.	JOL-08-7	-0.05	0.22**	-0.19**	0	-0.008	0.17	0.26	-0.32*	-0.19	-0.02
10.	JOL-08-12	0.17**	0.07	0.16**	0.01	0.10**	-0.47*	0.38*	0.25	0.45*	0.15
	S.E.g_i	0.11	0.08	0.10	0.10	0.05	0.39	0.36	0.29	0.34	0.16
MALES (TESTERS)											
11.	Arka Anamika	-0.19**	-0.19**	-0.12**	-0.09*	-0.15**	-0.44**	-0.03	-0.06	-0.09	-0.15**
12.	Pusa Sawani	0.07	-0.09**	-0.01	-0.04	-0.02	0.37**	-0.006	0.01	0.17	0.14*
13.	Parbhani Kranti	0.15**	0.26**	0.04	0.11**	0.14**	0.11	-0.04	0.22*	0.37**	0.16**
14.	GO-2	-0.04	-0.01	0.01	-0.01	-0.01	-0.01	0.09	0.10	-0.20	-0.005
15.	VRO-6	0.02	0.03	0.07	0.04	0.04*	-0.02	-0.01	-0.28**	-0.25*	-0.14*
	S.E.g_i	0.07	0.06	0.07	0.07	0.03	0.27	0.26	0.21	0.24	0.11
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	-0.06	-0.05	0.10	0.22	0.05	0.42	-0.21	-0.11	0.26	0.08
17.	JDNOL-11-1 x Pusa Sawani	0.05	0.14	-0.37**	0.11	-0.01	0.24	0.19	0.03	-0.14	0.08
18.	JDNOL-11-1 x Parbhani Kranti	0.08	0.16	-0.31*	-0.005	-0.01	0.33	0.20	-0.44	0.90*	0.25
19.	JDNOL-11-1 x GO-2	0.16	0.25*	0.20	-0.28*	0.08	1.28**	0.31	0.89**	0.17	0.66**
20.	JDNOL-11-1 x VRO-6	-0.09	-0.13	0.29*	-0.17	-0.03	-1.04*	0.31	-0.34	0.04	-0.25
21.	JDNOL-11-3 x Arka Anamika	-0.04	0.20*	-0.20	0.10	0.01	0.51	0.43	0.522	0.45	0.48*
22.	JDNOL-11-3 x Pusa Sawani	-0.14	-0.11	0.13	0.44**	0.08	-0.87*	-0.65	-0.15	-0.46	-0.53**
23.	JDNOL-11-3 x Parbhani Kranti	0.33**	0.04	0.11	-0.17	0.08	-0.09	-0.88*	0.87*	-0.15	-0.06
24.	JDNOL-11-3 x GO-2	-0.12	-0.42**	0.40**	-0.36**	-0.12*	-0.74	0.05	-1.02**	-0.63	-0.58**
25.	JDNOL-11-3 x VRO-6	-0.15	-0.07	-0.36**	0.12	-0.11*	-0.05	0.24	-0.23	-0.43	-0.12
26.	JDNOL-11-11 x Arka Anamika	-0.30*	0.33**	-0.51**	-0.007	-0.12*	0.22	-0.42	-1.58**	-0.36	-0.53**
27.	JDNOL-11-11 x Pusa Sawani	-0.21	-0.43**	-0.27 *	-0.07	-0.25**	-0.21	0.15	0.25	-0.11	0.02
28.	JDNOL-11-11 x Parbhani Kranti	0.04	0.07	0.22	-0.18	0.04	-0.65	0.17	-0.50	-1.12**	-0.52**
29.	JDNOL-11-11 x GO-2	-0.30*	0.16	0.06	0.58**	0.12*	-0.02	0.27	0.43	0.18	0.21

Table 4.4.14 Continue...

Sr. No.	Genotypes	Crude fiber content (%)					Vitamin 'C' (mg/100 g pulp)				
		E 1	E 2	E 3	E4	Pooled	E 1	E 2	E 3	E4	Pooled
30.	JDNOL-11-11 x VRO-6	-0.07	-0.67**	-0.05	-0.24*	-0.26**	0.53	-1.39**	0.43	0.27	-0.03
31.	JDNOL-11-12 x Arka Anamika	-0.13	0.27**	0.42**	-0.18	0.09	0.15	0.14	-0.48	1.11**	0.23
32.	JDNOL-11-12 x Pusa Sawani	0.46**	-0.61**	-0.10	-0.62**	-0.22**	0.70	0.62	0.42	-0.65	0.27
33.	JDNOL-11-12 x Parbhani Kranti	-0.32**	0.08	0.05	0.12	-0.01	0.26	-0.06	-0.59	-0.45	-0.21
34.	JDNOL-11-12 x GO-2	0.29*	0.61**	0.08	0.47**	0.36**	-0.06	0.31	1.01**	1.06**	0.58**
35.	JDNOL-11-12 x VRO-6	0.56**	0.18	0.10	0.14	0.24**	-0.91*	0.20	0.60	0.07	-0.01
36.	JDNOL-11-14 x Arka Anamika	-0.15	-0.27**	0.40**	-0.24*	-0.06	-0.60	0.04	-0.39	0.44	-0.12
37.	JDNOL-11-14 x Pusa Sawani	0.33**	0.72**	0.47**	0.13	0.41**	0.58	0.24	0.91**	0.43	0.54**
38.	JDNOL-11-14 x Parbhani Kranti	-0.19	-1.00**	-0.01	-0.14	-0.34**	-0.28	-0.44	-0.78*	-0.13	-0.41*
39.	JDNOL-11-14 x GO-2	-0.32*	-0.60**	-0.46**	-0.43**	-0.45**	0.19	-0.27	-0.70*	-0.81*	-0.39*
40.	JDNOL-11-14 x VRO-6	-0.37**	0.24*	-0.59**	0.32**	-0.10	0.34	-0.29	0.02	-0.10	-0.007
41.	AOL-07-9 x Arka Anamika	0.51**	-0.26**	-0.62**	-0.09	-0.11	-0.17	-0.008	-0.22	-1.41**	-0.45*
42.	AOL-07-9 x Pusa Sawani	0.11	0.35**	0.17	0.10	0.19**	-0.33	-0.02	0.28	0.41	0.08
43.	AOL-07-9 x Parbhani Kranti	-0.36**	0.03	0.28*	-0.20	-0.06	-0.37	0.09	0.12	0.43	0.06
44.	AOL-07-9 x GO-2	0.35**	0.45**	0.15	0.49**	0.36**	0.36	0.581	0.70*	0.72	0.59**
45.	AOL-07-9 x VRO-6	0.09	0.33**	0.18	0.06	0.16**	0.27	0.08	0.06	0.003	0.10
46.	AOL-08-5 x Arka Anamika	0.23	0.23*	-0.10	0.09	0.11	0.45	0.12	0.60	-0.17	0.25
47.	AOL-08-5 x Pusa Sawani	-0.10	-0.04	0.34**	-0.01	0.04	-0.29	-0.12	-0.10	0.59	0.01
48.	AOL-08-5 x Parbhani Kranti	-0.07	-0.01	-0.16	-0.13	-0.09	0.77	-0.11	0.35	-0.36	0.16
49.	AOL-08-5 x GO-2	0.63**	0.06	-0.19	-0.40**	0.02	-1.74**	0.006	0.03	0.87*	-0.20
50.	AOL-08-5 x VRO-6	0.008	0.16	0.78**	0.36**	0.32**	0.56	0.40	0.38	-0.45	0.22
51.	JOL-6k-2 x Arka Anamika	-0.10	0.03	-0.10	-0.009	-0.04	-0.43	-0.39	0.82*	0.89*	0.22
52.	JOL-6k-2 x Pusa Sawani	-0.04	-0.03	-0.24	0.003	-0.08	0.73	0.46	-0.14	-0.01	0.25
53.	JOL-6k-2 x Parbhani Kranti	0.04	-0.06	-0.23	0.22	-0.004	-0.09	0.51	-0.67*	-1.21**	-0.36
54.	JOL-6k-2 x GO-2	-0.28*	-0.08	0.20	0.03	-0.03	0.7	-0.13	0.22	0.10	0.22
55.	JOL-6k-2 x VRO-6	-0.30*	-0.25*	-0.30*	-0.17	-0.25**	-0.65	-0.75	-1.50**	-0.23	-0.78**
56.	JOL-08-7 x Arka Anamika	0.29*	-0.24*	0.10	-0.06	0.02	-0.50	0.46	1.49**	-0.16	0.32
57.	JOL-08-7 x Pusa Sawani	-0.06	-0.38**	-0.17	-0.15	-0.19**	-0.31	-0.46	-1.10**	-0.77*	-0.66**
58.	JOL-08-7 x Parbhani Kranti	0.13	0.79**	0.26*	0.46**	0.41**	-0.18	0.17	1.37**	0.72	0.52**
59.	JOL-08-7 x GO-2	-0.16	0.11	0.39**	0.52**	0.21**	0.29	-0.31	-0.66	-0.41	-0.27
60.	JOL-08-7 x VRO-6	0.54**	0.41**	-0.41**	-0.27*	0.06	-0.39	0.96*	-0.49	0.24	0.08
61.	JOL-08-12 x Arka Anamika	-0.23	-0.25*	0.49**	0.18	0.04	-0.06	-0.18	-0.64	-1.05**	-0.48*
62.	JOL-08-12 x Pusa Sawani	-0.38**	0.40**	0.02	0.07	0.03	-0.22	-0.40	-0.39	0.71	-0.07
63.	JOL-08-12 x Parbhani Kranti	0.30*	-0.10	-0.22	0.03	0.004	0.3	0.34	0.27	1.38**	0.57**
64.	JOL-08-12 x GO-2	-0.23	-0.55**	-0.86**	-0.63**	-0.57**	-0.26	-0.81	-0.92**	-1.26**	-0.81**
65.	JOL-08-12 x VRO-6	-0.19	-0.191	0.38**	-0.16	-0.04	1.35**	0.22	1.07**	0.6	0.81**
	S.E.s_{ij}	0.24	0.19	0.24	0.24	0.11	0.87	0.82	0.66	0.77	0.37

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

In E_2, gca effects for lines and testers ranged from -1.50 (JDNOL-11-12) to 0.90 (JDNOL-11-11) and -0.03 (Arka Anamika) to 0.09 (GO-2), respectively. Among lines, JDNOL-11-11 (0.90), JDNOL-11-3 (0.43) and JOL-08-12 (0.38) recorded significant and positive gca effect, while, among testers, none of tester recorded significant and positive gca effect. The sca effects varied from -1.39 (JDNOL-11-11 x VRO-6) to 0.96 (JOL-08-7 x VRO-6). Only JOL-08-7 x VRO-6 (0.96) recorded with significant and positive sca effect.

While in E_3, gca effects for lines and testers ranged from -0.48 (AOL-07-9) to 0.30 (JDNOL-11-14) and -0.28 (VRO-6) to 0.22 (Parbhani Kranti), respectively. Among lines, only JDNOL-11-14 (0.30) recorded significant and positive gca effect, while, among testers, Parbhani Kranti (0.22) recorded significant and positive gca effect. The sca effects varied from -1.58 (JDNOL-11-11 x Arka Anamika) to 1.49 (JOL-08-7 x Arka Anamika). Nine crosses showed significant and positive sca effect. JOL-08-7 x Arka Anamika (1.49), JOL-08-7 x Parbhani Kranti (1.37) and JOL-08-12 x VRO-6 (1.07) were top three hybrids.

In E_4, gca effects for lines and testers ranged from -2.14 (JDNOL-11-12) to 0.93 (AOL-08-5) and -0.25 (VRO-6) to 0.37 (Parbhani Kranti), respectively. Among lines, AOL-08-5 (0.93), JDNOL-11-14 (0.72) and JOL-08-12 (0.45) recorded significant and positive gca effect, while, among testers, Parbhani Kranti (0.37) recorded significant and positive gca effect. The sca effects varied from -1.41 (AOL-07-9 x Arka Anamika) to 1.38 (JOL-08-12 x Parbhani Kranti). Six crosses showed significant and positive sca effect. JOL-08-12 x Parbhani Kranti (1.38), JDNOL-11-12 x Arka Anamika (1.11) and JDNOL-11-12 x GO-2 (1.06) were top three hybrids.

Whereas, in pooled analysis, gca effects for lines and testers varied from -1.12 (JDNOL-11-12) to 0.33 (AOL-08-5) and -0.15 (Arka Anamika) to 0.16 (Parbhani Kranti), respectively. Among lines, five parents *viz.,* AOL-08-5 (0.33), JDNOL-11-14 (0.29), JDNOL-11-11 (0.29), JDNOL-11-3 (0.26) and JDNOL-11-1 (0.24) recorded significant and positive gca effect, while, among testers, Parbhani Kranti (0.16) and Pusa Sawani (0.14) recorded significant and positive gca effect. The sca effects for crosses varied from -0.81 (JOL-08-12 x GO-2) to 0.81 (JOL-08-12 x VRO-6). Eight crosses showed significant and positive sca effect. The crosses JOL-08-12 x VRO-6 (0.81), JDNOL-11-1 x GO-2 (0.66) and JDNOL-11-12 x GO-2 (0.58) were top three hybrids.

Looking to the scrutiny of σ^2gca/σ^2sca ratio in E_1 (0.25), E_2 (1.33), E_3 (0.07), E_4 (0.62) and pooled analysis (0.43) revealed preponderance of additive gene action and non-additive gene action for E_2, and E_1, E_3, E_4 and pooled, respectively.

4.5 Genotype x environment interactions and stability parameters

Genotype x Environment (G x E) interaction measures the differential response of genotype to changes in the environments. This interaction constitutes an important limiting factor in the estimation of variance components and for efficient selection programme. The magnitude of G x E interactions and stability parameters for various traits were estimated as per the procedure outlined by Eberhart and Russell (1966).

4.5.1 Analysis of variance for phenotypic stability (Table 4.5.1)

The mean squares for phenotypic stability for different traits on the basis of pooled data are presented in Table 4.5.1. The mean squares due to genotypes including both parents and hybrids were highly significant for all the traits except days to first picking. Highly significant differences were also observed amongst environments for all the traits except crude fiber content and vitamin 'C' when tested against pooled error and pooled deviation which indicated the presence of considerable environmental differences for all the traits. The genotypes plus G x E interactions were non-significant for all the traits except plant height when tested against pooled error. This indicated that genotype interacted non-significantly in different environments. The mean squares due to environment plus G x E interactions were significant for most of the traits except days to first picking, fruit length, fruit girth, number of branches per plant, crude fibre content and vitamin 'C' when tested against pooled deviations. The lack of significant G x E interaction for rest of the traits under study indicated that genotypes responded consistently over the environments for these traits.

The additive environmental variance was significant for all the traits except crude fibre content and vitamin 'C' as evidence by significant environment (linear) component which indicated micro-environmental differences at four environments. The mean squares due to pooled deviation were significant for all traits, but its magnitude was higher than linear component, only in case of days to 50 per cent flowering, fruit length, total number of seeds per fruit, days to last picking and crude fibre content. For remaining trait, linear components was

Table 4.5.1: Analysis of variance for phenotypic stability pertaining to various traits

Source	d.f.	Traits				
		Days to 50 % flowering	Days to first picking	Fruit length (cm)	Fruit girth (cm)	No. of branches per plant
Genotypes (G)	65	11.934**	5.979	0.525**	0.803**	0.099**
Environments (E)	3	389.313**	16.732*	1.941**	2.538**	0.145**
G + (G X E)	195	6.667	4.663	0.251	0.333	0.031
E + (G X E)	198	12.465**	4.845	0.277	0.367	0.032
Environments (linear)	1	1167.940**	50.196**	5.824**	7.616**	0.437**
G X E (linear)	65	6.489	5.259	0.216	0.423*	0.031
Pooled deviation	132	6.654**	4.298**	0.265**	0.284**	0.030**
Pooled error	520	2.503	2.701	0.147	0.054	0.012

Source	d.f.	Traits				
		Internodal length (cm)	Plant height (cm)	Fruit yield per plant (g)	Total No. of fruits per plant	Total No. of seed per fruit
Genotypes (G)	65	0.826**	256.025**	1249.731**	5.101**	11.548**
Environments (E)	3	535.902**	43785.191**	167546.231**	332.642**	740.862**
G + (G X E)	195	0.481	88.333**	229.637	1.72	3.929
E + (G X E)	198	8.593**	450.407**	2764.737**	6.733**	15.094**
Environments (linear)	1	1607.708**	131355.573**	502638.69**	997.928**	2222.587**
G X E (linear)	65	0.546	161.931**	277.278	2.123*	3.157
Pooled deviation	132	0.441**	50.754**	202.698**	1.495**	4.249**
Pooled error	520	0.201	27.146	94.710	0.875	2.521

Source	d.f.	Traits			
		Days to last picking	Crude protein content (%)	Crude fiber content (%)	Vitamin 'C' (mg/100g pulp)
Genotypes (G)	65	57.922**	1.506**	0.322**	1.865**
Environments (E)	3	3105.842**	35.830**	0.100	0.169
G + (G X E)	195	24.335	0.736	0.091	0.462
E + (G X E)	198	71.025**	1.268**	0.091	0.457
Environments (linear)	1	9317.527**	107.491**	0.300	0.509
G X E (linear)	65	21.192	0.740	0.069	0.468
Pooled deviation	132	25.514**	0.723*	0.100**	0.451**
Pooled error	520	14.982	0.535	0.013	0.156

* and ** are significant at 5 % and 1 % level, respectively.

Table 4.5.2: Estimates of environmental index for various traits under different environments

Sr. No.	Traits	Environmental index			
		E_1 Timely Summer-2014	E_2 Late Summer-2014	E_3 Timely *kharif*-2014	E_4 Late *kharif*-2014
1.	**Days to 50 % flowering**	1.973	2.221	-2.293	-1.901
2.	**Days to first picking**	-0.383	-0.481	0.363	0.501
3.	**Fruit length (cm)**	-0.208	-0.013	0.211	0.010
4.	**Fruit girth (cm)**	-0.111	-0.075	0.293	-0.108
5.	**Number of branches per plant**	0.062	0.011	-0.035	-0.038
6.	**Internodal length (cm)**	-2.341	-2.590	2.551	2.379
7.	**Plant height (cm)**	-22.629	-21.969	21.609	22.99
8.	**Fruit yield per plant (g)**	-46.559	-40.50	40.513	46.546
9.	**Total number of fruits per plant**	-1.934	-1.938	2.190	1.681
10.	**Total number of seed per fruit**	-2.105	-3.547	3.414	2.238
11.	**Days to last picking**	-8.909	-1.821	6.045	4.685
12.	**Crude protein content (%)**	-1.046	0.089	0.663	0.294
13.	**Crude fiber content (%)**	-0.027	0.001	-0.029	0.055
14.	**Vitamin 'C' (mg/100 g pulp)**	0.006	0.036	0.031	-0.073

greater, thereby suggested that the prediction of performance of genotypes over environment based on regression analysis for these traits could be reliable with respect to these characters.

4.5.2 Environmental index (I_j) (Table 4.5.2)

The estimates of environmental indices revealed that the components traits for earliness and dwarfness (4.5.2) *viz.*, days to 50 per cent flowering (E_3 and E_4), internodal length, plant height and days to first picking were favoured in E_1 and E_2, while the yield attributing traits like number of branches per plant (E_1 and E_2), total number of fruits per plant, days to last picking, fruit length, fruit girth were more favoured in E_2, E_3 and E_4. As far as quality parameter crude fibre content (E_3 and E_1), crude protein content, crude fibre content and vitamin 'C' (E_1, E_2 and E_3) were favourable, respectively. For the trait fruit yield per plant E_1 and E_2 was found to be the most unfavourable and E_3 and E_4 the most favourable. In general, the environment E_3 and E_4 was found to be the most favourable for fruit yield and other related traits.

4.5.3 Stability parameters (Table 4.5.3 to 4.5.9)

Stability performance is one of the most desirable properties of a genotype for its wide adaptation. The stability parameters *viz.,* mean performance, regression coefficient (b_i) and individual squared deviation from linear regression (S^2d_i) for parents as well as hybrids were estimated for fourteen traits to assess the stability over the environments and are presented in Table 4.5.3 to 4.5.9.

4.5.3.1 Days to 50 per cent flowering (Table 4.5.3)

Significant linear and non-linear components were reflected by two and 17 genotypes respectively, thereby suggesting major role of non-linear component towards G x E interaction. Among parents, line, AOL-07-9 (45.91 days) followed by JOL-08-12 (46.98 days) and tester, VRO-6 (46.39 days) were found stable as they were flowered earlier and exhibited unit regression coefficient along with non-significant value of deviation from regression.

Twenty six out of 50 hybrids were found to be average stable owing to their lower mean values and non-significant values of linear and non-linear components. The five most stable hybrids among them were JDNOL-11-3 x Parbhani Kranti (45.52 days), AOL-08-5 x GO-2 (45.76 days), JDNOL-11-1 x Arka Anamika (47.47 days), JDNOL-11-3 x Pusa Sawani (47.67 days) and

JDNOL-11-11 x GO-2 (47.73 days). The hybrids JOL-11-12 x Pusa Sawani (47.51 days) was earlier in flowering with regression coefficient around unity and linear regression significantly deviating from zero was considered as unpredictable.

4.5.3.2 Days to first picking (Table 4.5.3)

Significant linear and non-linear components were reflected by three and 12 genotypes respectively, thereby suggested major role of non-linear component towards G x E interaction. Among parents, lines, JOL-08-7 (50.85 days) while, among testers, Parbhani Kranti (50.17 days) and Arka Anamika (51.41 days) were found stable as they had lower mean than parental mean and exhibited unit regression coefficient along with non-significant value of deviation from regression.

Eighteen hybrids recorded lower mean values than hybrid mean with non-significant regression coefficient and least deviation from linear regression thus, identified as average stable for this trait. The best three among them were JDNOL-11-11 x VRO-6 (46.91 days), JDNOL-11-14 x GO-2 (47.99 days), JOL-08-12 x Pusa Sawani (48.13 days), JDNOL-11-11 x Parbhani Kranti (49.01 days) and JDNOL-11-14 x Parbhani Kranti (48.73 days).

However, crosses JOL-08-12 x Parbhani Kranti (48.43 days), JOL-08-12 x Arka Anamika (49.16 days), JDNOL-11-14 x Pusa Sawani (47.60 days) and JDNOL-11-3 x Parbhani Kranti (49.33 days) were found to be unpredictable in their performance due to their significant deviation from regression.

4.5.3.3 Fruit length (Table 4.5.4)

Significant linear and non-linear components were reflected by two and 12 genotypes, respectively, thereby suggested major role of non-linear component towards G x E interaction. Among parents, lines, JOL-08-12 (12.34 cm), JDNOL-11-14 (11.89 cm) and JOL-11-1 (11.31 cm), while, among testers, Pusa Sawani (12.12 cm) and VRO-6 (12.08 cm) were found to be average stable owing to their higher mean values and non-significant values of linear and non-linear components.

Eighteen out of 50 hybrids were found to be average stable owing to their higher mean values and non-significant values of linear and non-linear components. Among them top three

Table 4.5.3: Stability parameters of individual genotypes for days to 50 % flowering and days to first picking

Sr. No.	Genotypes	Days to 50% flowering			Days to first picking		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
PARENTS							
FEMALES (LINES)							
1.	JDNOL-11-1	47.68	0.87	-0.80	52.37	0.69	-1.14
2.	JDNOL-11-3	46.28	1.18	-2.35	50.95	5.00	-0.01
3.	JDNOL-11-11	48.93	1.52	0.17	51.98	1.40	-1.63
4.	JDNOL-11-12	46.52	1.07	4.55	50.18	-0.23	-2.19
5.	JDNOL-11-14	47.25	0.79	0.95	50.45	2.17	-1.63
6.	AOL-07-9	45.91	0.27	1.93	50.99	0.35	2.47
7.	AOL-08-5	49.71	2.04*	-1.93	50.87	-2.56	6.12*
8.	JOL-6k-2	49.53	0.59	7.70*	50.81	-0.87	0.80
9.	JOL-08-7	48.74	0.33	9.96**	50.85	1.94	-2.04
10.	JOL-08-12	46.98	0.83	-0.34	50.52	-0.33	-0.38
	Parental Mean	47.75	-	-	51.00	-	-
MALES (TESTERS)							
11.	Arka Anamika	47.12	0.38	17.18**	51.41	1.59	-1.91
12.	Pusa Sawani	46.53	0.94	-1.80	49.73	-0.29	-1.63
13.	Parbhani Kranti	47.10	1.2	-1.25	50.17	1.54	0.23
14.	GO-2	51.33	1.09	-1.48	51.52	0.75	-2.54
15.	VRO-6	46.39	0.91	2.90	49.28	2.35	0.83
	Parental Mean	47.69	-	-	50.42	-	-
HYBRIDS							
16.	JDNOL-11-1 x Arka Anamika	47.47	1.11	-0.77	50.83	3.03	0.06
17.	JDNOL-11-1 x Pusa Sawani	50.74	1.08	25.39**	49.37	-1.13	-0.28
18.	JDNOL-11-1 x Parbhani Kranti	47.24	1.42	-2.26	50.27	3.74	3.62
19.	JDNOL-11-1 x GO-2	48.60	1.42	-1.83	48.96	0.07	-0.40
20.	JDNOL-11-1 x VRO-6	48.28	0.35	18.86**	48.46	3.84	3.71
21.	JDNOL-11-3 x Arka Anamika	49.90	0.96	15.59**	51.01	8.07*	-2.51
22.	JDNOL-11-3 x Pusa Sawani	47.67	1.36	-0.12	49.07	2.80	4.09
23.	JDNOL-11-3 x Parbhani Kranti	45.52	0.91	-0.23	49.33	1.02	5.71*
24.	JDNOL-11-3 x GO-2	48.24	0.19	13.44**	49.81	3.72	0.66
25.	JDNOL-11-3 x VRO-6	46.46	1.27	0.30	51.05	1.20	-1.30
26.	JDNOL-11-11 x Arka Anamika	45.83	-0.15	4.22	49.10	1.64	2.50
27.	JDNOL-11-11 x Pusa Sawani	47.64	1.00	1.77	50.59	0.42	1.74
28.	JDNOL-11-11 x Parbhani Kranti	49.78	0.69	14.78**	49.01	3.89	0.92
29.	JDNOL-11-11 x GO-2	47.73	1.22	-0.73	50.63	-2.08	-0.84
30.	JDNOL-11-11 x VRO-6	45.21	0.64	-2.03	46.91	2.52	0.16
31.	JDNOL-11-12 x Arka Anamika	49.92	1.44	-1.01	49.80	1.25	8.63*
32.	JDNOL-11-12 x Pusa Sawani	47.51	0.63	7.80*	49.10	2.99	-0.58
33.	JDNOL-11-12 x Parbhani Kranti	47.63	-0.19	3.37	50.92	0.92	-2.15
34.	JDNOL-11-12 x GO-2	48.91	1.04	1.65	51.24	4.47	3.19
35.	JDNOL-11-12 x VRO-6	49.02	1.40	32.63**	51.32	4.10	19.76**
36.	JDNOL-11-14 x Arka Anamika	49.46	1.03	0.007	49.24	0.75	-1.77

Table 4.5.3 Conti...

Table 4.5.3 Conti...

Sr. No.	Genotypes	Days to 50% flowering			Days to first picking		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
37.	JDNOL-11-14 x Pusa Sawani	46.66	1.13	-2.19	47.60	5.68	10.12**
38.	JDNOL-11-14 x Parbhani Kranti	45.87	0.60	-1.16	48.73	3.10	3.08
39.	JDNOL-11-14 x GO-2	46.75	1.39	-2.15	47.99	-3.74	0.60
40.	JDNOL-11-14 x VRO-6	46.65	1.40	0.33	50.55	1.18	-1.58
41.	AOL-07-9 x Arka Anamika	52.37	0.045	2.43	49.47	4.62	-2.05
42.	AOL-07-9 x Pusa Sawani	47.78	2.283	3.46	51.32	-0.36	6.44*
43.	AOL-07-9 x Parbhani Kranti	48.81	0.16	0.67	49.96	-3.95	-1.47
44.	AOL-07-9 x GO-2	47.12	0.85	3.11	49.82	-1.27	-2.05
45.	AOL-07-9 x VRO-6	47.96	1.73	13.51**	49.85	0.46	0.55
46.	AOL-08-5 x Arka Anamika	50.46	1.93	11.79**	50.60	-0.39	6.06*
47.	AOL-08-5 x Pusa Sawani	47.68	1.47*	-2.32	49.45	2.03	-1.08
48.	AOL-08-5 x Parbhani Kranti	45.92	1.16	1.32	48.50	-2.78	-1.07
49.	AOL-08-5 x GO-2	45.76	1.64	-0.36	51.40	-2.58	1.42
50.	AOL-08-5 x VRO-6	45.48	0.67	-1.94	47.30	-3.56*	-2.07
51.	JOL-6k-2 x Arka Anamika	52.74	1.18	3.792	51.38	1.29	5.99*
52.	JOL-6k-2 x Pusa Sawani	47.69	0.49	6.05*	51.23	1.03	3.98
53.	JOL-6k-2 x Parbhani Kranti	48.81	2.32	3.17	49.04	-3.92	2.11
54.	JOL-6k-2 x GO-2	51.23	-0.04	0.14	49.43	8.89*	-1.60
55.	JOL-6k-2 x VRO-6	47.56	0.98	-2.09	50.20	-0.21	1.85
56.	JOL-08-7 x Arka Anamika	50.66	-0.34	37.38**	48.91	1.05	6.01*
57.	JOL-08-7 x Pusa Sawani	47.01	0.82	0.19	47.13	1.03	-0.86
58.	JOL-08-7 x Parbhani Kranti	46.64	1.06	2.77	48.71	-0.30	11.92**
59.	JOL-08-7 x GO-2	46.23	1.14	5.50*	50.25	-0.48	3.71
60.	JOL-08-7 x VRO-6	49.24	0.34	5.70*	49.68	0.13	-2.38
61.	JOL-08-12 x Arka Anamika	48.66	1.30	3.48	49.16	1.47	13.09**
62.	JOL-08-12 x Pusa Sawani	48.02	2.90	18.78**	48.13	-1.19	0.38
63.	JOL-08-12 x Parbhani Kranti	45.58	0.96	-1.38	48.43	0.05	6.60*
64.	JOL-08-12 x GO-2	49.82	0.60	0.63	51.66	1.68	-1.39
65.	JOL-08-12 x VRO-6	46.16	1.44	0.54	49.07	0.93	2.39
66.	CHECK (GJOH-3)	47.39	1.33	-2.27	50.89	17.15	-2.06
	Cross Mean	48.00	-	-	49.61	-	-

*,** significant at 5 and 1 per cent level, respectively.

Table 4.5.4: Stability parameters of individual genotypes for fruit length (cm) and fruit girth (cm)

Sr. No.	Genotypes	Fruit length (cm)			Fruit girth (cm)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
PARENTS							
FEMALES (LINES)							
1.	JDNOL-11-1	11.31	0.26	0.28	5.20	1.39	-0.04
2.	JDNOL-11-3	12.23	-0.50	-0.05	5.42	3.02	0.01
3.	JDNOL-11-11	11.82	-0.95	-0.08	4.90	1.49	0.13*
4.	JDNOL-11-12	11.46	2.46	-0.05	5.73	0.67	0.14*
5.	JDNOL-11-14	11.89	1.64	-0.13	6.25	2.43*	-0.05
6.	AOL-07-9	11.76	0.62	0.13	5.95	0.14	0.34**
7.	AOL-08-5	11.29	1.79	0.15	5.39	3.82	0.27**
8.	JOL-6k-2	11.43	0.88	0.25	5.00	1.01	0.07
9.	JOL-08-7	11.30	2.21	-0.08	5.77	1.29	0.02
10.	JOL-08-12	12.34	0.88	-0.12	6.08	3.18	0.04
	Parental Mean	11.68	-	-	5.57	-	-
MALES (TESTERS)							
11.	Arka Anamika	11.68	-0.04	-0.14	5.41	1.78	0.07
12.	Pusa Sawani	12.12	1.64	-0.07	6.18	1.44	0.15*
13.	Parbhani Kranti	12.09	0.09	-0.07	6.22	1.66	-0.04
14.	GO-2	11.14	2.61	-0.13	5.06	-1.84	0.16*
15.	VRO-6	12.08	1.55	-0.13	6.23	2.02	0.005
	Parental Mean	11.82	-	-	5.82	-	-
HYBRIDS							
16.	JDNOL-11-1 x Arka Anamika	11.96	0.06	-0.12	5.69	2.70	0.03
17.	JDNOL-11-1 x Pusa Sawani	12.13	0.56	-0.07	5.89	3.65	0.05
18.	JDNOL-11-1 x Parbhani Kranti	11.91	0.13	0.004	5.46	1.74	0.44**
19.	JDNOL-11-1 x GO-2	11.86	-0.43	0.08	5.49	0.67	0.01
20.	JDNOL-11-1 x VRO-6	11.79	4.64	0.05	5.87	-4.00*	-0.05
21.	JDNOL-11-3 x Arka Anamika	12.08	-0.42	-0.12	6.05	1.36	0.16*
22.	JDNOL-11-3 x Pusa Sawani	11.79	0.61	0.29	5.72	1.21	-0.04
23.	JDNOL-11-3 x Parbhani Kranti	12.82	0.58	0.04	6.19	3.36	0.58**
24.	JDNOL-11-3 x GO-2	11.93	-1.60	0.21	5.75	2.02	-0.04
25.	JDNOL-11-3 x VRO-6	12.05	0.10	-0.14	5.82	2.83	0.78**
26.	JDNOL-11-11 x Arka Anamika	11.72	3.23	0.07	5.82	4.23*	-0.05
27.	JDNOL-11-11 x Pusa Sawani	12.12	0.38	0.01	5.56	-0.92	0.23**
28.	JDNOL-11-11 x Parbhani Kranti	11.82	3.49	-0.05	5.53	-0.44	0.59**
29.	JDNOL-11-11 x GO-2	11.64	2.00	0.08	4.95	-0.03	0.26**
30.	JDNOL-11-11 x VRO-6	12.88	2.46	-0.05	6.47	2.56	-0.02
31.	JDNOL-11-12 x Arka Anamika	11.99	2.45	-0.01	5.38	-0.13	-0.02
32.	JDNOL-11-12 x Pusa Sawani	11.63	0.91	1.14**	5.48	4.09*	-0.01
33.	JDNOL-11-12 x Parbhani Kranti	11.96	2.47*	-0.14	5.54	4.76*	-0.04
34.	JDNOL-11-12 x GO-2	11.52	-2.98	0.04	5.73	-0.93	0.78**
35.	JDNOL-11-12 x VRO-6	12.13	0.88	-0.08	5.75	-0.15	1.24**
36.	JDNOL-11-14 x Arka Anamika	11.64	2.97	1.00**	5.66	1.28	0.06

Table 4.5.4 Conti...

Table 4.5.4 Conti...

Sr. No.	Genotypes	Fruit length (cm)			Fruit girth (cm)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
37.	JDNOL-11-14 x Pusa Sawani	12.24	2.68	-0.04	5.92	4.14	0.51**
38.	JDNOL-11-14 x Parbhani Kranti	12.36	0.59	0.09	6.05	1.78	0.06
39.	JDNOL-11-14 x GO-2	12.30	0.86	-0.11	6.42	0.55	-0.05
40.	JDNOL-11-14 x VRO-6	12.70	5.08	0.66**	4.92	-0.07	0.01
41.	AOL-07-9 x Arka Anamika	12.20	3.56*	-0.14	5.00	-0.96	0.02
42.	AOL-07-9 x Pusa Sawani	12.00	1.59	0.31*	5.80	-0.87	0.09
43.	AOL-07-9 x Parbhani Kranti	11.86	0.58	-0.03	6.16	-4.15	0.42**
44.	AOL-07-9 x GO-2	11.58	1.98	-0.06	6.20	-1.10	1.32**
45.	AOL-07-9 x VRO-6	11.64	-1.53	0.44*	6.67	-0.10	0.349**
46.	AOL-08-5 x Arka Anamika	11.78	0.61	0.05	5.30	0.13	0.11*
47.	AOL-08-5 x Pusa Sawani	12.35	0.43	0.03	6.00	3.01	0.03
48.	AOL-08-5 x Parbhani Kranti	12.37	0.62	-0.06	6.11	2.29	0.80**
49.	AOL-08-5 x GO-2	12.12	1.22	0.70**	6.22	2.21	0.02
50.	AOL-08-5 x VRO-6	12.34	0.45	-0.14	6.35	-0.49	0.22**
51.	JOL-6k-2 x Arka Anamika	11.50	-2.38	0.47*	5.64	1.31	0.06
52.	JOL-6k-2 x Pusa Sawani	11.65	1.10	0.97**	5.16	1.79	1.56**
53.	JOL-6k-2 x Parbhani Kranti	11.64	1.53	0.77**	5.67	1.27	0.15*
54.	JOL-6k-2 x GO-2	11.74	3.08	-0.09	6.14	-3.80	0.20**
55.	JOL-6k-2 x VRO-6	11.96	1.59	0.13	6.52	-0.84	0.43**
56.	JOL-08-7 x Arka Anamika	11.86	-0.99	-0.04	5.79	0.90	-0.04
57.	JOL-08-7 x Pusa Sawani	12.28	2.26	1.11**	6.00	1.66	0.22**
58.	JOL-08-7 x Parbhani Kranti	12.40	1.72	0.46*	6.32	2.60	0.23**
59.	JOL-08-7 x GO-2	12.25	-0.02	-0.06	5.86	-1.28	0.02
60.	JOL-08-7 x VRO-6	12.08	2.77	0.26	5.90	0.75	1.00**
61.	JOL-08-12 x Arka Anamika	11.63	-2.27	0.14	5.79	-2.51	0.26**
62.	JOL-08-12 x Pusa Sawani	11.93	1.03	-0.14	5.83	-0.51	0.03
63.	JOL-08-12 x Parbhani Kranti	12.02	-0.04	0.003	5.89	0.81	0.63**
64.	JOL-08-12 x GO-2	11.61	-0.78	0.35*	5.98	1.37	-0.04
65.	JOL-08-12 x VRO-6	12.52	0.59	-0.12	6.61	1.73	0.11
66.	CHECK (GJOH-3)	12.33	0.52	-0.12	6.98	1.05	0.12*
	Cross Mean	12.00	-	-	5.84	-	-

*,** significant at 5 and 1 per cent level, respectively.

were JDNOL-11-11 x VRO-6 (12.88 cm), JOL-08-12 x VRO-6 (12.52 cm), AOL-08-5 x Parbhani Kranti (12.37 cm), AOL-08-5 x VRO-6 (12.34 cm) and JDNOL-11-14 x GO-2 (12.30 cm) was found to be average stable.

4.5.3.4 Fruit girth (Table 4.5.4)

The stability analysis for individual genotypes showed that regression coefficient was significant for five genotypes while, deviation mean square were significant for 32 genotypes. Line, JOL-08-7 (5.77 cm) and tester, Parbhani Kranti (6.22 cm) manifested high mean value accompanied with non-significant regression coefficient and least deviation from regression.

Hybrids, AOL-07-9 x VRO-6 (6.67 cm), JOL-6k-2 x VRO-6 (6.52 cm) and JOL-08-7 x Parbhani Kranti (6.32 cm) were possessed high mean accompanied with significant S^2d_i value and therefore, its performance was unpredictable in nature under changing environments. Out of 50 crosses, eight crosses recorded higher mean with non-significant regression coefficient and least deviation from linear regression thus, identified as average stable for this trait. The three most stable hybrids among them were JOL-08-12 x VRO-6 (6.61 cm), JDNOL-11-14 x GO-2 (6.42 cm) and JOL-08-12 x GO-2 (5.98 cm).

4.5.3.5 Number of branches per plant (Table 4.5.5)

Four and sixteen genotypes exhibited significant b_i and S^2d_i values, respectively, indicated the greater contribution of non linear component towards G x E interaction. Parents JDNOL-11-14 (2.60) and Pusa Sawani (2.57) was average stable across the environments as evident from non-significant b_i and S^2d_i values coupled with higher mean.

Out of 50 hybrids, eight were found average stable across the environments as reflected through non-significant linear and non linear components accompanied by higher mean. The three best specific combinations were JDNOL-11-11 x VRO-6 (2.82), JOL-08-7 x Parbhani Kranti (2.63) and AOL-08-5 x VRO-6 (2.46). Fourteen crosses exhibited unpredictable behavior due to their significant S^2d_i values.

Table 4.5.5: Stability parameters of individual genotypes for number of branches per plant and internodal length (cm)

Sr. No.	Genotypes	Number of branches per plant			Internodal length (cm)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
PARENTS							
FEMALES (LINES)							
1.	JDNOL-11-1	2.23	1.70	0.01	9.22	0.88	-0.05
2.	JDNOL-11-3	2.48	1.53	0.005	9.43	0.84	-0.15
3.	JDNOL-11-11	2.24	3.71	-0.007	8.64	0.96	-0.15
4.	JDNOL-11-12	2.28	0.79	-0.01	8.99	0.82*	-0.16
5.	JDNOL-11-14	2.60	-1.78	-0.006	9.50	0.87	-0.16
6.	AOL-07-9	2.57	-0.60	-0.01	9.51	0.85	-0.14
7.	AOL-08-5	2.34	-1.58	0.08**	8.64	1.14	0.09
8.	JOL-6k-2	2.31	0.99	0.01	8.89	0.76	0.16
9.	JOL-08-7	2.25	0.12	-0.006	8.74	1.02	-0.01
10.	JOL-08-12	2.36	2.60	0.01	8.98	0.78	-0.12
	Parental Mean	2.37	-	-	9.05	-	-
MALES (TESTERS)							
11.	Arka Anamika	2.53	-1.47	0.04**	8.97	1.02	0.34
12.	Pusa Sawani	2.57	-1.19	0.01	9.87	0.92	-0.14
13.	Parbhani Kranti	2.34	-1.26*	-0.01	9.57	0.79	-0.12
14.	GO-2	2.30	-0.02	-0.007	9.30	0.75*	-0.15
15.	VRO-6	2.44	-0.89	-0.008	9.53	0.78*	-0.18
	Parental Mean	2.44	-	-	9.45	-	-
HYBRIDS							
16.	JDNOL-11-1 x Arka Anamika	2.44	2.16	-0.001	9.95	1.07	1.85**
17.	JDNOL-11-1 x Pusa Sawani	2.35	1.19	0.001	9.57	0.80	0.13
18.	JDNOL-11-1 x Parbhani Kranti	2.28	2.51	0.007	9.14	1.00	0.17
19.	JDNOL-11-1 x GO-2	2.28	2.94*	-0.01	9.49	0.85	-0.02
20.	JDNOL-11-1 x VRO-6	2.40	4.48	0.004	9.54	0.87	-0.04
21.	JDNOL-11-3 x Arka Anamika	2.28	0.96	0.04*	8.74	1.18	0.40*
22.	JDNOL-11-3 x Pusa Sawani	2.32	-1.06	0.009	9.21	1.00	0.09
23.	JDNOL-11-3 x Parbhani Kranti	2.61	-5.65	0.05**	10.24	0.96	-0.04
24.	JDNOL-11-3 x GO-2	2.26	-1.49	-0.010	8.67	0.96	-0.17
25.	JDNOL-11-3 x VRO-6	2.33	3.97	-0.001	8.97	1.03	0.64*
26.	JDNOL-11-11 x Arka Anamika	2.34	2.48	0.03*	9.15	1.13	-0.11
27.	JDNOL-11-11 x Pusa Sawani	2.36	2.84	-0.01	10.00	1.19	1.63**
28.	JDNOL-11-11 x Parbhani Kranti	2.25	1.50	-0.001	9.30	0.85	0.19
29.	JDNOL-11-11 x GO-2	2.26	2.83	-0.001	9.68	1.11	-0.09
30.	JDNOL-11-11 x VRO-6	2.82	-1.45	0.004	10.67	1.39	0.62*
31.	JDNOL-11-12 x Arka Anamika	2.31	-0.09	0.004	8.74	1.00	0.38
32.	JDNOL-11-12 x Pusa Sawani	2.32	0.87	-0.012	9.19	1.00	-0.19
33.	JDNOL-11-12 x Parbhani Kranti	2.43	-1.66	0.007	9.60	1.10	-0.13
34.	JDNOL-11-12 x GO-2	2.23	0.30	0.011	9.52	1.02	0.24
35.	JDNOL-11-12 x VRO-6	2.25	-0.53	-0.002	8.54	1.18*	-0.16

Table 4.5.5 Conti...

Table 4.5.5 Conti...

Sr. No.	Genotypes	Number of branches per plant			Internodal length (cm)		
		Mean	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**
36.	JDNOL-11-14 x Arka Anamika	2.44	2.75	0.08**	9.96	1.03	-0.09
37.	JDNOL-11-14 x Pusa Sawani	2.69	-0.70	0.10**	10.35	1.25	1.16**
38.	JDNOL-11-14 x Parbhani Kranti	2.42	0.46	-0.008	9.84	1.10	0.17
39.	JDNOL-11-14 x GO-2	2.38	5.35*	-0.012	9.64	1.22	1.79**
40.	JDNOL-11-14 x VRO-6	2.64	-1.67	0.02*	9.71	1.00	-0.06
41.	AOL-07-9 x Arka Anamika	2.30	3.62	0.02	9.92	1.00	0.16
42.	AOL-07-9 x Pusa Sawani	2.38	4.73	0.02	9.38	1.23	-0.09
43.	AOL-07-9 x Parbhani Kranti	2.34	4.82	0.01	9.48	0.84	-0.10
44.	AOL-07-9 x GO-2	2.36	3.01	-0.011	9.18	0.86	-0.012
45.	AOL-07-9 x VRO-6	2.34	0.97	-0.004	9.89	1.09	0.58*
46.	AOL-08-5 x Arka Anamika	2.34	4.49	0.02*	9.36	0.94	0.26
47.	AOL-08-5 x Pusa Sawani	2.66	2.90	0.05**	9.76	0.85	0.12
48.	AOL-08-5 x Parbhani Kranti	2.58	-2.64	0.03*	10.13	1.03	0.04
49.	AOL-08-5 x GO-2	2.37	-0.03	-0.008	9.52	0.96	0.44*
50.	AOL-08-5 x VRO-6	2.46	-0.20	0.0001	9.73	1.10	0.09
51.	JOL-6k-2 x Arka Anamika	2.40	3.80	-0.004	9.31	0.86*	-0.18
52.	JOL-6k-2 x Pusa Sawani	2.26	0.95	0.007	9.92	0.99	0.47*
53.	JOL-6k-2 x Parbhani Kranti	2.33	-1.70	0.016	9.94	0.87	0.55*
54.	JOL-6k-2 x GO-2	2.51	1.85	0.015	9.41	0.81	0.50*
55.	JOL-6k-2 x VRO-6	2.33	2.81*	-0.012	9.97	1.04	1.48**
56.	JOL-08-7 x Arka Anamika	2.28	1.29	0.03*	9.19	1.11	0.70*
57.	JOL-08-7 x Pusa Sawani	2.71	3.61	0.03*	9.59	1.15	0.11
58.	JOL-08-7 x Parbhani Kranti	2.63	-0.62	0.012	9.36	0.96	0.52*
59.	JOL-08-7 x GO-2	2.36	0.86	-0.011	9.42	1.02	0.20
60.	JOL-08-7 x VRO-6	2.55	0.42	-0.008	9.64	1.37	1.65**
61.	JOL-08-12 x Arka Anamika	2.49	0.28	0.21**	9.44	1.38	0.52*
62.	JOL-08-12 x Pusa Sawani	2.79	3.36	0.01	10.17	1.06	0.27
63.	JOL-08-12 x Parbhani Kranti	2.40	2.27	0.013	9.93	0.94	0.46*
64.	JOL-08-12 x GO-2	2.43	-1.28	0.17**	9.56	0.98	-0.04
65.	JOL-08-12 x VRO-6	2.68	1.52	0.03*	9.92	1.05	-0.15
66.	CHECK (GJOH-3)	2.90	-1.08	0.01	10.05	1.04	-0.12
	Cross Mean	2.41	-	-	9.56	-	-

*,** significant at 5 and 1 per cent level, respectively.

4.5.3.6 Internodal length (Table 4.5.5)

A perusal of the data revealed that linear component was significant for 5 genotypes, while non-linear component was significant for 18 genotypes, indicating larger contribution of non-linear component towards G x E interaction. Among parents, lines, JDNOL-11-11 (8.64 cm), JOL-08-7 (8.74 cm) and JOL-08-12 (8.98 cm) while, among testers, GO-2 (9.30 cm) and VRO-6 (9.53 cm) were found stable as they were dwarf in stature and exhibited unit regression coefficient along with non-significant value of deviation from regression.

Seven hybrids registered significant deviation of b_i ($b_i > 1$) from unity with S^2d_i is equal to or nearer to zero were classified as stable for better environment. Among them top three were JDNOL-11-3 x Arka Anamika (8.74 cm), JDNOL-11-3 x VRO-6 (8.97 cm), JOL-08-7 x Arka Anamika (9.19 cm) and JOL-08-7 x Parbhani Kranti (9.36 cm).

Seventeen hybrids out of 40 hybrids were found to be average stable owing to their lower mean values and non-significant values of linear and non-linear components. The five most stable hybrids among them were JDNOL-11-3 x GO-2 (8.67 cm), JDNOL-11-12 x Arka Anamika (8.74 cm), JDNOL-11-1 x Parbhani Kranti (9.14 cm), JDNOL-11-11 x Arka Anamika (9.15 cm) and AOL-07-9 x GO-2 (9.18 cm).

4.5.3.7 Plant height (Table 4.5.6)

Significant linear and non-linear components were reflected by 12 and 15 genotypes respectively, thereby suggesting major role of non-linear component towards G x E interaction. Dwarfness is a desirable trait in okra. Among parents, lines, JDNOL-11-11 (136.81 cm) and JOL-08-12 (141.69 cm), while, among testers, GO-2 (126.34 cm) was found stable as they were dwarf in stature and exhibited unit regression coefficient along with significant value of deviation from regression.

Nine hybrids recorded dwarfism (lower mean values) with non-significant regression coefficient and least deviation from linear regression thus, identified as average stable for this trait. The best three among them were JDNOL-11-3 x GO-2 (126.34 cm), JOL-6k-2 x VRO-6 (131.46 cm), AOL-08-5 x VRO-6 (138.21 cm), JOL-6k-2 x Parbhani Kranti (138.84 cm) and JDNOL-11-12 x Pusa Sawani (140.38 cm). However, crosses JDNOL-11-1 x VRO-6 (120.20 cm), AOL-07-9 x GO-2 (134.10 cm), JDNOL-11-11 x GO-2 (136.19 cm) and JOL-08-7 x GO-2 (137.67 cm) were found to be unpredictable in their performance due to their significant deviation from regression.

4.5.3.8 Fruit yield per plant (Table 4.5.6)

Significant linear and non-linear components were reflected by 5 and 20 genotypes respectively, thereby suggested major role of non-linear component towards G x E interaction. Among parents, lines, AOL-07-9 (261.70 g) and JDNOL-11-14 (255.80 g), while, among testers, VRO-6 (253.70 g) and Parbhani Kranti (247.20 g) were found stable as they had higher mean and exhibited unit regression coefficient along with non-significant value of deviation from regression.

Seventeen hybrids recorded as high yielder (higher mean values) with non-significant regression coefficient and least deviation from linear regression thus, identified as stable for this trait *viz.*, JOL-08-7 x Parbhani Kranti (279.60 g), JOL-08-12 x VRO-6 (267.40 g), JDNOL-11-3 x Parbhani Kranti (262.90 g) and JDNOL-11-11 x VRO-6 (261.60 g).

However, total four crosses were found to be unpredictable in their performance due to their significant deviation from regression. Among them top three crosses were JOL-08-12 x Pusa Sawani (271.40 g), JDNOL-11-14 x Parbhani Kranti (270.30 g) and JOL-08-7 x Pusa Sawani (260.90 g).

4.5.3.9 Total number of fruit per plant (Table 4.5.7)

The stability analysis for individual genotypes showed that regression coefficient was significant for twelve genotypes while, deviation mean square were significant for three genotypes. Lines, AOL-07-9 (20.93) and JDNOL-11-14 (19.62) and testers, Parbhani Kranti (19.28) and Pusa Sawani (20.80) manifested high mean value accompanied with non-significant regression coefficient and least deviation from regression.

Hybrids, JDNOL-11-14 x VRO-6 (22.29), JOL-08-12 x VRO-6 (21.01) and JOL-08-12 x Pusa Sawani (20.14) were possessed high mean accompanied with significant S^2d_i value and therefore, its performance was unpredictable in nature under changing environments. Out of 50 crosses, 19 crosses recorded higher mean with non-significant regression coefficient and least

Table 4.5.6: Stability parameters of individual genotypes for plant height (cm) and fruit yield per plant (g)

Sr. No.	Genotypes	Plant height(cm)			Fruit yield per plant (g)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
PARENTS							
FEMALES (LINES)							
1.	JDNOL-11-1	146.33	1.35*	-14.20	231.10	0.88	428.41**
2.	JDNOL-11-3	151.36	1.12	-23.70	251.90	1.05	-75.80
3.	JDNOL-11-11	136.81	1.41*	-15.20	237.60	1.09	458.80**
4.	JDNOL-11-12	148.26	1.26	-11.70	228.20	0.92	-51.22
5.	JDNOL-11-14	153.83	1.19	66.60*	255.80	0.88	-78.90
6.	AOL-07-9	154.45	1.11	11.70	261.70	0.97	-93.00
7.	AOL-08-5	129.79	0.50	64.10*	232.60	1.07	-81.51
8.	JOL-6k-2	123.36	0.39*	10.90	169.90	1.67*	10.80
9.	JOL-08-7	135.95	0.68	91.40*	211.00	1.19	167.41
10.	JOL-08-12	141.69	1.40*	-20.20	244.20	0.91	214.20*
	Parental Mean	142.18	-	-	232.40	-	-
MALES (TESTERS)							
11.	Arka Anamika	138.91	0.79	270.30**	228.30	0.66	425.20**
12.	Pusa Sawani	154.77	0.95	-21.60	240.30	0.85	623.20**
13.	Parbhani Kranti	144.00	0.77*	-24.90	247.20	1.20	-70.00
14.	GO-2	126.34	0.23*	-26.60	227.10	0.91	487.70**
15.	VRO-6	142.83	0.57	87.21*	253.70	1.16	-73.51
	Parental Mean	141.37	-	-	239.32	-	-
HYBRIDS							
16.	JDNOL-11-1 x Arka Anamika	146.07	1.16	-21.10	235.00	0.76	402.0**
17.	JDNOL-11-1 x Pusa Sawani	146.23	0.99	-26.10	232.20	1.04	82.91
18.	JDNOL-11-1 x Parbhani Kranti	137.56	0.93*	-26.80	231.40	0.92	-50.01
19.	JDNOL-11-1 x GO-2	146.83	1.01	-25.40	225.00	0.71	380.80**
20.	JDNOL-11-1 x VRO-6	120.20	0.51	104.90**	230.50	0.66	525.8**
21.	JDNOL-11-3 x Arka Anamika	142.31	0.78*	-22.00	242.30	0.97	347.70**
22.	JDNOL-11-3 x Pusa Sawani	128.20	0.44*	-1.80	245.60	1.08	-80.70
23.	JDNOL-11-3 x Parbhani Kranti	153.58	1.42	39.00	262.90	1.12	-83.30
24.	JDNOL-11-3 x GO-2	126.34	0.53*	-24.20	237.90	0.68	508.30**
25.	JDNOL-11-3 x VRO-6	150.52	1.11	-17.70	244.80	1.03	96.80
26.	JDNOL-11-11 x Arka Anamika	150.49	1.15	52.60	240.80	1.11	-44.30
27.	JDNOL-11-11 x Pusa Sawani	149.14	1.27	-13.50	211.70	0.83	287.60*
28.	JDNOL-11-11 x Parbhani Kranti	144.91	1.31	-5.90	232.10	0.99	232.90*
29.	JDNOL-11-11 x GO-2	136.19	0.68	94.30*	236.10	0.89	-20.80
30.	JDNOL-11-11 x VRO-6	152.81	1.09	0.20	261.60	0.94	-2.80
31.	JDNOL-11-12 x Arka Anamika	136.05	0.48*	-2.40	247.20	0.89	341.80*
32.	JDNOL-11-12 x Pusa Sawani	140.38	0.80	-17.80	237.50	0.93	-32.90
33.	JDNOL-11-12 x Parbhani Kranti	143.15	1.20	-0.50	230.90	1.16	80.01
34.	JDNOL-11-12 x GO-2	145.32	1.36	282.60**	220.50	0.83	455.30**
35.	JDNOL-11-12 x VRO-6	146.74	1.27	9.80	241.70	1.24	96.70

Table 4.5.6 Conti...

Table 4.5.6 Conti...

Sr. No.	Genotypes	Plant height(cm)			Fruit yield per plant (g)		
		Mean	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**
36.	JDNOL-11-14 x Arka Anamika	141.16	0.82	-13.80	211.70	0.83*	-84.60
37.	JDNOL-11-14 x Pusa Sawani	145.42	0.93	187.20**	249.60	1.09	-51.60
38.	JDNOL-11-14 x Parbhani Kranti	150.38	1.20	28.70	270.30	1.30	303.40*
39.	JDNOL-11-14 x GO-2	145.43	1.20	-20.10	259.90	1.06	-78.30
40.	JDNOL-11-14 x VRO-6	148.24	1.10	-17.00	258.30	1.01	129.10
41.	AOL-07-9 x Arka Anamika	146.31	1.07	-16.00	248.50	1.02	-37.70
42.	AOL-07-9 x Pusa Sawani	130.22	0.57*	-25.40	234.10	0.96	26.00
43.	AOL-07-9 x Parbhani Kranti	142.70	0.96	18.30	231.80	1.11	-72.80
44.	AOL-07-9 x GO-2	134.10	0.55	86.10*	247.30	1.12	-36.80
45.	AOL-07-9 x VRO-6	146.66	1.08	-6.30	216.50	0.80	-12.70
46.	AOL-08-5 x Arka Anamika	141.22	1.30	63.20*	238.90	1.10	220.70*
47.	AOL-08-5 x Pusa Sawani	150.89	1.27	26.00	254.20	1.13	-77.40
48.	AOL-08-5 x Parbhani Kranti	152.63	1.25	-17.90	260.10	0.87	-39.90
49.	AOL-08-5 x GO-2	147.54	1.28	22.70	257.90	1.24*	-71.60
50.	AOL-08-5 x VRO-6	138.21	0.93	0.70	243.30	0.69	16.90
51.	JOL-6k-2 x Arka Anamika	148.72	0.98	-25.90	227.40	0.97	514.20**
52.	JOL-6k-2 x Pusa Sawani	144.76	1.03	75.10*	229.30	0.91	-85.00
53.	JOL-6k-2 x Parbhani Kranti	138.84	0.97	29.90	248.00	1.14	-39.10
54.	JOL-6k-2 x GO-2	139.56	0.72	109.60**	247.70	0.88	-30.90
55.	JOL-6k-2 x VRO-6	131.46	1.10	-19.90	240.50	0.87	166.30
56.	JOL-08-7 x Arka Anamika	145.68	1.10	7.40	252.00	0.91	-70.70
57.	JOL-08-7 x Pusa Sawani	152.33	1.22	-19.90	260.90	0.95	289.00*
58.	JOL-08-7 x Parbhani Kranti	147.15	1.26	12.40	279.60	1.23	-32.40
59.	JOL-08-7 x GO-2	137.67	0.93	138.40**	257.30	1.52*	-63.00
60.	JOL-08-7 x VRO-6	147.76	1.00	8.00	239.90	0.82	94.20
61.	JOL-08-12 x Arka Anamika	144.07	1.20	45.10	229.60	1.40*	-68.90
62.	JOL-08-12 x Pusa Sawani	148.72	1.18	79.0*	271.40	0.99	467.00**
63.	JOL-08-12 x Parbhani Kranti	148.95	1.17	-5.70	256.40	0.94	52.40
64.	JOL-08-12 x GO-2	143.66	1.24	8.90	252.00	1.00	68.40
65.	JOL-08-12 x VRO-6	152.80	1.05	21.60	267.40	1.07	-59.70
66.	CHECK (GJOH-3)	151.27	1.08	-25.60	269.10	0.88	-42.00
	Cross Mean	143.52	-	-	244.28	-	-

*,** significant at 5 and 1 per cent level, respectively.

Table 4.5.7: Stability parameters of individual genotypes for total number of fruits per plant and total number of seed per fruit

Sr. No.	Genotypes	Total number of fruits per plant			Total number of seed per fruit		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
PARENTS							
FEMALES (LINES)							
1.	JDNOL-11-1	18.61	1.52	2.18*	46.01	0.99	-2.23
2.	JDNOL-11-3	20.47	1.08	0.41	47.21	1.03	-1.28
3.	JDNOL-11-11	17.90	1.32	-0.41	44.31	1.06	-2.06
4.	JDNOL-11-12	17.98	1.00	-0.56	46.49	0.43	2.03
5.	JDNOL-11-14	19.62	0.85	-0.03	47.67	0.96	-1.35
6.	AOL-07-9	20.93	1.01	-0.67	47.12	1.64	-1.52
7.	AOL-08-5	19.42	1.48	0.38	45.47	1.06	-2.47
8.	JOL-6k-2	17.57	1.95*	-0.63	46.07	1.52	2.17
9.	JOL-08-7	17.23	1.04	0.52	44.79	0.88*	-2.50
10.	JOL-08-12	19.58	0.34	1.65	48.26	0.91	-1.69
	Parental Mean	18.93	-	-	46.34	-	-
MALES (TESTERS)							
11.	Arka Anamika	19.49	0.47	-0.18	46.59	1.47	5.50*
12.	Pusa Sawani	20.80	1.18	1.42	48.51	1.48	-1.36
13.	Parbhani Kranti	19.28	1.07	-0.79	49.06	1.15	-2.33
14.	GO-2	17.85	1.13	0.42	44.11	0.89	-1.37
15.	VRO-6	20.78	1.01	1.35	47.75	1.22	-1.11
	Parental Mean	19.64	-	-	47.20	-	-
HYBRIDS							
16.	JDNOL-11-1 x Arka Anamika	19.80	1.06	-0.81	45.12	1.17	-0.76
17.	JDNOL-11-1 x Pusa Sawani	19.58	1.15	0.26	45.56	0.46	-1.19
18.	JDNOL-11-1 x Parbhani Kranti	19.70	1.20	-0.30	44.90	0.90	-2.43
19.	JDNOL-11-1 x GO-2	19.54	0.97	0.68	46.27	0.73	-1.99
20.	JDNOL-11-1 x VRO-6	20.48	0.86	0.39	46.42	1.49	0.65
21.	JDNOL-11-3 x Arka Anamika	20.06	1.08	-0.30	45.92	0.93	8.11*
22.	JDNOL-11-3 x Pusa Sawani	19.06	1.24	-0.37	46.47	0.82	-0.26
23.	JDNOL-11-3 x Parbhani Kranti	21.87	1.25	-0.30	49.32	1.31*	-2.44
24.	JDNOL-11-3 x GO-2	18.29	1.17	0.30	45.82	0.60	-0.59
25.	JDNOL-11-3 x VRO-6	19.88	1.02	-0.50	45.70	0.49	3.51
26.	JDNOL-11-11 x Arka Anamika	19.17	1.44*	-0.86	47.28	0.94	-1.55
27.	JDNOL-11-11 x Pusa Sawani	19.78	1.48	7.19**	45.87	0.48	20.62**
28.	JDNOL-11-11 x Parbhani Kranti	19.06	1.12	0.42	47.08	0.83	17.77**
29.	JDNOL-11-11 x GO-2	18.91	1.19	3.79**	47.14	0.97	8.16*
30.	JDNOL-11-11 x VRO-6	21.73	0.72	1.57	50.35	1.08	0.79
31.	JDNOL-11-12 x Arka Anamika	18.54	1.03	0.29	44.82	0.82	2.75
32.	JDNOL-11-12 x Pusa Sawani	19.80	1.23	0.12	45.37	1.29	-2.05
33.	JDNOL-11-12 x Parbhani Kranti	18.82	1.65	1.22	47.73	0.83	-1.32
34.	JDNOL-11-12 x GO-2	20.40	1.42	-0.46	48.64	0.82	22.86**
35.	JDNOL-11-12 x VRO-6	18.50	0.68	1.09	47.95	1.55	13.49**

Table 4.5.7 Conti...

Table 4.5.7 Conti...

Sr. No.	Genotypes	Total number of fruits per plant			Total number of seed per fruit		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
36.	JDNOL-11-14 x Arka Anamika	20.10	0.01	0.53	46.75	0.82	1.10
37.	JDNOL-11-14 x Pusa Sawani	19.75	0.50	-0.39	49.91	1.07	-1.85
38.	JDNOL-11-14 x Parbhani Kranti	20.37	0.96	0.23	48.10	1.56	-1.50
39.	JDNOL-11-14 x GO-2	20.66	0.78	1.12	48.34	1.01	6.38*
40.	JDNOL-11-14 x VRO-6	22.29	0.96	4.13**	47.92	0.56	-0.16
41.	AOL-07-9 x Arka Anamika	20.09	1.00	0.30	47.96	1.23	1.61
42.	AOL-07-9 x Pusa Sawani	19.19	1.38	2.20*	44.47	1.08	-0.81
43.	AOL-07-9 x Parbhani Kranti	19.95	0.83	0.34	45.94	0.86	-1.59
44.	AOL-07-9 x GO-2	18.05	0.21	0.28	47.29	1.17	-1.12
45.	AOL-07-9 x VRO-6	19.86	1.44	1.79*	47.96	0.93	3.87
46.	AOL-08-5 x Arka Anamika	18.80	1.62	0.51	45.37	1.14	-1.54
47.	AOL-08-5 x Pusa Sawani	21.33	0.73	-0.37	49.33	1.56	-0.01
48.	AOL-08-5 x Parbhani Kranti	19.67	0.50	2.33*	49.64	1.33	0.60
49.	AOL-08-5 x GO-2	21.04	0.77	-0.29	50.25	0.49	2.67
50.	AOL-08-5 x VRO-6	20.20	0.80	-0.52	47.58	1.24	3.67
51.	JOL-6k-2 x Arka Anamika	19.14	1.07	-0.59	46.46	1.12	-1.16
52.	JOL-6k-2 x Pusa Sawani	18.06	0.44	2.04*	46.14	0.77	-1.69
53.	JOL-6k-2 x Parbhani Kranti	18.98	0.50	5.01**	46.46	0.67	0.16
54.	JOL-6k-2 x GO-2	19.18	0.90	0.24	48.06	0.45*	-2.16
55.	JOL-6k-2 x VRO-6	20.42	0.92	-0.57	47.20	0.95	3.17
56.	JOL-08-7 x Arka Anamika	18.50	1.34	-0.43	45.68	1.46	6.39*
57.	JOL-08-7 x Pusa Sawani	20.59	0.92	1.13	50.12	0.80	-1.32
58.	JOL-08-7 x Parbhani Kranti	21.27	1.07	-0.70	50.81	0.61	-1.69
59.	JOL-08-7 x GO-2	21.29	1.33	-0.57	48.06	1.24	2.10
60.	JOL-08-7 x VRO-6	19.64	0.03*	-0.84	48.64	0.82	16.29**
61.	JOL-08-12 x Arka Anamika	19.23	1.12	1.97*	46.12	1.12	4.72
62.	JOL-08-12 x Pusa Sawani	20.14	0.86	2.15*	48.99	1.01	0.52
63.	JOL-08-12 x Parbhani Kranti	20.13	0.93	-0.43	47.92	0.91	4.90
64.	JOL-08-12 x GO-2	18.34	1.30	-0.05	44.43	0.94	-1.06
65.	JOL-08-12 x VRO-6	21.01	0.92	2.04*	50.59	0.69	3.87
66.	CHECK (GJOH-3)	22.25	0.46	-0.49	49.42	1.21	-1.91
	Cross Mean	19.80	-	-	47.32	-	-

*,** significant at 5 and 1 per cent level, respectively.

deviation from linear regression thus, identified as average stable for this trait. The three most stable hybrids among them were JDNOL-11-3 x Parbhani Kranti (21.87), JDNOL-11-11 x VRO-6 (21.73) and AOL-08-5 x Pusa Sawani (21.33).

4.5.3.10 Number of seeds per fruits (Table 4.5.7)

Significant linear and non-linear components were reflected by 3 and 10 genotypes respectively, thereby suggesting major role of non-linear component towards G x E interaction. Among parents, lines, JDNOL-11-11 (44.31) and AOL-08-5 (45.47), while, among testers, GO-2 (44.11) was found stable as they exhibited unit regression coefficient along with non-significant value of deviation from regression.

Twenty-two hybrids recorded lower mean values with non-significant regression coefficient and least deviation from linear regression thus, identified as average stable for this trait. The best three among them were JOL-08-12 x GO-2 (44.43), AOL-07-9 x Pusa Sawani (44.47), JDNOL-11-12 x Arka Anamika (44.82) and JDNOL-11-1 x Parbhani Kranti (44.90). However, crosses JOL-08-7 x Arka Anamika (45.68), JDNOL-11-11 x Pusa Sawani (45.87), JDNOL-11-3 x Arka Anamika (45.92) and JDNOL-11-11 x Parbhani Kranti (47.08) were found to be unpredictable in their performance due to their significant deviation from regression.

4.5.3.11 Days to last picking (Table 4.5.8)

The stability analysis for individual genotypes showed that regression coefficient was significant for eleven genotypes while, deviation mean square were significant for three genotypes. Lines, JDNOL-11-14 (126.20 days) and JDNOL-11-3 (121.90 days) and tester, VRO-6 (122.10 days) manifested high mean value accompanied with non-significant regression coefficient and least deviation from regression.

Five hybrids possessed high mean accompanied with significant S^2d_i value and therefore, its performance was unpredictable in nature under changing environments. Among them top three cross combinations were AOL-07-9 x Pusa Sawani (123.30 days), AOL-07-9 x VRO-6 (121.80 days) and JDNOL-11-11 x Arka Anamika (121.70 days). Out of 50 crosses, 18 crosses recorded higher mean with non-significant regression coefficient and least deviation from linear regression thus, identified as average stable for this trait. The three most stable hybrids among

Table 4.5.8: Stability parameters of individual genotypes for days to last picking and crude protein content (%)

Sr. No.	Genotypes	Days to last picking			Crude protein content (%)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
PARENTS							
FEMALES (LINES)							
1.	JDNOL-11-1	116.00	1.00	2.40	26.28	0.46	0.24
2.	JDNOL-11-3	121.90	1.07	-11.60	27.31	0.68	1.31*
3.	JDNOL-11-11	115.50	0.33	-9.80	25.85	0.52	0.29
4.	JDNOL-11-12	120.10	0.92	-2.00	26.17	0.86	0.58
5.	JDNOL-11-14	126.20	1.09	-14.60	26.69	1.25	1.24*
6.	AOL-07-9	121.10	0.64	17.10	26.19	1.23	0.04
7.	AOL-08-5	112.70	0.50	0.00	26.26	0.84	-0.04
8.	JOL-6k-2	111.70	1.20	18.70	26.11	1.03	-0.48
9.	JOL-08-7	113.00	1.33	35.50*	25.18	1.29	0.73
10.	JOL-08-12	118.90	1.33	6.50	27.07	0.99	-0.23
	Parental Mean	117.71	-	-	26.31	-	-
MALES (TESTERS)							
11.	Arka Anamika	121.70	0.57	12.90	26.52	1.36	-0.52
12.	Pusa Sawani	119.40	0.74	0.00	26.48	1.68	0.22
13.	Parbhani Kranti	122.30	0.93	28.70	26.39	0.49	-0.13
14.	GO-2	109.40	1.56	69.30**	25.92	1.42	-0.29
15.	VRO-6	122.10	0.53	-7.20	27.57	0.20	-0.41
	Parental Mean	118.98	-	-	26.57	-	-
HYBRIDS							
16.	JDNOL-11-1 x Arka Anamika	119.60	1.09	84.80**	26.53	0.54	-0.25
17.	JDNOL-11-1 x Pusa Sawani	115.00	0.85	15.70	26.35	1.88	0.50
18.	JDNOL-11-1 x Parbhani Kranti	118.10	0.64	13.20	26.41	0.49	-0.43
19.	JDNOL-11-1 x GO-2	117.90	1.18	38.10*	26.17	1.72	0.22
20.	JDNOL-11-1 x VRO-6	114.20	2.08	9.00	26.67	0.88	-0.08
21.	JDNOL-11-3 x Arka Anamika	116.60	1.32	18.00	26.34	-0.34	0.86
22.	JDNOL-11-3 x Pusa Sawani	116.80	0.77	-10.90	25.87	1.01	-0.22
23.	JDNOL-11-3 x Parbhani Kranti	119.80	1.12	105.00**	27.05	1.20	-0.43
24.	JDNOL-11-3 x GO-2	118.30	1.10	-11.40	25.48	0.70	1.25*
25.	JDNOL-11-3 x VRO-6	112.80	1.39	26.20	25.84	0.78	0.62
26.	JDNOL-11-11 x Arka Anamika	121.70	0.62	84.20**	24.82	1.87	2.25**
27.	JDNOL-11-11 x Pusa Sawani	122.00	0.88	-9.10	25.82	2.20	0.45
28.	JDNOL-11-11 x Parbhani Kranti	116.00	0.82	-6.80	26.40	1.54	1.80*
29.	JDNOL-11-11 x GO-2	116.60	0.73	28.40	26.42	1.57	-0.15
30.	JDNOL-11-11 x VRO-6	125.40	0.92	-14.50	27.18	0.74	-0.26
31.	JDNOL-11-12 x Arka Anamika	122.00	1.07	-11.60	25.92	0.27	-0.07
32.	JDNOL-11-12 x Pusa Sawani	120.90	1.00	1.40	25.24	1.33	-0.46
33.	JDNOL-11-12 x Parbhani Kranti	118.40	1.38	-9.60	26.14	1.16	-0.40
34.	JDNOL-11-12 x GO-2	120.00	1.40*	-13.90	26.42	-0.36	-0.13
35.	JDNOL-11-12 x VRO-6	118.80	1.36	-5.20	26.14	1.80	0.52

Table 4.5.8 Conti...

Table 4.5.8 Conti...

Sr. No.	Genotypes	Days to last picking			Crude protein content (%)		
		Mean	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**
36.	JDNOL-11-14 x Arka Anamika	114.90	0.90	36.70*	26.28	-0.60*	-0.36
37.	JDNOL-11-14 x Pusa Sawani	123.70	0.88	-11.90	26.46	1.65	0.82
38.	JDNOL-11-14 x Parbhani Kranti	121.00	0.60	-5.10	26.72	0.64	1.31*
39.	JDNOL-11-14 x GO-2	124.30	1.09	-13.00	27.39	1.47	0.28
40.	JDNOL-11-14 x VRO-6	115.50	1.40	-1.00	26.76	0.66	-0.36
41.	AOL-07-9 x Arka Anamika	119.20	1.56*	-13.10	26.36	0.58	-0.22
42.	AOL-07-9 x Pusa Sawani	123.30	0.08	101.20**	25.61	1.23	1.11*
43.	AOL-07-9 x Parbhani Kranti	115.30	0.19	47.70*	26.44	1.71	-0.47
44.	AOL-07-9 x GO-2	114.10	0.27	1.10	24.99	1.46	-0.41
45.	AOL-07-9 x VRO-6	121.80	0.63	65.20**	26.35	0.09	-0.42
46.	AOL-08-5 x Arka Anamika	116.40	1.62*	-13.80	25.52	0.37	1.12*
47.	AOL-08-5 x Pusa Sawani	123.10	1.53	4.50	26.91	1.26	-0.31
48.	AOL-08-5 x Parbhani Kranti	122.10	0.74	-6.20	26.66	1.53	0.03
49.	AOL-08-5 x GO-2	119.90	1.93	-5.10	26.67	0.31	0.88
50.	AOL-08-5 x VRO-6	119.60	0.68	3.10	26.44	0.89	0.03
51.	JOL-6k-2 x Arka Anamika	119.00	1.02	-1.80	25.39	1.59	0.89
52.	JOL-6k-2 x Pusa Sawani	114.70	1.30	8.80	26.07	1.26	-0.44
53.	JOL-6k-2 x Parbhani Kranti	117.30	0.93	43.90*	26.49	1.09	-0.12
54.	JOL-6k-2 x GO-2	117.50	1.25	21.30	25.89	1.78	0.09
55.	JOL-6k-2 x VRO-6	117.40	1.35	-4.90	26.59	1.23	-0.42
56.	JOL-08-7 x Arka Anamika	115.00	0.73	-13.10	25.58	0.19	-0.43
57.	JOL-08-7 x Pusa Sawani	122.50	0.80	-6.40	27.01	1.12	-0.48
58.	JOL-08-7 x Parbhani Kranti	123.20	0.81	-8.80	27.11	1.13	0.58
59.	JOL-08-7 x GO-2	121.70	1.29	11.80	27.20	-1.06	0.06
60.	JOL-08-7 x VRO-6	120.20	0.75	3.60	25.96	0.15	-0.32
61.	JOL-08-12 x Arka Anamika	114.10	1.30	16.30	25.86	1.77	0.43
62.	JOL-08-12 x Pusa Sawani	120.30	0.67	5.20	26.67	1.37	0.33
63.	JOL-08-12 x Parbhani Kranti	125.50	1.24	-4.60	26.53	2.20	0.03
64.	JOL-08-12 x GO-2	113.80	1.19	-13.10	25.03	1.53	0.12
65.	JOL-08-12 x VRO-6	124.60	0.91	-13.50	27.02	0.20	0.81
66.	CHECK (GJOH-3)	125.40	0.95	-10.00	27.56	1.94	-0.03
	Cross Mean	119.04	-	-	26.26	-	-

*,** significant at 5 and 1 per cent level, respectively.

them were JOL-08-12 x Parbhani Kranti (125.50 days), JDNOL-11-11 x VRO-6 (125.40 days) and JOL-08-12 x VRO-6 (124.60 days).

4.5.3.12 Crude protein content (Table 4.5.8)

One and eight genotypes exhibited significant b_i and S^2d_i values, respectively, indicated greater contribution of non linear component towards G x E interaction. Parents JOL-08-12 (27.07) and JOL-6k-2 (26.11) was average stable across the environments as evident from non-significant b_i and S^2d_i values coupled with higher mean.

Out of 50 hybrids, 27 were found average stable across the environments as reflected through non-significant linear and non-linear components accompanied by higher protein content. The three best specific combinations were JDNOL-11-14 x GO-2 (27.39), JOL-08-7 x GO-2 (27.20) and JDNOL-11-11 x VRO-6 (27.18).

The performance of 3 hybrids *viz.*, JDNOL-11-14 x Parbhani Kranti (26.72), JDNOL-11-11 x Parbhani Kranti (26.40) and AOL-07-9 x Pusa Sawani (25.61) could not be predicted due to their significant S^2d_i values.

4.5.3.13 Crude fiber content (%) (Table 4.5.9)

One and forty-four genotypes exhibited significant b_i and S^2d_i values, respectively, indicated greater contribution of non linear component towards G x E interaction.

Parents JDNOL-11-1 (4.48), JDNOL-11-11 (4.60), GO-2 (4.61) and Parbhani Kranti (4.85) were average stable across the environments as evident from non-significant b_i and S^2d_i values coupled with lower mean.

Out of 50 hybrids, 9 were found average stable across the environments as reflected through non-significant linear and non linear components accompanied by lower mean. Among them top thee cross combination were JDNOL-11-3 x Arka Anamika (4.48), JOL-08-12 x Arka Anamika (4.71) and JOL-08-12 x GO-2 (4.71). Sixteen crosses exhibited unpredictable behavior due to their significant S^2d_i values.

Table 4.5.9: Stability parameters of individual genotypes for crude fiber content (%) and vitamin 'C' (mg/100 g pulp)

Sr. No.	Genotypes	Crude fiber content (%)			Vitamin 'C' (mg/100 g pulp)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
PARENTS							
FEMALES (LINES)							
1.	JDNOL-11-1	4.48	-0.09	0.01	14.13	-2.83	0.09
2.	JDNOL-11-3	5.07	4.74	0.01	15.22	-7.84	0.29
3.	JDNOL-11-11	4.60	1.29	0.02	14.35	-8.59	0.09
4.	JDNOL-11-12	4.39	0.02	0.07**	13.39	10.08	-0.10
5.	JDNOL-11-14	4.77	-0.11	0.09**	15.11	0.20	-0.08
6.	AOL-07-9	4.92	5.38	0.10**	14.96	-0.45	-0.11
7.	AOL-08-5	4.76	-3.31	0.03*	13.21	0.01	0.23
8.	JOL-6k-2	4.69	-0.83	-0.01	14.39	-0.46	-0.12
9.	JOL-08-7	4.64	-3.33*	-0.01	12.44	-9.13	2.32**
10.	JOL-08-12	4.98	1.51	-0.01	14.90	-8.84	0.02
	Parental Mean	4.73	-	-	14.21	-	-
MALES (TESTERS)							
11.	Arka Anamika	4.84	0.80	0.03*	14.45	-0.89	0.02
12.	Pusa Sawani	5.13	-1.06	0.01	15.14	-1.52	0.21
13.	Parbhani Kranti	4.85	2.46	0.00	14.65	0.16	0.14
14.	GO-2	4.61	3.31	0.03	12.74	-10.07	0.59**
15.	VRO-6	4.98	5.28	0.05**	14.96	-0.63	0.33*
	Parental Mean	4.88	-	-	14.38	-	-
HYBRIDS							
16.	JDNOL-11-1 x Arka Anamika	4.76	5.04	0.01	14.61	-4.29	-0.12
17.	JDNOL-11-1 x Pusa Sawani	4.72	5.89	0.10**	14.29	-7.02	1.12**
18.	JDNOL-11-1 x Parbhani Kranti	4.94	-2.53	0.02*	14.72	-9.68	-0.08
19.	JDNOL-11-1 x GO-2	4.96	2.34	0.02	14.93	7.02	-0.02
20.	JDNOL-11-1 x VRO-6	4.93	-1.50	0.05**	14.86	9.81	0.27
21.	JDNOL-11-3 x Arka Anamika	4.48	6.99	0.01	14.63	7.13	-0.08
22.	JDNOL-11-3 x Pusa Sawani	4.38	3.85	0.08**	14.87	5.62	-0.15
23.	JDNOL-11-3 x Parbhani Kranti	5.21	-0.13	0.05*	15.42	2.64	-0.04
24.	JDNOL-11-3 x GO-2	4.68	1.16	0.08**	14.72	0.32	-0.04
25.	JDNOL-11-3 x VRO-6	4.50	2.24	0.05**	13.90	5.97	0.27
26.	JDNOL-11-11 x Arka Anamika	4.72	2.90	0.01	14.82	-4.26	0.71**
27.	JDNOL-11-11 x Pusa Sawani	4.91	-4.16	0.00	14.34	12.22	0.53*
28.	JDNOL-11-11 x Parbhani Kranti	4.69	0.28	0.23**	14.48	-2.37	0.18
29.	JDNOL-11-11 x GO-2	4.78	0.62	-0.01	14.89	12.46	-0.02
30.	JDNOL-11-11 x VRO-6	5.35	3.89	0.05**	15.11	5.25	0.31
31.	JDNOL-11-12 x Arka Anamika	4.45	-5.88	0.06**	13.82	17.77	1.05**
32.	JDNOL-11-12 x Pusa Sawani	4.62	6.53	0.19**	13.67	13.03	0.45*
33.	JDNOL-11-12 x Parbhani Kranti	4.20	-1.10	0.07**	13.08	14.05	0.94**
34.	JDNOL-11-12 x GO-2	4.52	-8.24	0.08**	13.10	6.64	0.56*
35.	JDNOL-11-12 x VRO-6	4.78	3.75	0.35**	12.89	14.33	1.06**

Table 4.5.9 Conti...

Table 4.5.9 Conti...

Sr. No.	Genotypes	Crude fiber content (%)			Vitamin 'C' (mg/100 g pulp)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
36.	JDNOL-11-14 x Arka Anamika	4.92	1.12	0.01	14.31	-4.94	0.60**
37.	JDNOL-11-14 x Pusa Sawani	4.82	0.51	0.05**	14.83	-12.53	1.48**
38.	JDNOL-11-14 x Parbhani Kranti	5.15	14.00	0.31**	14.89	-6.96	0.12
39.	JDNOL-11-14 x GO-2	5.42	3.29	0.09**	14.95	6.98	-0.07
40.	JDNOL-11-14 x VRO-6	5.22	-0.05	0.46**	14.66	-2.94	0.40*
41.	AOL-07-9 x Arka Anamika	4.75	3.99	0.01	14.53	-0.68	-0.14
42.	AOL-07-9 x Pusa Sawani	4.97	-4.69	0.14**	14.59	-14.18	0.19
43.	AOL-07-9 x Parbhani Kranti	4.92	0.51	0.19**	13.92	8.46	-0.06
44.	AOL-07-9 x GO-2	4.84	1.64	0.03	14.43	-5.58	0.19
45.	AOL-07-9 x VRO-6	4.99	0.75	0.37**	13.58	6.56	0.39*
46.	AOL-08-5 x Arka Anamika	5.08	5.90	0.04*	14.08	-5.23	0.33*
47.	AOL-08-5 x Pusa Sawani	4.91	-10.85	0.19**	15.19	4.49	-0.03
48.	AOL-08-5 x Parbhani Kranti	5.49	-0.31	0.07**	15.02	-11.49	0.16
49.	AOL-08-5 x GO-2	5.06	1.76	0.00	15.03	-0.42	-0.02
50.	AOL-08-5 x VRO-6	5.23	2.88	0.17**	14.55	-14.80*	-0.11
51.	JOL-6k-2 x Arka Anamika	4.76	-4.28	0.04*	14.00	7.28	0.89**
52.	JOL-6k-2 x Pusa Sawani	4.80	1.88	0.00	14.15	6.74	0.00
53.	JOL-6k-2 x Parbhani Kranti	4.92	-2.04	0.08**	14.46	0.12	0.27
54.	JOL-6k-2 x GO-2	4.82	3.78	0.05**	13.85	20.37	0.16
55.	JOL-6k-2 x VRO-6	4.88	-0.33	0.14**	14.65	-2.73	0.00
56.	JOL-08-7 x Arka Anamika	4.59	-2.96	0.05*	13.67	5.88	0.72**
57.	JOL-08-7 x Pusa Sawani	5.22	5.15	0.13**	15.14	-1.89	-0.12
58.	JOL-08-7 x Parbhani Kranti	5.38	5.78	0.15**	15.18	0.22	-0.12
59.	JOL-08-7 x GO-2	4.82	3.35	0.05**	14.64	6.68	0.12
60.	JOL-08-7 x VRO-6	4.34	1.63	0.14**	13.46	9.43	0.54*
61.	JOL-08-12 x Arka Anamika	4.71	4.52	-0.01	14.31	4.86	0.51*
62.	JOL-08-12 x Pusa Sawani	5.21	-4.06	0.08**	14.72	1.00	1.02**
63.	JOL-08-12 x Parbhani Kranti	5.30	-1.54	0.03*	14.86	-1.64	0.02
64.	JOL-08-12 x GO-2	4.71	0.75	-0.01	13.80	-4.67	0.28
65.	JOL-08-12 x VRO-6	4.99	-4.28	0.10**	15.26	2.24	-0.13
66.	CHECK (GJOH-3)	5.48	0.53	0.40**	15.27	-0.50	0.85**
	Cross Mean	4.87	-	-	14.43	-	-

*,** significant at 5 and 1 per cent level, respectively.

4.5.3.14 Vitamin 'C' (mg/100 g pulp) (Table 4.5.9)

Significant linear and non-linear components were reflected by 1 and 22 genotypes respectively, thereby suggested major role of non-linear component towards G x E interaction. Among parents, lines, JDNOL-11-3 (15.22) and JDNOL-11-14 (15.11), while, among testers, Parbhani Kranti (14.65) and Pusa Sawani (15.14) were found stable as they had higher mean and exhibited unit regression coefficient along with non-significant value of deviation from regression.

Twenty-five hybrids recorded as high vitamin 'C' (higher mean values) with non-significant regression coefficient and least deviation from linear regression thus, identified as average stable for this trait. Among them top three crosses were JDNOL-11-3 x Parbhani Kranti (15.42), JOL-08-12 x VRO-6 (15.26), AOL-08-5 x Pusa Sawani (15.19) and JOL-08-7 x Parbhani Kranti (15.18).

However, total four crosses were found to be unpredictable in their performance due to their significant deviation from regression. Among them top three crosses were JDNOL-11-14 x Pusa Sawani (14.83), JDNOL-11-11 x Arka Anamika (14.82), JOL-08-12 x Pusa Sawani (14.72) and JDNOL-11-14 x VRO-6 (14.66).

DISCUSSION

V. DISCUSSION

Bhindi [*Abelmoschus esculentus* (L.) Moench] is one of the most important vegetables grown throughout the country. Its fast growth, short duration and photo-insensitive nature enable the geneticist and a plant breeder to grow more than one generation in a year, facilitating quicker genetic improvement.

Plant breeding can be divided into three stages; assembly or creation of a gene pool of variable germplasm, selection of superior individuals from the gene pool and utilisation of the selected individuals directly for commercial cultivation or in hybridization to create a superior variety (Dudley and Moll, 1969). The improvement in yield or economically important traits is considered as a final product in almost all the crop plants, is usually obtained by screening, spotting and selecting out the suitable genes available from a huge collection of germplasm, synthesizing and accumulating them in a productive genotype for commercial cultivation.

Crop yield normally depends on genotype, environment and interaction between them. This clearly indicates that G x E interaction has a major importance in developing suitable genotypes. The selected individuals should be used to avoid risk in losing a high level of performance by introducing unknown breeding stock in crossing programme. The outdated varieties would have a deleterious effect on the elite population mean. By selecting only the best and well-adapted genotypes from different sources of population improvement programme, the breeders might be able to maintain the yield level and increase the genetic variability in favorable direction. For improving genetic yield potential of varieties and hybrids, the decision should be made about the choice of right type of parents for hybridization. The *per se* performance in respect of yield and other desirable economic traits could be considered as an important criteria in selection of the parents. Further, success in genetic improvement depends on the understanding of the nature of inheritance of yield and its component traits as well as identification of parents showing genetic prepotency for yield. This emphasizes on the importance of testing the parents for their combing ability because many times the high yielding parents may not combine well to give good segregates.

In order to exploit different types of gene action through appropriate breeding methodology, the information regarding relative magnitude of genetic variances and combining ability of important agronomic traits is essential. Such information is of paramount importance to breeders in the choice of parents, their hybridization and subsequent selection strategies. It is unlikely that all high yielding parents combine well to give good segregants. Hence, testing of parents for their combining ability is essential. The knowledge pertaining to combining ability helps in identifying the best combiner which may be hybridized either to exploit heterosis or to accumulate desirable genes through selection in segregating generations with appropriate breeding procedure.

The information regarding the types of gene action involved in expression of various traits and the extent of heterosis is of great value in development of superior hybrids. Further, for the systematic and successful breeding programme, the knowledge of G x E interactions and stability parameters is of immense value and provide guidance in the selection of stable and high yielding genotypes. The genotypes specifically adapted to high and poor management conditions and those showing general adaptation can be identified. The extent and amount of G x E interaction is useful in unbiased estimation of genetic variability and in rational apportionment of the physical and financial facilities.

The present investigation was therefore undertaken to get first hand information pertaining to the extent of heterosis and combining ability in a range of environments for fourteen traits utilising line x tester mating system involving ten lines and five testers over four environments (E_1-Timely summer, E_2-Late summer, E_3-Timely *kharif* and E_4-Late *kharif*). In order to estimate standard heterosis, one standard hybrid (check) *viz.,* 'GJOH-3' was also included in the study. The studies pertaining to phenotypic stability of genotypes (females, males, hybrids and check together) were also carried out. This experiment was conducted at Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan during the period of February-2014 to December-2014.

5.1 Mean performance of parents and hybrids (Appendix II to VIII)

For any hybrid to be acceptable by the farmers for commercial cultivation, it should possess significant superiority in fruit yield over the best commercial hybrid. In the present study, the performance of fifty hybrids was compared with the standard check 'GJOH-3.' A perusal of mean values revealed that in general the performance of parents and their hybrids were better under E_3

and E_4 (with overall mean of 282.26 g and 288.35 g, respectively for fruit yield per plant). The mean data over environments revealed that the female parents JDNOL-11-14 and AOL-08-5 and male parent Parbhani Kranti were found to be superior in respect of fruit yield per plant as well as yield components such as days to 50 per cent flowering, days to first picking, fruit length, fruit girth, number of branches per plant, total number of fruits per plant, crude protein content and vitamin 'C.' From the data, it is conspicuous that the high yielding parents for fruit yield had high per se performance for either one or more yield attributes. Further, the parents manifesting superior *per se* performance for majority of the traits also ranked high in their hybrid performance. These results are in accordance with the findings of Dhankhar and Dhankhar (2001) that the parents selected on their mean performances could result into hybrids of general superiority over their parents.

On pooled basis, the hybrid JOL-08-7 x Parbhani Kranti was found to be the best in respect to fruit yield per plant. High yielding hybrid, in general had high *per se* performance genotype as one of its parent and this hybrid significantly surpassed its parents as well as the check. The superiority of this hybrid seems to have been resulted largely by virtue of its yield contributing traits like number of branches per plant, number of fruits per plant, higher plant height, minimum days taken for first picking (ultimately long cropping period), fruit length and fruit girth. The wide range of *per se* performance of the parents for the traits studied suggesting the prevalence of considerable amount of genetic variability which is one of the causes of heterosis. Deviation observed in the *per se* performance of the hybrids compare to that of the parents is also indication of the manifestation of heterosis in the hybrids. The above results are in conformity with Badiger *et al.* (2014).

A critical study of the mean performance of the parents, hybrids and standard check ‘GJOH-3’ for fruit yield and yield attributing traits revealed that some hybrids were early, tall, dwarf and high yielding with greater number of branches per plant, minimum internodal length, maximum fruits per plant, less number of seeds per fruit, high fruit length, girth and minimum to medium fiber content as compared to the parents. This indicated the presence of heterosis for these traits.

5.2 Analysis of Variance (Table 4.2.1 to Table 4.2.7)

The analysis of variance for fruit yield and its component traits in individual environment as well as pooled data over the environments revealed significant differences among genotypes for all the traits, which indicated the presence of considerable amount of variability among genotypes for various traits under study. The mean squares due to parents and their resultant hybrids in pooled analysis for different traits revealed significant differences except days to first picking in parents, among parents as well as among hybrids for majority of traits studied which suggested presence of considerable amount of genetic variation in the materials. The variance due to parents was further partitioned into variance due to females, males and females vs. males. The results followed the same trend as it was for parents. The results revealed that mean squares due to males and females were highly significant for all traits in individual as well as pooled over environments (except days to first picking, in case of female, while, in case of male for days to first picking and internodal length), indicated significant variability among males and females. Pooled analysis of variance due to females vs. males was highly significant for traits like fruit girth, number of branches per plant, internodal length, fruit yield per plant, total number of fruits per plant, total number of seeds per fruit, and crude fiber content suggesting considerable variation between males and females for these traits.

The significance of mean squares due to parents vs. hybrids for all the traits proved that the differences in the performance of parents and hybrids were real and manifested the presence of heterosis for most of the traits studied. Similar results were obtained by Mehta *et al.* (2007), Hosamani *et al.* (2008), Weerasekara *et al.* (2008), Kumar and Pathania (2011), Raghuvanshi *et al.* (2011), Khatik *et al.* (2012), Sharma and Singh (2012), Kishor *et al.* (2013), Kumar *et al.* (2013), Das *et al.* (2013) and Badiger *et al.* (2014).

In pooled analysis, higher magnitude of variance due to environments for all the traits (except vitamin 'C') revealed appreciable influence of environments on the expression of various traits. Both parents and hybrids interacted significantly with change in environments. However, higher magnitude of variance due to hybrids x environments interactions revealed that hybrids were more sensitive to environmental fluctuations compared to their parents. The average performance of hybrids was different from that of parents in different environments which evidents from the significance of parents v/s hybrids x environment interaction for all the traits studied except for days to 50 per cent flowering, days to first picking, number of branches per plant, fruit length, total number of fruits per plant, total number of seeds per fruit, crude fiber content and vitamin 'C' indicated significant effect of environment on heterosis.

5.3 Magnitude of heterosis (Table 4.3.1 to Table 4.3.28)

The breeder needs an objective method of deciding whether or not to produce hybrids. Even after having decided to embark on a hybrid breeding programme, he has to face with many practical problems such as the amount of inbreeding needed in the inbred lines, choice about type of crosses; single cross, three way cross or double cross, within which to select; attention that should be given to the order in which the lines are combined; estimation and interpretation of variance among crosses and prediction of the performance of one type of cross from that of another *etc.* (Cockerham, 1961). Production of hybrids, as opposed to inbreds or open pollinated varieties, depends largely on the level of dominance and/or epistasis (especially dominance x dominance). Again, level of dominance and forms of epistasis will influence the selection of parents to develop open pollinated varieties. For cheap production of hybrid seeds, availability of suitable male sterility system (maintenance and restoration) is essential for crop having economic importance. Cotton is unique example in which successful exploitation of hybrid vigour, in the absence of male sterility system is feasible by hand emasculation and pollination. Like cotton, Bhindi also belongs to Malvaceae having similar floral structure hence there are enough chances to exploit heterosis on commercial scale. Keeping these facts in view heterosis was studied in okra. The estimates of heterosis were worked out with respect to standard heterosis. Standard heterosis is really useful to the growers in replacing existing cultivars/hybrids with new one. Therefore, standard heterosis was worked out by comparing F_1 with standard check hybrid ‘GJOH-3’ statistically. The salient findings of the present study on pooled basis with regards to heterosis are discussed in this part.

The number of crosses, which registered significant negative heterosis for days to fifty per cent flowering, was three, two, three, fourteen and six, five, five, sixteen and one in each and two over mid parent, better parent and standard check in E_1, E_2, E_3 and E_4, respectively. None of hybrid exhibited negative and significant standard heterosis for days to 50 per cent flowering in pooled over environment (Table 4.3.1 to Table 4.3.2). The maximum negative and significant relative heterosis and heterobeltiosis exhibited by AOL-08-5 x GO-2 followed by JOL-08-7 x GO-2 and

AOL-08-5 x VRO-6. Similar results showing favorable heterosis for days to 50 per cent flowering have been reported by Singh *et al.* (2004), Borgaonkar *et al.* (2005), Singh and Syamal (2006), Mamidwar and Mehta (2006), Manivannam *et al.* (2007), Mehta *et al.* (2007[a]), Jaiprakashnarayan *et al.* (2008[a]), Kumar and Sreeparvathy (2010), Wammanda *et al.* (2010), Solankey and Singh (2011), Jagan *et al.* (2013[a]), Chaubey *et al.* (2014), Nagesh *et al.* (2014[ab]), Kumar (2014) and Patel and Patel (2016).

In the present investigation, standard heterosis across environments for fruit yield per plant ranged from -21.32 per cent to 3.93 per cent. The maximum standard heterosis for fruit yield per plant recorded by cross combination JOL-08-7 x Parbhani Kranti (3.93 %) followed by JOL-08-12 x Arka Anamika (0.88 %), JDNOL-11-14 x Parbhani Kranti (0.46 %). The crosses, JOL-6k-2 x GO-2 (24.76 and 9.05 %), JOL-08-7 x Parbhani Kranti (22.07 and 13.12 %) and JOL-08-7 x GO-2 (17.48 and 13.30 %) recorded significant and positive mid parent and better parent heterosis, respectively (Table 4.3.15 to Table 4.3.16). The trait, fruit yield being economically important deserves a special mention. It is a complex trait and multiplicative product of several basic components. Heterosis for fruit yield per plant could be ascribed mainly to heterosis observed for plant height, fruit length, fruit girth. Heterosis for growth parameters is an indication of heterosis for yield as growth and yield parameters are strongly associated. Good combiner parents produces high heterotic cross due to complementation of favorable dominant genes. Heterosis is thought to result from the combined action and interaction of allelic and non allelic factors and is usually closely and positively correlated with heterozygosity (Falconer, 1952). Positive heterosis is due to differences in genetic background of lines used in hybridization and it is confirmed by the significant difference in parental variances for all the traits. Similar observations were reported earlier for fruit yield per plant by many researchers like Nichal *et al.* (2000), Sood and Sharma (2001), Rewale *et al.* (2003) Singh *et al.* (2004), Borgaonkar *et al.* (2005), Bhalekar *et al.* (2004), Mamidwar and Mehta (2006), Varmani *et al.* (2006), Manivannan *et al.* (2007), Dhake *et al.* (2007), Hosamani *et al.* (2008), Khanpara *et al.* (2009), Singh and Sanwal (2010), Khatki *et al.* (2012), Das *et al.* (2013), Kumar *et al.* (2013), Paul (2013), Nagesh *et al.* (2014), Akotkar *et al.* (2014), Badiger *et al.* (2014), Tiwari *et al.* (2015) and Patel and Patel (2016).

The number of branches per plant and total number of fruits per plant (Table 4.3.9 to 4.3.10 and Table 4.3.17 to 4.3.18) are major yield attributing components contributing to higher productivity. Standard heterotic range (pooled analysis) for these traits varied from -23.20 per cent (JDNOL-11-12 x GO-2) to -2.56 (JDNOL-11-11 x VRO-6) and -18.89 (AOL-07-9 x GO-2) to 0.19 (JDNOL-11-14 x VRO-6), respectively. In present study none of hybrid exhibited positive and significant standard heterosis in pooled analysis. Apart from this, JDNOL-11-11 x VRO-6, JOL-08-7 x Parbhani Kranti and JOL-08-12 x Pusa Sawani in case of number of branches per plant and JOL-08-7 x GO-2, JOL-08-7 x Parbhani Kranti and AOL-08-5 x GO-2 in case of total number of fruits per plant exhibited highest relative heterosis and heterobeltiosis, respectively. Among them highest heterosis exhibiting hybrids were JOL-08-7 x GO-2, AOL-08-5 x GO-2, JDNOL-11-11 x VRO-6 for number of branches per plant. Increase in number of branches ultimately lead to increase in number of fruits per plant. Increase in number of fruits per plant was significantly associated with increase in yield (Jethava, 2014). Same type of findings for number of branches per plant and number of fruits per plant in okra have been reported earlier by many researchers, Nichal *et al.* (2000), Rewale *et al.* (2003), Tripathi *et al.* (2004), Kumar *et al.* (2006), Desai *et al.* (2007), Hosamani *et al.* (2008), Kumar and Sreeparvathy (2010), Raghuvanshi *et al.* (2011), Khatik *et al.* (2012), Paul (2013), Medagam *et al.* (2012), Kishor *et al.* (2013), Obiadalla *et al.* (2013), Kumar *et al.* (2013), Lyngdoh *et al.* (2013), Akotkar *et al.* (2014), Nagesh *et al.* (2014), Tiwari *et al.* (2015) and Patel and Patel (2016).

Plant height and internodal length (Table 4.3.13 to 4.3.14 and, Table 4.3.11 and 4.3.12) at fully matured stages is one of the important ideotype in okra for higher yield. For plant height and internodal length, crosses showing higher negative values may be used for developing dwarf varieties. The higher heterosis for these traits indicated the presence of non-additive gene action. Heterotic range for plant height varied from -16.48 per cent (JDNOL-11-3 x GO-2) to 1.53 per cent (JDNOL-11-3 x Parbhani Kranti). Mid parent and better parent significant negative heterosis was recorded by JDNOL-11-1 x VRO-6 (-16.86 and -17.86) and AOL-07-9 x Pusa Sawani (-15.78 and -15.86). Heterosis for plant height in okra in desired direction (significant and negative) was reported by Rewale *et al.* (2003), Tripathi *et al.* (2004), Amutha *et al.* (2007), Desai *et al.* (2007), Khanpara *et al.* (2009), Kumar and Sreeparvathy (2010), Raghuvanshi *et al.* (2011), Khatik *et al.* (2012), Paul (2013), Kishor *et al.* (2013), Obiadalla *et al.* (2013), Kumar *et al.* (2013), Lyngdoh *et al.* (2013), Akotkar *et al.* (2014), Nagesh *et al.* (2014), Badiger *et al.* (2014) and Tiwari *et al.* (2015). Range of standard heterosis for internodal length was observed from -15.01 per cent (JDNOL-11-14 x Arka Anamika) to 6.19 per cent (JDNOL-11-11 x VRO-6).

Heterosis in desired direction for internodal length (significant and negative) was reported by Sood and Kalia (2001), Borgaonkar *et al.* (2003), Singh *et al.* (2004), Singh *et al.* (2006), Hosamani *et al.* (2008), Khanpara *et al.* (2009), Medagam *et al.* (2012), Reddy *et al*. (2013) Srivastava *et al*. (2013), Akotkar *et al.* (2014) and Kumar *et al.* (2014).

It can be seen from the results that the top heterotic crosses for fruit yield does not exhibited earliness in flowering. Early picking is a desirable trait in crop plants in general and in okra in particular. The range for standard heterosis for days to first picking was -7.83 per cent (JDNOL-11-11 x VRO-6) to 1.51 per cent (JOL-08-12 x GO-2). JDNOL-11-11 x VRO-6 (-7.83 %), JOL-08-7 x Pusa Sawani (-7.40) and AOL-08-5 x VRO-6 (-7.06) were the top three crosses over the environments with significant and negative standard heterosis for days to first picking (Table 4.3.3 to Table 4.3.4). Significant and negative standard heterosis for days to first picking was recorded by Borgaonkar *et al.* (2003), Khanpara *et al.* (2009), Singh *et al.* (2009), Kumar and Pathania (2011), Raghuvanshi *et al.* (2011), Khatik *et al.* (2012), Kishor *et al.* (2013), Kumar *et al.* (2013), Jagan *et al.* (2013), Kumar *et al.* (2014), Nagesh *et al.* (2014) and Badiger *et al.* (2014).

Another yield attributing components is days to last picking (Table 4.3.21 to Table 4.3.22). None of hybrid exhibited significant and positive standard heterosis in individual and pooled over environment. The extent of standard heterosis over environments ranged from -10.06 per cent (JDNOL-11-3 x VRO-6) to 0.07 per cent (JOL-08-12 x Parbhani Kranti). JOL-08-7 x GO-2 (9.43 and 7.70), AOL-08-5 x GO-2 (7.98 and 6.38) and JOL-6k-2 x GO-2 (6.30 and 5.19) were recorded significant and positive relative heterosis and heterobeltiosis, respectively. For days to last picking significant and positive heterosis was reported by Obi (2009), Jethava (2014), Kumar (2014) and Tiwari *et al.* (2015).

The range for standard heterosis for fruit length and fruit girth (Table 4.3.5 to Table 4.3.8) was -6.69 per cent (JOL-6k-2 x Arka Anamika) to 4.50 per cent (JDNOL-11-11 x VRO-6) and -29.47 per cent (JDNOL-11-14 x VRO-6) to -4.38 (AOL-07-9 x VRO-6), respectively. Only one hybrids in pooled analysis exhibited significant standard heterosis in desired direction for fruit traits like fruit length was JDNOL-11-11 x VRO-6, but 13 and 5 hybrids exhibited significant and positive relative heterosis and heterobeltiosis, respectively. Among them highest significant positive heterosis exhibiting hybrids were JOL-08-7 x GO-2, AOL-08-5 x GO-2 and JDNOL-11-11 x VRO-6. None of hybrid exhibited significant and positive standard heterosis in desired direction for fruit girth, but JOL-6k-2 x GO-2, AOL-08-5 x GO-2 and JDNOL-11-3 x Arka Anamika exhibited significant and positive relative heterosis and heterobeltiosis for fruit girth. Above pronounced results regarding fruit traits have been noticed by Nichal *et al.* (2000), Bhalekar *et al.* (2004), Kumar *et al.* (2006), Mehta *et al.* (2007), Hosamani *et al.* (2008), Khanpara *et al.* (2009), Kumar and Sreeparvathy (2010), Solankey and Singh (2011), Khatik *et al.* (2012), Paul (2013), Kishor *et al.* (2013), Obiadalla *et al.* (2013), Kumar *et al.* (2013), Akotkar *et al.* (2014), Nagesh *et al.* (2014), Badiger *et al.* (2014) and Tiwari *et al.* (2015).

Among seed related traits *viz.*, total number of seeds per fruit (Table 4.3.19 to Table 4.3.20) is an important quality parameter as far as okra breeding is concerned. As many as twenty-three hybrids in pooled analysis exhibited significant and negative standard heterosis for total number of seeds per fruit. Magnitude of standard heterosis for total number of seeds per fruits over environments varied from -10.09 per cent (JOL-08-12 x GO-2) to 2.82 per cent (JOL-08-7 x Parbhani Kranti) in pooled analysis. The present findings are in close association with results reported by Dhankhar *et al.* (1996), Nichal *et al.* (2000), Yadav *et al.* (2002), Mehta *et al.* (2007), Hosamani *et al.* (2008), Weerasekara *et al.* (2008), Singh *et al.* (2009), Khanpara *et al.* (2009), Dabhi *et al.* (2010[a]), Paul (2013), Das *et al.* (2013), Kumar *et al.* (2014), Nagesh *et al.* (2014) and Badiger *et al.* (2014).

Very few workers have worked on heterosis for quality traits in okra. Okra pods with high crude protein and vitamin 'C' and lower crude fiber are considered as good in quality (Table 4.3.23 to Table 4.3.28). The extent of significant and positive standard heterosis revealed the range of JDNOL-11-14 x GO-2 (-0.60) to JDNOL-11-11 x Arka Anamika (-9.93) and JDNOL-11-12 x VRO-6 (-15.54) to JDNOL-11-3 x Parbhani Kranti (1.00) in crude protein and vitamin 'C,' respectively. None of hybrid exhibited significant and positive standard heterosis in crude protein and vitamin 'C' in pooled analysis. In crude protein content four and one hybrid exhibited significant and positive relative heterosis and heterobeltiosis, respectively. Among them the highest significant and positive relative heterosis and heterobeltiosis exhibiting hybrid was JOL-08-7 x GO-2 for crude protein content. While, in case of vitamin 'C' twelve and three hybrids exhibited significant and positive relative heterosis and heterobeltiosis, respectively. Among them JOL-08-7 x GO-2, AOL-08-5 x GO-2 and JDNOL-11-1 x GO-2 were top three hybrids. In case of crude fiber content, estimation of heterosis revealed the range of -23.27 per cent (JDNOL-

11-12 x Parbhani Kranti) to 0.21 per cent (AOL-08-5 x Parbhani Kranti) in pooled analysis. In present study, positive significant heterosis for crude protein content and vitamin 'C' and negative significant heterosis for crude fiber observed which was in confirmation with Shobha and Marriappan (2007) and Tiwari *et al.* (2015).

The utility of hybrid breeding approach lies in the identification of most heterotic and useful cross combination in order to make commercial cultivation of hybrids beneficial. The most heterotic crosses for fruit yield per plant over standard check are depicted in Table 5.1 along with their mean performance and heterotic effects. Component-wise examination of the crosses revealed that crosses showing economic heterosis for days to first picking, fruit girth, internodal length, number of fruits per plant, days to last picking and crude fiber content were the main contributors to fruit yield per plant. Only three crosses *viz.,* JOL-08-7 x Parbhani Kranti, JDNOL-11-14 x Parbhani Kranti, JOL-08-12 x VRO-6, JDNOL-11-14 x GO-2 and JDNOL-11-14 x VRO-6 depicted significant and positive sca effects for fruit yield per plant.

Manifestation of heterosis for all the traits in single cross may not be possible, but the exploitation of hybrid vigour in one or more yield-attributing traits will significantly improve the crop performance over existing hybrid or variety (Hosamani *et al.,* 2008). Some crosses for fruit yield traits which were non-heterotic, may be ascribed to cancellation of positive and negative effects showed by the parents involved in a cross combination and can also happen when the dominance is not unidirectional (Mather and Jinks, 1971). While formulating suitable breeding methodology for the improvement in this crop, attention must be paid for the improvement of visual appearance as well as the biochemical qualitative aspects too, besides the productivity.

The magnitude of heterosis found in the present study stressed the importance of using genetically divergent parents in hybridization programme. Apart from these, there were some F_1 hybrids not showing significant heterosis, but were still better than the superior parents. Further, the maximum heterosis observed in the F_1 was not expressed by the best performing parents, but

Table 5.1: Promising hybrids for fruit yield per plant with standard heterosis, GCA effects, SCA effects and component traits showing significant desired heterosis based on pooled over environments

Sr. No.	Hybrid	Fruit yield per plant (g)	Standard heterosis (%)	GCA effects	SCA effects	Useful and significant for component traits
						Standard heterosis (%)
1.	JOL-08-7 x Parbhani Kranti	279.63	3.93	G X G	24.49**	FG, IL
2.	JOL-08-12 x Pusa Sawani	271.41	0.88	G X P	-8.23	DFP, FG,TNFP, CFC
3	JDNOL-11-14 x Parbhani Kranti	270.30	0.46	G X G	-10.93*	FG, TNFP, CFC
4	JOL-08-12 x VRO-6	267.43	-0.61	G X A	11.41*	FG, CFC
5	JDNOL-11-3 x Parbhani Kranti	262.87	-0.30	A X G	-4.76	FG, CFC
6	JDNOL-11-11 x VRO-6	261.64	-2.76	P X A	0.81	DFP, FL, FG
7	JOL-08-7 x Pusa Sawani	260.9	-3.03	G X P	-2.55	DFP, FG, TNFP, CFC
8	AOL-08-5 x Parbhani Kranti	260.12	-3.32	G X G	-0.72	FG, TNFP
9	JDNOL-11-14 x GO-2	259.89	-3.40	G X A	-11.24*	DFP, FG, TNFP
10.	JDNOL-11-14 x VRO-6	258.26	-4.01	G X A	13.79*	FG, LP, CFC

*, ** Significant at 5 and 1 per cent probability levels, respectively; G = Good parent having significant gca effect in desired direction; A = Average parent having either positive or negative but non-significant gca effects.

DFF : Days to fifty per cent flowering
DFP : Days to first picking
FL : Fruit length (cm)
FG : Fruit girth (cm)
NBP : Number of branches per plant
IL : Internodal length (cm)
PH : Plant height (cm)
FYP : Fruit yield per plant (g)
TNFP : Total number of fruits per plant
TNSF : Total number of seeds per fruit
DLP : Days to last picking
CPC : Crude protein content (%)
CFC : Crude fiber content (%)
V-C : Vitamin-C (mg/100g pulp)

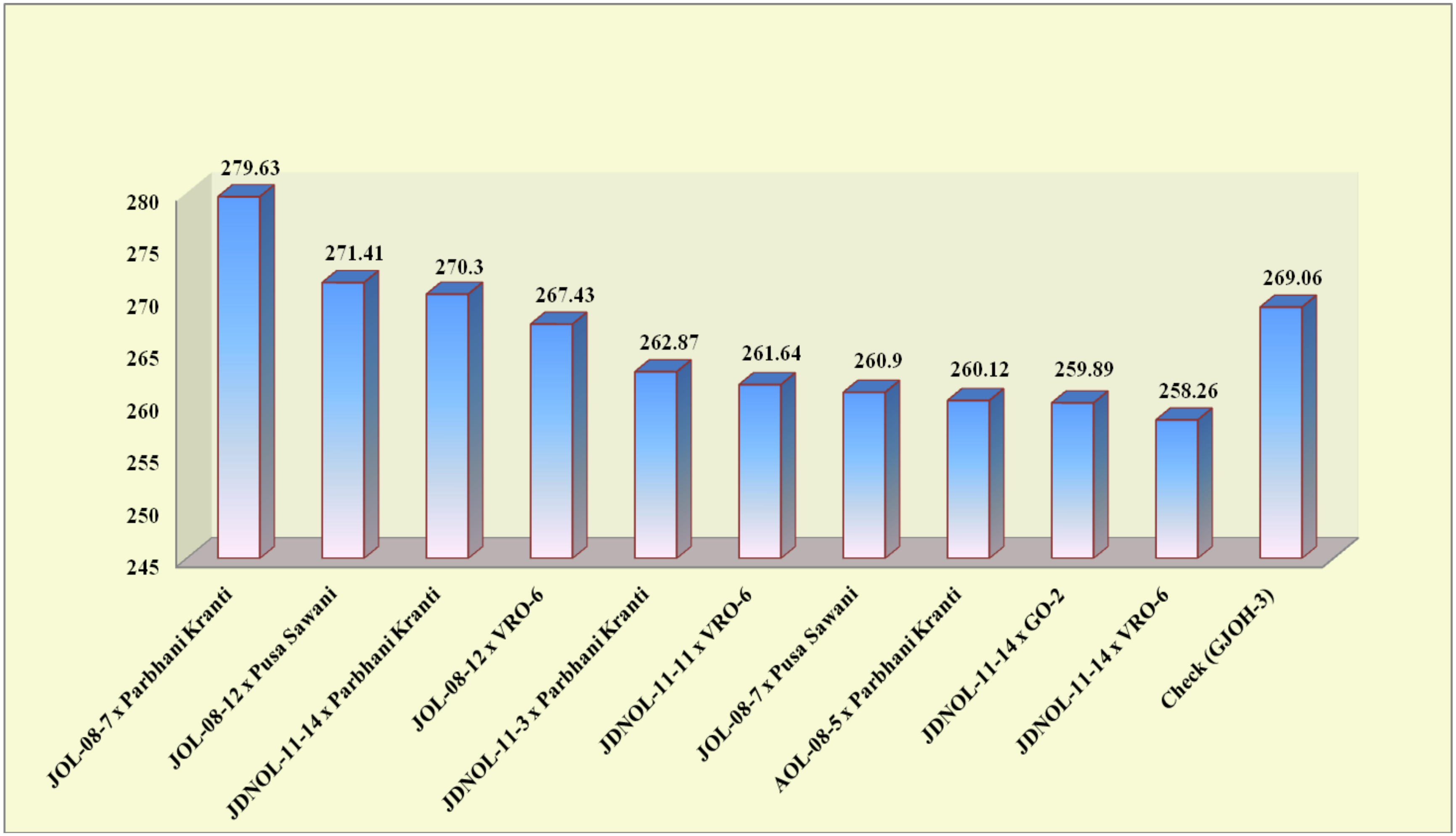

Fig. 1 : Top ten single cross hybrids for fruit yield per plant (g) in okra

at least one poor or average performing parent was involved in these significantly high heterotic F_1 hybrids (Amutha *et al.,* 2007).

5.4 Combining ability analysis

Combining ability analysis is a powerful tool to identify the parents having good potential to transmit desirable characteristics to their progenies and also to help in sorting out promising crosses for fruit yield and its components. At the same time, it also elucidates the nature of gene action involved in the inheritance of traits. The general combining ability is attributed to additive genetic effects and are theoretically fixable. On the other hand, specific combining ability is attributable to non-additive gene action, which may be due to dominance or epistasis or both and is non-fixable in nature. The presence of non-additive genetic variance is the primary justification for initiating the hybrid breeding programme (Cockerham, 1961). In the present investigation, combining ability studies were carried out to identify superior parents and cross combinations. The results obtained are briefly discussed in subsequent paragraphs.

The ultimate choice of parents to be used in breeding programme is determined by *per se* performance and their behaviour in hybrid combination. Some idea on the usefulness of the parents may be obtained from their individual performance, particularly in respect of yield components. Therefore, it is necessary to assess genetic potentialities of the parent in hybrid combination through systematic studies in relation to general and specific combining abilities. Line x Testers method has been used in the present study for estimating combining abilities.

5.4.1 Analysis of variance for combining ability (Table 4.4.1 to Table 4.4.7)

Analysis of variance for combining ability over the environments revealed that mean squares due to environment were highly significant for all the traits indicated considerable differences among the environments under which the study was conducted. This was further recognised by significant estimates of variance due environments (σ^2e). The mean squares due to females were significant for most of the yield attributing traits like number of branches per plant, internodal length, fruit yield per plant, crude fiber content and vitamin 'C' under individual as well as across the environments, while, the mean square due to males was significant for fruit length and crude protein content signifying that both females and males had considerable gca towards these traits and contributed towards additive genetic variance. Highly significant mean squares due to females x males were manifested by all the traits reflecting its significant contribution in favour of sca and non-additive variances.

An assessment of gca of females (σ^2 females) and gca of males (σ^2 males) for their contribution towards σ^2 gca (average gca) on the basis of pooled analysis revealed that for all the traits females contributed largely towards σ^2 gca except days to 50 per cent flowering and crude protein content, emphasizing the importance of additive and non-additive gene actions in inheritance of these traits. This was expected, since divergent material was included in the study. Same results were obtained by Sood and Kalia (2001). The additive and non-additive gene effects could be exploited in okra by the use of good general combiners in hybridization and selecting desirable segregants from segregating generations.

However, perusal of σ^2 gca/σ^2 sca ratio revealed preponderance of non-additive gene action for all the traits. As preponderance of non-additive gene action and high heterosis is apparent for fruit yield and majority of yield contributing traits, it is recommended that heterosis breeding could be used for exploitation of hybrid vigour on commercial scale. The importance of non-additive genetic variances for fruit yield per plant has been reported by several workers such as Sood and Kalia (2001), Dhankhar and Dhankhar (2001), Rajani *et al.* (2001), Borgaonkar *et al.* (2003), Prakash *et al.* (2002), Rajedra *et al.* (2005), Singh *et al.* (2006), Mehta *et al.* (2007), Jayprakashnarayan *at al.* (2008), Singh *et al.* (2009), Wammanda *et al.* (2010), Raghuvanshi *et al.* (2011), Khatik *et al.* (2012), Medagam *et al.* (2012), Obiadalla *et al.* (2013), Jethava (2014) and Katagi *at al.* (2015).

The success of breeding programme based on the results of combining ability depends on the extent of genetic parameters remaining stable over the environments. Perusal of variance components over the environments revealed that σ^2 females x environment and σ^2 males x environment were non-significant for all the traits indicated that the general combining ability of females and males were not influenced by environment and this was endorsed by non-significance of σ^2 gca x environments for all the traits. Moreover, it was also seen from the interaction of σ^2 sca with environment for all the traits that there was a no role of environment on sca effect as evident from non-significant estimates due to σ^2 sca x environments. Similar findings were reported by Wammanda *et al.* (2010) in okra. The sensitivity of both gca and sca variances for environmental variations indicated that evaluation of genotypes in multi-location and/or multi-season trials would be essential for estimating these variances with reliable precision.

The estimates of σ^2 sca were higher in magnitude than that of σ^2 gca for all the traits under all the individual environments and pooled over environments indicated preponderance of non-additive gene action in the expression of fruit yield and all the yield attributing traits. Similar findings were also reported by Singh *et al.* (2001), Sood (2001), Prakash *et al.* (2002), Dahake and Bangar (2006), Weerasekara *et al.* (2008), Balakrishnan *et al.* (2009), Wammanda *et al.* (2010) and Singh (2011). However, Pal and Hossain (2000), Bhalekar *et al.* (2006) and Singh *et al.* (2009) reported importance of both additive and non-additive gene action for expression of different traits in okra.

The importance of non-additive genetic variances for fruit yield per plant has been reported by several workers such as Sood and Kalia (2001), Dhankhar and Dhankhar (2001), Singh *et al.* (2006), Mehta *et al.* (2007) Javia *et al.* (2009), Khanpara *et al.* (2009), Wammanda *et al.* (2010), Singh (2011), Kumar and Pathania (2011), Aulakh *et al.* (2012), Medagam *et al.* (2012), Das *et al.* (2013), Atotkar *et al.* (2014) and Katagi *et al.* (2015).

Similar findings have been reported for days to 50 per cent flowering by Singh *et al.* (2006), Mehta *et al.* (2007), Singh *et al.* (2009), Wammanda *et al.* (2010), Kumar and Pathania (2011), Singh (2011), Aulakh *et al.* (2012), Medagam *et al.* (2012), Das *et al.* (2013), Atotkar *et al.* (2014) and Katagi *et al.* (2015).

Preponderance of non-additive gene action was reported for plant height and internodal length by several workers *viz.,* Sood and Kalia (2001), Dhankhar and Dhankhar (2001), Rajani *et al.* (2001), Borgaonkar *et al.* (2003), Singh *et al.* (2006), Mehta *et al.* (2007), Weerasekara *et al.* (2008b), Javia *et al.* (2009), Wammanda *et al.* (2010), Singh (2011), Medagam *et al.* (2012), Das *et al.* (2013) and Atotkar *et al.* (2014).

Above mentioned results in the regards to number of branches per plant and total number of fruits per plant corroborated with those of Dhankhar and Dhankhar (2001), Rajani *et al.* (2001), Singh *et al.* (2006), Weerasekara *et al.* (2008[b]), Srivastava *et al.* (2008), Khanpara *et al.* (2009), Wammanda *et al.* (2010), Singh (2011), Medagam *et al.* (2012), Das *et al.* (2013), Atotkar *et al.* (2014) and Katagi *et al.* (2015).

In case of days to first picking and days to last picking the role of non-additive genetic variances was prominent. Similar findings have been reported by Obi (2009), Jethava (2014) and Kumar (2014).

Preponderance of non-additive gene action for fruit traits like fruit length and fruit girth was substantiated by several workers *viz.*, Rajani *et al.* (2001), Singh *et al.* (2006), Mehta *et al.* (2007), Jaiprakashnarayan *et al.* (2008b), Javia *et al.* (2009), Wammanda *et al.* (2010), Kumar and Pathania (2011), Singh (2011), Medagam *et al.* (2012), Das *et al.* (2013), Atotkar *et al.* (2014) Katagi *et al.* (2015) and Tiwari (2015).

Various workers namely Mehta *et al.* (2007), Das *et al.* (2013), Jethava (2014) and Katagi *et al.* (2015) reported non additive gene action in seed related traits like total number of seeds per fruit in okra. Preponderance of non-additive gene action was reported for crude protein, crude fiber and vitamin 'C' content by Jethava (2014) and Kumar (2014).

It is clear from the above discussion that the high degree of non-additive gene action for all the component traits observed in the present study favours breeding methodology such as biparental mating, recurrent selection and diallel selective mating (Jensen, 1988) than conventional pedigree or backcross techniques which would leave the unfixable components of genetic variances unexploited for yield and its components.

From the present results, it was evident that the non-additive gene action had greater role in the expression of all the traits under study, hence, merely selection will result in no or slow genetic improvement. Successful breeding methods are those that accumulate the genes to form superior gene constellations interacting in a favorable manner. The importance of non-additive gene action for all yield components and quality traits in the present study indicates that heterosis breeding is the best possible option for improving these traits in okra. This is the common breeding strategy followed for the traits where non additive genetic effects had a great impact on their genetic variation (Das *et al.*, 2013). The disparities in interpretation between the present study and previous reports might be due to the differences in parental materials used and the environment under which the trail was conducted because estimates of gene effects change with environments and genotype.

5.4.2 Estimates of general and specific combining ability effects (Table 4.4.8 to Table 4.4.14)

Nature and magnitude of combining ability effects helps in identifying superior parents and their utilisation in further breeding programme. The parents classified as good, average and poor combiners based on estimates of general combining ability (gca) effects on pooled basis for various traits.

Based on the estimates of general combining ability effects on pooled basis, the parents were classified as good, average and poor combiners for fourteen traits. If the genotype is having significant gca effect in desirable direction than good general combiner for the trait. If non-significant gca effect than average combiner and significant gca effect in undesirable direction than poor general combiner. Nature and magnitude of combining ability effects provided guideline in identifying the better parents and their utilisation. The summary of the general combining ability effects of the parents revealed that none of the parent found to be good general combiners for all the characters. An overall appraisal of gca effects revealed that among the females, JDNOL-11-14 found to be good general combiners for 8 characters *viz.,* days to 50 per cent flowering, days to first picking, fruit length, number of branches per plant, fruit yield per plant, total number of fruits per plant and vitamin 'C.' AOL-08-5 was good general combiner for six characters *viz.*, AOL-08-5 for days to 50 per cent flowering, fruit length, fruit girth, number of branches per plant, fruit yield per plant and vitamin 'C' while JOL-08-7 for four characters *viz.*, fruit girth, number of branches per plant, fruit yield per plant and total number of fruits per plant (Table 5.2).

The female *viz.,* JOL-08-12 for fruit girth, number of branches per plant and fruit yield per plant, JDNOL-11-11 for plant height and vitamin 'C' and JDNOL-11-1 for days to 50 per cent flowering and vitamin 'C.'

The male parents *viz.*, VRO-6 for days to 50 per cent flowering, fruit length, fruit girth, number of branches per plant and total number of fruits per plant, Parbhani Kranti for days to 50 per cent flowering, fruit yield per plant, crude protein content and vitamin 'C' and Pusa Sawani

Table 5.2: GCA effects of the parents for different traits (on pooled basis)

Parents	Characters													
	DF	DFP	FL	FG	NBP	IL	PH	FYP	TNFP	TNSF	DLP	CPC	CFC	V-C
Females (Line)														
JDNOL-11-1	P	A	P	P	P	A	G	P	A	G	P	A	A	G
JDNOL-11-3	A	P	A	A	P	G	G	A	A	A	P	P	G	G
JDNOL-11-11	G	A	A	P	P	P	P	P	P	P	A	P	P	G
JDNOL-11-12	P	P	P	P	P	G	A	P	P	A	A	P	G	P
JDNOL-11-14	G	G	G	P	G	P	P	G	G	P	A	G	P	G
AOL-07-9	P	P	P	G	P	P	G	P	P	A	P	P	P	P
AOL-08-5	G	A	G	G	G	P	P	G	A	P	A	A	P	G
JOL-6k-2	P	P	P	P	P	P	G	P	P	A	P	P	A	P
JOL-08-7	A	A	A	G	G	P	P	G	G	P	A	A	A	P
JOL-08-12	A	A	P	G	G	P	P	G	P	P	A	P	P	A
Males (Tester)														
Arka Anamika	P	P	P	P	P	G	P	P	P	G	P	P	G	P
Pusa Sawani	A	A	A	P	G	P	P	P	P	A	G	P	A	G
Parbhani Kranti	G	A	A	A	A	P	P	G	A	P	A	G	P	G
GO-2	P	P	P	A	P	G	G	A	P	P	P	P	A	P
VRO-6	G	A	G	G	G	P	P	A	G	P	P	A	P	P

G Significant in desired direction
A Non significant
P Significant in undesired direction

DF : Days to 50 per cent flowering
DFP : Days to first picking
FL : Fruit length (cm)
FG : Fruit girth (cm)
NBP : Number of branches per plant
IL : Internodal length (cm)
PH : Plant height (cm)
FYP : Fruit yield per plant (g)
TNFP : Total number of fruits per plant
TNSF : Total number of seeds per fruit
DLP : Days to last picking
CPC : Crude protein content (%)
CFC : Crude fiber content (%)
V-C : Vitamin-C (mg/100g pulp)

for number of branches per plant, days to last picking and vitamin 'C' found to be good general combiner. The parent Arka Anamika was the good general combiners for three characters *viz.*, internodal length, total number of seeds per fruit and crude fiber content, while GO-2 was good general combiner for internodal length and plant height. The importance of gca particularly in crosses involving diverse germplasm was brought out by the studies of Singh *et al.* (2006), Mehta *et al.* (2007), Wammanda *et al.* (2011), Medagam *et al.* (2012), Das *et al.* (2013), Atotkar *et al.* (2014), Nagesh *et al.* (2014) and Katagi *et al.* (2015).

The estimates of gca effects further revealed that the parental lines showing high gca effects for fruit yield per plant also exhibited high to average gca effects for majority of its yield components (Table 5.2). It was also interesting to note that involvement of parents with good gca effects had resulted into hybrids expressing useful heterosis for various traits in majority of cases. Pal and Hossain (2000), Singh *et al.* (2001), Sood and Kalia (2001), Dhankhar and Dhankhar (2001), Rajani *et al.* (2001), Borgaonkar *et al.* (2003), Sushmita and Das (2003), Kumar *et al.* (2005), Singh *et al.* (2006), Dahake and Bangar (2006), Mehta *et al.* (2007), Khanpara *et al.* (2009), Singh *et al.* (2009), Wammanda *et al.* (2010) and Raghuvanshi *et al.* (2011), Kumar and Pathania (2011), Singh (2011), Aulakh *et al.* (2012), Medagam *et al.* (2012), Das *et al.* (2013), Nagesh *et al.* (2014), Atotkar *et al.* (2014) and Katagi *et al.* (2015) also reported similar results which supported the present findings.

Earliness and dwarf stature are desirable traits in okra. Negative gca effects are desirable for the traits like days to 50 per cent flowering, internodal length, plant height, days to first picking, total number of seeds per fruit and crude fiber content. Desirable gca effects among females for these particular traits were exhibited by AOL-08-5 followed by JDNOL-11-14 for days to 50 per cent flowering. For internodal length, it was recorded by JDNOL-11-12 and JDNOL-11-3, for plant height, JDNOL-11-1 recorded higher gca effect followed by AOL-07-9, For days to first picking, it was recorded by JDNOL-11-14 and JOL-08-7. In case of total number of seeds per fruit and crude fiber content, it was recorded by JDNOL-11-1, JDNOL-11-12 and JDNOL-11-3. Among male parents, VRO-6 recorded higher gca effects for days to fifty per cent flowering, while Arka Anamika and GO-2 for internodal length and plant height, respectively. In case of total number of seeds per fruit among testers, Arka Anamika was good general combiner.

After the overall picture of gca effects was accessed, it appeared that the female parent, JOL-08-12 and male parent, GO-2 found to be good general combiners for fruit yield, thereby classifying these parents as good sources of favourable genes for increasing production of fruits. Because a high gca effect is related to additive and additive x additive interactions and represents fixable components of genetic variances, hence these two parents can be used in breeding for high yield and better fruit quality. It is desirable to search out parental lines with high gca effects and low sensitivity to environmental variation in a crop improvement programme.

Parents with superior combining ability can be intensively used in the hybridization programme aimed at improvement of fruit yield. In order to synthesize dynamic population with most of the favourable genes accumulated, it will be relevant to make use of the aforesaid parents which were good general combiners for several traits, in a multiple crossing programme.

The crosses exhibiting desirable and significant sca effects and heterosis for fruit yield per plant was also associated with high and favourable sca effects for multiple yield contributing traits. The highest fruit yielding hybrid JOL-08-7 x Parbhani Kranti (Good x Good) had significant desirable sca effect, but non-significant standard heterosis as well for fruit yield and fruit girth followed by cross, JDNOL-11-3 x Arka Anamika. Corresponding to these findings, Das *et al.* (2013) reported that positive sca effects were visible in the hybrids involving both the parents possessing significant and positive gca effects. These good x good combinations could result in the capitalization of non-additive (dominance x dominance variance) effects over the super structure of the additive gene effects. Hybrids involving both the parents possessing significant and positive gca effects with higher significant sca effects for number of fruits per plant, fruit yield per plant and total fruit yield in okra have been earlier reported by Sivakumar *et al.* (1995), Sood and Kalia (2001), Dhankhar and Dhankhar (2001), Singh *et al.* (2006), Mehta *et al.* (2007), Weerasekara *et al.* (2008), Singh *et al.* (2009), Ramya *et al.* (2010[ab]), Kumar and Pathania (2011), Singh *et al.* (2011), Raghuvanshi *et al.* (2011), Wammanda *et al.* (2011), Singh (2011), Aulakh *et al.* (2012), Medagam *et al.* (2012), Nagesh *et al.* (2014), Das *et al.* (2013), Akotkar *et al.* (2014) and Katagi *et al.* (2015).

Looking to the Table 5.3, it was evident that the traits except number of branches per plant and fruit yield per plant involved the poor x poor, average x good and good x poor parental combination. Female parent AOL-07-9 and male parent VRO-6 was good general combiner for

Table 5.3: Summary of three best performing parents, best general combining parents and best performing hybrids along with their GCA effects and SCA effects and per cent standard heterosis for various traits on pooled basis

Character	Best performing parents		Best general combiner		Best performing hybrids	GCA effect	SCA effect	Standard heterosis
	Female	Male	Female	Male				
Days to 50 per cent flowering	AOL-07-9	VRO-6	AOL-08-5	Parbhani Kranti	JDNOL-11-1 x Parbhani Kranti	P X G	-3.15**	0.33
	JDNOL-11-3	Pusa Sawani	JDNOL-11-14	VRO-6	JDNOL-11-1 x Arka Anamika	P X P	-2.73**	0.18
	JDNOL-11-12	Parbhani Kranti	JDNOL-11-11	Pusa Sawani	JOL-6k-2 x GO-2	P X P	-1.76*	0.09**
Days to first picking	JDNOL-11-12	VRO-6	JDNOL-11-14	Pusa Sawani	JOL-08-7 x Parbhani Kranti	A X A	-2.16*	-4.30
	JDNOL-11-14	Pusa Sawani	JOL-08-7	Parbhani Kranti	JOL-08-12 x Arka Anamika	A X P	-1.96*	-3.41
	JOL-08-12	Parbhani Kranti	JDNOL-11-11	VRO-6	AOL-08-5 x VRO-6	A X A	-1.33	-7.06**
Fruit length (cm)	JDNOL-11-1	Pusa Sawani	JDNOL-11-14	VRO-6	JOL-08-7 x Parbhani Kranti	A X A	0.64**	0.57
	JDNOL-11-14	Parbhani Kranti	AOL-08-5	Parbhani Kranti	JDNOL-11-14 x Pusa Sawani	G X A	0.57**	-0.72
	JOL-08-7	VRO-6	JOL-08-7	Pusa Sawani	JDNOL-11-3 x Arka Anamika	A X P	0.51**	-2.03
Fruit girth (cm)	JDNOL-11-14	Parbhani Kranti	JOL-08-12	VRO-6	AOL-08-5 x GO-2	G X A	0.59**	-10.93**
	JOL-08-12	VRO-6	AOL-08-5	Parbhani Kranti	JOL-08-7 x Parbhani Kranti	G X A	0.55**	-9.37**
	AOL-07-9	Pusa Sawani	JOL-08-7	GO-2	JOL-08-12 x Arka Anamika	G X P	0.45**	17.09**
Number of branches per plant	JDNOL-11-14	Pusa Sawani	JOL-08-12	VRO-6	JOL-08-7 x Parbhani Kranti	G X A	0.35**	-9.26**
	AOL-07-9	Arka Anamika	JDNOL-11-14	Pusa Sawani	JDNOL-11-14 x Pusa Sawani	G X G	0.24**	-7.33*
	JDNOL-11-3	VRO-6	JOL-08-7	Parbhani Kranti	JOL-6k-2 x Parbhani Kranti	P X A	0.22**	-19.47**
Internodal length (cm)	JDNOL-11-11	Arka Anamika	JDNOL-11-12	Arka Anamika	JOL-08-7 x GO-2	P X G	-0.66**	-6.24
	AOL-08-5	GO-2	JDNOL-11-3	GO-2	JDNOL-11-14 x Parbhani Kranti	P X P	-0.58*	-2.06
	JOL-08-7	VRO-6	JOL-08-7	-	JDNOL-11-14 x Arka Anamika	P X G	-0.52*	-0.91
Plant height (cm)	JOL-6k-2	GO-2	JDNOL-11-1	GO-2	JOL-08-7 x Arka Anamika	P X P	-19.19**	-3.69
	AOL-08-5	Arka Anamika	AOL-07-9	-	JDNOL-11-11 x Pusa Sawani	P X P	-12.09**	-1.40
	JOL-08-7	VRO-6	JDNOL-11-3	-	AOL-08-5 x Pusa Sawani	P X P	-10.58**	-0.25
Fruit yield per plant (g)	AOL-07-9	VRO-6	JOL-08-7	Parbhani Kranti	JOL-08-7 x Parbhani Kranti	G X G	24.49**	3.93
	JDNOL-11-14	Parbhani Kranti	JOL-08-12	GO-2	JDNOL-11-3 x Arka Anamika	A X P	19.34**	-9.93**
	JDNOL-11-3	Pusa Sawani	AOL-08-5	VRO-6	JDNOL-11-1 x GO-2	P X A	18.08**	-16.36**
Total number of fruits per plant	AOL-07-9	Pusa Sawani	JDNOL-11-12	VRO-6	JDNOL-11-14 x Pusa Sawani	G X P	1.86**	-11.24**
	JDNOL-11-3	VRO-6	JOL-08-7	Parbhani Kranti	AOL-08-5 x GO-2	A X P	1.42**	-5.46
	JDNOL-11-14	Arka Anamika	AOL-08-5	-	JOL-08-7 x Parbhani Kranti	G X A	1.40**	4.38

Table 5.3 Continue…								
Character	**Best performing parents**		**Best general combiner**		**Best performing hybrids**	**GCA effect**	**SCA effect**	**Standard heterosis**
	Female	**Male**	**Female**	**Male**				
Total number of seed per fruit	JDNOL-11-11	GO-2	JDNOL-11-1	Arka Anamika	JOL-6k-2 x VRO-6	A X P	-3.28**	-4.50
	JOL-08-7	Arka Anamika	JDNOL-11-3	Pusa Sawani	JDNOL-11-12 x Arka Anamika	A X G	-2.15**	-9.29**
	AOL-08-5	VRO-6	AOL-07-9	-	JDNOL-11-3 x Pusa Sawani	A X A	-1.88*	-5.96*
Days to last picking	JDNOL-11-14	Parbhani Kranti	JOL-08-7	Pusa Sawani	AOL-07-9 x VRO-6	P X P	5.19**	-2.86
	JDNOL-11-3	VRO-6	JDNOL-11-11	Parbhani Kranti	JOL-08-7 x Parbhani Kranti	A X A	5.08**	-1.74
	AOL-07-9	Arka Anamika	AOL-08-5	-	AOL-08-5 x VRO-6	A X P	5.06**	-4.63*
Crude protein content (%)	JDNOL-11-3	Arka Anamika	JDNOL-11-14	Parbhani Kranti	JOL-08-7 x Parbhani Kranti	A X G	0.82*	-1.64
	JOL-08-12	Pusa Sawani	JOL-08-7	VRO-6	JDNOL-11-3 x Arka Anamika	P X P	0.81*	-4.44*
	JDNOL-11-14	Parbhani Kranti	AOL-08-5	-	AOL-08-5 x VRO-6	A X A	0.76*	-4.07*
Crude fiber content (%)	JDNOL-11-12	GO-2	JDNOL-11-12	Arka Anamika	JOL-08-12 x GO-2	P X A	-0.57**	-14.06**
	JDNOL-11-1	Arka Anamika	JDNOL-11-3	Pusa Sawani	JDNOL-11-14 x GO-2	P X A	-0.45**	-1.05
	JDNOL-11-11	Parbhani Kranti	JOL-6k-2	GO-2	JDNOL-11-14 x Parbhani Kranti	P X P	-0.34**	-5.96**
Vitamin 'C' (mg/100 g pulp)	JDNOL-11-3	Pusa Sawani	JOL-08-12	GO-2	JOL-08-12 x VRO-6	A X P	0.81**	-0.03
	JDNOL-11-14	VRO-6	-	-	JDNOL-11-1 x GO-2	G X P	0.66**	-2.20
	AOL-07-9	Parbhani Kranti	-	-	JDNOL-11-12 x GO-2	P X P	0.58**	-14.20**

*, ** Significant at 5 and 1 per cent probability levels, respectively; G = Good parent having significant GCA effect in desired direction; A = Average parent having either positive or negative, but non-significant GCA effects; P = Poor parent having significant GCA effects in undesired direction.

the traits followed by female parent JDNOL-11-14 and male parent Parbhani Kranti while, hybrids JOL-08-7 x Parbhani Kranti and JDNOL-11-3 x Arka Anamika recorded higher sca effects in desired direction for most of the traits.

In fact, in majority of the cases, the best specific combinations for different traits involved either good x poor or average x good general combiners. This suggested that information on gca effect should be supplemented by sca effect and performance of cross combination to predict the transgressive types possibly made available in segregating generations. Selection is rapid if gca effect of the parents and sca effect of crosses are in same direction. If the crosses showing high sca effect which involve at least one parent possessing good gca effect and high mean value they could be exploited for practical breeding.

Inclusion of poor x poor parental combination giving higher sca effects in desirable direction for various traits in okra have been brought out by many researchers. In case of earliness (days to 50 % flowering and plant height) same results were noticed by Sivakumar *et al.* (1995), Sood and Kalia (2001), Borgaonkar *et al.* (2003), Singh *et al.* (2006), Mehta *et al.* (2007), Singh *et al.* (2009) and Raghuvanshi *et al.* (2011).

A summarised account of the best performing parents, best general combiners, best performing hybrids and specific cross combinations (Table 5.3) revealed that for some of the traits, the best performing parents were also found to be best general combiners though their relative ranking were different. Further, the best general combiners may not always produce best specific cross combinations for all the traits. However, in few cases good x good combinations exhibited high sca effect. In this situation, it would be better to look for good transgressive segregants in advance generations to make their use in breeding programme.

The cross, JDNOL-11-14 x Pusa Sawani was exhibited good x good sca effect number of branches per plant. Hybrids which involved good, average and poor parents and exhibited higher sca effects for number of branches per plant was observed by Rajani *et al.* (2001), Dhankhar and Dhankhar (2001) and Weerasekara *et al.* (2008).

JOL-08-7 x Parbhani Kranti and AOL-08-5 x GO-2 were good specific combiners consisting two average or average and good parents. So far fruit traits (fruit length, fruit girth) are concerned, Sivakumar *et al.* (1995), Rajani *et al.* (2001), Sood and Kalia (2001), Borgaonkar *et al.*

(2003), Singh *et al.* (2006), Mehta *et al.* (2007), Weerasekara *et al.* (2008), Singh *et al.* (2009), Kumar and Pathania (2011), Singh (2011) obtained same results in okra.

For total number of seeds per fruits JOL-6k-2 x VRO-6 and JDNOL-11-12 x Arka Anamika were best specific combiner. Looking to total number of seeds per fruit, Mehta *et al.* (2007), Weerasekara *et al.* (2008), Jethava (2014) and Katagi *et al.* (2015) observed the same trend. JOL-08-7 x Parbhani Kranti and JOL-08-12 x Arka Anamika were best specific combiner obtained with involvement of (A x A) and (A x P) combiner in this study for days to first picking. It was in accordance with that of Sood and Kalia (2001) and Kumar and Pathania (2011). For fiber content, JDNOL-11-14 x Parbhani Kranti (P x P) exhibited higher sca effects with the involvement of poor x poor combiners which continues results obtained by Jethava (2014).

Appraisal of data (Table 5.3) revealed that for most of the traits hybrids exhibiting higher sca effects involved poor x poor parents. It was noted that parents with good x poor or poor x poor gca effects could produce transgressive segregants by the virtue of additive genetic system in case of good combiner and complementary epistatic effect present in case of poor combiner (Singh *et al.*, 2006).

Mean performance seems to be more appropriate for selecting the best cross combinations. Progress of improving the desired trait will be slow if parental selection is based on mean performance alone. For continuous improvement, selection of parents should be based on mean performance as well as combining ability and heterosis. The SCA effects represent dominance effects and can be related with heterosis. This may be due to the fact that per se performance is a realised value, whereas sca effect is an estimate measured as the deviation of F_1 over parental performance. Therefore, for a given hybrid performance sca effect may or may not be high depending upon the performance of parental lines. Selection of a particular cross combination on the basis of *per se* performance was more reliable than sca effect. The cross combination showing high sca effect involving both the parents with good gca effect, the same is likely to be exploited rather more profitably in a plant breeding programme.

5.5 Genotype x environment interaction and stability analysis

The breeders and geneticists continually strive to broaden the genetic base of crop species for wider adaptability of genotypes and also to prevent problems associated with narrow genetic base. With emphasis on broadening the genetic base and unpredictable weather parameters encountered at different sites and/or years, differential responses are expected of improved cultivars/hybrids in different environments. These differential genotypic responses to differential environments are collectively called genotype x environment (G x E) interactions. Breeding genotypes with wide adaptability has long been universal goal among the plant breeders. To achieve this goal, growing of breeding lines over time and space has become an integral part of any plant breeding programme. Despite such vigorous testing and subsequent selection, G x E interaction has been a major concern.

The occurrence of G x E interactions had created a major challenge in obtaining a complete understanding of genetic control of the variability. This has posed serious problems in interpreting evolutionary trends and hampered the rationalization of policy and procedure in breeding for improved performance in economically important crops. Phenotypic stability may be influenced by the allelic balance of genotypes which results in the ability of the genotypes to buffer against the environmental changes. Thus, in plant breeding programme, many potential genotypes are usually evaluated in different environments by conducting evaluation trials at different locations and over different years before selecting desirable genotypes. For quantitative traits such as yield, the relative performance of different genotypes often varies from one environment to another, *i.e.*, G x E interaction exists. Such statistical interactions results from changes in the relative ranking of the genotypes or change in the magnitude of differences between genotypes from one environment to another. Change in ranking makes it difficult for the plant breeders to decide which genotype to be selected. Progress from selection is also reduced due to effect of a large G x E interaction as shown by Comstock and Moll (1963).

Knowledge of the nature and relative magnitude of the various types of G x E interaction is important in making decisions concerning breeding methods, selection programme and testing procedures in crop plants (Baker, 1969). In order to minimize G x E interaction and to increase precisions in selections, stratifications of environments has been employed. However, even with this refinement of technique, the interaction of genotypes with environments within the same year remains very large (Allard and Bradshaw, 1964). Sprague *et al.* (1962) opined that the possibility of G x E interaction in the field experiment is questionable in spite of knowing the factors responsible for such interactions. The breeders have long been aware of the problems of differential response of genotypes when tested under different environments; however, they were unable to quantify the same and modified their methodology. This was largely due to problem of their inability to define and measure the adaptability and/or the complexities of environments.

Genotype x environment interaction is an important subject in quantitative genetics as related to plant breeding (Kang, 1994). Agricultural researchers have long been cognizant of the various implications of G x E interactions in breeding programmes (Allard and Bradshaw, 1964). If none of the genotype has superiority in all the situations, G x E interaction indicates the potential for genetic differentiation of populations under prolonged selection in different environments (Via, 1984).

Thus far, agricultural production has kept pace with the world's population growth mainly because of innovative ideas and efforts of agricultural researchers. The world's population is expected to be double in the next 40 to 50 years (Lee, 1995). The key to doubling agricultural production is increased efficiency in utilisation of resources and that includes a better understanding of G x E interaction and way to exploit it.

5.5.1 Analysis of variance for phenotypic stability (Table 4.5.1)

The statistical techniques to measure the G x E interaction developed by Finlay and Wilkinson (1963), Eberhart and Russell (1966) and Perkins and Jinks (1968) have been very useful in breeding programmes. Such techniques have been used to study phenotypic stability of different genotypes of okra by several workers Korla and Rastogi (1979), Babu *et al.* (1983), Ariyo (1987), Jindal *et al.* (2008), Jindal *et al.* (2009), Babariya *et al.* (2009) and Javia (2014).

In the present study, the approach suggested by Eberhart and Russell (1966) has been employed to understand the differential G x E interaction of parents and hybrids to access the stability of individual genotypes. The results revealed that mean square due to genotypes and environments were highly significant for all the traits except for days to first picking, crude fiber content and vitamin 'C' in environments, mean square when tested against pooled error as well as pooled deviation indicating significant differences among them. The mean squares due to G x E interactions were non-significant for all traits except plant height when tested against pooled deviations. The lack of significant G x E interaction mean squares for rest of the traits under study indicated that genotypes responded consistently over the environments for these traits. The G X E interaction components were non-significant for the majority of the traits which satisfied the requirements of stability analysis suggesting differential reaction of genotypes to varied environments. The significance of G x E interactions have also been reported by Ariyo (1990), Ariyo and Ayo-Vaughan (2000), Jindal *et al.* (2009), Babariya *et al.* (2009), Ramya and Senthilkumar (2010), Dabhi *et al.* (2010), Akotkar *et al.* (2011), Senthilkumar (2011), Kachhadia *et al.* (2011), Srivastava *et al.* (2011), Hamed and Hafiz (2012) and Javia (2014).

The mean squares due to environments (linear) were highly significant for all the traits when tested against pooled deviation except for crude fiber content and vitamin 'C.' However, the same was significant for all the traits when tested against pooled error. This indicated that variation among environments was linear and it signifies unit change in environmental index for each unit change in the environmental conditions.

The variance due to G x E were further partitioned in two components (i) G x E (linear) and (ii) G x E (non-linear) *i.e.,* pooled deviation. G x E (linear) was found to be non-significant for all the traits except fruit girth, plant height and total number of fruits per plant when tested against pooled error indicating differential performance of genotypes under diverse environments but with considerably varying norms, *i.e.*, the linear sensitivity of different genotypes is variable. The mean squares due to pooled deviations were significant for all the traits which suggested that performance of different genotypes not fluctuated significantly from their respective linear path of response to environments.

On comparing relative magnitude of G x E (linear) and pooled deviation from linearity (non-linear), it was found that the linear component was high for all the traits except days to 50 per cent flowering, fruit length, fruit yield per plant, total number of seeds per fruit, days to last picking and crude fiber content indicating that linear component contributed more towards the G x E interactions. These results were in general, concurring with those of Korla and Rastogi (1979), Babu *et al.* (1983), Ariyo (1987), Adetunji and Chheda (1989), Jindal *et al.* (2008), Jindal *et al.* (2009), Babariya *et al.* (2009), Senthilkumar (2011), Ezekiel *et al.* (2011) and Javia (2014).

5.5.2 Stability parameters (Table 4.5.3 to Table 4.5.9)

The stability is the consistency in performance of a variety over a wide range of environments (Singh and Chaudhary, 1985). Genotype may react to variable environments in such a way that its development is buffered against environmental variations and more or less similar phenotype is produced under varying environmental conditions. Thus, stability depends upon the relative insensitivity of a genotype to varied environments. Such conditions have been termed as "developmental stability" (Mather, 1943), "phenotypic stability" (Lewis, 1954), "developmental homeostasis" (Lerner, 1954) and "canalization" (Waddington, 1942). The genotype of an individual may create different phenotypes in different environments and such phenotype being better adapted to a particular situation. This type of situation has been regarded as individual adaptability and individual buffering (Allard and Bradshaw, 1964). The adaptive response of a population as a whole is known as population buffering. Levin and Kerster (1970) defined adaptive population as one, which contributes most off springs to the species gene pool of the following generation in relation to other population. Thus, both individual and population buffering can be measured in terms of genotype x environment interaction.

Eberhart and Russell (1966) defined a stable genotype as one, which produced high mean yield and depicted regression coefficient (b_i) around unity and deviations from regression (S^2d_i) near zero. Later on, Breese (1969), Samuel *et al.* (1970) and Paroda and Hayes (1971) suggested that linear regression (b_i) should be regarded as measure of response of a particular genotype, whereas, the deviation from regression (S^2d_i) as measure of stability.

Result of stability parameters of 66 genotypes revealed that none of the genotypes was stable for all the traits studied. Same results were reported by Patil (2013). Thus, any generalization regarding stability of genotypes for all the traits is too difficult since the genotype may not simultaneously exhibit uniform responsiveness and stability patterns for all these traits. Among 66 genotypes five crosses were found to be stable for fruit yield per plant owing to high mean, regression coefficient near unity and least deviation from regression (Table 5.4). Among them hybrids, JOL-08-7 x Parbhani Kranti (279.63 g) had high mean fruit yield per plant with regression coefficient near unity and non-significant deviation from regression. It also manifested average stability for days to fifty per cent flowering, days to first picking, number of branches per plant, total number of fruits per plant, days to last picking, crude protein content

Table 5.4: Stable hybrids identified on the basis of high means for fruit yield per plant and other characters over four and specific environments

Sr. No.	Hybrids	Fruit yield per plant (g)	Average stable	Favourable	Unfavourable
1.	JOL-08-7 x Parbhani Kranti	279.63	DFF, DFP, CPC, DLP, FYP, NBP, TNFP, V-C	-	-
2.	JOL-08-12 x VRO-6	267.40	DFP, CPC, DLP, NBP,	-	-
3.	JDNOL-11-3 x Parbhani Kranti	262.90	DFF, DFP, DLP, FG, FL, TNFP, V-C	-	-
4.	JDNOL-11-11 x VRO-6	261.60	DFF, DFP, CPC, DLP, FG, FL, FYP, V-C	-	-
5.	AOL-08-5 x Parbhani Kranti	260.10	DFF, CPC, FL, FYP, TNFP, V-C	DFP, TNSF	-

DFF : Days to fifty per cent flowering
DFP : Days to first picking
FL : Fruit length (cm)
FG : Fruit girth (cm)
NBP : Number of branches per plant
IL : Internodal length (cm)
PH : Plant height (cm)
FYP : Fruit yield per plant (g)
TNFP : Total number of fruits per plant
TNSF : Total number of seeds per fruit
DLP : Days to last picking
CPC : Crude protein content (%)
CFC : Crude fiber content (%)
V-C : Vitamin-C (mg/100g pulp)

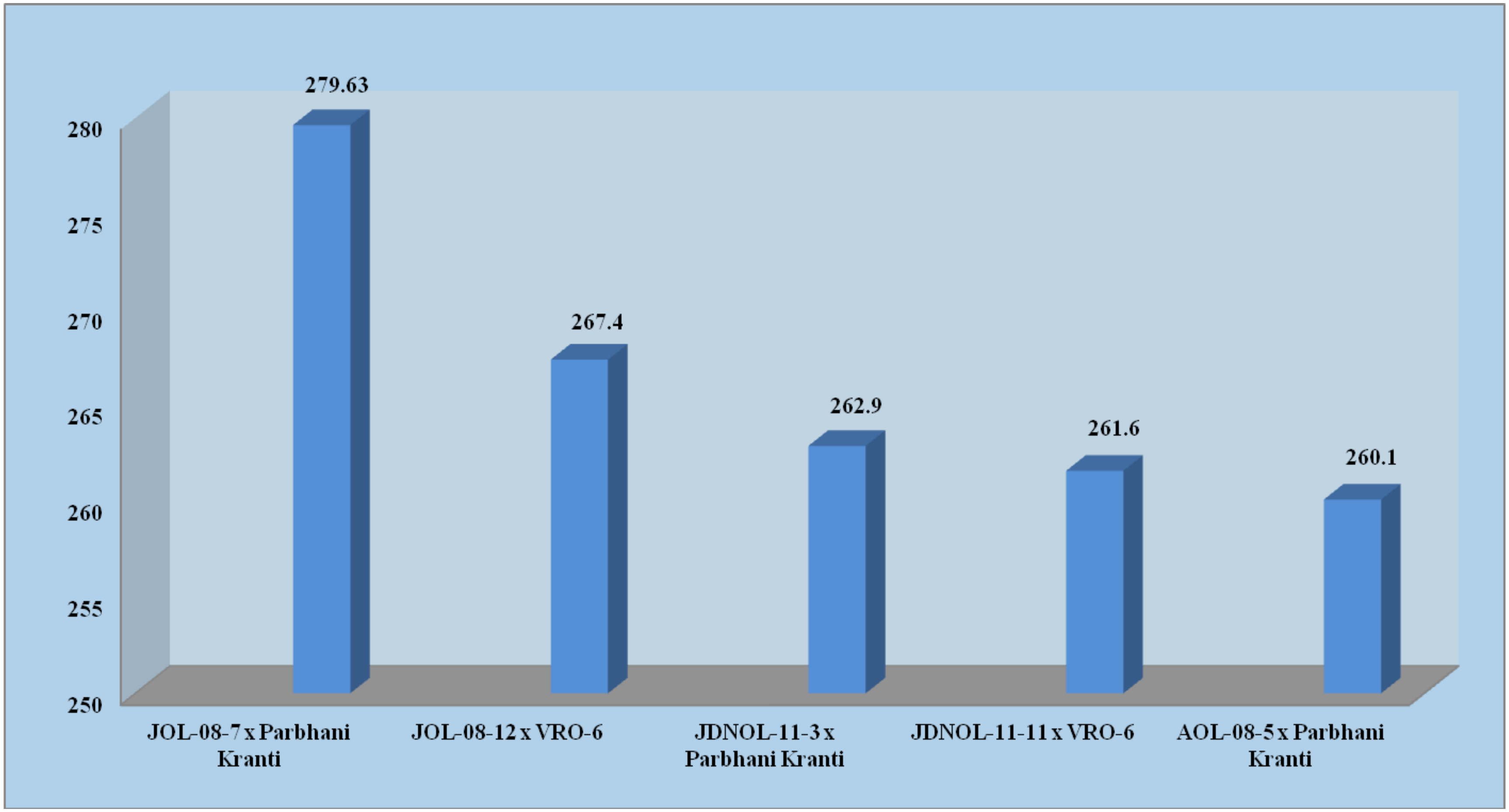

Fig. 2 : Top five stable hybrids with mean fruit yield (g) value of okra

Table 5.5: Character wise list of best three stable parents and hybrids for general and specific environments

Characters	Genotypes with general adaptability		Specific adaptability to favourable environment		Specific adaptability to unfavourable environment	
	Parents	Hybrids	Parents	Hybrids	Parents	Hybrids
Days to 50 % flowering	AOL-07-9 JDNOL-11-3 VRO-6	JDNOL-11-11 x VRO-6 AOL-08-5 x VRO-6 JDNOL-11-3 x Parbhani Kranti	AOL-08-5	AOL-08-5 x Pusa Sawani	-	-
Days to first picking	JDNOL-11-12 VRO-6 Pusa Sawani	JDNOL-11-11 x VRO-6 JOL-08-7 x Pusa Sawani JDNOL-11-14 x GO-2	-	JOL-08-12 x Parbhani Kranti JOL-08-7 x Arka Anamika JDNOL-11-3 x Parbhani Kranti	-	-
Fruit length (cm)	JOL-08-12 Pusa Sawani Parbhani Kranti	JDNOL-11-11 x VRO-6 JDNOL-11-3 x Parbhani Kranti JOL-08-12 x VRO-6	-	AOL-07-9 x Arka Anamika	-	-
Fruit girth (cm)	JOL-08-12 VRO-6	JOL-08-12 x VRO-6 JDNOL-11-11 x VRO-6 JDNOL-11-14 x GO-2	JDNOL-11-14	JDNOL-11-11 x Arka Anamika JDNOL-11-12 x Parbhani Kranti JDNOL-11-12 x Pusa Sawani	-	JDNOL-11-1 x VRO-6
Number of branches per plant	JDNOL-11-14 AOL-07-9 Pusa Sawani	JDNOL-11-11 x VRO-6 JOL-08-12 x Pusa Sawani JOL-08-7 x Parbhani Kranti	-	JDNOL-11-14 x GO-2 JOL-6k-2 x VRO-6 JDNOL-11-1 x GO-2	Parbhani Kranti	-
Internodal length (cm)	JDNOL-11-11 AOL-08-5 Arka Anamika	JDNOL-11-3 x GO-2 JDNOL-11-12 x Arka Anamika JDNOL-11-1 x Parbhani Kranti	-	JDNOL-11-12 x VRO-6	JDNOL-11-12	JOL-6k-2 x Arka Anamika
Plant height (cm)	-	JDNOL-11-3 x GO-2 JOL-6k-2 x VRO-6 AOL-08-5 x VRO-6	JDNOL-11-11 JOL-08-12	-	Parbhani Kranti	JDNOL-11-3 x Pusa Sawani AOL-07-9 x Pusa Sawani JDNOL-11-12 x Arka Anamika
Fruit yield per plant (g)	AOL-07-9 JDNOL-11-14 Parbhani Kranti	JOL-08-7 x Parbhani Kranti JOL-08-12 x VRO-6 JDNOL-11-3 x Parbhani Kranti	JOL-6k-2	AOL-08-5 x GO-2 JOL-08-7 x GO-2	-	JDNOL-11-14 x Arka Anamika

Table 5.5 Continue…

Table 5.5 Continue…

Characters	Genotypes with general adaptability		Specific adaptability to favourable environment		Specific adaptability to unfavourable environment	
	Parents	Hybrids	Parents	Hybrids	Parents	Hybrids
Total number of fruits per plant	AOL-07-9 Pusa Sawani	JDNOL-11-3 x Parbhani Kranti JDNOL-11-11 x VRO-6 AOL-08-5 x Pusa Sawani	JOL-6k-2	JDNOL-11-11 x Arka Anamika	-	JOL-08-7 x VRO-6
Total number of seed per fruit	JDNOL-11-11 AOL-08-5 GO-2	JOL-08-12 x GO-2 AOL-07-9 x Pusa Sawani JDNOL-11-12 x Arka Anamika	-	JDNOL-11-3 x Parbhani Kranti	JOL-08-7	JOL-6k-2 x GO-2
Days to last picking	JDNOL-11-14 JDNOL-11-3 Parbhani Kranti	JOL-08-12 x Parbhani Kranti JDNOL-11-11 x VRO-6 JOL-08-12 x VRO-6	-	JDNOL-11-12 x GO-2 AOL-07-9 x Arka Anamika	-	-
Crude protein content (%)	JOL-08-12 VRO-6 Arka Anamika	JDNOL-11-14 x GO-2 JOL-08-7 x GO-2 JDNOL-11-11 x VRO-6	-	-	-	JDNOL-11-14 x Arka Anamika
Crude fiber content (%)	JDNOL-11-1 JDNOL-11-11 GO-2	JDNOL-11-3 x Arka Anamika JOL-08-12 x Arka Anamika JOL-08-12 x GO-2	-	-	JOL-08-7	-
Vitamin 'C' (mg/100 g pulp)	Pusa Sawani Parbhani Kranti AOL-07-9	JDNOL-11-3 x Parbhani Kranti JOL-08-12 x VRO-6 AOL-08-5 x Pusa Sawani	-	-	-	AOL-08-5 x VRO-6

and vitamin 'C,' followed by cross JOL-08-12 x Pusa Sawani (271.41 g), which manifested average stability for days to first picking, number of branches per plant, days to last picking and crude protein content.

In general, the hybrid which found stable for fruit yield also depicted stability in respect of its one or more yield component (Table 5.4). This indicated that the stability of various component traits might be responsible for observed stability of hybrids for fruit yield. The chance for selection of stable genotypes could be strengthened by selection in favour of stability in some yield component. Grafius (1956) also suggested that the stability of fruit yield might be due to the stability of various yield components.

The mean yield of each genotype depends on the particular set of environmental conditions. It is therefore, suggested that in order to identify stable genotype, actual testing over a wide range of environments including poor and good ones would be advantageous while making selection and attention should be paid to the phenotypic stability of traits directly related to fruit yield, particularly number of fruits per plant, plant height, days to last picking and internodal length so as to achieve maximum stability for the end product *i.e.*, fruit yield in okra.

The best stable hybrids for fruit yield per plant were JOL-08-7 x Parbhani Kranti, JOL-08-12 x Pusa Sawani and JDNOL-11-14 x Parbhani Kranti. These hybrids exhibited positive significant relative heterosis and heterobeltiosis. JOL-08-12 x VRO-6, JDNOL-11-3 x Parbhani Kranti were stable for fruit girth and crude fiber content, whereas JOL-08-7 x Pusa Sawani was stable for days to first picking, fruit girth, total number of fruits per plant and crude fiber content. Phenotypic stability of various component traits reflecting into fruit yield stability were also reported by various workers *viz.,* Nimbalkar *et al.* (2005), Jindal *et al.* (2008), Babariya *et al.* (2009), Kachhadia *et al.* (2011), Akotkar *et al.* (2011), Srivastava *et al.* (2011) and Javia (2014) in okra.

The yield is a polygenic complex character and is an effect of the joint action of a large number of component traits. Therefore, a proper understanding of relationship between yield and component traits could be of great help in choosing the proper components that may contribute effectively towards higher manifestation of complex characters with concomitant stability of performance, high heterosis and desirable sca effects. The identification of parents having high mean good gca effects and high stability under favourable environments is of great value to a plant breeder in executing breeding programme.

5.6 Implications in okra breeding

The extent of possible improvement in yield is usually get through screening and selecting out the best adapted genotypes from the source population and utilising them directly or through hybridisation to generate high-yielding variety or hybrid. On the basis of the results obtained in the present study, it is apparent that the following points should be kept in mind before undertaking okra breeding programme.

[1] The magnitude of heterosis for fruit yield components suggested the use of heterosis on commercial scale. The superiority of JOL-08-7 x Parbhani Kranti in yield and most of the other traits is indicating that there might be possibility of exploiting the heterosis commercially after testing on large scale.

[2] For hybrid breeding programme, selection of parental line is very important. From the *per se* performance, yield of parental lines indicated that high performing lines generally performed better in cross combinations.

[3] The data revealed that both gca and sca variances were found important in inheritance of all the traits. The predominance of sca variance suggested that there is a considerable scope for further improvement through hybrid breeding programme.

Among the parents, JOL-08-7, JOL-08-12, AOL-08-5, Parbhani Kranti, GO-2 and VRO-6 were good general combiners for fruit yield and most of the yield contributing traits. The crosses with high sca effects for fruit yield and its components involved good x good, good x average, good x poor, average x average, average x poor and poor x poor general combiners. This reflected the role of both additive and non-additive gene actions in the genetic control of these traits. The presence of additive gene action would enhance the chance for making improvement through simple selection. For exploitation of non-additive effects, it appears worthwhile to intermate the selected progenies in early segregating generations, which would be resulted in the accumulation of favourable genes for the traits. Hence, biparental progeny selection may be useful to get some desirable transgressive segregants from such crosses.

SUMMARY AND CONCLUSION

V. SUMMARY AND CONCLUSION

The present investigation entitled, "Heterosis, combining ability and stability analysis in okra [*Abelmoschus esculentus* (L.) Moench]" was undertaken using Line x Tester method of crossing to estimate the extents of magnitude of heterosis, combining ability effects and its interactions over environments and stability performance over different environments for quantitative and qualitative traits. Experimental material comprised of 15 parents [10 females (lines) and 5 males (testers)], their fifty hybrids and one standard check were planted in randomized block design (RBD) with three replications over the environments *viz.*, Timely summer-2014 (E_1), Late summer-2014, (E_2) Timely *kharif*-2014 (E_3) and Late *kharif*-2014 (E_4) at Seed Spices Research Center, Sardarkrushinagar Dantiwada Agricultural University, Jagudan (District : Mehsana). The observations for fourteen traits *viz.*, days to fifty per cent flowering, days to first picking, fruit length (cm), fruit girth (cm), number of branches per plant, internodal length (cm), plant height (cm), fruit yield per plant (g), total number of fruits per plant, total number of seeds per fruit, days to last picking, crude protein content (%), crude fiber content (%) and vitamin 'C' (mg/100 g pulp) were recorded for each season on randomly selected five competitive individual plants. The salient findings are summarised here as under:

Analysis of variances in individual and over environments:

[1] Considerable genetic differences were observed among genotypes including parents and crosses for most of the characters in individual environments as well as pooled over environments.

[2] Mean sum of squares due to parents vs. hybrids over individual environment were significant for all traits, days to fifty per cent flowering (E_1, E_2, E_3 and E_4), fruit girth (E_1 and E_4), number of branches per plant (E_1), internodal length (E_1 and E_2), plant height (E_1, E_2, E_3 and E_4), total number of fruits per plant (E_2 and E_3) total number of seeds per fruit (E_1, E_3 and E_4), days to last picking (E_1 and E_4), crude protein content (E_1, E_3 and E_4), crude fiber content (E_1) and vitamin 'C' (E_1, E_3 and E_4). The pooled comparison of parents vs. hybrids over environments was significant for days to fifty per cent flowering, number of branches per plant, days to last picking and crude protein content indicating inconsistent differences between the average performance of parents and hybrids for these traits over varying environments.

[3] The analysis of variance over pooled environments indicated significant differences among genotypes, parents and hybrids for all the characters except days to first picking in parents. This indicated that genotypes, parents and hybrids interacted differently in different environments for the said traits. This evinced the importance of genotype x environment interaction in enhancing the efficiency of crop improvement endeavors in okra as the performance of genotypes, parents and hybrids were inconsistent in varying environment for the traits. Environment x Parents vs. Hybrids interaction was significant except days to fifty per cent flowering, days to first picking, fruit length, total number of fruits per plant, total number of seeds per fruits, crude protein content and crude fiber content. This suggested the presence of varying magnitude of heterosis for these traits over environments.

[4] Across the environments, on the basis of mean value of hybrid, JOL-08-7 x Parbhani Kranti was the most outstanding for fruit yield per plant followed by JDNOL-11-3 x Arka Anamika and JDNOL-11-1 x GO-2 whereas among the parents AOL-07-9 and JDNOL-11-14 recorded highest *per se* performance for fruit yield per plant followed by VRO-6 and Parbhani Kranti.

[5] Considerable degree of heterosis was evident of mid parent, better parents and standard check for fruit yield per plant. Over all range of relative heterosis was -19.64 per cent (E_4) to 46.90 per cent (E_2). The estimates of heterobeltiosis varied from -25.90 per cent (E_3) 32.74 per cent (E_3) and the standard heterosis varied from -27.20 per cent (E_2) to 10.21 per cent (E_3) for fruit yield.

[6] The maximum value of relative heterosis for fruit yield per plant was observed for JOL-6k-2 x GO-2, JOL-08-7 x Parbhani Kranti, JOL-6k-2 x Parbhani Kranti and JOL-08-7 x GO-2. The high heterotic response in these hybrids for fruit yield per plant resulted mainly due to substantial heterosis for days to fifty per cent flowering, number of branches per plant, number of fruits per plant, fruit length and fruit girth.

[7] None of hybrid exhibited significant and positive heterosis over standard check across the environment and in individual environment for fruit yield per plant. These indicating that none of hybrids offer best possibilities of further exploitation for development of high yielding varieties over standard check.

[8] The analysis of variance for combining ability over pooled environments revealed that the magnitude of various environment were significant for all the characters studied. The mean squares due to females were highly significant for all the character, except days to fifty per cent flowering, days to first picking, fruit length, fruit girth, plant height, total number of fruits per plant, total number of seeds per fruit, days to last picking and crude protein content. Whereas, mean squares due to males was non-significant for all the characters, except days to fifty per cent flowering and crude protein content.

[9] The mean squares due to females with environment was significant for days to fifty per cent flowering, days to last picking, fruit length, fruit girth, number of branches per plant, plant height fruit yield per plant, total number of fruits per plant, total number of seeds per fruit, days to last picking and crude fiber, whereas males with environments were found significant for fruit length. These indicated the role of environment in the contribution to gca variances for females. The significant mean squares due to (females x males) x environments for all the characters except crude protein content indicated the estimates of sca variance were influenced by the environments.

[10] Mean squares due to GCA variance, SCA variance, GCA x environments and SCA x environments were non-significant for all the characters. The variance ratio of σ^2gca/ σ^2sca was lesser than unity in all the characters suggested greater role of non-additive gene action in the inheritance of these traits. Further, the relative estimates of variances and their ratios indicated the preponderance of additive gene action for fruit length and days to last picking in E_1 environment.

[11] The estimation of general combining affects enabled the identification of desirable parents. None of the parents was good general combiner for all the traits under study. Among female parents, AOL-08-5, JDNOL-11-12 and JOL-08-7 and male parents VRO-6 and Parbhani Kranti were classified as good general combiners for fruit yield per plant and related traits.

[12] An overall appraisal of gca effects revealed that among the females, JDNOL-11-14 was found to be good general combiners for eight characters *viz.*, days to fifty per cent flowering, days to first picking, fruit length, number of branches per plant, fruit yield per plant, total number of fruits per plant and vitamin 'C.' Followed by AOL-08-5 for six characters and JOL-08-7 for four characters *viz.*, AOL-08-5 for days to fifty per cent flowering, fruit length, fruit girth, number of branches per plant, fruit yield per plant and vitamin 'C' and JOL-08-7 for fruit girth, number of branches per plant, fruit yield per plant and total number of fruits per plant.

[13] Among the male parents VRO-6 found good general combiner for five characters *viz.*, days to fifty per cent flowering, fruit length, fruit girth, number of branches per plant and total number of fruits per plant, Parbhani Kranti for four characters *viz.*, days to fifty per cent flowering, fruit yield per plant, crude protein content and vitamin 'C' and Pusa Sawani for three characters *viz.*, number of branches per plant, days to last picking and vitamin 'C,' whereas, Arka Anamika and GO-2 were the good general combiners for three and two characters, respectively *viz.*, Arka Anamika for internodal length, total number of seeds per fruit and crude fiber content, while GO-2 for internodal length and plant height.

[14] The estimates of sca effects revealed that none of the hybrids was superior for all the characters. The hybrids, JOL-08-7 x Parbhani Kranti, JOL-08-12 x Pusa Sawani, JDNOL-11-14 x Parbhani Kranti, JOL-08-12 x VRO-6 and JDNOL-11-3 x Parbhani Kranti having high sca effects for fruit yield per plant also registered high and desirable sca effects for most of the yield attributing traits like, fruit girth, total number of fruits per plant.

[15] Parents exhibiting high mean performance also evinced good general combining ability effects for most of the characters. This showed consonance between *per se* performance and gca effects of parents that could be used as reliable and efficient selection criterion for good combiners for different characters on the basis of *per se* performance of parents.

[16] The mean squares due to genotypes were highly significant for all the traits except days to first picking indicating enormous genetic variation among the genotypes. Similarly, mean square due to environments was highly significant for all the characters except crude fiber content and vitamin 'C. This indicated significantly sufficient variation among genotypes and environment. The environment (linear) component was significant for all the characters except crude fiber content and vitamin 'C' indicated sufficient environmental differences at four environments. The mean squares due to G x E (linear) was significant for fruit girth, plant height and total number of fruits per plant. This suggested that linear components play important role in building up total G x E interaction for these trait. The mean squares due to pooled deviation were significant for characters, but its magnitude was lesser than linear component, only in case of days to fifty per cent flowering, fruit girth, days to last picking and crude fiber content. For the remaining traits, linear component was greater, thereby suggested that the prediction of performance of genotypes over environments based on regression analysis could be reliable with respect to these characters.

[17] The female parents AOL-07-9, JDNOL-11-14, whereas male parent VRO-6 and Parbhani Kranti were average stable with desirable gca effect for fruit yield per plant and its attributes. Out of fifty crosses, only three crosses were found most stable for fruit yield per plant across the environments, *i.e.*, JOL-08-7 x Parbhani Kranti, JOL-08-12 x VRO-6 and JDNOL-11-3 x Parbhani Kranti. Whereas, the crosses JDNOL-11-11 x VRO-6, AOL-08-5 x VRO-6 and JDNOL-11-3 x Parbhani Kranti were stable for days to 50 per cent flowering, three crosses *viz.*, JDNOL-11-11 x VRO-6, JOL-08-7 x Pusa Sawani and JDNOL-11-14 x GO-2 were stable for days to first picking. The crosses JDNOL-11-11 x VRO-6, JDNOL-11-3 x Parbhani Kranti and JOL-08-12 x VRO-6 were found to be stable for fruit length. While JOL-08-12 x VRO-6 and JDNOL-11-11 x VRO-6 were stable for fruit girth. The crosses, JDNOL-11-3 x Parbhani Kranti, JDNOL-11-11 x VRO-6 and AOL-08-5 x Pusa Sawani were stable for total number of fruits per plant, whereas, JOL-08-12 x Parbhani Kranti, JDNOL-11-11 x VRO-6 and JOL-08-12 x VRO-6 found to be stable for days to last picking. JDNOL-11-14 x GO-2 and JDNOL-11-3 x Parbhani Kranti were found stable for crude protein content and vitamin 'C,' respectively. The crosses *viz.*, JDNOL-11-3 x Arka Anamika, JOL-08-12 x Arka Anamika and JOL-08-12 x GO-2 were stable for crude fiber content.

[18] As both additive and non-additive components were evident for most of the characters studied, breeding procedures that exploit both components would be more appropriate. As such methods like biparental mating, reciprocal recurrent selection or for that matter diallel selective mating design could be used to fix desired genes and also to get desirable lines from the population.

REFERENCES

REFERENCES

Adetunji, I.A. and Chedda, H.R. (1989). Seed yield stability of okra as influenced by planting date. *Plant Breeding*. **103** (3): 212-215.

Adiger, S.; Shanthakumar, G. and Salimath, P.M. (2013). Selection of parents based on combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Karnataka Journal Agriculture Science*. **26** (1): 6-9.

Ahlawat, T.R. (2004). Line x tester analysis for combining ability, heterosis and gene action in okra [*Abelmoschus esculentus* (L.) Moench]. Ph.D., Thesis, Submitted to Anand Agricultural University, Anand.

Ahmed, N.; Hakim, M.A. and Gandroo, M.Y. (1999). Exploitation of hybrid vigour in okra. *Indian Journal Horticulture*. **56** (3): 247-251.

Akotkar, P.K.; De, D.K. and Dubey, U. (2014). Genetic studies on fruit yield and yield attributes of okra [*Abelmoschus esculentus* (L.) Moench]. *Electronic Journal Plant Breeding*. **5** (1): 38-44.

Akotkar, P.K.; De, D.K. and Ghoshdastidar, K.K. (2011). Stability analysis for fruit yield and component characters in okra [*Abelmoschus esculentus* (L.) Moench]. *In : National Seminar on Contemporary Approaches to Crop Improvement. Abstract.* **62** : 196.

Allard, R.W. and Bradshaw, A.D. (1964). Implications of genotype environmental interactions in applied plant breeding. *Crop Science.* **4**: 503-508.

Amutha, R.; Venkatesan, M.; Senthil, K.N. and Thangavel, P. (2007). Hybrid vigour and inbreeding depression in bhindi [*Abelmoschus esculentus* (L.) Moench]. *Agriculture Science Digest.* **27** (2): 131-133.

Anonymous (2011). Series of Crop Specific Biology Documents, Biology of *Abelmoschus esculentus* L. (Okra). Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. pp. 3-4.

Anonymous (2015). National Horticulture Database. www.nhb.gov.in

Ariyo, O.J. (1987). Stability of performance of okra as influenced by planting date. *Theoretical and Applied Genetics.* **74** (1): 83-86.

Ariyo, O.J. (1990). Effectiveness and relative discriminatory abilities of techniques measuring genotype x environment interaction and stability in okra [*Abelmoschus esculentus* (L.) Moench]. *Euphytica*. **47** (2): 99-105.

Ariyo, O.J. and Vaughan, A. (2000). Analysis of genotype x environment interaction of okra. *Journal of Genetics and Breeding*. **54** (1): 35-40.

Aulakh, P.S.; Dhall, R.K. and Singh, J. (2012). Genetics of early and total yield in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Science*. **39** (2): 165-168.

Babariya, H.M.; Dhaduk, L.K.; Mehta, D.R.; Patel, N.B. and Poshiya, V.K. (2009). Stability analysis for fruit yield and its attributing characters in okra [*Abelmoschus esculentus* (L.) Moench]. *Gujarat Agricultural Universities Research Journal*. **34** (1): 20-28.

Babel, Y.S. and Yadav, S. (1971). All about okra or bhindi for commercial grower. *Farmer and Parliament*. **6** (6): 11-12.

Babu, K.V.S.; Gopalkrishnan, P.K. and Peter, K.V. (1983). Phenotypic stability in okra. *Indian Journal of Agriculture Science*. **53** (4): 261-264.

Badiger, M.; Pitchaimuthu, M.; Parvati, B. and Sachin, U. (2014). Heterosis studies in conventional and genetic male sterility based hybrids in okra (*Abelmoschus esculentus*). *Green Farming International Journal*. **5** (4): 524-528.

Baker, R.S. (1969). Genotype x environment interactions in yield of wheat. *Canadian Journal of Plant Science*. **49**: 743-751.

Bhalekar, M.N.; Patil, B.T.; Patil, S.G. and Shinde, K.G. (2014). Combining ability studies in okra (*Abelmoschus esculentus* L.). Abstracts of National Symposium on *Precision Horticulture for Small and Marginal Farmers* held from 24th to 27th June, 2014 at Indira Gandhi Krishi Vishwavidyalaya, Raipur. pp. 8-9.

Bhalekar, S.G.; Desai, U.T. and Nimbalkar, C.A. (2004). Heterosis studies in okra. *Journal of Maharashtra Agriculture University*. **29** (3): 360-362.

Borgaonkar, S.B.; Vaddoria, M.A.; Dhaduk, H.L. and Poshiya, V.K. (2005). Heterosis in okra [*Abelmoschus esculentus* (L.) Moench]. *Agriculture Science Digest*. **25** (4): 251-253.

Breese, E.L. (1969). The measurement and significance of genotype environment interactions in grasses. *Heredity*. **24**: 27-44.

Chaubey, P.K.; Pandey, D.D.; Singh, B.; Chaubey, T.; Jha, A. and Upadhyay, D. K. (2014). Exploitation of heterosis in Okra (*Abelmoschus esculentus* L. Moench). Abstracts of National Symposium on *Precision Horticulture for Small and Marginal Farmers* held from 24th to 27th June, 2014 at Indira Gandhi Krishi Vishwavidyalaya, Raipur. pp. 72.

Chauhan, S. and Singh, Y. (2002). Heterosis studies in okra. *Vegetable Science.* **29** (2): 116-118.

Cockerham, C.C. (1961). Implication of genetic variances in a hybrid breeding programme. *Crop Science.* **1**: 47-52.

Comstock, R.E. and Moll, R.H. (1963). Genotype-environment interactions. In: "Statistical Genetics and Plant Breeding" (Hanson, W.D. and Robinson, H.F. Eds.), *NAS-NRC Publication 982*. Washington, D.C. pp. 164-197.

Dabhi, K.H.; Vachhani, J.H.; Poshiya, V.K.; Jivani, L.L. and Chitaroda, J.D. (2010). Stability analysis in okra [*Abelmoschus esculentus* (L.) Moench]. *Research on Crops.* **11** (2): 391-396.

Dabhi, K.H.; Vachhani, J.H.; Poshiya, V.K.; Jivani, L.L.; Vekariya, D.H. and Shekhati, H.G. (2009). Heterosis for fruit yield and its components over environments in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Agricultural Sciences.* **5** (2): 572-576.

Dabhi, K.H.; Vachhani, J.H.; Poshiya, V.K.; Jivani, L.L. and Kachhadia, V.H. (2010a). Combining ability for fruit yield and its components over environments in okra [*Abelmoschus esculentus* (L.) Moench]. *Research on Crops.* **11 (**2): 383-390.

Dahake, K.D. and Bangar, N.D. (2006). Combining ability analysis in okra. *Journal Maharashtra Agriculture University*. **31** (1): 39-41.

Dahake, K.D.; Bangar, N.D.; Lad, D.B. and Patil, H.E. (2007). Heterosis studies for fruit yield and its contributing characteristics in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Science.* Muzaffarnagar. **2** (2): 137-140.

Das, S.; Chattopadhyay, A.; Dutta, S.; Chattopadhyay, S. and Hazra, P. (2013). Breeding okra for higher productivity and yellow vein mosaic tolerance. *International Journal of Vegetable Science*. **19**: 58-77.

Datta, P.C. and Naug, A. (1968). A few strains of *Abelmoschus esculentus* (L.) Moench their karyological in relation to phylogeny and organ development. *Beitrage zur Biologie der Pflanzen.* **45**: 113-126.

Desai, D.T. (1990). Genetic analysis of some quantitative characters in okra [*Abelmoschus esculentus* (L.) Moench]. Ph.D. Thesis (Unpublished), M.P.K.V., Rahuri.

Desai, S.S.; Bendale, V.W.; Bhave, S.G. and Jadhav, B.B. (2007). Heterosis for yield and yield components in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal Maharashtra Agriculture University*. **32** (1): 41-44.

Dhankhar, B.S. and Dhankhar, S.K. (2001). Heterosis and combining ability studies for some economic characters in okra. *Haryana Journal of Horticulture Science*. **30** (3-4): 230-233.

Dudley, J.W. and Moll, R.H. (1969). Interaction and use of estimate of heritability and genetic advance in plant breeding. *Crop Science*. **9**: 257-262.

Eberhart, S.A. and Russell, W.A. (1966). Stability parameters for comparing varieties. *Crop Science*. **6**: 26-40.

Ezekiel, S.A.; Ariyo, O.J. and Kehinde, O.B. (2011). Stability assessment of some West African okra (*Abelmoschus caillei*) genotypes in Nigerian Gene Bank. *Journal of Life Sciences*. **5**: 906-912.

Finlay, K.W. and Wilkinson, G.N. (1963). Analysis of adaptation in plant breeding programme. *Australian Journal of Agricultural Research*. **14**: 742-754.

Fisher, R.A. and MacKenzie, W.A. (1923). Studies in crop variation II. The manorial response of different potato varieties. *Journal of Agriculture Sciences*. **13**: 311-320.

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

Giriraj, K. and Swamy, R.T. (1973). Note on simple crossing technique in okra. *Indian Journal of Agricultural Sciences*. **43**: 1089.

Gondane, S.U. and Lai, G. (1993). Study of genotype x environment interaction in okra [*Abelmoschus esculentus* (L.) Moench]. *Annuls of Plant Physiology*. **7** (2): 242-246.

Gopalan, C.; Rama Sastri, B.V. and Balasubramanian, S. (2007). Nutritive Value of Indian Foods. *National Institute of Nutrition* (NIN), ICMR.

Grafius, J.E. (1956). Components of yield in oats, a geometrical interpretation. *Agronomy Journal*. **51**: 515-554.

Hamed, H.H. and Hafiz, M.R. (2012). Selection of local okra (*Abelmoschus esculentus* L.) genotypes for stability under saline conditions. *Bulletin of Faculty of Agriculture, Cairo University*. **63** (2): 188-200.

Hosamani, R.M.; Ajjapalavara, P.S.; Basavarajeshwari C.; Smith, R.P. and Ukkand, K.C. (2008). Heterosis for yield and yield components in okra. *Karnataka Journal of Agricultural Sciences*. **21** (3): 473-475.

Jackson, M.L. (1957). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India. pp. 327-350.

Jagan, K.; Reddy, K.R.; Sujatha, M.; Reddy, S.M. and Sravanthi, V. (2013[a]). Combining Ability Studies In Okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Innovative Research and Development*. **2** (8): 314-325.

Jagan, K.; Reddy, K.R.; Sujatha, M.; Sravanthi, V. and Reddy, M.S. (2013). Heterosis for yield and yield components in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Pharmacy and Biological Sciences*. **7** (4): 69-70.

Jaiprakashnarayan, R.P.; Prashanth, S.J.; Mulge, R. and Madalageri, M.B. (2008[ab]). Study on heterosis and combining ability for earliness and yield parameters in okra [*Abelmoschus esculentus* (L.) Moench]. *The Asian Journal of Horticulture.* **3** (1): 136-141.

Javia, R.M. (2014). Stability analysis for fruit yield and it's attributing characters in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Sciences.* **9** (1): 35-39.

Javia, R.M.; Patel, N.B.; Vaddoria, M.A.; Mehta, D.R. and Chovatia, V.P. (2009). Combining ability analysis for fruit yield and its attributes in okra [*Abelmoschus esculentus* (L.) Moench]. *Crop Improvement.* **36** (1): 88-94.

Jensen, N.F. (1988). Plant breeding methodology. John Wiley and Sons, New York.

Jethava, B.A. (2014). Heterosis and combining ability in Okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis, Submitted to Navsari Agricultural University, Navsari.

Jindal, S.K.; Arora, D. and Ghai, T.R. (2009). Genotype x Environment interaction for fruit traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Crop Improvement.* **36** (1): 1-5.

Jindal, S.K.; Arora, D. and Ghai, T.R. (2010). Heterosis and combining ability for yield traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Research in Punjab Agricultural University*. **47** (1-2): 42-45.

Jindal, S.K; Arora, D. and Ghai, T.R. (2008). Stability analysis for earliness in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Research in Punjab Agricultural University*. **45** (3-4): 148-155.

Kachhadia, V.H.; Dangaria, C.J.; Vachhani, J.H.; Jivani, L.L. and Shekhat, H.G. (2011). Stability analysis in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Sciences*. **6** (1): 34-39.

Kang, M.S. (1994). Applied quantitative genetics. M. S. Kang Publisher, Baton Rouge, LA.

Katagi, A.; Tirakannanvar, S. and Jagadeesha, R.C. (2015). Combining ability through diallel analysis in okra [*Abelmoschus esculentus* (L.) Moench]. *Green Farming International Journal*. **6** (1): 26-29.

Kempthrone, O. (1957). An Introduction to Genetics Statistics. John Willey and Sons. New York. pp. 453-471.

Khanpara, M.D.; Jivani, L.L.; Vachhani, J.H.; Kachhadia, V.H. and Madaria, R.B. (2009). Heterosis studies in okra. *International Journal of Agricultural Sciences.* **5** (2): 497-500.

Khanpara, M.D.; Jivani, L.L.; Vachhani, J.H.; Shekhat, H.G. and Mehta, D.R. (2009). Line x tester analysis for combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Agricultural Sciences.* **5** (2): 554-557.

Khatik, K.R.; Chaudhary, R. and Khatik, C.L. (2012). Heterosis studies in okra. *Annals of Horticulture*. **5** (2): 213-218.

Kishor, D.S.; Arya, K.; Duggi Shrishail; Magadum, S.; Raghavendra, N.R.; Venkateshwaralu, Challa and Reddy, P.S. (2013). Studies on heterosis for yield and yield contributing traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Molecular Plant Breeding.* **4** (35): 277-284.

Kishor, D.S.; Shrishail, D.K.; Arya, K. and Magadam, S. (2013[a]). Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Bioinfolet.* **10** (2): 490-494.

Koelreuter, J.G. (1766). Vorlacvfigen nachricht von. einigon de geschlechtter pflanzen betreffenden versuchen and beobachtum. *Genetics Leipzig.* p. 266.

Korla, B.N. and Rastogi, K.B. (1979). A note on phenotypic stability for fruit yield in *bhindi*. *Punjab Horticulture Journal.* **19** (3-4): 182-183.

Krishnamurthy, K.H. (1994). Okra "In Vegetable Health Series, Traditional Family Medicine". Published by Books for all, Ashok Vihar, Delhi. pp. 12-15.

Kumar, Ashwani; Baranwal, D.K.; Judy, Aparna and Srivastava, K. (2013[a]). Combining ability and heterosis for yield and its contribution characters in okra [*Abelmoschus esculentus* (L.) Moench]. *Madras Agriculture Journal.* **100** (1-3): 30-35.

Kumar, D.S.; Tony, D.E.; Kumar, A.P.; Kumar, K.A.; Rao, D.B.S. and Nadendla, R. (2013). A Review on : *Abelmoschus esculentus* (Okra). *International Research Journal on Pharmaceutical and Applied Sciences.* **3** (4): 129-132.

Kumar, N. (2006). Breeding of Horticultural crops. New Delhi: New India Publishing Agency. pp. 173-177.

Kumar, N. (2014). Heterosis and combining ability for yield and yield attributes in okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis, (Unpublished), Submitted to Navsari Agricultural University, Navsari.

Kumar, P.; Singh, V. and Dubey, R.K. (2012). Combining ability analysis in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Sciences*. **39** (2): 180-182.

Kumar, S. and Pathania, N.P. (2007). Heterosis and combining ability studies for shoot and fruit borer infestation (*Earias* spp.) in okra [*Abelmoschus esculentus* (L.) Moench]. *The Asian Journal of Horticulture*. **2** (1): 126-130.

Kumar, S. and Pathania, N.P. (2011[ab]). Combining ability and gene action studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Research in Punjab Agricultural University*. **48** (1-2): 43-47.

Kumar, S.; Singh, A.K.; Das, R.; Datta, S. and Arya, K. (2014). Combining ability and its relationship with gene action in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal Crop and Weed*. **10** (1): 82-92.

Kumar, S.P. and Sreeparvathy, S. (2010). Studies on heterosis in okra [*Abelmoschus esculentus* (L.) Moench]. *Electronic Journal Plant Breeding*. **1** (6): 1431 -1433.

Kumar, S.P.; Srirama, P. and Kuruppiah, P. (2006). Studies on combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *Indian Journal of Horticulture*. **63** (2): 182-184.

Kumbani, R.P.; Godhani, P.R. and Fougat, R.S. (1993[a]). Hybrid vigour in eight diallel cross in okra. *Gujarat Agricultural Universities Research Journal.* **18** (2): 13-18.

Lee, M. (1995). DNA markers and plant breeding programmes. *Advances in Agronomy*. **55**: 265-344.

Lerner, I.M. (1954). Genetic homeostasis. John Wiley, New York.

Levin, D.A. and Kerster, H.W. (1970). Phenotypic dimorphism and population fitness in phlox. *Evolution*. **24**: 128-134.

Lewis, D. (1954). Genotype-environment interaction : A relationship between dominance, heterosis, phenotypic stability and variability. *Heredity*. **8**: 333-356.

Lyngdoh, R.; Mulge, R. and Shadap, A. (2013[ab]). Heterosis and combining ability studies in near homozygous lines of okra [*Abelmoschus esculentus* (L.) Moench] for growth parameters. *The Bioscan*. **8** (4): 1275-1279.

Mamidwar, S.R. and Nandan Mehta (2006). Heterobeltiosis in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Sciences*. **1** (1): 127-129.

Mandal, N. and Dana, I. (1994). Phenotypic stability in okra [*Abelmoschus esculentus* (L.) Moench]. *Environment Ecology*. **12** (2): 396-398.

Manivannan, M.I.; Rajangam, J. and Aruna, P. (2007). Heterosis for yield and yield governing traits in okra. *Asian Journal of Horticulture*. **2** (2): 96-103.

Martin, F.W. and Ruberte, R. (1978). Vegetables for the hot humid tropics. Part 2 Okra, *Abelmoschus esculentus*, Science and Education Administration, United States Department of Agriculture, (USDA) New Orleans. p. 22.

Mather, K. (1943). Polygenic inheritance and natural selection. *Biological Reviews*. **18**: 32-64.

Mather, K. and Jinks, J.L. (1971). Biometrical genetics. Chapman and Hill Ltd., London. p. 382.

Medagam, T.R.; Kadiyala, H.; Mutyala, G. and Hameedunnisa, Begum (2012). Heterosis for yield and yield components in okra. *Chilean Journal of Agriculture Research*. **72** (3): 316-325.

Mehta, N.; Asati, B.S. and Mamidwar, S.R. (2007[ab]). Heterosis and gene action in okra. *Bangladesh Journal of Agriculture Research*. **32** (3): 421-432.

Mehta, Y.R. (1959). Vegetable growing in Uttar Pradesh. *Bureau of Agriculture Research*. **31**: 215-218.

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

Nagesh, G.C.; Mulge, R.; Rathod, V.; Basavaraj, L.B. and Mahaveer, S.M. (2014[ab]). Heterosis and combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench] for yield and quality parameters. *The Bioscan.* **9** (4): 1717-1723.

Naphade, P.V.; Potdukhe, N.R.; Parmar, J.N. and Sable, N.H. (2006). Line x Tester analysis for combining ability in okra. *Annals of Plant Physiology.* **20** (1): 91-94.

Nichal, S.S.; Datke, S.B.; Deshmukh, D.T. and Patil, N.P. (2000). Heterobeltiosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Annals of Plant Physiology*. **15** (1): 34-39.

Nichal, S.S.; Mehta, N. and Saxena, R.R. (2006). Study Of Heterosis Through Diallel Crosses Of Okra [*Abelmoschus esculentus* (L.) Moench]. *Plant Archives*. **6** (1): 109-113.

Nimbalkar, C.A.; Bajaj, V.H.; Deshmukh, V.D. and Baviskar, A.P. (2005). AMMI analysis for fruit yield trial of okra. *Journal of Indian Society of Agricultural Statistics.* **591** (1): 32-47.

Obi, S.U. (2009). Studies on heterosis in [*Abelmoschus esculentus* (L.) Moench] and *A. callei* (A. Chev) stevels cultivars during shorter day photoperiods in south eastern Nigeria. *Pakistan Journal of Biological Sciences*. **12** (21): 1388-1398.

Obiadalla-Ali.; Eldekashi, M.H. and Helaly, A.A. (2013[a]). Combining ability and heterosis studies for yield and its components in some cultivars of okra. *American-Eurasian Journal of Agricultural and Environmental Sciences*. **13** (2): 162-167.

Olayiwola, M.O. and Ariyo, O.J. (2013). Relative discriminatory ability of GGE biplot and YS_i in the analysis of genotype x Environment interaction in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Breeding and Genetics*. **7** (3): 146-158.

Pal, A.K. and Hossain, M. (2000). Combining ability analysis for seed yield, its components and seed quality in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Interacademicia*. **4** (2): 216-223.

Panda, P.K. and Singh, K.P. (1999). Heterosis and inbreeding depression for yield and pod characters in okra. *Journal of Maharashtra Agricultural Universities*. **23** (3): 249-251.

Panse, V.G. and Sukhatme, P.V. (1967). Statistical Methods for Agricultural Workers, Indian Council of Agricultural Research, New Delhi, India. pp. 152-161.

Paroda, R.S. and Hayes, J.D. (1971). An investigation of genotype-environment interactions on rate of ear emergence in spring barley. *Heredity.* **26**: 157-175.

Patel, B.G. (2013). Genetic analysis of yield and yield attributing characters in Okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis (Unpublished), Submitted to Navsari Agricultural University, Navsari.

Patel, B.G. and Patel, A.I. (2016). Heterosis Studies in Okra [*Abelmoschus esculentus* (L.) Moench]. *Annals of Agricultural and Environment Sciences*. **1** (1): 15-20.

Pathak, M. and Prabhat, K. (2014). Heterosis in okra [*Abelmoschus esculentus* (L.) Moench]. Abstract of national symposium on *"Precision Horticulture for Small and Marginal Farmers"* held at 24th to 27th June, 2014 at Indira Gandhi Krishi Vishwavidyalaya, Raipur.

Pathak, R. and Shymal, M.M. (1997). Line x tester analysis for heterobeltiosis for yield and its components in okra [*Abelmoschus esculentus* (L.) Moench]. *Punjab Vegetable Grower*. **32**: 20-23.

Patil, S.S. (2013). Genetic analysis for yield and yield contributing traits in okra [*Abelmoschus esculentus* (L.) Moench] over environments. Ph.D. Thesis (Unpublished), Submitted to Navsari Agricultural University, Navsari.

Paul, T. (2013). Genetic architecture and fruit yield analysis in okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis (Unpublished), Submitted to Navsari Agricultural University, Navsari.

Perkins, J.M. and Jinks, J.L. (1968). Environmental and genotype-environmental components of variability. III. Multiple lines and crosses. *Heredity*. **23**: 339-356.

Poshiya, V.K. and Shukla, P.T. (1986). Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Gujarat Agricultural Universities Research Journal.* **11** (2): 21-25.

Poshiya, V.K. and Vashi, P.S. (1995). Heterobeltiosis in relation to general and specific combining ability in okra. *Gujarat Agricultural Universities Research Journal.* **20 (**2): 69-72.

Poshiya, V.K. and Vashi, P.S. (1997). Phenotypic stability of hybrids and their parents for fruit yield in okra [*Abelmoschus esculentus* (L.) Moench]. *Indian Journal of Genetics.* **57** (3): 266-268.

Prakash, M.; Kumar, M.S.; Saravanan, K.; Kannan, K. and Ganesan, J. (2002[a]). Line x tester analysis in okra. *Annals of Agricultural Research.* **23** (2): 233-237.

Purewal, S.S and Randhawa, G.S. (1947). Studies in *Hibiscus esculentus*, chromosome and pollination studies. *Indian Journal of Agricultural Sciences.* **17**: 129-136.

Raghuvanshi, M.; Singh, T.B.; Singh, A.P.; Singh, U.; Singh, P. and Singh, B. (2011). Combining ability in okra. *Vegetable Sciences.* **38** (1): 26-29.

Rajani, B.; Manju, P.; Manikantan Nair, P. and Saraswathy, P. (2001). Combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Tropical Agriculture.* **39**: 98-101.

Rajendra, K.; Yadav, J.R.; Tripathi, P. and Tiwari, S.K. (2005). Evaluating genotypes for combining ability through diallel analysis in okra. *Indian Journal of Horticulture*. **62** (1): 88-90.

Ramya, K. and Kumar, N. (2010[ab]). Heterosis and combining ability for fruit yield in okra. *Crop Improvement*. **37** (1): 41-45.

Ramya, K. and Senthilkumar, N. (2010). Genotype x environment interaction and screening saline tolerant genotypes in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Sciences*. **5** (1): 198-202.

Ranganna, S. (1977). Chapter 5 : Ascorbic acid, in : Manual of Analysis of fruit and vegetable Products (Ed.), Tata McGraw Hill Publishing Company, New Delhi. pp. 94-96.

Rani, M.; Arora, S.K. and Dhall, R.K. (2003). Heterobeltiosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Research, Punjab Agricultural University*. **39** (4): 491-498.

Reddy, T.M.; Babu, K.H.; Ganesh, M.; Hameedunnisa, Begam.; Dilipbabu, J. and Reddy, R.S.K. (2013). Gene action and combining ability of yield and its components for late *kharif* season in okra [*Abelmoschus esculentus* (L.) Moench]. *Chilean Journal of Agricultural Research*. **73** (1): 9-16.

Rekhi, S.S. (1976). Grow bhindi for more profits. *Seeds and Farms*. **2** (2): 25-27.

Rewale, V.S.; Bendale, V.W.; Bhave, S.G.; Madav, R.R. and Jadhav, B.B. (2003). Heterosis for yield and yield components in okra. *Journal of Maharashtra Agricultural Universities*. **28** (3): 247-249.

Rewale, V.S.; Bendale, V.W.; Bhave, S.G.; Madav, R.R. and Jadhav, B.B. (2003[a]). Combining ability of yield and yield components in okra *Journal of Maharashtra Agricultural Universities*. **28** (3): 244-246.

Samuel, C.J.A.; Hill, J.; Breese, E.L. and Davis, A. (1970). Assessing and predicting environmental response in Lolium. *Perreene Journal of Agricultural Sciences, Cambridge*. **75**: 1-9.

Senthilkumar, N. (2011). Stability of bhindi hybrids [*Abelmoschus esculentus* (L.) Moench] for fruit yield traits under saline environment. *Plant Archives*. **11** (2): 797-799.

Sharma, J.P. and Singh, A.K. (2012). Line x Tester analysis for combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Sciences*. **39** (2): 132-135.

Shobha, K. and Marriappan, S. (2007). Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench] for some important biometrical traits. *Acta Horticulturae.* **75** (2): 437-438.

Shull, G.H. (1908). The composition of field of maize. *Report American Breeders Association*. **4**: 296-301.

Shull, G.H. (1948). What is heterosis? *Genetics.* **33**: 439-446.

Siemonsma, J.E. (1982). West African okra-morphological and cytogenetical indications for the existence of a natural amphidiploid of [*Abelmoschus esculentus* (L.) Moench] and *A. manihot* (L.) *Medikus. Euphytica.* **31**: 241-252.

Singh, B. and Sanwal, S.K. (2010[a]). Heterosis, combining ability and gene action studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Sciences.* **37** (2): 187-189.

Singh, B. and Singh, S.P. (2003). Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Plant Archives*. **3** (1): 133-136.

Singh, B.; Singh, S.P.; Yadav, J.R. and Kumar, R. (2002). Heterobeltiosis and inbreeding depression in okra. *Plant Archives.* **2**: 127-132.

Singh, B.; Singh. S.; Pal, A.K. and Rai, M. (2004). Heterosis for yield and yield components in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Sciences.* **31** (2): 168-171.

Singh, D.R. and Syamal, M.M. (2006). Heterosis in okra [*Abelmoschus esculentus* (L.) Moench]. *Orissa Journal of Horticulture*. **34** (2): 124-127.

Singh, D.R.; Singh, P.K.; Syamal, M.M. and Gautam, S.S. (2009). Studies on combining ability in okra. *Indian Journal of Horticulture*. **66** (2): 277-280.

Singh, R.K. and Chaudhary, B.D. (1985). Biometrical Methods in Quantitative Genetic Analysis. *Kalyani Publishers,* New Delhi.

Singh, S.; Singh, B. and Pal, A.K. (2006). Line x Tester analysis of combining ability in okra. *Indian Journal of Horticulture.* **63** (4): 397-401.

Singh, S.P. (2011). Combining ability analysis for yield and yield contributing characters in okra. *Vegetable Sciences.* **38** (2): 212-214.

Sivakumar, S.; Ganesan, J. and Sivasubramanian, V. (1995). Combining ability analysis in bhindi. *South Indian Horticulture*. **43** (1-2): 21-24.

Solankey, S.S. and Singh, A.K. (2010). Studies on combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *The Asian Journal of Horticulture*. **5** (1): 49-53.

Solankey, S.S. and Singh, A.K. (2011). Manifestation of heterosis in relation to seasonal variation in Okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Sciences.* **38** (1): 107-110.

Sood, S. and Kalia, P. (2001). Heterosis and combining ability studies for some quantitative traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Haryana Journal of Horticultural Sciences.* **30** (1-2): 92-94.

Sood, S. and Sharma, S.K. (2001). Heterosis and gene action for economic traits in okra. SABRAO. *Journal of Breeding and Genetics.* **33 (**1): 41-46.

Sprague, G.F. and Tatum, L.A. (1942). General vs. specific combining ability in single crosses of corn. *Journal of American Society of Agronomy.* **34**: 927-932.

Sprague, G.F.; Rusell, W.A.; Penny, L.H. and Hanson, W.D. (1962). Epistatic gene action and grain yield in maize. *Crop Sciences*. **21**: 205-208.

Srivastava, K.; Aparna, J.; Singh, P.K. and Kumar, S. (2011). Stability performance of okra hybrids over environments. *In : National Seminar on Contemporary Approaches to Crop Improvement. Abstract.* **138**. p. 244.

Srivastava, K.; Kumar, A.; Baranwal, D.K. and Aparna, Judy (2013). Combining Ability and Heterosis for yield and its contributing characters in okra [*Abelmoschus esculentus* (L.) Moench]. *Madras Agriculture Journal.* **100** (1-3): 30-35.

Srivastava, M.K.; Kumar, S. and Pal, A.K. (2008). Studies on combining ability in okra through diallel analysis. *Indian Journal of Horticulture*. **65** (1): 48-51.

Sulikiri, G.S. and Swamy, R. (1972). Studies on floral biology and fruit formation in okra [*Abelmoschus esculentus* (L.) Moench] varieties. *Progressive Agriculture.* **4**. p. 71.

Sundhari, S.S.; Irulappan, I.; Arumugam, R. and Sankar, S.J. (1992). Combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *South Indian Horticulture*. **40** (1): 21-27.

Sushmita, M. and Das, N.D. (2005). Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Interacademicia*. **7** (4): 382-387.

Thimmaiah, S.R. (1999). Standard methods of biochemical analysis. *Kalyani publishers*, New Delhi. pp. 64-65.

Thippeswamy, S. (2001). Line x tester analysis for heterosis and combining ability using male sterility in okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis, U.A.S., Bangalore.

Tiwari, J.N.; Kumar, S.; Ahlawat, T.R.; Kumar, A. and Patel, N. (2015). Heterosis for yield and its components in okra [*Abelmoschus esculentus* (L.) Moench]. *Asian Journal of Horticulture*. **10** (2): 201-206.

Tripathi, P.; Yadav, J.R.; Tiwari, S.K. and Kumar, R. (2004). Useful heterosis and inbreeding depression for yield and it's components in okra. *Horticulture Journal*. **17** (3): 227-233.

Udengwu, O.S. (2008). Inheritance of fruit colour in Nigerian local okra, *Abelmoschus esculentus* (L.) Moench, cultivars. *Journal of Tropical Agriculture, Food, Environment and Extension.* **7** (3): 216-222.

Verma, M.M. and Gill, K.S. (1975). Genotype x Environment interactions. Its measurement and significance in Plant Breeding. P.A.U., Ludhiana, *Teaching Aid Bulletin.* **1**: 1-39.

Vermani, A. and Vidya Sagar (2006). Implications of mean performance, heterosis and specific combining ability effects on performance of okra crosses. *Crop Research, Hisar*. **31** (2): 288-290.

Via, S. (1984). The quantitative genetics of polyphagy in an insect herbivore. I. Genotype-environment interaction in larval performance on different host plant species. *Evolution*. **38**: 881-895.

Vijayaraghavan, C. and Warrier, V.A. (1946). Evaluation of high yielding hybrids in bhindi (*Hibiscus esculentus*). *Proceedings of 33rd Indian Science Congress*. **33** (33).

Waddington, C.H. (1942). Canalization of development and the inheritance of acquired characters. *Nature*. **150**: 563-565.

Wammanda, D.T.; Kadams, A.M. and Jonah, P.M. (2010[a]). Combining ability analysis and heterosis in a diallel cross of okra. *African Journal of Agricultural Research.* **5** (16): 2108-2115.

Weerasekara, D.; Jagadeesha, R.C.; Wali, M.C.; Salimath, P.M.; Hosamani, R.M. and Kalappanavar, I.K. (2008[a]). Combining ability of yield and yield components in okra. *Indian Journal of Horticulture.* **65** (2): 236-238.

Wircke, G. and Weber, W.E. (1986). Quantitative genetics and selection in plant breeding. *Walter de Gruyter*, New York.

Yadav, J.R.; Bhargava, L.; Kumar, S.; Mishra, G.; Yadav, A.; Parihar, N.S. and Singh, S.P. (2007). Useful heterosis for yield and its components in okra [*Abelmoschus esculentus* (L.) Moench]. *Progressive Agriculture*. **7** (1-2): 5-7.

Yadav, J.R.; Kumar, R.; Singh, B. and Srivastava, J.P. (2002.) Unmasking heterosis artifact in okra. *Progressive Agriculture.* **2** (1): 44-48.

Yawalkar, K.S. (1980). Vegetable crops of India. (2nd Edn.) Agriculture-Horticultural Publishing House, Nagpur.

APPENDICES

Appendix-I: Meteorological data recorded at Jagudan (District : Mehsana) during the period of experiment (February, 2014 to November - 2014)

Month and Year	Std. weeks	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Rainy days
		Max.	Min.			
Feb. - 2014	5	24.5	9.8	71	-	-
	6	29.6	11.2	86	-	-
	7	29.2	11.3	79	-	-
	8	29.4	11.2	83	-	-
Mar. - 2014	9	30.4	14.6	79	-	-
	10	31.7	14.2	67	-	-
	11	34.7	17.0	70	-	-
	12	37.0	16.8	73	-	-
	13	36.0	17.8	60	-	-
Apr. - 2014	14	38.3	19.4	67	-	-
	15	38.5	18.4	56	-	-
	16	39.6	19.9	57	-	-
	17	41.8	24.9	43	-	-
May - 2014	18	49.5	23.3	39	-	-
	19	41.9	25.0	41	1.8	1
	20	39.2	24.9	34	2.0	1
	21	42.3	27.7	35	-	-
	22	43.0	28.2	46	-	-
June - 2014	23	44.2	29.1	74	-	-
	24	40.2	24.2	74	-	-
	25	39.9	28.9	79	-	-
	26	39.2	28.2	78	-	-
Aug. - 2014	31	32.1	24.5	82	236.2	4
	32	31.2	24.7	82	15.0	3
	33	33.2	26.3	82	5.0	3
	34	34.8	26.1	84	34.2	1
	35	34.4	25.4	85	71.6	3
Sept. - 2014	36	32.6	23.4	76	166.0	4
	37	31.2	20.0	78	222.8	5
	38	34.7	25.2	81	-	-
	39	35.4	25.8	83	-	-
Oct. - 2014	40	36.1	26.1	82	-	-
	41	36.8	26.7	85	-	-
	42	36.0	22.8	78	-	-
	43	36.0	28.4	79	-	-
Nov. - 2014	44	33.0	21.6	78	-	-
	45	34.1	22.1	78	-	-
	46	33.9	22.0	84	-	-
	47	31.9	18.2	84	-	-
	48	31.7	18.0	89	-	-

Source : Department of Agricultural Meteorology, Seed Spices Research Station (SSRS), Sardarkrushinagar Dantiwada Agricultural University (SDAU), Jagudan (District: Mehsana).

Appendix II: Mean values of parents and hybrids in individual environments and pooled over environment for days to 50 per cent flowering and days to first picking

Sr. No.	Genotypes	Days to 50% flowering					Days to first picking				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	48.22	50.67	45.09	46.75	47.68	51.59	52.31	53.90	51.66	52.37
2.	JDNOL-11-3	48.43	49.05	43.27	44.36	46.28	50.65	47.03	53.17	52.93	50.95
3.	JDNOL-11-11	51.18	53.18	46.80	44.57	48.93	51.07	51.50	53.56	51.80	51.98
4.	JDNOL-11-12	45.91	51.47	44.03	44.66	46.52	49.92	50.70	49.48	50.62	50.18
5.	JDNOL-11-14	50.33	47.48	44.38	46.80	47.25	50.62	48.58	50.69	51.89	50.45
6.	AOL-07-9	44.29	48.56	45.43	45.35	45.91	52.27	49.30	52.90	49.49	50.99
7.	AOL-08-5	54.03	53.89	44.38	46.52	49.71	51.48	51.98	53.12	46.88	50.87
8.	JOL-6k-2	51.60	49.71	45.27	51.54	49.53	50.18	52.32	48.87	51.85	50.81
9.	JOL-08-7	53.03	46.08	48.10	47.76	48.74	49.65	50.22	52.33	51.21	50.85
10.	JOL-08-12	50.11	47.41	44.89	45.49	46.98	49.81	51.23	51.88	49.17	50.52
Minimum		44.29	46.08	43.27	44.36	45.91	49.65	47.03	48.87	46.88	50.18
Maximum		54.03	53.89	48.10	51.54	49.71	52.27	52.32	53.90	52.93	52.37
Mean		49.71	49.75	45.16	46.38	47.75	50.72	50.52	51.99	50.75	51.00
MALES (TESTERS)											
11.	Arka Anamika	52.09	44.16	47.90	44.32	47.12	51.68	49.84	52.19	51.95	51.41
12.	Pusa Sawani	49.22	47.88	44.56	44.44	46.53	49.31	50.47	48.74	50.40	49.73
13.	Parbhani Kranti	48.50	50.73	44.90	44.28	47.10	49.32	49.41	52.56	49.39	50.17
14.	GO-2	53.17	53.97	47.91	50.26	51.33	50.97	51.44	51.53	52.15	51.52
15.	VRO-6	45.88	50.53	43.72	45.45	46.39	50.05	46.53	51.01	49.54	49.28
Minimum		45.88	44.16	43.72	44.28	46.39	49.31	46.53	48.74	49.39	49.28
Maximum		53.17	53.97	47.91	50.26	51.33	51.68	51.44	52.56	52.15	51.52
Mean		49.77	49.46	45.80	45.75	47.69	50.27	49.54	51.21	50.69	50.42
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	49.18	50.51	46.09	44.13	47.47	48.81	49.92	53.57	51.02	50.83
17.	JDNOL-11-1 x Pusa Sawani	48.49	57.01	45.25	52.22	50.74	49.68	50.24	47.33	50.22	49.37

Appendix II: Continue…

18.	JDNOL-11-1 x Parbhani Kranti	49.56	50.84	43.93	44.61	47.24	46.33	50.81	51.08	52.86	50.27
19.	JDNOL-11-1 x GO-2	52.23	50.99	45.45	45.74	48.60	49.26	48.87	47.37	50.35	48.96
20.	JDNOL-11-1 x VRO-6	47.17	51.14	51.52	43.28	48.28	47.75	45.59	52.35	48.16	48.46
21.	JDNOL-11-3 x Arka Anamika	47.89	55.55	45.83	50.33	49.90	48.21	46.83	54.25	54.76	51.01
22.	JDNOL-11-3 x Pusa Sawani	51.32	49.89	45.71	43.74	47.67	47.09	48.89	47.58	52.72	49.07
23.	JDNOL-11-3 x Parbhani Kranti	48.61	46.43	44.22	42.81	45.52	51.02	46.68	51.72	47.90	49.33
24.	JDNOL-11-3 x GO-2	45.91	50.97	44.92	51.17	48.24	47.11	48.94	52.77	50.41	49.81
25.	JDNOL-11-3 x VRO-6	49.66	48.78	45.01	42.40	46.46	51.48	49.81	50.50	52.40	51.05
26.	JDNOL-11-11 x Arka Anamika	44.29	46.85	48.36	43.82	45.83	46.18	50.44	49.26	50.54	49.10
27.	JDNOL-11-11 x Pusa Sawani	47.50	51.88	45.45	45.73	47.64	48.66	51.76	52.30	49.63	50.59
28.	JDNOL-11-11 x Parbhani Kranti	48.11	53.89	45.37	51.75	49.78	49.14	45.89	49.03	51.99	49.01
29.	JDNOL-11-11 x GO-2	50.29	50.45	46.18	44.02	47.73	50.07	52.77	50.49	49.20	50.63
30.	JDNOL-11-11 x VRO-6	45.82	47.28	43.89	43.83	45.21	45.21	46.57	46.27	49.58	46.91
31.	JDNOL-11-12 x Arka Anamika	53.96	51.99	46.24	47.49	49.92	50.04	48.07	53.68	47.41	49.80
32.	JDNOL-11-12 x Pusa Sawani	50.20	47.83	48.82	43.19	47.51	46.64	48.94	49.56	51.26	49.10
33.	JDNOL-11-12 x Parbhani Kranti	48.03	46.24	45.90	50.33	47.63	50.77	50.19	51.98	50.74	50.92
34.	JDNOL-11-12 x GO-2	49.89	52.10	44.84	48.81	48.91	52.02	46.98	51.96	54.01	51.24
35.	JDNOL-11-12 x VRO-6	57.85	46.52	46.54	45.15	49.02	47.70	51.81	48.45	57.33	51.32
36.	JDNOL-11-14 x Arka Anamika	50.84	52.49	48.46	46.03	49.46	49.65	48.17	50.17	48.98	49.24
37.	JDNOL-11-14 x Pusa Sawani	48.56	49.53	44.47	44.10	46.66	46.66	44.29	45.91	53.55	47.60
38.	JDNOL-11-14 x Parbhani Kranti	46.52	47.83	45.44	43.70	45.87	46.21	48.72	47.84	52.15	48.73
39.	JDNOL-11-14 x GO-2	49.28	50.00	43.04	44.67	46.75	49.86	49.66	44.70	47.73	47.99
40.	JDNOL-11-14 x VRO-6	49.60	49.76	45.02	42.22	46.65	50.36	49.59	52.03	50.21	50.55
41.	AOL-07-9 x Arka Anamika	54.51	50.45	51.37	53.13	52.37	47.05	47.74	51.76	51.32	49.47
42.	AOL-07-9 x Pusa Sawani	50.20	54.93	43.82	42.17	47.78	51.09	51.37	54.43	48.39	51.32
43.	AOL-07-9 x Parbhani Kranti	47.89	50.22	47.18	49.95	48.81	50.58	52.55	49.37	47.34	49.96
44.	AOL-07-9 x GO-2	51.13	46.91	45.88	44.57	47.12	51.13	49.72	49.12	49.30	49.82
45.	AOL-07-9 x VRO-6	55.50	47.95	44.05	44.32	47.96	49.88	49.19	51.90	48.45	49.85
46.	AOL-08-5 x Arka Anamika	50.77	57.87	44.40	48.78	50.46	49.48	51.49	53.49	47.92	50.60
47.	AOL-08-5 x Pusa Sawani	50.33	51.23	44.57	44.57	47.68	47.88	49.32	49.19	51.40	49.45

Appendix II: Continue…

48.	AOL-08-5 x Parbhani Kranti	46.94	49.82	44.68	42.22	45.92	48.31	50.87	48.12	46.69	48.50
49.	AOL-08-5 x GO-2	47.79	50.63	42.78	41.83	45.76	54.49	50.73	50.61	49.77	51.40
50.	AOL-08-5 x VRO-6	47.56	46.26	43.85	44.24	45.48	47.97	49.68	45.64	45.90	47.30
51.	JOL-6k-2 x Arka Anamika	53.40	56.76	48.19	52.60	52.74	53.16	48.45	53.71	50.19	51.38
52.	JOL-6k-2 x Pusa Sawani	51.68	45.97	46.57	46.54	47.69	48.90	52.18	53.77	50.07	51.23
53.	JOL-6k-2 x Parbhani Kranti	55.81	51.73	43.86	43.82	48.81	52.80	49.00	46.88	47.49	49.04
54.	JOL-6k-2 x GO-2	49.56	52.55	50.80	51.99	51.23	45.59	45.40	53.72	53.00	49.43
55.	JOL-6k-2 x VRO-6	49.22	50.07	45.82	45.12	47.56	51.72	49.26	48.21	51.58	50.19
56.	JOL-08-7 x Arka Anamika	56.26	43.85	49.96	52.56	50.66	48.37	48.97	46.16	52.13	48.91
57.	JOL-08-7 x Pusa Sawani	47.78	49.78	46.45	44.03	47.01	47.72	45.90	46.35	48.53	47.12
58.	JOL-08-7 x Parbhani Kranti	49.95	48.03	46.09	42.49	46.64	45.60	52.03	46.52	50.66	48.70
59.	JOL-08-7 x GO-2	50.73	46.50	41.92	45.76	46.23	50.93	50.42	47.37	52.29	50.25
60.	JOL-08-7 x VRO-6	48.82	50.79	45.92	51.44	49.24	49.24	50.01	49.33	50.12	49.68
61.	JOL-08-12 x Arka Anamika	49.44	53.38	47.28	44.52	48.66	48.49	49.14	45.47	53.53	49.16
62.	JOL-08-12 x Pusa Sawani	58.25	50.11	40.01	43.71	48.02	50.14	47.48	46.51	48.41	48.13
63.	JOL-08-12 x Parbhani Kranti	46.41	48.74	43.30	43.86	45.58	51.60	45.53	48.49	48.10	48.43
64.	JOL-08-12 x GO-2	49.19	52.87	48.51	48.72	49.82	51.31	50.43	53.40	51.49	51.66
65.	JOL-08-12 x VRO-6	48.04	50.41	44.23	41.95	46.16	48.29	48.66	51.82	47.51	49.07
Minimum		44.29	43.85	40.01	41.83	45.21	45.21	44.29	44.70	45.90	46.91
Maximum		58.25	57.87	51.52	53.13	52.74	54.49	52.77	54.43	57.33	51.66
Mean		49.96	50.29	45.75	46.00	48.00	49.15	49.12	49.87	50.33	49.62
66.	Check (GJOH-3)	49.67	50.67	44.03	45.19	47.39	52.48	53.36	48.43	49.30	50.89
General Mean		49.90	50.14	45.66	46.04	47.93	49.47	49.36	50.29	50.42	49.89
Parental Mean		49.73	49.65	45.37	46.17	47.73	50.57	50.19	51.72	50.73	50.80
Hybrids Mean		49.95	50.29	45.74	46.00	48.00	49.15	49.11	49.87	50.33	49.61
S.Em. ±		1.90	1.94	1.21	1.10	0.80	1.47	1.68	1.63	1.79	0.88

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

Appendix III: Mean values of parents and hybrids in individual environments and pooled over environment for fruit length (cm) and fruit girth (cm)

Sr. No.	Genotypes	Fruit length (cm)					Fruit girth (cm)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	11.72	10.98	11.82	10.74	11.31	5.12	4.94	5.63	5.14	5.20
2.	JDNOL-11-3	12.55	11.93	12.32	12.10	12.22	4.80	5.35	6.29	5.25	5.42
3.	JDNOL-11-11	12.17	11.53	11.75	11.82	11.82	5.21	4.44	5.37	4.59	4.90
4.	JDNOL-11-12	10.98	11.10	11.98	11.77	11.46	6.15	5.38	5.95	5.43	5.73
5.	JDNOL-11-14	11.46	12.02	12.16	11.90	11.89	5.92	6.14	6.96	6.00	6.25
6.	AOL-07-9	11.85	11.92	12.15	11.13	11.76	5.22	6.38	5.94	6.23	5.95
7.	AOL-08-5	11.05	11.62	11.85	10.66	11.29	5.61	4.89	6.53	4.53	5.39
8.	JOL-6k-2	10.79	11.95	11.18	11.79	11.43	5.23	4.95	5.30	4.53	5.00
9.	JOL-08-7	10.88	11.47	11.83	11.01	11.30	5.94	5.55	6.16	5.42	5.77
10.	JOL-08-12	12.13	12.20	12.49	12.55	12.34	5.90	6.03	7.00	5.39	6.08
Minimum		10.79	10.98	11.18	10.66	11.29	4.80	4.44	5.30	4.53	4.90
Maximum		12.55	12.20	12.49	12.55	12.34	6.15	6.38	7.00	6.23	6.25
Mean		11.56	11.67	11.95	11.55	11.68	5.51	5.40	6.11	5.25	5.57
MALES (TESTERS)											
11.	Arka Anamika	11.67	11.77	11.66	11.62	11.68	5.53	4.89	5.97	5.25	5.41
12.	Pusa Sawani	11.65	12.04	12.32	12.47	12.12	5.53	6.17	6.59	6.44	6.18
13.	Parbhani Kranti	11.88	12.32	11.92	12.24	12.09	5.92	6.13	6.70	6.11	6.22
14.	GO-2	10.51	11.21	11.61	11.23	11.14	5.58	5.43	4.51	4.73	5.06
15.	VRO-6	11.85	11.97	12.49	12.01	12.08	6.11	6.25	6.80	5.74	6.22
Minimum		10.51	11.21	11.61	11.23	11.14	5.53	4.89	4.51	4.73	5.06
Maximum		11.88	12.32	12.49	12.47	12.12	6.11	6.25	6.80	6.44	6.22
Mean		11.51	11.86	12.00	11.92	11.82	5.73	5.77	6.11	5.65	5.82
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	11.87	12.17	11.91	11.89	11.96	5.27	5.25	6.49	5.73	5.68
17.	JDNOL-11-1 x Pusa Sawani	12.18	11.79	12.40	12.13	12.13	5.76	5.27	6.99	5.52	5.89
18.	JDNOL-11-1 x Parbhani Kranti	12.10	11.89	12.17	11.48	11.91	5.63	4.49	6.04	5.67	5.46

Appendix III: Continue…

19.	JDNOL-11-1 x GO-2	11.94	11.41	11.71	12.35	11.86	5.61	5.16	5.71	5.48	5.49
20.	JDNOL-11-1 x VRO-6	10.60	12.27	12.58	11.70	11.79	6.28	6.16	4.70	6.37	5.88
21.	JDNOL-11-3 x Arka Anamika	12.17	11.93	11.98	12.23	12.08	5.44	6.42	6.41	5.93	6.05
22.	JDNOL-11-3 x Pusa Sawani	11.82	11.04	12.00	12.32	11.79	5.43	5.71	6.06	5.66	5.71
23.	JDNOL-11-3 x Parbhani Kranti	12.74	12.36	12.93	13.24	12.82	4.92	6.28	7.14	6.42	6.19
24.	JDNOL-11-3 x GO-2	12.55	12.04	11.92	11.20	11.93	5.42	5.73	6.33	5.51	5.75
25.	JDNOL-11-3 x VRO-6	12.09	11.98	12.13	11.99	12.05	6.53	4.94	6.72	5.11	5.82
26.	JDNOL-11-11 x Arka Anamika	11.17	11.13	12.47	12.09	11.72	5.34	5.47	7.07	5.42	5.83
27.	JDNOL-11-11 x Pusa Sawani	11.76	12.45	11.93	12.35	12.12	6.25	5.47	5.30	5.21	5.56
28.	JDNOL-11-11 x Parbhani Kranti	10.87	12.02	12.34	12.05	11.82	6.32	5.69	5.40	4.72	5.53
29.	JDNOL-11-11 x GO-2	11.19	12.10	12.08	11.18	11.64	5.56	4.82	4.96	4.46	4.95
30.	JDNOL-11-11 x VRO-6	12.15	13.03	13.18	13.17	12.88	6.02	6.48	7.20	6.18	6.47
31.	JDNOL-11-12 x Arka Anamika	11.53	11.56	12.52	12.34	11.99	5.35	5.61	5.32	5.23	5.38
32.	JDNOL-11-12 x Pusa Sawani	11.55	12.56	12.05	10.37	11.63	4.78	5.30	6.67	5.18	5.48
33.	JDNOL-11-12 x Parbhani Kranti	11.43	11.98	12.48	11.96	11.96	4.89	5.27	6.93	5.07	5.54
34.	JDNOL-11-12 x GO-2	11.97	11.41	10.69	12.02	11.52	6.34	4.72	5.55	6.32	5.73
35.	JDNOL-11-12 x VRO-6	12.12	11.84	12.47	12.10	12.13	4.65	5.70	5.70	6.93	5.75
36.	JDNOL-11-14 x Arka Anamika	11.36	10.33	12.49	12.39	11.64	5.88	5.25	6.06	5.45	5.66
37.	JDNOL-11-14 x Pusa Sawani	11.88	12.16	13.01	11.91	12.24	6.04	4.75	7.21	5.69	5.92
38.	JDNOL-11-14 x Parbhani Kranti	12.35	11.80	12.54	12.75	12.36	5.90	5.54	6.60	6.14	6.05
39.	JDNOL-11-14 x GO-2	12.19	12.39	12.56	12.06	12.30	6.35	6.45	6.57	6.30	6.42
40.	JDNOL-11-14 x VRO-6	11.00	13.18	13.14	13.47	12.70	5.09	5.08	4.89	4.64	4.92
41.	AOL-07-9 x Arka Anamika	11.42	12.25	12.93	12.21	12.20	5.33	5.16	4.72	4.82	5.01
42.	AOL-07-9 x Pusa Sawani	11.91	12.27	12.63	11.18	12.00	5.49	6.18	5.51	6.01	5.80
43.	AOL-07-9 x Parbhani Kranti	11.75	11.52	11.96	12.20	11.86	6.13	6.16	4.97	7.40	6.16
44.	AOL-07-9 x GO-2	11.38	11.34	12.21	11.40	11.58	4.99	7.04	5.81	6.97	6.20
45.	AOL-07-9 x VRO-6	11.87	11.03	11.16	12.49	11.64	5.98	6.90	6.62	7.19	6.67
46.	AOL-08-5 x Arka Anamika	11.90	11.24	12.11	11.88	11.78	5.69	4.89	5.37	5.24	5.30
47.	AOL-08-5 x Pusa Sawani	12.04	12.85	12.26	12.26	12.35	5.45	5.66	6.89	6.00	6.00
48.	AOL-08-5 x Parbhani Kranti	12.44	12.20	12.70	12.12	12.36	4.82	6.27	6.74	6.60	6.11
49.	AOL-08-5 x GO-2	11.87	12.96	12.48	11.16	12.12	5.99	5.76	6.89	6.22	6.22

50.	AOL-08-5 x VRO-6	12.18	12.38	12.37	12.43	12.34	6.16	7.02	6.15	6.08	6.35
51.	JOL-6k-2 x Arka Anamika	11.48	11.78	10.47	12.28	11.50	5.75	5.15	6.06	5.62	5.64
52.	JOL-6k-2 x Pusa Sawani	11.74	12.19	12.29	10.37	11.65	6.36	4.63	5.72	3.91	5.16
53.	JOL-6k-2 x Parbhani Kranti	10.74	11.77	11.35	12.71	11.64	5.51	6.06	6.00	5.10	5.67
54.	JOL-6k-2 x GO-2	11.07	11.97	12.39	11.55	11.74	6.12	6.30	5.03	7.10	6.14
55.	JOL-6k-2 x VRO-6	11.25	12.33	11.93	12.32	11.96	5.84	7.14	6.22	6.89	6.52
56.	JOL-08-7 x Arka Anamika	11.93	11.76	11.49	12.25	11.86	5.59	5.70	6.05	5.80	5.78
57.	JOL-08-7 x Pusa Sawani	12.16	12.82	13.20	10.93	12.28	5.50	5.56	6.51	6.43	6.00
58.	JOL-08-7 x Parbhani Kranti	11.73	12.11	12.39	13.37	12.40	6.65	5.78	7.12	5.75	6.32
59.	JOL-08-7 x GO-2	12.07	12.57	12.08	12.27	12.25	6.25	5.98	5.49	5.72	5.86
60.	JOL-08-7 x VRO-6	11.96	11.47	13.09	11.81	12.08	5.58	7.01	6.02	4.99	5.90
61.	JOL-08-12 x Arka Anamika	12.09	11.17	11.08	12.19	11.63	5.52	6.56	5.00	6.06	5.78
62.	JOL-08-12 x Pusa Sawani	11.74	11.84	12.17	11.96	11.93	5.56	6.02	5.67	6.08	5.83
63.	JOL-08-12 x Parbhani Kranti	12.21	11.56	12.16	12.16	12.02	5.94	6.61	6.06	4.94	5.89
64.	JOL-08-12 x GO-2	11.45	12.49	11.20	11.29	11.61	5.77	6.00	6.37	5.78	5.98
65.	JOL-08-12 x VRO-6	12.35	12.72	12.62	12.40	12.52	6.77	6.04	7.16	6.48	6.61
Minimum		10.60	10.33	10.47	10.37	11.50	4.65	4.49	4.70	3.91	4.92
Maximum		12.74	13.18	13.20	13.47	12.88	6.77	7.14	7.21	7.40	6.67
Mean		11.79	11.99	12.21	12.04	12.01	5.72	5.77	6.08	5.79	5.84
66.	Check (GJOH-3)	12.33	12.24	12.54	12.19	12.33	6.86	7.34	7.25	6.46	6.98
General Mean		11.73	11.92	12.15	11.95	11.94	5.68	5.71	6.09	5.69	5.79
Parental Mean		11.54	11.73	11.96	11.66	11.72	5.58	5.52	6.11	5.38	5.65
Hybrids Mean		11.78	11.98	12.20	12.03	12.00	5.71	5.77	6.08	5.78	5.84
S.Em. ±		0.41	0.45	0.32	0.32	0.19	0.24	0.25	0.23	0.19	0.12

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

Appendix IV: Mean values of parents and hybrids in individual environments and pooled over environment for number of branches per plant and internodal length (cm)

Sr. No.	Genotypes	Number of branches per plant					Internodal length (cm)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	2.44	2.05	2.16	2.28	2.23	6.76	7.32	11.48	11.30	9.21
2.	JDNOL-11-3	2.66	2.34	2.45	2.49	2.48	7.26	7.47	11.65	11.33	9.43
3.	JDNOL-11-11	2.51	2.19	2.10	2.15	2.24	6.60	5.96	11.04	10.96	8.64
4.	JDNOL-11-12	2.35	2.24	2.29	2.23	2.28	7.13	6.77	10.93	11.14	8.99
5.	JDNOL-11-14	2.45	2.65	2.70	2.59	2.60	7.40	7.29	11.55	11.76	9.50
6.	AOL-07-9	2.54	2.55	2.57	2.63	2.57	7.49	7.32	11.46	11.78	9.51
7.	AOL-08-5	2.23	2.36	2.06	2.70	2.34	6.53	5.18	11.39	11.46	8.64
8.	JOL-6k-2	2.47	2.12	2.28	2.36	2.31	7.08	6.92	10.23	11.31	8.89
9.	JOL-08-7	2.23	2.31	2.16	2.29	2.25	6.80	5.69	11.30	11.18	8.74
10.	JOL-08-12	2.56	2.31	2.14	2.42	2.36	7.24	6.88	10.71	11.10	8.98
Minimum		2.23	2.05	2.06	2.15	2.23	6.53	5.18	10.23	10.96	8.64
Maximum		2.66	2.65	2.70	2.70	2.60	7.49	7.47	11.65	11.78	9.51
Mean		2.44	2.31	2.29	2.41	2.37	7.03	6.68	11.17	11.33	9.05
MALES (TESTERS)											
11.	Arka Anamika	2.53	2.35	2.42	2.83	2.53	7.35	5.62	11.56	11.35	8.97
12.	Pusa Sawani	2.59	2.37	2.57	2.75	2.57	7.49	7.70	12.19	12.11	9.87
13.	Parbhani Kranti	2.28	2.28	2.38	2.41	2.34	7.43	7.78	11.60	11.47	9.57
14.	GO-2	2.31	2.29	2.23	2.38	2.30	7.31	7.55	11.18	11.17	9.30
15.	VRO-6	2.42	2.36	2.52	2.48	2.44	7.58	7.60	11.51	11.42	9.53
Minimum		2.28	2.28	2.23	2.38	2.30	7.31	5.62	11.18	11.17	8.97
Maximum		2.59	2.37	2.57	2.83	2.57	7.58	7.78	12.19	12.11	9.87
Mean		2.43	2.33	2.42	2.57	2.44	7.43	7.25	11.61	11.50	9.45
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	2.63	2.33	2.38	2.40	2.43	7.47	7.22	14.07	11.02	9.95
17.	JDNOL-11-1 x Pusa Sawani	2.36	2.49	2.23	2.31	2.35	7.67	7.55	12.17	10.88	9.57

Appendix IV: Continue…

18.	JDNOL-11-1 x Parbhani Kranti	2.46	2.27	2.06	2.33	2.28	6.94	6.45	12.26	10.90	9.14
19.	JDNOL-11-1 x GO-2	2.48	2.29	2.21	2.15	2.28	7.65	7.12	11.28	11.90	9.49
20.	JDNOL-11-1 x VRO-6	2.75	2.30	2.25	2.30	2.40	7.10	7.66	11.69	11.70	9.53
21.	JDNOL-11-3 x Arka Anamika	2.41	2.12	2.48	2.10	2.28	6.61	5.13	12.22	11.01	8.74
22.	JDNOL-11-3 x Pusa Sawani	2.27	2.29	2.21	2.51	2.32	7.42	6.12	11.59	11.71	9.21
23.	JDNOL-11-3 x Parbhani Kranti	2.19	2.69	3.01	2.56	2.61	7.68	8.05	12.45	12.78	10.24
24.	JDNOL-11-3 x GO-2	2.20	2.18	2.34	2.33	2.26	6.59	6.04	11.03	11.01	8.67
25.	JDNOL-11-3 x VRO-6	2.53	2.47	2.09	2.23	2.33	7.37	5.51	11.15	11.86	8.97
26.	JDNOL-11-11 x Arka Anamika	2.39	2.56	2.33	2.07	2.34	6.75	5.99	12.18	11.69	9.15
27.	JDNOL-11-11 x Pusa Sawani	2.51	2.45	2.24	2.24	2.36	7.44	6.72	14.35	11.47	10.00
28.	JDNOL-11-11 x Parbhani Kranti	2.37	2.20	2.11	2.30	2.24	7.50	6.91	10.86	11.92	9.30
29.	JDNOL-11-11 x GO-2	2.41	2.34	2.05	2.23	2.26	7.11	6.79	12.84	11.99	9.68
30.	JDNOL-11-11 x VRO-6	2.74	2.80	2.75	3.01	2.82	7.43	7.12	15.10	13.04	10.67
31.	JDNOL-11-12 x Arka Anamika	2.29	2.34	2.18	2.43	2.31	7.19	5.41	11.31	11.05	8.74
32.	JDNOL-11-12 x Pusa Sawani	2.39	2.30	2.28	2.31	2.32	6.91	6.53	11.79	11.52	9.19
33.	JDNOL-11-12 x Parbhani Kranti	2.30	2.45	2.61	2.35	2.43	7.22	6.56	12.25	12.37	9.60
34.	JDNOL-11-12 x GO-2	2.17	2.37	2.28	2.08	2.23	6.57	7.38	11.74	12.36	9.51
35.	JDNOL-11-12 x VRO-6	2.15	2.36	2.23	2.23	2.25	5.58	5.68	11.56	11.35	8.54
36.	JDNOL-11-14 x Arka Anamika	2.55	2.56	2.62	2.02	2.44	7.51	7.30	12.28	12.75	9.96
37.	JDNOL-11-14 x Pusa Sawani	2.44	3.08	2.70	2.52	2.69	6.84	7.72	14.52	12.30	10.35
38.	JDNOL-11-14 x Parbhani Kranti	2.49	2.35	2.43	2.42	2.42	6.69	7.52	12.41	12.76	9.84
39.	JDNOL-11-14 x GO-2	2.71	2.45	2.17	2.20	2.38	7.22	6.13	14.07	11.14	9.64
40.	JDNOL-11-14 x VRO-6	2.49	2.71	2.87	2.50	2.64	7.42	7.05	11.91	12.45	9.71
41.	AOL-07-9 x Arka Anamika	2.43	2.54	2.04	2.19	2.30	7.75	7.17	11.90	12.89	9.93
42.	AOL-07-9 x Pusa Sawani	2.57	2.64	2.24	2.07	2.38	6.65	6.02	12.24	12.59	9.38
43.	AOL-07-9 x Parbhani Kranti	2.65	2.37	2.00	2.34	2.34	7.64	7.20	11.91	11.19	9.48
44.	AOL-07-9 x GO-2	2.52	2.44	2.22	2.25	2.36	6.84	7.24	11.09	11.55	9.18
45.	AOL-07-9 x VRO-6	2.40	2.34	2.40	2.22	2.34	6.52	7.83	12.29	12.91	9.89
46.	AOL-08-5 x Arka Anamika	2.52	2.58	2.25	2.00	2.34	7.56	6.53	11.19	12.14	9.36
47.	AOL-08-5 x Pusa Sawani	2.75	2.86	2.29	2.72	2.66	7.45	7.86	12.42	11.31	9.76

Appendix IV: Continue…

48.	AOL-08-5 x Parbhani Kranti	2.38	2.61	2.87	2.45	2.58	7.41	7.79	13.14	12.19	10.13
49.	AOL-08-5 x GO-2	2.33	2.45	2.34	2.37	2.37	6.58	7.70	12.42	11.40	9.52
50.	AOL-08-5 x VRO-6	2.39	2.60	2.42	2.45	2.46	6.64	7.34	12.32	12.62	9.73
51.	JOL-6k-2 x Arka Anamika	2.60	2.51	2.17	2.31	2.40	7.39	6.97	11.52	11.35	9.31
52.	JOL-6k-2 x Pusa Sawani	2.29	2.32	2.35	2.08	2.26	6.99	7.90	11.88	12.89	9.92
53.	JOL-6k-2 x Parbhani Kranti	2.14	2.49	2.44	2.27	2.33	7.75	7.81	11.32	12.89	9.94
54.	JOL-6k-2 x GO-2	2.71	2.36	2.58	2.40	2.51	6.94	7.82	10.85	12.01	9.41
55.	JOL-6k-2 x VRO-6	2.52	2.33	2.26	2.22	2.33	7.54	7.21	11.35	13.77	9.97
56.	JOL-08-7 x Arka Anamika	2.22	2.57	2.15	2.17	2.28	7.57	5.39	11.96	11.85	9.19
57.	JOL-08-7 x Pusa Sawani	2.99	2.64	2.82	2.41	2.71	7.13	6.38	12.00	12.83	9.59
58.	JOL-08-7 x Parbhani Kranti	2.64	2.51	2.81	2.56	2.63	7.56	6.42	11.08	12.36	9.35
59.	JOL-08-7 x GO-2	2.39	2.41	2.33	2.29	2.36	7.47	6.37	12.49	11.37	9.42
60.	JOL-08-7 x VRO-6	2.54	2.63	2.49	2.53	2.55	6.60	5.99	14.46	11.52	9.64
61.	JOL-08-12 x Arka Anamika	2.52	2.48	2.00	2.95	2.49	5.69	6.37	13.65	12.04	9.44
62.	JOL-08-12 x Pusa Sawani	3.08	2.65	2.66	2.76	2.79	7.64	7.44	12.19	13.39	10.17
63.	JOL-08-12 x Parbhani Kranti	2.61	2.27	2.26	2.45	2.40	7.31	7.93	13.01	11.46	9.93
64.	JOL-08-12 x GO-2	2.48	2.13	2.92	2.20	2.43	6.93	7.36	12.28	11.69	9.57
65.	JOL-08-12 x VRO-6	2.86	2.51	2.83	2.51	2.68	7.50	7.17	12.37	12.63	9.92
Minimum		2.14	2.12	2.00	2.00	2.23	5.58	5.13	10.85	10.88	8.54
Maximum		3.08	3.08	3.01	3.01	2.82	7.75	8.05	15.10	13.77	10.67
Mean		2.49	2.46	2.39	2.35	2.42	7.14	6.90	12.25	12.00	9.57
66.	Check (GJOH-3)	2.92	2.69	3.06	2.92	2.90	7.45	7.50	12.49	12.76	10.05
General Mean		2.47	2.42	2.37	2.37	2.41	7.14	6.89	12.03	11.85	9.48
Parental Mean		2.43	2.31	2.33	2.46	2.38	7.16	6.87	11.31	11.38	9.18
Hybrids Mean		2.48	2.45	2.38	2.34	2.41	7.13	6.89	12.24	11.99	9.56
S.Em. ±		0.12	0.12	0.09	0.10	0.05	0.28	0.30	0.56	0.56	0.24

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

Appendix V: Mean values of parents and hybrids in individual environments and pooled over environment for plant height (cm) and fruit yield per plant (g)

Sr. No.	Genotypes	Plant height (cm)					Fruit yield per plant (g)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	113.29	118.69	178.50	174.85	146.33	189.14	198.23	243.08	293.92	231.09
2.	JDNOL-11-3	127.74	124.97	175.92	176.82	151.36	200.20	212.08	297.96	297.50	251.94
3.	JDNOL-11-11	108.20	102.34	167.75	168.96	136.81	189.48	189.48	305.77	265.79	237.63
4.	JDNOL-11-12	120.04	120.19	179.41	173.39	148.26	187.74	187.74	271.91	265.51	228.22
5.	JDNOL-11-14	127.44	126.84	189.34	171.70	153.83	211.12	224.33	291.91	295.82	255.79
6.	AOL-07-9	135.20	124.22	180.51	177.89	154.45	217.82	221.22	300.27	307.48	261.70
7.	AOL-08-5	124.71	112.96	133.03	148.48	129.79	185.77	185.77	277.91	281.01	232.61
8.	JOL-6k-2	110.81	118.53	126.89	137.19	123.36	96.70	96.71	247.01	239.23	169.91
9.	JOL-08-7	119.97	121.81	139.68	162.32	135.95	159.40	159.40	243.14	281.90	210.96
10.	JOL-08-12	107.29	113.35	172.33	173.81	141.69	200.18	210.33	263.02	303.32	244.21
Minimum		107.29	102.34	126.89	137.19	123.36	96.70	96.71	243.08	239.23	169.91
Maximum		135.20	126.84	189.34	177.89	154.45	217.82	224.33	305.77	307.48	261.70
Mean		119.47	118.39	164.33	166.54	142.18	183.75	188.53	274.20	283.15	232.41
MALES (TESTERS)											
11.	Arka Anamika	121.23	121.71	138.57	174.13	138.91	200.45	200.45	231.41	280.75	228.27
12.	Pusa Sawani	134.14	133.15	177.39	174.40	154.77	192.09	216.51	248.76	303.82	240.29
13.	Parbhani Kranti	125.00	128.28	160.53	162.21	144.00	191.64	198.66	290.62	307.85	247.19
14.	GO-2	120.40	121.64	131.46	131.84	126.34	188.14	188.14	239.41	292.83	227.13
15.	VRO-6	133.68	126.91	144.91	165.81	142.83	197.83	208.09	305.35	303.68	253.74
Minimum		120.40	121.64	131.46	131.84	126.34	188.14	188.14	231.41	280.75	227.13
Maximum		134.14	133.15	177.39	174.40	154.77	200.45	216.51	305.35	307.85	253.74
Mean		126.89	126.34	150.57	161.68	141.37	194.03	202.37	263.11	297.79	239.32
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	120.00	120.13	173.65	170.51	146.07	202.67	202.67	242.83	291.71	234.97
17.	JDNOL-11-1 x Pusa Sawani	122.97	125.34	167.47	169.15	146.23	186.49	186.49	287.80	268.20	232.25
18.	JDNOL-11-1 x Parbhani Kranti	116.25	117.11	158.05	158.85	137.56	191.49	191.50	262.40	280.14	231.38

Appendix V: Continue…

19.	JDNOL-11-1 x GO-2	125.01	123.71	169.31	169.29	146.83	193.53	193.53	276.09	236.99	225.04
20.	JDNOL-11-1 x VRO-6	119.58	98.09	127.67	135.47	120.20	187.70	218.26	235.10	281.11	230.54
21.	JDNOL-11-3 x Arka Anamika	125.00	124.86	156.99	162.41	142.31	201.14	197.77	302.81	267.65	242.34
22.	JDNOL-11-3 x Pusa Sawani	113.21	123.47	137.34	138.80	128.20	198.79	198.79	287.35	297.66	245.64
23.	JDNOL-11-3 x Parbhani Kranti	114.07	129.57	187.93	182.74	153.58	214.03	214.03	308.68	314.73	262.87
24.	JDNOL-11-3 x GO-2	115.16	113.52	139.26	137.42	126.34	209.17	209.17	240.12	293.11	237.89
25.	JDNOL-11-3 x VRO-6	123.44	128.17	176.75	173.72	150.52	185.06	215.09	293.56	285.59	244.82
26.	JDNOL-11-11 x Arka Anamika	124.35	125.27	184.30	168.05	150.49	192.59	192.59	279.48	298.72	240.84
27.	JDNOL-11-11 x Pusa Sawani	121.64	120.04	180.02	174.87	149.14	166.01	187.01	226.58	267.20	211.70
28.	JDNOL-11-11 x Parbhani Kranti	118.37	112.91	176.60	171.77	144.91	188.48	188.48	290.57	260.86	232.10
29.	JDNOL-11-11 x GO-2	110.20	131.99	148.13	154.45	136.19	197.69	197.70	263.71	285.42	236.13
30.	JDNOL-11-11 x VRO-6	124.65	132.22	180.34	174.01	152.81	223.74	216.62	307.37	298.82	261.64
31.	JDNOL-11-12 x Arka Anamika	129.30	121.36	143.71	149.85	136.05	207.46	207.46	304.92	268.93	247.19
32.	JDNOL-11-12 x Pusa Sawani	124.78	120.50	155.75	160.49	140.38	197.29	197.29	267.59	287.91	237.52
33.	JDNOL-11-12 x Parbhani Kranti	111.41	121.34	166.76	173.10	143.15	165.35	196.50	271.93	289.71	230.87
34.	JDNOL-11-12 x GO-2	128.37	101.30	185.54	166.07	145.32	183.55	183.55	278.32	236.74	220.54
35.	JDNOL-11-12 x VRO-6	115.07	121.79	179.46	170.63	146.74	185.10	189.43	306.11	286.11	241.69
36.	JDNOL-11-14 x Arka Anamika	119.18	126.83	158.11	160.50	141.16	175.22	175.22	243.69	252.69	211.70
37.	JDNOL-11-14 x Pusa Sawani	120.34	129.33	151.35	180.67	145.42	201.98	202.31	288.06	306.22	249.64
38.	JDNOL-11-14 x Parbhani Kranti	117.14	130.03	180.72	173.64	150.38	192.29	235.75	331.69	321.47	270.30
39.	JDNOL-11-14 x GO-2	118.57	118.92	173.88	170.33	145.43	213.73	213.73	305.40	306.71	259.89
40.	JDNOL-11-14 x VRO-6	124.42	122.69	175.04	170.79	148.24	214.85	214.86	283.97	319.34	258.26
41.	AOL-07-9 x Arka Anamika	123.69	121.06	172.34	168.14	146.31	203.87	203.87	297.04	289.38	248.54
42.	AOL-07-9 x Pusa Sawani	117.27	117.61	141.39	144.61	130.22	191.62	191.62	284.19	268.84	234.07
43.	AOL-07-9 x Parbhani Kranti	115.86	126.52	168.03	160.40	142.70	183.43	183.43	273.49	286.80	231.79
44.	AOL-07-9 x GO-2	129.73	114.23	138.76	153.67	134.10	198.56	198.57	285.92	306.34	247.35
45.	AOL-07-9 x VRO-6	120.78	124.34	165.71	175.82	146.66	181.13	181.14	258.16	245.57	216.50
46.	AOL-08-5 x Arka Anamika	121.22	103.11	169.21	171.35	141.22	190.36	190.36	301.60	273.38	238.92
47.	AOL-08-5 x Pusa Sawani	119.83	125.11	185.35	173.26	150.89	204.75	204.76	302.61	304.63	254.19
48.	AOL-08-5 x Parbhani Kranti	122.93	126.51	182.34	178.75	152.63	212.66	232.66	294.22	300.94	260.12
49.	AOL-08-5 x GO-2	112.34	125.85	178.20	173.79	147.54	203.32	203.32	311.64	313.17	257.86

Appendix V: Continue…

50.	AOL-08-5 x VRO-6	120.11	114.89	153.91	163.93	138.21	212.96	212.96	281.93	265.36	243.30
51.	JOL-6k-2 x Arka Anamika	125.71	128.11	170.31	170.77	148.72	185.91	185.91	241.38	296.19	227.35
52.	JOL-6k-2 x Pusa Sawani	118.61	124.90	176.76	158.78	144.76	189.77	189.77	264.49	273.08	229.28
53.	JOL-6k-2 x Parbhani Kranti	115.04	119.17	167.25	153.92	138.84	198.63	198.63	287.35	307.49	248.02
54.	JOL-6k-2 x GO-2	126.30	120.93	143.70	167.31	139.56	209.22	209.22	291.05	281.25	247.68
55.	JOL-6k-2 x VRO-6	109.27	104.72	155.00	156.86	131.46	203.00	203.00	259.38	296.51	240.47
56.	JOL-08-7 x Arka Anamika	114.94	127.37	169.43	170.99	145.68	212.22	212.22	293.11	290.45	252.00
57.	JOL-08-7 x Pusa Sawani	122.43	128.01	177.47	181.41	152.33	201.78	237.54	311.88	292.41	260.90
58.	JOL-08-7 x Parbhani Kranti	113.99	124.03	178.66	171.91	147.15	219.39	232.39	337.06	329.68	279.63
59.	JOL-08-7 x GO-2	121.02	113.40	145.32	170.95	137.67	190.52	190.52	322.75	325.54	257.33
60.	JOL-08-7 x VRO-6	124.23	126.79	163.49	176.53	147.76	198.98	208.33	287.22	265.05	239.90
61.	JOL-08-12 x Arka Anamika	125.26	109.10	170.42	171.51	144.07	168.07	168.07	289.61	292.51	229.56
62.	JOL-08-12 x Pusa Sawani	114.36	130.80	167.38	182.34	148.72	208.60	248.45	327.91	300.68	271.41
63.	JOL-08-12 x Parbhani Kranti	123.23	122.16	178.90	171.52	148.95	213.69	218.45	281.76	311.64	256.38
64.	JOL-08-12 x GO-2	116.61	115.07	176.47	166.47	143.66	207.89	207.89	305.43	286.67	251.97
65.	JOL-08-12 x VRO-6	128.87	129.61	182.61	170.14	152.80	212.14	229.81	312.63	315.12	267.43
Minimum		109.27	98.09	127.67	135.47	120.20	165.35	168.07	226.58	236.74	211.70
Maximum		129.73	132.22	187.93	182.74	153.58	223.74	248.45	337.06	329.68	279.63
Mean		120.12	121.28	166.25	166.46	143.53	197.56	203.37	285.80	288.45	243.79
66.	Check (GJOH-3)	127.48	126.72	173.81	177.07	151.27	221.04	240.70	305.84	308.64	269.06
General Mean		120.54	121.22	164.74	166.10	143.15	195.16	201.01	282.26	288.35	241.69
Parental Mean		121.94	121.04	159.74	164.91	141.91	187.17	193.14	270.50	288.02	234.71
Hybrids Mean		120.12	121.27	166.24	166.45	143.52	197.55	203.37	285.79	288.44	243.79
S.Em. ±		4.49	3.45	6.18	6.27	2.42	8.40	7.11	12.25	10.55	4.85

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

Appendix VI: Mean values of parents and hybrids in individual environments and pooled over environment for total number of fruits per plant and total number of seed per fruit

Sr. No.	Genotypes	Total number of fruits per plant					Total number of seed per fruit				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	13.97	17.33	21.50	21.66	18.61	43.51	42.87	49.76	47.92	46.01
2.	JDNOL-11-3	18.25	18.65	23.88	21.10	20.47	46.13	42.62	50.22	49.88	47.21
3.	JDNOL-11-11	16.04	14.65	20.79	20.12	17.90	42.81	39.97	47.90	46.56	44.31
4.	JDNOL-11-12	16.36	15.79	20.63	19.15	17.98	46.17	44.87	49.78	45.13	46.49
5.	JDNOL-11-14	17.09	18.85	21.22	21.33	19.62	45.42	44.63	51.91	48.73	47.67
6.	AOL-07-9	18.54	19.44	23.19	22.58	20.93	42.59	42.18	52.93	50.78	47.12
7.	AOL-08-5	15.62	17.37	22.02	22.65	19.42	43.26	41.66	48.91	48.03	45.47
8.	JOL-6k-2	13.32	14.27	21.98	20.72	17.57	45.24	38.80	50.79	49.44	46.07
9.	JOL-08-7	16.10	14.24	18.82	19.76	17.23	42.90	41.71	47.87	46.69	44.79
10.	JOL-08-12	17.39	20.50	20.63	19.79	19.58	46.55	45.02	52.15	49.31	48.26
Minimum		13.32	14.24	18.82	19.15	17.23	42.59	38.80	47.87	45.13	44.31
Maximum		18.54	20.50	23.88	22.65	20.93	46.55	45.02	52.93	50.78	48.26
Mean		16.27	17.11	21.47	20.89	18.93	44.46	42.43	50.22	48.25	46.34
MALES (TESTERS)											
11.	Arka Anamika	18.44	18.61	19.73	21.16	19.49	41.95	42.11	49.50	52.82	46.59
12.	Pusa Sawani	17.59	19.59	24.45	21.59	20.80	44.63	43.99	54.34	51.09	48.51
13.	Parbhani Kranti	17.10	17.37	21.86	20.80	19.28	46.36	45.16	52.71	52.03	49.06
14.	GO-2	16.30	15.13	21.24	18.71	17.85	43.06	40.18	46.42	46.78	44.11
15.	VRO-6	20.05	17.71	23.86	21.49	20.78	44.69	44.01	52.92	49.39	47.75
Minimum		16.30	15.13	19.73	18.71	17.85	41.95	40.18	46.42	46.78	44.11
Maximum		20.05	19.59	24.45	21.59	20.80	46.36	45.16	54.34	52.82	49.06
Mean		17.89	17.68	22.23	20.75	19.64	44.14	43.09	51.18	50.42	47.21
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	17.54	17.97	22.27	21.43	19.80	41.38	41.84	48.61	48.65	45.12
17.	JDNOL-11-1 x Pusa Sawani	16.39	18.37	22.48	21.10	19.58	43.82	44.68	48.00	45.75	45.56
18.	JDNOL-11-1 x Parbhani Kranti	17.74	16.92	21.73	22.41	19.70	42.90	41.76	47.73	47.19	44.90

Appendix VI: Continue…

19.	JDNOL-11-1 x GO-2	17.60	17.56	20.50	22.50	19.54	43.98	44.30	49.02	47.78	46.27
20.	JDNOL-11-1 x VRO-6	19.55	18.20	23.19	20.97	20.48	44.39	40.03	50.11	51.13	46.41
21.	JDNOL-11-3 x Arka Anamika	18.39	17.46	21.86	22.51	20.06	42.57	44.23	51.87	45.00	45.92
22.	JDNOL-11-3 x Pusa Sawani	16.31	17.09	22.33	20.52	19.06	45.14	42.99	47.95	49.81	46.47
23.	JDNOL-11-3 x Parbhani Kranti	19.70	19.31	25.29	23.19	21.87	46.70	44.52	53.58	52.48	49.32
24.	JDNOL-11-3 x GO-2	16.41	15.52	19.92	21.31	18.29	44.00	43.90	46.73	48.64	45.82
25.	JDNOL-11-3 x VRO-6	17.87	17.86	21.53	22.24	19.88	45.87	43.43	49.28	44.21	45.70
26.	JDNOL-11-11 x Arka Anamika	16.28	16.44	22.22	21.71	19.17	45.05	44.33	51.34	48.40	47.28
27.	JDNOL-11-11 x Pusa Sawani	16.92	17.28	25.66	19.26	19.78	50.21	40.06	47.08	46.12	45.87
28.	JDNOL-11-11 x Parbhani Kranti	17.18	16.73	22.56	19.76	19.06	48.90	41.99	52.54	44.89	47.08
29.	JDNOL-11-11 x GO-2	15.02	17.99	20.05	22.57	18.91	42.85	44.94	48.27	52.47	47.14
30.	JDNOL-11-11 x VRO-6	20.88	20.00	24.70	21.34	21.73	48.47	46.56	55.59	50.76	50.35
31.	JDNOL-11-12 x Arka Anamika	16.73	16.21	19.82	21.39	18.54	41.14	43.69	49.04	45.43	44.82
32.	JDNOL-11-12 x Pusa Sawani	17.62	17.09	21.60	22.90	19.80	42.99	40.66	50.30	47.55	45.37
33.	JDNOL-11-12 x Parbhani Kranti	14.75	16.66	23.44	20.43	18.82	45.05	45.35	49.99	50.51	47.73
34.	JDNOL-11-12 x GO-2	17.24	18.11	23.95	22.29	20.40	52.51	41.53	51.40	49.12	48.64
35.	JDNOL-11-12 x VRO-6	17.21	16.96	18.69	21.13	18.50	45.10	41.40	49.65	55.64	47.95
36.	JDNOL-11-14 x Arka Anamika	19.77	20.23	19.04	21.36	20.10	43.98	44.33	48.12	50.54	46.74
37.	JDNOL-11-14 x Pusa Sawani	19.18	18.46	21.41	19.95	19.75	47.97	46.03	54.22	51.43	49.91
38.	JDNOL-11-14 x Parbhani Kranti	18.16	18.74	21.52	23.05	20.37	44.04	43.05	52.83	52.49	48.10
39.	JDNOL-11-14 x GO-2	19.17	19.33	23.67	20.46	20.66	47.27	43.43	49.19	53.47	48.34
40.	JDNOL-11-14 x VRO-6	21.60	19.54	26.24	21.80	22.29	45.29	47.18	50.65	48.57	47.92
41.	AOL-07-9 x Arka Anamika	17.16	19.09	21.82	22.29	20.09	46.87	42.19	50.70	52.09	47.96
42.	AOL-07-9 x Pusa Sawani	15.32	17.54	20.94	22.94	19.18	40.88	41.53	47.75	47.73	44.47
43.	AOL-07-9 x Parbhani Kranti	18.66	18.17	22.76	20.19	19.95	44.10	43.07	49.74	46.84	45.94
44.	AOL-07-9 x GO-2	16.60	18.63	18.17	18.78	18.05	45.03	42.79	50.22	51.12	47.29
45.	AOL-07-9 x VRO-6	18.36	15.93	24.02	21.10	19.85	46.29	43.97	48.86	52.69	47.96
46.	AOL-08-5 x Arka Anamika	14.56	16.81	22.65	21.15	18.79	41.88	42.14	49.27	48.19	45.37
47.	AOL-08-5 x Pusa Sawani	19.34	20.52	23.31	22.14	21.33	45.69	44.35	56.07	51.23	49.33
48.	AOL-08-5 x Parbhani Kranti	18.40	18.78	19.11	22.40	19.67	48.31	43.60	53.03	53.61	49.64
49.	AOL-08-5 x GO-2	19.17	19.83	22.08	23.06	21.03	51.71	46.68	52.15	50.46	50.25

Appendix VI: Continue…

50.	AOL-08-5 x VRO-6	18.66	18.58	21.38	22.17	20.20	47.73	41.12	51.82	49.66	47.58
51.	JOL-6k-2 x Arka Anamika	17.58	16.57	21.66	20.74	19.14	42.84	43.49	50.56	48.95	46.46
52.	JOL-6k-2 x Pusa Sawani	18.92	15.54	19.21	18.52	18.05	43.66	43.98	48.39	48.51	46.14
53.	JOL-6k-2 x Parbhani Kranti	18.56	17.16	17.91	22.28	18.98	44.28	44.92	50.13	46.51	46.46
54.	JOL-6k-2 x GO-2	17.98	16.78	20.33	21.62	19.18	46.56	46.92	49.93	48.83	48.06
55.	JOL-6k-2 x VRO-6	19.19	18.11	22.55	21.84	20.42	42.86	45.41	49.57	50.94	47.19
56.	JOL-08-7 x Arka Anamika	16.42	15.44	21.86	20.27	18.50	39.36	42.89	50.33	50.14	45.68
57.	JOL-08-7 x Pusa Sawani	17.41	20.14	22.26	22.54	20.59	47.40	47.96	52.42	52.73	50.13
58.	JOL-08-7 x Parbhani Kranti	19.53	18.86	23.35	23.36	21.28	50.26	48.21	53.40	51.36	50.81
59.	JOL-08-7 x GO-2	18.92	18.57	24.71	22.97	21.29	47.05	42.17	50.75	52.26	48.06
60.	JOL-08-7 x VRO-6	19.69	19.43	19.57	19.85	19.63	43.83	48.72	54.59	47.44	48.64
61.	JOL-08-12 x Arka Anamika	18.43	15.57	20.85	22.08	19.23	42.64	43.46	52.23	46.13	46.12
62.	JOL-08-12 x Pusa Sawani	19.03	18.14	23.60	19.81	20.14	48.50	44.00	51.50	51.98	48.99
63.	JOL-08-12 x Parbhani Kranti	19.01	17.69	22.29	21.53	20.13	45.61	44.49	48.64	52.94	47.92
64.	JOL-08-12 x GO-2	16.10	15.45	20.40	21.43	18.34	42.32	41.42	48.72	45.27	44.43
65.	JOL-08-12 x VRO-6	20.74	17.62	22.37	23.31	21.01	46.67	50.26	54.15	51.29	50.59
Minimum		14.56	15.44	17.91	18.52	18.05	39.36	40.03	46.73	44.21	44.43
Maximum		21.60	20.52	26.24	23.36	22.29	52.51	50.26	56.07	55.64	50.81
Mean		17.98	17.82	21.90	21.52	19.80	45.28	43.92	50.56	49.54	47.32
66.	Check (GJOH-3)	21.24	21.56	23.81	22.38	22.25	47.06	45.11	54.22	51.28	49.42
General Mean		17.70	17.69	21.85	21.36	19.65	45.06	43.62	50.55	49.40	47.16
Parental Mean		16.81	17.30	21.72	20.83	19.16	44.35	42.65	50.53	48.97	46.62
Hybrids Mean		17.97	17.81	21.89	21.51	19.80	45.27	43.92	50.56	49.53	47.32
S.Em. ±		0.88	0.87	0.97	0.97	0.46	1.67	1.32	1.75	1.60	0.81

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

Appendix VII: Mean values of parents and hybrids in individual environments and pooled over environment for days to last picking and crude protein content (%)

Sr. No.	Genotypes	Days to last picking					Crude protein content (%)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	104.72	118.63	119.16	121.59	116.03	26.10	25.90	27.44	25.67	26.28
2.	JDNOL-11-3	113.22	118.46	130.01	125.95	121.91	27.03	25.71	28.40	28.09	27.31
3.	JDNOL-11-11	113.83	112.26	117.57	118.27	115.48	25.46	24.91	26.20	26.82	25.85
4.	JDNOL-11-12	114.08	114.48	127.94	123.94	120.11	25.37	25.27	26.53	27.53	26.17
5.	JDNOL-11-14	116.37	124.28	132.25	131.84	126.18	25.77	25.18	28.01	27.81	26.69
6.	AOL-07-9	114.07	121.69	119.35	129.35	121.11	25.20	25.53	27.67	26.35	26.19
7.	AOL-08-5	109.25	109.30	113.28	119.10	112.73	25.44	26.72	27.21	25.68	26.26
8.	JOL-6k-2	104.12	102.95	118.74	121.10	111.73	24.95	26.49	26.65	26.34	26.11
9.	JOL-08-7	105.42	101.99	123.14	121.31	112.97	23.64	26.50	26.04	24.54	25.18
10.	JOL-08-12	104.27	122.06	125.30	124.07	118.92	26.18	27.13	28.22	26.76	27.07
Minimum		104.12	101.99	113.28	118.27	111.73	23.64	24.91	26.04	24.54	25.18
Maximum		116.37	124.28	132.25	131.84	126.18	27.03	27.13	28.40	28.09	27.31
Mean		109.94	114.61	122.67	123.65	117.72	25.51	25.93	27.24	26.56	26.31
MALES (TESTERS)											
11.	Arka Anamika	113.34	126.90	122.83	123.65	121.68	25.10	26.75	27.47	26.77	26.52
12.	Pusa Sawani	115.25	113.47	125.32	123.73	119.44	24.58	27.57	27.58	26.19	26.48
13.	Parbhani Kranti	117.60	112.97	127.78	130.66	122.25	25.64	26.86	26.09	26.96	26.39
14.	GO-2	100.53	96.06	118.55	122.43	109.39	24.25	26.57	26.45	26.43	25.92
15.	VRO-6	116.81	121.76	122.54	127.23	122.09	27.45	27.16	27.78	27.89	27.57
Minimum		100.53	96.06	118.55	122.43	109.39	24.25	26.57	26.09	26.19	25.92
Maximum		117.60	126.90	127.78	130.66	122.25	27.45	27.57	27.78	27.89	27.57
Mean		112.71	114.23	123.40	125.54	118.97	25.40	26.98	27.07	26.85	26.58
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	104.59	126.88	117.92	128.84	119.56	26.09	26.58	27.35	26.10	26.53
17.	JDNOL-11-1 x Pusa Sawani	108.49	112.56	125.57	113.53	115.04	24.13	27.72	27.35	26.19	26.35
18.	JDNOL-11-1 x Parbhani Kranti	109.31	123.36	120.78	119.15	118.15	26.00	26.06	26.87	26.72	26.41

Appendix VII: Continue...

19.	JDNOL-11-1 x GO-2	102.98	124.50	123.00	120.99	117.87	24.29	27.15	27.47	25.78	26.17
20.	JDNOL-11-1 x VRO-6	97.95	105.49	125.40	127.99	114.21	25.87	26.00	27.30	27.51	26.67
21.	JDNOL-11-3 x Arka Anamika	108.38	107.40	127.14	123.57	116.62	26.63	25.58	25.51	27.61	26.34
22.	JDNOL-11-3 x Pusa Sawani	108.80	117.59	120.12	120.74	116.81	24.66	26.05	26.03	26.75	25.87
23.	JDNOL-11-3 x Parbhani Kranti	116.40	104.55	129.44	128.75	119.79	25.75	27.02	27.62	27.79	27.05
24.	JDNOL-11-3 x GO-2	108.09	117.44	126.22	121.49	118.31	24.28	27.16	25.14	25.34	25.48
25.	JDNOL-11-3 x VRO-6	104.37	102.76	124.40	119.64	112.79	24.63	26.57	25.30	26.85	25.84
26.	JDNOL-11-11 x Arka Anamika	113.54	127.39	131.60	114.27	121.70	22.24	26.08	24.43	26.53	24.82
27.	JDNOL-11-11 x Pusa Sawani	115.59	117.46	127.76	127.01	121.96	23.34	27.12	27.22	25.62	25.82
28.	JDNOL-11-11 x Parbhani Kranti	109.75	113.05	123.77	117.59	116.04	25.27	24.67	28.14	27.51	26.40
29.	JDNOL-11-11 x GO-2	109.08	118.49	125.93	112.88	116.59	24.73	26.21	27.12	27.61	26.42
30.	JDNOL-11-11 x VRO-6	116.99	124.03	130.42	130.25	125.42	26.54	26.61	27.82	27.74	27.18
31.	JDNOL-11-12 x Arka Anamika	113.41	118.23	129.88	126.35	121.97	25.51	25.81	25.56	26.78	25.92
32.	JDNOL-11-12 x Pusa Sawani	114.42	114.23	128.63	126.13	120.85	23.81	25.63	26.16	25.34	25.24
33.	JDNOL-11-12 x Parbhani Kranti	106.09	115.56	124.67	127.33	118.41	24.82	26.33	26.57	26.85	26.14
34.	JDNOL-11-12 x GO-2	107.26	117.68	127.54	127.59	120.02	26.57	26.73	25.55	26.83	26.42
35.	JDNOL-11-12 x VRO-6	106.42	116.37	124.11	128.48	118.84	24.61	25.05	27.93	26.98	26.14
36.	JDNOL-11-14 x Arka Anamika	110.09	108.05	126.98	114.46	114.89	27.05	25.71	26.07	26.28	26.28
37.	JDNOL-11-14 x Pusa Sawani	115.00	124.11	129.13	126.74	123.74	24.28	27.55	26.45	27.58	26.46
38.	JDNOL-11-14 x Parbhani Kranti	114.60	122.57	126.13	120.81	121.03	25.54	27.73	25.82	27.80	26.72
39.	JDNOL-11-14 x GO-2	114.64	122.17	129.64	130.92	124.35	25.76	28.39	28.51	26.91	27.39
40.	JDNOL-11-14 x VRO-6	105.21	108.58	124.27	123.98	115.51	26.23	26.39	27.57	26.86	26.76
41.	AOL-07-9 x Arka Anamika	104.75	117.56	129.31	125.33	119.24	25.72	26.89	26.90	25.91	26.36
42.	AOL-07-9 x Pusa Sawani	118.33	133.17	128.00	113.88	123.34	23.81	27.03	25.31	26.27	25.61
43.	AOL-07-9 x Parbhani Kranti	115.89	109.12	111.87	124.25	115.28	24.60	26.87	27.57	26.72	26.44
44.	AOL-07-9 x GO-2	109.41	118.44	115.05	113.65	114.14	23.32	25.45	25.63	25.57	24.99
45.	AOL-07-9 x VRO-6	111.19	129.78	118.90	127.38	121.81	26.25	26.63	26.53	26.00	26.35
46.	AOL-08-5 x Arka Anamika	101.75	114.07	126.97	122.94	116.44	25.58	24.00	26.54	25.95	25.52
47.	AOL-08-5 x Pusa Sawani	106.70	125.36	129.98	130.16	123.05	25.75	26.46	28.05	27.36	26.90
48.	AOL-08-5 x Parbhani Kranti	116.82	118.59	129.24	123.63	122.07	24.87	27.68	27.49	26.58	26.66
49.	AOL-08-5 x GO-2	100.87	119.93	129.67	129.24	119.93	26.21	26.17	26.12	28.16	26.67

Appendix VII: Continue...

50.	AOL-08-5 x VRO-6	116.12	113.43	125.95	122.87	119.59	25.52	27.03	27.37	25.84	26.44
51.	JOL-6k-2 x Arka Anamika	108.66	120.27	126.88	120.33	119.03	23.46	26.92	26.24	24.95	25.39
52.	JOL-6k-2 x Pusa Sawani	106.09	106.52	124.40	121.93	114.74	24.88	25.83	27.15	26.42	26.07
53.	JOL-6k-2 x Parbhani Kranti	105.01	122.49	116.42	125.12	117.26	25.16	27.37	26.97	26.46	26.49
54.	JOL-6k-2 x GO-2	102.75	122.36	122.19	122.83	117.53	23.77	27.01	26.64	26.14	25.89
55.	JOL-6k-2 x VRO-6	104.14	117.81	126.92	120.83	117.43	25.26	27.04	27.43	26.62	26.59
56.	JOL-08-7 x Arka Anamika	107.75	114.85	118.30	119.01	114.98	25.26	25.98	25.48	25.59	25.58
57.	JOL-08-7 x Pusa Sawani	115.45	121.36	130.04	123.16	122.50	25.90	26.82	27.84	27.47	27.01
58.	JOL-08-7 x Parbhani Kranti	114.59	124.36	126.39	127.55	123.22	26.33	26.01	28.66	27.42	27.11
59.	JOL-08-7 x GO-2	107.34	125.29	129.44	124.60	121.67	28.44	27.31	27.07	25.99	27.20
60.	JOL-08-7 x VRO-6	114.44	117.68	128.92	119.57	120.15	25.64	26.21	25.60	26.38	25.96
61.	JOL-08-12 x Arka Anamika	105.82	105.10	122.66	122.85	114.11	24.38	24.90	27.79	26.35	25.86
62.	JOL-08-12 x Pusa Sawani	116.97	113.68	125.10	125.30	120.26	25.60	26.03	28.47	26.58	26.67
63.	JOL-08-12 x Parbhani Kranti	112.45	127.09	132.01	130.38	125.48	24.50	26.25	28.73	26.63	26.53
64.	JOL-08-12 x GO-2	102.42	113.23	120.64	118.93	113.81	23.73	24.21	26.59	25.60	25.03
65.	JOL-08-12 x VRO-6	115.76	124.36	129.72	128.61	124.61	27.08	27.04	28.15	25.80	27.02
Minimum		97.95	102.76	111.87	112.88	112.79	22.24	24.00	24.43	24.95	24.82
Maximum		118.33	133.17	132.01	130.92	125.48	28.44	28.39	28.73	28.16	27.39
Mean		109.66	117.73	125.51	123.28	119.04	25.19	26.42	26.86	26.57	26.26
66.	Check (GJOH-3)	115.74	125.76	129.36	130.74	125.40	25.80	27.23	29.53	27.68	27.56
General Mean		109.93	116.97	124.91	123.50	118.83	25.25	26.38	26.93	26.59	26.29
Parental Mean		110.85	114.48	122.91	124.28	118.13	25.47	26.28	27.18	26.65	26.39
Hybrids Mean		109.65	117.72	125.50	123.27	119.04	25.19	26.42	26.86	26.57	26.26
S.Em. ±		4.18	3.71	3.89	3.75	1.87	0.85	0.70	0.70	0.65	0.37

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

Appendix VIII: Mean values of parents and hybrids in individual environments and pooled over environment for crude fiber content (%) and vitamin 'C' (mg/100 g pulp)

Sr. No.	Genotypes	Crude fiber content (%)					Vitamin 'C' (mg/100 g pulp)				
		E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4	Pooled
PARENTS											
FEMALES (LINES)											
1.	JDNOL-11-1	4.66	4.44	4.34	4.49	4.48	13.52	14.16	14.36	14.49	14.13
2.	JDNOL-11-3	4.82	5.25	4.94	5.27	5.07	15.94	14.42	14.94	15.59	15.22
3.	JDNOL-11-11	4.75	4.50	4.45	4.70	4.60	14.32	13.55	14.59	14.96	14.35
4.	JDNOL-11-12	4.69	4.39	4.10	4.38	4.39	13.36	14.01	13.50	12.68	13.39
5.	JDNOL-11-14	5.06	4.88	4.42	4.72	4.77	15.19	14.83	15.35	15.06	15.11
6.	AOL-07-9	5.04	5.11	4.39	5.14	4.92	15.11	15.08	14.70	14.97	14.96
7.	AOL-08-5	4.78	4.54	5.06	4.66	4.76	13.77	13.43	12.57	13.09	13.21
8.	JOL-6k-2	4.73	4.77	4.64	4.61	4.69	14.51	14.48	14.16	14.40	14.39
9.	JOL-08-7	4.68	4.70	4.76	4.44	4.64	10.46	12.81	12.86	13.61	12.44
10.	JOL-08-12	4.91	4.98	4.96	5.06	4.98	15.08	14.12	14.92	15.47	14.90
Minimum		4.66	4.39	4.10	4.38	4.39	10.46	12.81	12.57	12.68	12.44
Maximum		5.06	5.25	5.06	5.27	5.07	15.94	15.08	15.35	15.59	15.22
Mean		4.81	4.76	4.60	4.75	4.73	14.12	14.09	14.20	14.43	14.21
MALES (TESTERS)											
11.	Arka Anamika	4.69	4.70	5.05	4.94	4.84	14.75	14.63	13.96	14.45	14.45
12.	Pusa Sawani	5.04	5.06	5.31	5.09	5.13	15.64	14.46	15.37	15.10	15.14
13.	Parbhani Kranti	4.84	4.73	4.79	5.02	4.85	14.34	14.31	15.26	14.70	14.65
14.	GO-2	4.67	4.38	4.52	4.86	4.61	13.16	11.43	13.04	13.31	12.73
15.	VRO-6	4.77	4.72	5.08	5.37	4.98	15.66	14.28	15.10	14.80	14.96
Minimum		4.67	4.38	4.52	4.86	4.61	13.16	11.43	13.04	13.31	12.73
Maximum		5.04	5.06	5.31	5.37	5.13	15.66	14.63	15.37	15.10	15.14
Mean		4.80	4.72	4.95	5.06	4.88	14.71	13.82	14.55	14.47	14.39
HYBRIDS											
16.	JDNOL-11-1 x Arka Anamika	4.59	4.59	4.76	5.10	4.76	14.82	14.34	14.43	14.86	14.61
17.	JDNOL-11-1 x Pusa Sawani	4.62	5.08	4.26	4.91	4.72	15.44	14.16	13.04	14.51	14.29
18.	JDNOL-11-1 x Parbhani Kranti	4.85	4.83	5.23	4.84	4.94	14.34	14.59	14.43	15.52	14.72

Appendix VIII: Continue…

19.	JDNOL-11-1 x GO-2	5.04	5.06	4.70	5.05	4.96	15.28	14.81	15.31	14.32	14.93
20.	JDNOL-11-1 x VRO-6	5.17	4.63	4.96	4.95	4.93	14.31	15.04	15.82	14.28	14.86
21.	JDNOL-11-3 x Arka Anamika	4.46	4.48	4.12	4.86	4.48	14.44	15.18	14.72	14.17	14.63
22.	JDNOL-11-3 x Pusa Sawani	4.47	4.00	4.33	4.72	4.38	14.80	15.17	15.01	14.48	14.87
23.	JDNOL-11-3 x Parbhani Kranti	5.09	5.52	5.13	5.10	5.21	15.34	15.22	15.88	15.23	15.42
24.	JDNOL-11-3 x GO-2	4.45	4.47	4.98	4.83	4.68	14.33	15.00	14.73	14.80	14.72
25.	JDNOL-11-3 x VRO-6	4.57	4.18	4.51	4.73	4.50	14.31	14.54	13.35	13.39	13.90
26.	JDNOL-11-11 x Arka Anamika	4.78	4.79	4.45	4.85	4.72	14.40	15.67	13.93	15.28	14.82
27.	JDNOL-11-11 x Pusa Sawani	5.01	4.80	5.11	4.72	4.91	14.24	15.66	13.95	13.53	14.34
28.	JDNOL-11-11 x Parbhani Kranti	4.85	4.08	4.92	4.92	4.69	14.34	15.01	13.87	14.72	14.48
29.	JDNOL-11-11 x GO-2	4.77	4.78	4.75	4.81	4.78	15.28	15.48	14.89	13.90	14.89
30.	JDNOL-11-11 x VRO-6	5.04	5.65	5.23	5.46	5.35	14.31	15.66	15.52	14.94	15.11
31.	JDNOL-11-12 x Arka Anamika	4.44	4.24	4.91	4.20	4.45	14.87	13.36	14.81	12.22	13.82
32.	JDNOL-11-12 x Pusa Sawani	4.23	4.25	4.89	5.12	4.62	14.39	13.34	14.43	12.51	13.67
33.	JDNOL-11-12 x Parbhani Kranti	4.29	3.84	4.41	4.27	4.20	14.34	12.76	13.50	11.72	13.08
34.	JDNOL-11-12 x GO-2	5.05	4.23	4.65	4.17	4.52	12.28	13.18	14.11	12.82	13.10
35.	JDNOL-11-12 x VRO-6	4.32	4.34	5.30	5.15	4.78	14.31	12.75	13.04	11.48	12.89
36.	JDNOL-11-14 x Arka Anamika	4.73	4.97	5.03	4.97	4.92	13.24	14.70	14.35	14.96	14.31
37.	JDNOL-11-14 x Pusa Sawani	5.03	4.52	4.79	4.95	4.82	15.64	13.01	15.21	15.47	14.83
38.	JDNOL-11-14 x Parbhani Kranti	4.80	5.80	4.31	5.69	5.15	15.19	14.07	15.00	15.29	14.89
39.	JDNOL-11-14 x GO-2	4.99	5.44	5.65	5.60	5.42	15.28	14.91	15.24	14.35	14.94
40.	JDNOL-11-14 x VRO-6	5.59	5.75	4.51	5.02	5.22	14.31	15.36	13.98	15.00	14.66
41.	AOL-07-9 x Arka Anamika	4.48	4.87	4.73	4.93	4.75	14.46	14.64	14.43	14.60	14.53
42.	AOL-07-9 x Pusa Sawani	4.67	5.04	5.47	4.70	4.97	14.93	14.38	13.50	15.54	14.59
43.	AOL-07-9 x Parbhani Kranti	5.39	4.87	4.48	4.96	4.92	14.34	14.18	13.96	13.21	13.92
44.	AOL-07-9 x GO-2	4.57	4.88	4.97	4.91	4.83	13.95	13.94	14.89	14.94	14.43
45.	AOL-07-9 x VRO-6	4.51	4.65	5.63	5.16	4.99	14.31	14.04	13.04	12.94	13.58
46.	AOL-08-5 x Arka Anamika	4.77	4.92	5.17	5.46	5.08	13.23	13.98	14.43	14.66	14.08
47.	AOL-08-5 x Pusa Sawani	5.65	4.51	5.05	4.45	4.91	15.64	15.27	15.08	14.75	15.18
48.	AOL-08-5 x Parbhani Kranti	5.38	5.85	5.38	5.35	5.49	14.34	14.59	15.15	16.01	15.02
49.	AOL-08-5 x GO-2	5.02	5.17	4.93	5.12	5.06	15.28	15.22	14.60	15.00	15.02

Appendix VIII: Continue…

50.	AOL-08-5 x VRO-6	4.75	5.67	5.26	5.24	5.23	14.31	14.24	13.96	15.69	14.55
51.	JOL-6k-2 x Arka Anamika	5.09	4.82	4.63	4.50	4.76	13.39	13.64	15.35	13.59	13.99
52.	JOL-6k-2 x Pusa Sawani	4.71	4.95	4.68	4.85	4.80	14.57	14.49	13.96	13.56	14.15
53.	JOL-6k-2 x Parbhani Kranti	4.75	5.27	4.97	4.69	4.92	13.68	14.61	14.89	14.65	14.46
54.	JOL-6k-2 x GO-2	4.96	4.88	4.43	5.00	4.82	13.83	15.18	13.96	12.41	13.85
55.	JOL-6k-2 x VRO-6	5.29	4.90	4.49	4.85	4.88	14.21	14.89	14.53	14.97	14.65
56.	JOL-08-7 x Arka Anamika	4.46	4.48	4.94	4.47	4.59	13.40	14.88	13.04	13.36	13.67
57.	JOL-08-7 x Pusa Sawani	5.16	5.62	4.73	5.36	5.22	14.90	15.16	15.15	15.34	15.14
58.	JOL-08-7 x Parbhani Kranti	5.29	5.82	4.86	5.54	5.38	15.07	15.39	15.06	15.20	15.18
59.	JOL-08-7 x GO-2	4.45	4.99	4.88	4.95	4.82	15.28	14.82	14.45	13.99	14.63
60.	JOL-08-7 x VRO-6	4.57	4.58	3.87	4.34	4.34	14.31	14.02	12.92	12.58	13.46
61.	JOL-08-12 x Arka Anamika	4.67	4.69	4.52	4.96	4.71	13.45	15.18	14.41	14.21	14.31
62.	JOL-08-12 x Pusa Sawani	5.65	5.05	5.11	5.04	5.21	13.40	15.17	15.32	14.99	14.72
63.	JOL-08-12 x Parbhani Kranti	5.26	5.56	5.24	5.12	5.30	14.34	15.01	14.99	15.12	14.86
64.	JOL-08-12 x GO-2	4.66	4.68	4.73	4.76	4.71	13.28	14.32	13.30	14.29	13.80
65.	JOL-08-12 x VRO-6	4.84	4.80	5.47	4.82	4.99	15.28	15.18	15.50	15.09	15.26
Minimum		4.23	3.84	3.87	4.17	4.20	12.28	12.75	12.92	11.48	12.89
Maximum		5.65	5.85	5.65	5.69	5.49	15.64	15.67	15.88	16.01	15.42
Mean		4.85	4.88	4.85	4.93	4.88	14.42	14.59	14.45	14.29	14.44
66.	Check (GJOH-3)	4.80	6.01	5.76	5.34	5.48	15.73	14.16	16.03	15.13	15.27
General Mean		4.83	4.84	4.81	4.91	4.85	14.39	14.45	14.41	14.32	14.39
Parental Mean		4.80	4.74	4.71	4.85	4.78	14.31	13.99	14.31	14.44	14.26
Hybrids Mean		4.84	4.87	4.85	4.92	4.87	14.4	14.58	14.44	14.28	14.43
S.Em. ±		0.12	0.09	0.12	0.12	0.05	0.43	0.41	0.33	0.388	0.19

Note : E_1, E_2, E_3 and E_4 are different environments *viz.*, Timely summer, Late summer, Timely *kharif* and Late *kharif*, respectively.

CERTIFICATE

This is to certify that, I have no objection for supplying to any scientist only one copy or any part of this thesis at a time through reprographic process, if necessary for rendering reference service in a library or documentation center.

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Date : 26th September, 2017