# STUDY ON PHENOTYPIC CHARACTERIZATION ALONG WITH $F_1$ OKRA HYBRID ANALYSIS FOR HETEROSIS, COMBINING ABILITY AND STABILITY

Thesis Submitted for the Award of the Degree of

**DOCTOR OF PHILOSOPHY**

**in**

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**LOVELY PROFESSIONAL UNIVERSITY,**

**PUNJAB 2025**

# DECLARATION

I hereby declare that the project work entitled in **" Study on Phenotypic characterization along with $F_1$ okra hybrid analysis for heterosis, combining ability and stability"** is an authentic record of my work carried at Lovely professional University as requirement for the award of degree of **Doctor of Philosophy (Ph.D)** in the discipline of **Genetics and Plant Breeding,** under the guidance of **Dr. Talekar Nilesh Suryakant,** Assistant Professor, School of Agriculture, Lovely Professional University, Phagwara-144411, Punjab, India and no part of this research work has been submitted for any other degree or diploma.

**(Signature of Scholar)**

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# CERTIFICATE

This is to certify that the thesis entitled**" Study on Phenotypic characterization along with $F_1$ okra hybrid analysis for heterosis, combining ability and stability"** submitted impartial fulfilment of requirements for degree **Doctor of Philosophy (Ph.D)** in the discipline of **Genetics and Plant Breeding** from School of Agriculture, Lovely Professional University, Phagwara is a record of bonafide research work carried out by **Pujala Venkata Abhilash** of **Reg. No. 12021134** under my guidance and supervision and no part of thesis has been submitted for any other degree or diploma. All the assistance and help received during investigation have been acknowledged.

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## ABSTRACT

# STUDY ON PHENOTYPIC CHARACTERIZATION ALONG WITH $F_1$ OKRA HYBRID ANALYSIS FOR HETEROSIS, COMBINING ABILITY AND STABILITY



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An investigation was carried out on "Study on Phenotypic characterization along with $F_1$ okra hybrid analysis for heterosis, combining ability and stability" to obtain first-hand information of fifty- five okra genotypes based on genetic variability, association and genetic diversity analysis. Based on diversity analysis the parents were selected and crossed to estimate the extent of heterosis and combining ability by using a line x tester mating system involving ten lines and five testers. Parent and their cross combinations were evaluated in three different environments (early, timely and late sowing). The experiments were carried out during 2021 to 2023. Seventeen biometrical traits which includes growth, earliness, yield and yield attributing were used for the study in experiment-I, experiment-II crossing program carried out and whereas in experiment-III were used for evaluation.

Analysis of variance revealed that the genotypes for differed significantly for all the traits, which indicate that sufficient variability is present in the genotypes taken for the study. The phenotypic coefficient of variation was marginally higher than the genotypic coefficient of variation for all the traits. The traits *viz*., number of fruits per plant, number of marketable fruits, fruit yield per plant, had a high of GCV, PCV and a high heritability (bs) coupled with a high GA % as a mean. Using Mahalanobis $D^2$ analysis, classified the samples into seven clusters, with the largest being cluster I, which compose 34 germplasm. The inter-cluster distance was highest between clusters II and VII, whereas the intra-cluster distance was greatest in Cluster III. The number of fruits per plant had the highest percent contribution to the divergence.

Based on the morphological diversity, a total of 15 (10 lines and 5 testers) parents were selected for the crossing in line x tester mating design, the crossing programme was done to obtain 50 hybrids. Combining ability analysis revealed that most of the traits studied, the variances for SCA were greater than GCA, this indicates that non-additive gene action plays a

dominant role in the expression of these seventeen traits. Positive general combining ability effects for fruit yield per plant were observed for Kashi Kranti in lines and Kashi Pragati, EC169459 in the testers and in cross combinations, positive specific combining ability were recorded for IC052302 x EC169452, IC045993 x EC169452, IC045993 x IC052310, Pusa Sawani x IC052310 in pooled analysis. Based on pooled analysis heterosis (heterobeltoisis and standard heterosis) the cross combination IC058710 x EC169459, Kashi Kranti x Kashi Pragati and IC052302 x EC169452 resulted high fruit yield per plant along with other fruit related characters. Hence, these hybrid combinations can be utilized for commercial exploitation. Stability analyses based on the regression model were carried out for the parents and hybrids *viz.*, IC058235 and Pusa Sawani x EC169459 is the best hybrid in overall environments for fruit yield per plant.

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| **Abbreviations** | | **Stands for** |
|---|---|---|
| % | - | percentage |
| □ | - | square root |
| Σ | - | summation |
| σ | - | sigma |
| ‘t’ test | - | student ‘t’ test |
| cm | - | centimeter |
| mm | - | millimeter |
| df | - | degree of freedom |
| *et al*., | - | and co-workers |
| gm | - | gram |
| kg | - | Kilogram |
| SE | - | standard error |
| S.V. | - | sources of variations |
| S.S. | - | sum of squares |
| M.S.S. | - | mean sums of squares |
| *viz*., | - | namely |
| *v/s* | - | Versus |
| C.V. | - | Coefficient of variation |
| GM | - | Grand mean |
| C.D. | - | Critical difference |
| GA | - | Genetic advance |
| Min | - | Minimum |
| Max | - | Maximum |
| No. | - | Number |
| PCV | - | Phenotypic coefficient of variation |
| GCV | - | Genotypic coefficient of variation |
| $h^2$ (bs) | - | Heritability in broad sense |
| $\sigma^2\mathbf{g}$ | - | Genotypic variance |
| $\sigma^2\mathbf{p}$ | - | Phenotypic variance |
| SSR | - | Simple Sequence Repeats |
| PIC | - | Polymorphic information content |
| PCoA | - | Principal coordinate analysis |

| | | |
|---|---|---|
| L x T | - | Line x Tester |
| G | - | Genotypes |
| P | - | Parents |
| L | - | Lines |
| T | - | Testers |
| H | - | Hybrids |
| GCA | - | General combining ability variance |
| SCA | - | Specific combining ability variance |
| *gca* | - | General combining ability effects |
| *sca* | - | Specific combining ability effects |
| G x E | - | Genotype x Environment |
| AMMI | - | Additive main effects and multiplicative interaction |
| GGE | - | Genotype and Genotype x Environment (Interaction) |
| PCA | - | Principal component analysis |
| IPCA | - | Interactive principal component analysis |
| PC | - | Principal component |
| AEA | - | Average environment axis |

***CHAPTER - 1***

# INTRODUCTION

Okra or Bhendi [*Abelmoschus esculentus* (L.) Moench] is India's significant, nutritious vegetable crop within the Malvaceae family. This dicotyledon plant is a warm-season annual vegetable crop with a growing season of 90–100 days and is cultivated in tropical and subtropical regions of the world ranging from sandy to clayey soil. It is predominantly grown in parts of Africa and Asia (Ivin, J. *et al*., 2022). Bhendi, frequently undergoes often cross-pollination, with a recorded range of 4-19% cross-pollination rate, of which insects are responsible for 42.2% of this cross-pollination, as they are attracted to the plant's large and attractive blooms. Additionally, the protogynous nature of bhendi contributes to its susceptibility to cross-pollination. Bhendi is an allopolyploid and the chromosome number (2n) varies from 56 to 200, but in the present day many regular polyploids have been developed in okra bearing 2n = 56, 72, 180, 120, 132 and 144. Indian varieties are classified as belonging to the group with 2n = 130 (where n = 65) chromosomes.

Lady’s Finger / Okra also has good nutritional values, mainly Vitamin C (30mg/100gm of okra fruit), calcium (90 mg/100 gm of okra fruit) and iron (1.5 mg/100 gm of okra fruit), which is a potential exporter for over 13% of the fresh vegetable export (Singh *et al*., 2022). Okra has vast socioeconomic potential for improving people’s livelihood in both rural and urban areas which is used as stewed with meat, soups and in curries. Okra fruits in the off-season can also be either dried or green and canned forms. Seeds of okra are used as a stand in for edible oil extraction which has a higher oil content of about 40% (Samindre *et al*., 2022). Lady finger is boasts easily digestible fiber content, making it a dietary choice that is not only low in calories but also free from fat, enhancing its nutritional appeal (Reddy *et al*., 2013). Okra has high soluble fibre content in the form of gum and pectin which reduces heart risks and lower cholesterol levels, type 2 diabetes, digestive diseases and cancers and also have valuable medicinal applications when used as plasma exchange or blood volume expander (Maurya *et al*., 2022). Okra contains a variety of bioactive substances that are important for maintaining human health, including polysaccharides, rhamnogalacturonan, pectin, lectin, and polyphenolic chemicals. Fruit is abundant in iodine, which helps alleviate goitre (Elkhalifa *et al*., 2021). Typically, the roots and stems of okra can be used to clarify sugarcane juice in order to produce brown sugar and gur. (Sreedevi and Madhava, 2022).

According to FAOSTAT (2022), India is the world's largest producer of okra, accounting for around 73.96% of the global okra area, is cultivated on 555 thousand hectares in India, producing 6819 thousand MT with an average productivity of 12.07 tonnes per hectare (Agriculture Statistics at a Glance 2022). West Bengal is the top okra producing state, accounting for 13.39 percent of total production, while Punjab ranks sixteenth in the area under okra cultivation and seventeenth in production of total production (Nimbrayan *et al*., 2023).

Despite its importance, no major advances have been made in this crop, and farmers continuing to grow their own local variety or open-pollinated cultivars. The total area dedicated to F1 hybrid farming is quite limited, with Uttar Pradesh and Karnataka being the leading states in India for hybrid crop cultivation. Yield is a common breeding goal, and genotypes must be chosen for high yielding, resistance, or tolerance to biotic and abiotic stress to improve production (Kumar *et al*., 2016).

The first essential stage in any hybridization programme is to analyze genetic variability for required characteristics among accessible genotypes. Heritability is an approach used by plant breeders to effectively differentiate the amount of genetic variation from overall phenotypic variation. Strong genetic advancement and high heritability give the best selection options (Johnson *et al*., 1955). Understanding genetic variability, heritability, and other relevant factors plays a pivotal role in improving fruit production through the deliberate selection of specific traits and their influence on yield. The primary goal of genetic improvement in agriculture is to acquire insights into the genetic variability, interrelationships, and patterns of inheritance associated with specific genetic traits.

Recombination of several desired features scattered over varied genotypes is critical for improving yield and associated traits in any crop. The efficiency of tools such as Mahalanobis' $D^2$ statistics in assessing a population's genetic diversity has proven valuable (Mahendiratta and Singh, 1971). It is widely accepted that genetically heterogeneous parents will exhibit the most heterosis and provide the greatest opportunity for isolating transgressive segregants. Its objective is to find the finest recombinants from populations.

In order to design a successful heterosis breeding programme in okra, genetic architecture and assessed prepotency of parents in hybrid combinations should be known. In hybrid breeding, selection based only on phenotypic performance does not provide the expected objectives. As a result, research on parents' combining abilities is critical when selecting parents. To gather information about combining ability, many biometrical approaches have been designed. Among them, Line x Tester (Kempthorne, 1957) analysis is extensively used to analyze the parents' combining ability to select the best for heterosis breeding. It is an effective method for screening germplasm for GCA and SCA (Sprague and Tatum, 1942) variances and effects, it also aids in comprehending the underlying nature of gene action influencing the expression of multiple quantitative traits, which is pivotal for advancing the development of promising okra hybrids in crop enhancement programs. For the first time, Vijayaraghavan and Wariar (1946) discovered hybrid vigour in okra. The degree of heterosis serves as a foundation for genetic variety and as a guide for selecting appropriate parents for creating better $F_1$ hybrids. Poshiya and Shukla (1986) and Kumbhani *et al*., (1993) have previously reported on the amount of heterosis in okra in relation to yield and its components. The type and breadth of heterosis, as well as its exploitation, are the most crucial factors in assessing the viability of a hybrid. As a result, selecting the appropriate kind of parent for hybridization is critical for increasing the genetic yield potential of varieties and hybrids. This emphasizes the necessity of assessing the parents for combining ability and hybrid vigour expression, since high-yielding parents may not combine well enough to produce desirable hybrids.

The concept 'phenotypic variation' encompasses the interplay of three distinct variables: genotypic differences, environmental factors, and the interaction between genotype and environment. In research focused on varieties and breeding lines, it is common practice to cultivate multiple genotypes under diverse environmental conditions. When all genotypes exhibit comparable responses across the various tested environments, it becomes possible to make reasonably confident predictions about their performance in different environmental conditions. Baker (1988) identified a Genotype x Environment (G x E) interaction in variations in the performance of varieties across different environmental conditions. The existence of G x E interaction poses a significant challenge in obtaining precise estimates of heritability. This interaction also hinders the accurate prediction of genetic progress under selection for a specific trait with greater precision (Kang, 1998).

In light of the factors mentioned earlier, the present study involves a $D^2$ analysis to differentiate okra genotypes based on cluster performance. Selected genotypes undergo L x T mating design to develop hybrids. Efforts have been directed towards assessing G x E interactions for fruit yield in elite okra genotypes, aiming to identify stable genotypes best suited to the diverse environments of Punjab.

Keeping these considerations in mind, the current research was designed objectives:

1. To study the extant of genetic divergence in okra genotypes for parent selection.
2. To study the nature and magnitude of heterosis for fruit yield and its component traits
3. To estimate the general and specific combining ability of parents and crosses, respectively for various traits.
4. To study the nature and magnitude of gene actions governing fruit yield and its component traits.
5. To investigate stability of performance of the parents and their hybrids for key quality attributes.

*CHAPTER - 2*

# REVIEW OF LITERATURE

Knowledge of prior research in a specific field is crucial and serves as a prerequisite before embarking on any systematic research endeavour. In the okra research, significant contributions have been documented in recent years, particularly in the areas of genetics and breeding. A comprehensive summary of noteworthy and relevant studies conducted both in India and internationally, pertaining to the current research inquiry, is reviewed under the following sub-categories:

2.1 Genetic variability, heritability and genetic advance

2.2 Genetic divergence

2.3 Heterosis

2.4 Combining ability and Gene action

2.5 Stability analysis

2.6 Characterization

## 2.1 Genetic variability, heritability and genetic advance

It is essential to comprehend the extent and kind of genotypic and phenotypic variation across crop species in order to design an effective breeding program that will produce improved cultivars. Johannsen (1903) introduced the concept of variety, while expanding on the idea of pure lines. Any crop's potential for improvement is primarily based on the type and intensity of its variability. Table 1 provides a complete character-wise evaluation of GCV, PCV, GA as % and $h^2$ (bs).

**Table 1. Review of literature for variability, genetic advance and heritability on okra**

1. **First flowering node**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Ranga *et al.*, 2021 | 15 | 99.51 | 45.58 | 22.72 | 22.67 | High heritability and high GA% M were found, PCV is greater than GCV |
| **2** | Vani *et al.*, 2021 | 12 | 80 | 14.81 | 8.99 | 8.04 | High heritability and moderate GA% M found, PCV greater than GCV |
| **3** | Vinay *et al.*, 2021 | 15 | 75.42 | 10.44 | 12.70 | 10.81 | High heritability and moderate GA% M found, PCV greater than GCV |
| **4** | Awasthi *et al.*, 2022 | 18 | 88.30 | 21.87 | 12.02 | 11.03 | High heritability and high GA% M found, PCV greater than GCV |
| **5** | Baghel *et al.*, 2022 | 16 | 69.26 | 24.03 | 17.34 | 14.02 | High heritability and high GA% M found, PCV greater than GCV |
| **6** | Kharat *et al.*, 2022 | 35 | 79.00 | 15.91 | 9.74 | 8.67 | High heritability and medium GA% M found, PCV greater than GCV |
| **7** | Reddy *et al.*, 2022 | 60 | 73.26 | 20.27 | 13.43 | 11.49 | High heritability high GA% M found, PCV greater than GCV |
| **8** | Srivarsha *et al.*, 2022 | 26 | 78.97 | 23.07 | 14.18 | 12.60 | High heritability and medium GA% M found, PCV greater than GCV |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **9** | Pattnaik *et al.*, 2023 | 15 | 77.28 | 23.83 | 14.97 | 13.16 | High heritability and high GA% M found, PCV greater than GCV |
| **10** | Singh *et al.*, 2023 | 19 | 62.3 | 17.13 | 13.34 | 10.53 | High heritability and medium GA% M found, PCV greater than GCV |

**2. First fruiting node**

| **S.No** | **Reference** | **No. of genotypes** | **$h^2$ %** | **GA % mean** | **PCV %** | **GCV %** | **Finding** |
|---|---|---|---|---|---|---|---|
| **1** | Singh *et al.*, 2020 | 59 | 61.30 | 22.14 | 12.14 | 6.76 | High heritability and high GA% M found, PCV greater than GCV |
| **2** | Choudhary *et al.*, 2022 | 28 | 41.14 | 2.67 | 3.15 | 2.02 | Moderate heritability and moderate GA% M found, PCV greater than GCV |
| **3** | Jadhav *et al.*, 2022 | 26 | 92.40 | 30.68 | 2.24 | 1.98 | High heritability and high GA% M found, PCV greater than GCV |
| **4** | Reddy *et al.*, 2022 | 60 | 70.21 | 18.80 | 13.00 | 10.89 | High heritability and moderate GA% M found, PCV greater than GCV |
| **5** | Syad *et al.*, 2023 | 68 | 42.00 | 12.98 | 15.08 | 9.75 | High heritability and moderate GA% M found, PCV greater than GCV |

### 3. Days to first flowering

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Alam *et al*., 2020 | 40 | 80.91 | 16.14 | 9.68 | 8.71 | High heritability and moderate GA% M found, PCV greater than GCV |
| **2** | Sravanthi *et al*., 2021 | 32 | 83.58 | 14.68 | 8.52 | 7.79 | High heritability and moderate GA% M found, PCV greater than GCV |
| **3** | Awasthi *et al*., 2022 | 18 | 98.10 | 9.45 | 4.67 | 4.63 | High heritability was found, and the GA% M was low PCV was higher than GCV. |
| **4** | Choudhary *et al*., 2022 | 28 | 51.33 | 3.16 | 2.99 | 2.14 | Moderate heritability and low GA% M found, PCV greater than GCV |
| **5** | Mohammed *et al*., 2022 | 36 | 80.41 | 10.69 | 6.11 | 5.3 | Very high heritability and moderate GA% M found, PCV greater than GCV |
| **6** | Srivarsha *et al*., 2022 | 26 | 83.18 | 21.45 | 12.52 | 11.42 | Very high heritability and high GA% M found, PCV greater than GCV |
| **7** | Prakash *et al*., 2022 | 50 | 89.89 | 7.65 | 4.12 | 3.91 | High heritability and low GA% M found, PCV greater than GCV |
| **8** | Gendre *et al*., 2023 | 20 | 69.49 | 13.79 | 9.63 | 8.03 | High heritability and moderate GA% M found, PCV greater than GCV |
| **9** | Kumar *et al*., 2023 | 8 | 62.60 | 7.40 | 5.73 | 4.53 | High heritability and low GA% M found, PCV greater than GCV |
| **10** | Singh *et al*., 2023 | 19 | 48.30 | 7.12 | 7.17 | 4.98 | High heritability and moderate GA% M found, PCV greater than GCV |

**4. Days to 50 % flowering**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Awasthi *et al.*, 2022 | 18 | 99.00 | 10.50 | 5.15 | 5.12 | High heritability and moderate GA% M found, PCV greater than GCV |
| **2** | Jadhav *et al.*, 2022 | 26 | 98.86 | 16.37 | 8.03 | 7.29 | High heritability and moderate GA% M found, PCV greater than GCV |
| **3** | Kharat *et al.*, 2022 | 35 | 64.00 | 4.47 | 3.39 | 2.71 | High heritability and low GA% M found, PCV greater than GCV |
| **4** | Prakash *et al.*, 2022 | 50 | 86.25 | 8.5 | 4.78 | 4.44 | High heritability was found, and the GA% M was low. PCV was higher than GCV. |
| **5** | Srivarsha *et al.*, 2022 | 26 | 83.32 | 14.50 | 8.45 | 7.71 | Very high heritability and high GA% M found, PCV greater than GCV |
| **6** | Gendre *et al.*, 2023 | 20 | 63.74 | 10.87 | 8.28 | 6.61 | High heritability and moderate GA% M found, PCV greater than GCV |
| **7** | Karmata *et al.*, 2023 | 50 | 40.55 | 5.12 | 6.13 | 3.90 | Moderate heritability and low GA% M found, PCV greater than GCV |
| **8** | Kumar *et al.*, 2023 | 8 | 74.80 | 16.73 | 4.52 | 3.97 | High heritability and moderate GA% M found, PCV greater than GCV |
| **9** | Singh *et al.*, 2023 | 19 | 58.00 | 8.48 | 7.09 | 5.40 | High heritability and moderate GA% M found, PCV greater than GCV |
| **10** | Pattnaik *et al.*, 2023 | 15 | 70.79 | 14.12 | 9.68 | 8.15 | High heritability and moderate GA% M found, PCV greater than GCV |

## 5. Plant height

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Rathod *et al.*, 2019 | 155 | 71.99 | 14.57 | 9.83 | 8.34 | High heritability and high GA% M found, PCV greater than GCV |
| **2** | Kumar *et al.*, 2020 | 30 | 87.03 | 7.86 | 4.38 | 4.09 | Very high heritability and high GA% M found, PCV greater than GCV |
| **3** | Lateef *et al.*, 2020 | 45 | 79.0 | 5.58 | 3.40 | 3.03 | High heritability and moderate GA% M found, PCV greater than GCV |
| **4** | Maurya *et al.*, 2020 | 30 | 79.91 | 12.87 | 7.82 | 6.99 | High heritability and high GA% M found, PCV greater than GCV |
| **5** | Hamisu *et al.*, 2021 | 8 | 97.84 | 48.92 | 15.70 | 15.53 | High heritability and moderate GA% M found, PCV greater than GCV |
| **6** | Jadhav *et al.*, 2022 | 24 | 97.22 | 18.20 | 9.08 | 8.96 | High heritability and high GA% M found, PCV greater than GCV |
| **7** | Kharat *et al.*, 2022 | 35 | 41.00 | 2.73 | 3.27 | 2.08 | High heritability and high GA% M found, PCV greater than GCV |
| **8** | Pundir *et al.*, 2022 | 30 | 75.06 | 16.74 | 10.83 | 9.38 | High heritability and moderate GA% M found, PCV greater than GCV |
| **9** | Reddy *et al.*, 2022 | 60 | 21.73 | 1.82 | 4.06 | 1.89 | High heritability and high GA% M found, PCV greater than GCV |
| **10** | Kute *et al.*, 2023 | 36 | 95.7 | 25.38 | 12.86 | 12.59 | High heritability and high GA% M found, PCV greater than GCV |

**6. Days to 1st fruit harvest**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Temam *et al*., 2020 | 36 | 94.17 | 49.84 | 25.65 | 24.89 | High heritability and high GA% M found, PCV greater than GCV |
| **2** | Sravanthi *et al*., 2021 | 32 | 98.57 | 84.98 | 41.85 | 41.55 | High heritability and high GA% M found, PCV greater than GCV |
| **3** | Jadhav *et al*., 2022 | 26 | 97.90 | 36.35 | 17.97 | 17.78 | High heritability and high GA% M found, PCV greater than GCV |
| **4** | Kharat *et al*., 2022 | 35 | 92.00 | 12.86 | 6.49 | 6.75 | High heritability and moderate GA% M found, PCV greater than GCV |
| **5** | Srivarsha *et al*., 2022 | 26 | 88.88 | 42.27 | 23.09 | 21.77 | Very high heritability and high GA% M found, PCV greater than GCV |
| **6** | Pundir *et al*., 2022 | 30 | 82.49 | 19.54 | 11.50 | 10.44 | High heritability and moderate GA% M found, PCV greater than GCV |
| **7** | Gendre *et al*., 2023 | 20 | 98.82 | 96.66 | 47.43 | 47.20 | High heritability and high GA% M found, PCV greater than GCV |
| **8** | Karmata *et al*., 2023 | 50 | 77.85 | 31.18 | 12.13 | 10.20 | High heritability and high GA% M found, PCV greater than GCV |
| **9** | Kumar *et al*., 2023 | 8 | 96.60 | 16.73 | 8.41 | 8.26 | High heritability and moderate GA% M found, PCV greater than GCV |
| **10** | Pattnaik *et al*., 2023 | 15 | 98.15 | 23.13 | 11.44 | 11.33 | High heritability and moderate GA% M found, PCV greater than GCV |

## 7. Internodal length

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Chetana *et al*., 2021 | 42 | 93.30 | 25.13 | 13.07 | 12.63 | High heritability and high GA% M found, PCV greater than GCV |
| **2** | Alemu, 2022 | 25 | 97.16 | 58.45 | 29.16 | 28.75 | High heritability and high GA% M found, PCV greater than GCV |
| **3** | Mohammed *et al*., 2022 | 36 | 76.6 | 50.04 | 31.66 | 27.71 | High heritability and high GA% M found, PCV greater than GCV |
| **4** | Srivarsha *et al*., 2022 | 26 | 71.19 | 24.87 | 16.96 | 14.31 | High heritability and high GA% M found, PCV greater than GCV |
| **5** | Prakash *et al*., 2022 | 50 | 85.19 | 27.31 | 15.54 | 14.35 | Very high heritability and high GA% M found, PCV greater than GCV |
| **6** | Gendre *et al*., 2023 | 23 | 98.18 | 51.50 | 25.47 | 25.23 | High heritability and high GA% M found, PCV greater than GCV |
| **7** | Karmata *et al*., 2023 | 50 | 86.11 | 38.29 | 21.59 | 20.03 | High heritability and high GA% M found, PCV greater than GCV |
| **8** | Kumar *et al*., 2023 | 75 | 94.70 | 62.89 | 32.24 | 31.37 | High heritability and high GA% M found, PCV greater than GCV |
| **9** | Kute *et al*., 2023 | 36 | 84.9 | 21.51 | 12.28 | 11.32 | High heritability and high GA% M found, PCV greater than GCV |
| **10** | Pattnaik *et al*., 2023 | 15 | 79.79 | 23.81 | 14.48 | 12.94 | High heritability and high GA% M found, PCV greater than GCV |

**8. No. of nodes/plant**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Temam *et al*., 2020 | 36 | 93.17 | 45.68 | 23.76 | 22.94 | High heritability and high GA% M found, PCV greater than GCV |
| **2** | Vinay *et al*., 2021 | 15 | 72.32 | 25.55 | 29.47 | 24.75 | High heritability and high GA% M found, PCV greater than GCV |
| **3** | Alemu, 2022 | - | 72.84 | 16.40 | 10.91 | 9.31 | High heritability and moderate GA% M found, PCV greater than GCV |
| **4** | Srivarsha *et al*., 2022 | 26 | 71.19 | 24.87 | 16.96 | 14.31 | High heritability and high GA% M found, PCV greater than GCV |
| **5** | Gendre *et al*., 2023 | 23 | 93.48 | 37.03 | 22.28 | 21.79 | High heritability and high GA% M found, PCV greater than GCV |
| **6** | Karmata *et al*., 2023 | 50 | 86.50 | 35.31 | 19.82 | 18.43 | High heritability and high GA% M found, PCV greater than GCV |
| **7** | Pattnaik *et al*., 2023 | 15 | 82.62 | 16.38 | 9.62 | 8.75 | High heritability and moderate GA% M found, PCV greater than GCV |
| **8** | Syad *et al*., 2023 | 68 | 24.00 | 3.88 | 7.85 | 3.84 | Very high heritability and high GA% M found, PCV greater than GCV |
| **9** | Singh *et al*., 2023 | 19 | 71.5 | 20.89 | 14.18 | 11.99 | High heritability and high GA% M found, PCV greater than GCV |
| **10** | Abdelkader *et al*., 2024 | 16 | 97.01 | 29.93 | 4.89 | 4.74 | High heritability and high GA% M found, PCV greater than GCV |

**9. No. of branches/plant**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Gurve *et al.*, 2021 | 74 | 98.85 | 163.90 | 80.49 | 80.02 | High heritability and high GA% M found, PCV greater than GCV |
| **2** | Vinay *et al*., 2021 | 15 | 80.22 | 33.52 | 32.22 | 28.32 | High heritability and high GA% M found, PCV greater than GCV |
| **3** | Alemu, 2022 | - | 96.57 | 60.81 | 30.53 | 30.00 | High heritability and high GA% M were found, and PCV was higher than GCV. |
| 4 | Prakash *et al*.,2022 | 50 | 63.65 | 26.41 | 20.11 | 16.05 | High heritability and high GA% M found, PCV greater than GCV |
| 5 | Gendre *et al*., 2023 | 23 | 95.88 | 40.43 | 20.47 | 20.05 | High heritability and high GA% M found, PCV greater than GCV |
| 6 | Karmata *et al*., 2023 | 50 | 93.90 | 39.22 | 20.28 | 19.65 | High heritability and high GA% M found, PCV greater than GCV |
| 7 | Nanditha *et al.*, 2023 | 32 | 97.41 | 69.33 | 34.55 | 34.10 | High heritability and high GA% M found, PCV greater than GCV |
| 8 | Pattnaik *et al*., 2023 | 15 | 82.13 | 33.09 | 19.56 | 17.72 | High heritability and high GA% M found, PCV greater than GCV |
| 9 | Syad *et al*., 2023 | 68 | 33.00 | 10.95 | 16.00 | 9.23 | Moderate heritability and moderate GA% M found, PCV greater than GCV |
| 10 | Vinod and Lal, 2023 | 20 | 97 | 44.96 | 22.508 | 22.16 | High heritability and high GA% M found, PCV greater than GCV |

**10. Fruit length**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Jadhav *et al*., 2022 | 26 | 97.42 | 118.28 | 58.93 | 58.17 | High heritability and high GA% M found, PCV greater than GCV |
| **2** | Kharat *et al*., 2022 | 35 | 71.00 | 8.08 | 5.51 | 4.65 | High heritability and low GA% M found, PCV greater than GCV |
| **3** | Prakash *et al*.,2022 | 50 | 83.03 | 20.37 | 11.89 | 10.84 | High heritability and high GA% M found, PCV greater than GCV |
| **4** | Pundir *et al*., 2022 | 30 | 83.26 | 16.72 | 16.72 | 15.25 | High heritability and moderate GA% M found, PCV greater than GCV |
| **5** | Reddy *et al*., 2022 | 60 | 64.90 | 15.52 | 11.53 | 9.29 | High heritability and moderate GA% M found, PCV greater than GCV |
| **6** | Srivarsha *et al*., 2022 | 26 | 93.41 | 40.96 | 21.29 | 20.57 | High heritability and high GA% M found, PCV greater than GCV |
| **7** | Gendre *et al*., 2023 | 23 | 95.01 | 38.12 | 19.48 | 18.99 | High heritability and high GA% M found, PCV greater than GCV |
| **8** | Karmata *et al*., 2023 | 50 | 70.77 | 17.67 | 12.13 | 10.20 | High heritability and moderate GA% M found, PCV greater than GCV |
| **9** | Syad *et al*., 2023 | 68 | 18.00 | 1.86 | 4.99 | 2.12 | Low heritability and low GA% M found, PCV greater than GCV |
| **10** | Pattnaik *et al*., 2023 | 15 | 74.09 | 10.88 | 7.13 | 6.13 | High heritability and moderate GA% M found, PCV greater than GCV |

**11. Fruit diameter**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Singh *et al.*, 2020 | 59 | 47.30 | 12.50 | 12.83 | 8.82 | Moderate heritability and moderate GA% M found, PCV greater than GCV |
| **2** | Sravanthi *et al.*, 2021 | 32 | 77.27 | 16.82 | 10.56 | 9.29 | High heritability and moderate GA% M found, PCV greater than GCV |
| **3** | Vinay *et al.*, 2021 | 15 | 85.23 | 34.80 | 24.22 | 20.46 | High heritability and high GA% M found, PCV greater than GCV |
| **4** | Kharat *et al.*, 2022 | 35 | 94.00 | 9.70 | 5.02 | 4.86 | High heritability and low GA% M found, PCV greater than GCV |
| **5** | Srivarsha *et al.*, 2022 | 26 | 73.57 | 24.42 | 16.11 | 13.82 | High heritability and high GA% M found, PCV greater than GCV |
| **6** | Prakash *et al.*,2022 | 50 | 91.31 | 20.37 | 11.89 | 10.84 | High heritability and high GA% M found, PCV greater than GCV |
| **7** | Reddy *et al.*, 2022 | 60 | 50.04 | 8.71 | 8.45 | 5.98 | Moderate heritability and low GA% M found, PCV greater than GCV |
| **8** | Gendre *et al.*, 2023 | 23 | 90.13 | 38.05 | 20.47 | 19.46 | High heritability and high GA% M found, PCV greater than GCV |
| **9** | Singh *et al.*, 2023 | 19 | 18.7 | 4.7 | 12.21 | 5.28 | low heritability and low GA% M found, PCV greater than GCV |

**12. No. of ridges/ fruit**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Chetana *et al*., 2021 | 42 | 41.20 | 9.62 | 11.35 | 7.28 | Moderate heritability and low GA% M found, PCV greater than GCV |
| **2** | Idehen *et al.*, 2021 | 18 | 97.00 | - | 35.63 | 35.17 | High heritability and PCV greater than GCV |
| **3** | Alemu, 2022 | 25 | 97.40 | 18.36 | 9.14 | 9.02 | High heritability and moderate GA% M found, PCV greater than GCV |
| **4** | Kharat *et al*., 2022 | 35 | 100.00 | 13.00 | 6.31 | 6.31 | High heritability and moderate GA% M found, PCV greater than GCV |
| **5** | Prakash *et al*.,2022 | 50 | 75.73 | 13.61 | 8.71 | 7.58 | High heritability and moderate GA% M found, PCV greater than GCV |
| **6** | Srivarsha *et al*., 2022 | 26 | 63.30 | 15.91 | 12.20 | 9.71 | High heritability and moderate GA% M found, PCV greater than GCV |
| **7** | Kumar *et al.*, 2023 | 75 | 97.79 | 34.90 | 17.33 | 17.13 | High heritability and high GA% M found, PCV greater than GCV |
| **8** | Kute *et al.*, 2023 | 36 | 99.9 | 51.87 | 25.19 | 25.18 | High heritability and high GA% M found, PCV greater than GCV |
| **9** | Setu *et al*., 2023 | 63 | 78.00 | 20.7 | 13.25 | 11.70 | High heritability and high GA% M found, PCV greater than GCV |

**13. Number of fruits per plant**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Awasthi *et al.*, 2022 | 18 | 98.50 | 35.25 | 17.37 | 17.24 | High heritability and high GA% M found, PCV greater than GCV |
| **2** | Gurve *et al.*, 2022 | 74 | 98.98 | 92.47 | 45.35 | 45.12 | High heritability and high GA% M found, PCV greater than GCV |
| **3** | Kharat *et al.*, 2022 | 35 | 91.00 | 29.20 | 15.50 | 14.82 | High heritability and high GA% M found, PCV greater than GCV |
| **4** | Mohammed *et al.*, 2022 | 36 | 68.38 | 23.63 | 16.75 | 13.85 | High heritability and high GA% M found, PCV greater than GCV |
| **5** | Prakash *et al.*,2022 | 50 | 89.33 | 47.81 | 25.94 | 24.52 | High heritability and high GA% M found, PCV greater than GCV |
| **6** | Srivarsha *et al.*, 2022 | 26 | 94.55 | 69.72 | 35.80 | 34.81 | High heritability and high GA% M found, PCV greater than GCV |
| **7** | Awasthi *et al.*, 2022 | 18 | 98.50 | 35.25 | 17.37 | 17.24 | High heritability and high GA% M found, PCV greater than GCV |
| **8** | Gurve *et al.*, 2022 | 74 | 98.98 | 92.47 | 45.35 | 45.12 | High heritability and high GA% M found, PCV greater than GCV |
| **9** | Kharat *et al.*, 2022 | 35 | 91.00 | 29.20 | 15.50 | 14.82 | High heritability and high GA% M found, PCV greater than GCV |

**14. Number of marketable fruits**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Reddy *et al*., 2015 | 20 | 62.00 | 28.53 | 22.45 | 17.63 | High heritability and high GA% M were found, and PCV was higher than GCV. |
| **2** | Priyanka *et al*., 2018 | 25 | 90.90 | 102.27 | 54.62 | 52.07 | High heritability and high GA% M were found, and PCV was higher than GCV. |
| **3** | Maurya *et al*., 2019 | 30 | 81.13 | 35.87 | 21.46 | 19.33 | High heritability and high GA% M were found, and PCV was higher than GCV. |
| **4** | Kumar *et al*., 2020 | 30 | 93.21 | 28.31 | 14.74 | 14.23 | High heritability and high GA% M were found, and PCV was higher than GCV. |
| **5** | Reddy *et al*., 2022 | 60 | 80.26 | 22.09 | 11.97 | 10.26 | High heritability and high GA% M were found, and PCV was higher than GCV. |

**15. Average fruit weight**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Temam *et al*., 2020 | 36 | 96.19 | 78.85 | 39.73 | 38.97 | High heritability and high GA% M found, PCV greater than GCV |
| **2** | Bhardwaj *et al*., 2021 | 20 | 22.50 | 31.80 | 15.08 | 14.74 | Low heritability and moderate GA% M found, PCV greater than GCV |
| **3** | Sravanthi *et al*., 2021 | 32 | 92.51 | 61.08 | 32.05 | 30.83 | High heritability and high GA% M found, PCV greater than GCV |
| **4** | Alemu, 2022 | 25 | 93.19 | 38.29 | 19.92 | 19.23 | High heritability and high GA% M found, PCV greater than GCV |
| **5** | Prakash *et al*., 2022 | 50 | 72.4 | 15.90 | 10.1 | 8.59 | High heritability and moderate GA% M found, PCV greater than GCV |
| **6** | Reddy *et al*., 2022 | 60 | 60.55 | 4.93 | 3.95 | 3.08 | High heritability and moderate GA% M found, PCV greater than GCV |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **7** | Jadhav *et al*., 2022 | 26 | 57.43 | 9.36 | 60.91 | 5.99 | Moderate heritability and GA% M found, PCV greater than GCV |
| **8** | Faizan *et al*., 2023 | 19 | 99.02 | 20.92 | 10.24 | 10.19 | High heritability and high GA% M found, PCV greater than GCV |
| **9** | Singh *et al*., 2023 | 19 | 88.9 | 20.12s | 10.98 | 10.36 | High heritability and high GA% M found, PCV greater than GCV |
| **10** | Pattnaik *et al*., 2023 | 15 | 66.78 | 12.11 | 8.80 | 7.19 | High heritability and moderate GA% M found, PCV greater than GCV |

**16. Number of pickings**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Katiyar, 2020 | 10 | 34.72 | 6.64 | 9.24 | 5.43 | Moderate heritability and low GA% M found, PCV greater than GCV |
| **2** | Komal *et al*., 2022 | 75 | 84.80 | 21.10 | 12.08 | 11.12 | High heritability and high GA% M found, PCV greater than GCV |
| **3** | Reddy *et al*., 2022 | 60 | 58.13 | 15.34 | 12.81 | 9.77 | Moderate heritability and GA% M found, PCV greater than GCV |

**17. Fruit yield per plant**

| S.No | Reference | No. of genotypes | $h^2$ % | GA % mean | PCV % | GCV % | Finding |
|---|---|---|---|---|---|---|---|
| **1** | Alam *et al*., 2020 | 40 | 92.08 | 24.03 | 12.67 | 12.16 | High heritability and high GA% M found, PCV greater than GCV |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2** | Rana *et al.*, 2020 | 17 | 99.91 | 30.09 | 14.62 | 14.61 | High heritability and high GA% M found, PCV greater than GCV |
| **3** | Chetana *et al*., 2021 | 42 | 99.70 | 25.19 | 12.27 | 12.25 | High heritability and high GA% M found, PCV greater than GCV |
| **4** | Vaani *et al.*, 2021 | 68 | 83 | - | 12.93 | 11.80 | High heritability and PCV greater than GCV |
| **5** | Kharat *et al.*, 2022 | 35 | 94.00 | 38.52 | 18.85 | 18.77 | High heritability and high GA% M found, PCV greater than GCV |
| **6** | Prakash *et al*.,2022 | 50 | 86.63 | 46.97 | 26.28 | 24.46 | High heritability and high GA% M found, PCV greater than GCV |
| **7** | Srivarsha *et al.*, 2022 | 26 | 78.48 | 51.85 | 32.07 | 28.41 | High heritability and high GA% M found, PCV greater than GCV |
| **8** | Karmata *et al*., 2023 | 50 | 62.99 | 33.49 | 25.81 | 20.48 | High heritability and high GA% M found, PCV greater than GCV |
| **9** | Singh *et al.*, 2023 | 19 | 96.9 | 11.12 | 6.01 | 5.91 | High heritability and moderate GA% M found, PCV greater than GCV |
| **10** | Pattnaik *et al*., 2023 | 15 | 71.88 | 23.75 | 16.04 | 13.59 | High heritability and high GA% M found, PCV greater than GCV |

## 2.2 Genetic divergence

Mahalanobis' $D^2$ statistics serve as a valuable tool for identifying clustering patterns, establishing connections between genetic diversity and geographical variation, and exploring the influence of various quantitative traits in defining the maximum degree of divergence among plant populations or varieties, Evaluation of the genetic diversity of Mahalanobis' $D^2$ statistics (Mahalanobis, 1936). Rao (1952) was the first to propose applying this method to assess plant genetic diversity. Individuals with greater fitness levels have a larger impact on the genetic composition of the population than those with lower fitness levels. The Mahalanobis $D^2$ statistic is a highly regarded approach for evaluating genetic divergence at the genotypic level among biological populations. Table 2 illustrates the $D^2$ cluster interaction within okra, shows the interconnected relationships.

**Table 2. Review of literature for genetic divergence in okra**

| Sr. No | Reference | Studied material | Divided into number of clusters | Maximum intra cluster distance | Maximum inter cluster distance | Significant findings |
|---|---|---|---|---|---|---|
| **1.** | Mudhalvan and Senthilkumar, 2018 | 15 | 5 clusters | Observed in cluster II (287.92) | noticed between cluster V and cluster I (6493.93) | Cluster I and II had largest no of genotypes with 5 each |
| **2.** | Samiksha *et al*., 2020 | 17 | 4 clusters | Observed in cluster II (9.27) | noticed between cluster I and cluster III (22.90) | Cluster II had largest no of genotypes with 8 |
| **3.** | Nanthakumar *et al*., 2021 | 46 | 5 clusters | Observed in cluster IV (28.70) | noticed between cluster V and cluster IV (2282.81) | Cluster V had largest no of genotypes with 31 |
| **4.** | Silva *et al*., 2021 | 46 | 7 clusters | Observed 0 | noticed between cluster I and cluster VII | Cluster III had largest no of genotypes 13 |
| **5.** | Sravanthi *et al*., 2022 | 32 | 6 clusters | Observed in cluster II (73.71) | noticed between cluster IV and cluster VI (723.37) | Cluster I had largest no of genotypes 15 |
| **6.** | Yadav et al., 2022 | 36 | 5 clusters | Observed in cluster I (16.95) | noticed between cluster III and cluster VI (723.37) | Cluster I had largest no of genotypes 22 |
| **7.** | Kumar *et al*., 2023 | 75 | 5 clusters | Observed in cluster I (18.23) | noticed between cluster I and cluster V (21.17) | Cluster III had largest no of genotypes with 27 |
| **8.** | Saleem *et al*., 2023 | 24 | 3 clusters | Observed 0 | noticed between cluster II and cluster I (123.97) | Cluster II had largest no of genotypes with 14 |
| **9.** | Pattan *et al*., 2023 | 48 | 9 clusters | Observed in cluster III (95.29) | noticed between cluster V and cluster IX (588.71) | Cluster IV had largest no of genotypes with 24. |
| **10.** | Fandan *et al*., 2024 | 30 | 5 clusters | Observed in cluster I (6.7) | noticed between cluster V and cluster III (16.7) | Cluster I had largest no of genotypes with 18. |

## 2.3 Heterosis

Heterosis is a acknowledged in which the offspring of two genetically distinct parents demonstrate increased or decreased vigor compared to their parents. The expression of heterosis is influenced by various factors such as heterozygosity, allelic interaction, non-allelic interaction, and mid parent value. The concept of heterosis was initially coined by G.H. Shull in 1914 and has been a subject of extensive infestation in both plant and animal breeding. In plants, the phenomenon was first observed by Koelreuter in 1763, who observed that hybrid vigor tended to rise as the dissimilarity between parental plants increased. Fonseca and Patterson (1968) and Mather and Jinks (1971) introduced the term heterobeltiosis and its measures the superiority of the $F_1$ hybrid over the better parent, while "heterosis" is usually calculated as the degree to which the $F_1$ hybrid surpasses the average of its parental lines. In "economic heterosis," which is compared to a standard variety, holds the most practical significance. Table 3 summarizes the findings of many researchers on the degree of heterosis in okra.

**Table 3 Review of literature for heterosis study in different traits in okra**

1. **First flowering node**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Medagam *et al*., 2012 | Half diallel (10 x 10) | -13.73 to 16.67 | -15.22 to 15.22 |
| **2** | Reddy *et al*., 2013 | Half diallel (10 x 10) | -14.71 to 16.67 | -16.55 to 15.11 |
| **3** | More *et al*., 2015 | Line x Tester (10 x 4) | - | -11.43 to 37.77 |

2. **First fruiting node**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Medagam *et al*., 2012 | Half diallel (10 x 10) | -13.73 to 16.67 | -15.22 to 15.22 |
| **2** | More *et al*., 2015 | L x T (10 x 4) | - | -11.43 to 37.77 |
| **3** | Kerure and Pitchaimuthu, 2019 | Half diallel (10 x 10) | -25.44 to 54.32 | -9.03 to 43.32 |
| **4** | Chowdhury and Kumar, 2019 | Half diallel (7 x 7) | -25.00 to 61.90 | -16.00 to 36.00 |
| **5** | Sidapara *et al*., 2021 | Half diallel (10 x 10) | -4.20 to 24.81 | -9.87 to 5.92 |

**3. Days to first flowering**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Makdoomi *et al*., 2018 | Diallel (10 x 10) | -11.38 to 8.82 | - |
| **2** | Chowdhury and Kumar, 2019 | Half diallel (7 x 7) | | |
| **3** | Rynjah *et al*., 2020 | L x T (6 x 6) | -12.05 to 6.41 | -13.05 to 4.12 |
| **4** | Shwetha *et al*., 2021 | Half diallel (8 x 8) | -10.59 to 4.94 | -8.43 to 3.61 |

**4. Days to 50% flowering**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Keerthana *et al*., 2021 | L x T (6 x 4) | -3.09 to 1.46 | -2.94 to 1.11 |
| **2** | Sood *et al*., 2022 | L x T (9 x 3) | -11.72 to 5.80 | -13.89 to 2.78 |
| **3** | Kharat *et al*., 2022 | L x T (10 x 2) | -4.40 to 11.24 | 0.00 to 9.20 |
| **4** | Shinde *et al*., 2023 | L x T (11 x 3) | -14.56 to 5.94 | -4.55 to 17.83 |

5. **Days to first fruit harvest**

| S. No | References | Mating Design | Heterobeltosis | Standard Heterosis |
|---|---|---|---|---|
| **1** | Sidapara *et al*., 2021 | Half diallel (10 x 10) | -4.20 to 24.81 | -9.87 to 5.92 |
| **2** | Kharat *et al*., 2022 | L x T (10 x 2) | -3.96 to 8.91 | -2.02 to 5.05 |
| **3** | Sood *et al*., 2022 | L x T (9 x 3) | -14.97 to 12.03 | -13.04 to 9.94 |
| **4** | Chaudhary *et al*., 2023 | L x T (9 x 4) | -22.37-17.32 | -18.12-8.70 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -13.51 to 5.50 | -4.95 to 9.90 |

6. **Plant height**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Kharat *et al*., 2022 | L x T (10 x 2) | -17.65 to 6.05 | -7.72 to 15.35 |
| **2** | Mundhe *et al*., 2022 | Half diallel (9 x 9) | -8.74 to 26.21 | |
| **3** | Sood *et al*., 2022 | L x T (9 x 3) | -21.22 to 33.99 | -24.77 to 19.32 |
| **4** | Chaudhary *et al*., 2023 | L x T (9 x 4) | -43.77- 55.92 | -28.80 -44.43 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -28.99 to 33.22 | -5.58 to 36.40 |

7. **Internodal length**

| **S. No** | **References** | **Mating Design** | **Heterobeltosis** | **Economic heterosis** |
|---|---|---|---|---|
| **1** | Rynjah *et al*., 2020 | L x T (6 x 6) | -33.19 to 9.13 | -29.2 to 30.87 |
| **2** | Kharat *et al*., 2022 | L x T (10 x 2) | -19.46 to -0.97 | -12.63 to 5.83 |
| **3** | Mundhe *et al*., 2022 | Half diallel (9 x 9) | -24.29 to 2.82 | -23.77 to 5.99 |
| **4** | Sood *et al*., 2022 | L x T (9 x 3) | -26.81 to 46.60 | -23.53 to 23.17 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -24.26 to 43.70 | -14.81 to 26.67 |

8. **Number of nodes per plant**

| **S. No** | **References** | **Mating Design** | **Heterobeltosis** | **Economic heterosis** |
|---|---|---|---|---|
| **1** | Pithiya *et al*., 2019 | L x T (6 x 5) | -29.76 to 46.61 | -24.03 to 12.34 |
| **2** | Mundhe *et al*., 2022 | Half diallel (9 x 9) | -11.46 to 34.52 | -10.53 to 37.72 |
| **3** | Kharat *et al*., 2022 | L x T (10 x 2) | -16.53 to 6.25 | -6.45 to 8.76 |
| **4** | Sood *et al*., 2022 | L x T (9 x 3) | -15.28 to 9.69 | -16.58 to 15.08 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -22.05 to 5.99 | -4.55 to 17.83 |

**9. Number of branches per plant**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Rynjah *et al*., 2020 | L x T (6 x 6) | 0.12 to 19.2 | 0.5 to 24.4 |
| **2** | Singh *et al*., 2022 | L x T (7 x 3) | -49.30 to 99.29 | -23.08 to 90.80 |
| **3** | Mundhe *et al*., 2022 | Half diallel (9 x 9) | -35.00 to 42.11 | -40.91 to 22.73 |
| **4** | Kharat *et al*., 2022 | L x T (10 x 2) | -42.50 to -3.23 | -3.57 to 42.86 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -29.27 to 4.88 | -11.43 to 17.14 |

**10. Fruit length**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Kharat *et al*., 2022 | L x T (10 x 2) | -15.77 to 3.74 | 4.08 to 20.41 |
| **2** | Mundhe *et al*., 2022 | Half diallel (9 x 9) | -24.05 to 11.24 | -21.96 to 11.56 |
| **3** | Singh *et al*., 2022 | L x T (7 x 3) | -5.82 to 31.48 | -0.00 to 44.58 |
| **4** | Sood *et al*., 2022 | L x T (9 x 3) | -18.27 to 3.36 | -10.73 to 10.35 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -33.33 to 25.26 | -19.01 to 30.28 |

**11. Fruit diameter**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Kharat *et al*., 2022 | L x T (10 x 2) | -21.05 to 5.26 | -7.89 to 5.26 |
| **2** | Mundhe *et al*., 2022 | Half diallel (9 x 9) | -27.54 to 29.82 | -25.77 to 19.02 |
| **3** | Singh *et al*., 2022 | L x T (7 x 3) | -26.52 to 13.27 | -26.52 to 4.33 |
| **4** | Sood *et al*., 2022 | L x T (9 x 3) | -12.10 to 8.85 | -10.50 to 7.66 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -17.72 to 4.82 | -5.49 to 20.43 |

**12. Number of ridges per fruit**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Kerure and Pitchaimuthu, 2019 | Half diallel (10 x 10) | -13.07 to 15.09 | |
| **2** | Singh *et al*., 2019 | L x T (12 x 2) | -16.67 to 9.68 | -12.64 to 20.69 |
| **3** | Anyaoha *et al*., 2022 | Diallel (5 x 5) | -37.50 to 18.52 | - |
| **4** | Kharat *et al*., 2022 | L x T (10 x 2) | -16.67 to 20.00 | 0.00 to 20.00 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -41.30 to 66.67 | -10.34 to 63.79 |

**13. Number of fruits per plant**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Kharat *et al*., 2022 | L x T (10 x 2) | -39.02 to 43.48 | -32.67 to 17.16 |
| **2** | Mundhe *et al*., 2022 | Half diallel (9 x 9) | -8.71 to 38.85 | -1.74 to 34.03 |
| **3** | Singh *et al*., 2022 | L x T (7 x 3) | -26.30 to 25.47 | -0.09 to 62.86 |
| **4** | Sood *et al*., 2022 | L x T (9 x 3) | -24.14 to 8.96 | -20.40 to 15.41 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -34.58 to 19.64 | - |

**14. Number of marketable fruits per plant**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Medagam *et al*., 2012 | Half diallel (10 x 10) | -25.83 to 34.81 | -37.68 to 0.16 |
| **2** | Reddy *et al*., 2013 | Half diallel (10 x 10) | -24.97 to 36.74 | -38.23 to -1.42 |
| **3** | Reddy *et al*., 2014 | Half diallel (10 x 10) | -22.84 to 38.93 | -37.64 to -0.12 |
| **4** | Kumar *et al*., 2016 | Half diallel (6 x 6) | -7.17 to 54.93 | -31.26 to 21.68 |

**15. Average fruit weight**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Singh *et al*., 2022 | L x T (7 x 3) | -33.80 to 32.21 | -28.28 to 15.53 |
| **2** | Mundhe *et al*., 2022 | Half diallel (9 x 9) | -31.04 to 9.11 | -26.53 to 16.24 |
| **3** | Kharat *et al*., 2022 | L x T (10 x 2) | -22.73 to 15.15 | -1.11 to 28.89 |
| **4** | Sood *et al*., 2022 | L x T (9 x 3) | -26.21 to 16.22 | -12.61 to 35.25 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -34.72 to 21.47 | 3.85 to 60.77 |

**16. Number of pickings**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Kerure and Pitchaimuthu, 2019 | Half diallel (10 x10) | -13.07 to 15.09 | -3.85 to 17.31 |
| **2** | Zate *et al*., 2021 | Generation mean (6 x 4) | -11.33 to 40.00 | 0.00 to 40.00 |
| **3** | Harsiddhi and Mehta, 2023 | Diallel (9 x 9) | -20.00 to 4.24 | -18.37 to 6.12 |

**17. Fruit yield per plant**

| S. No | References | Mating Design | Heterobeltosis | Economic heterosis |
|---|---|---|---|---|
| **1** | Kharat *et al*., 2022 | L x T (10 x 2) | -38.09 to 55.00 | -22.53 to 27.03 |
| **2** | Mundhe *et al*., 2022 | Half diallel (9 x 9) | -37.19 to 52.70 | -33.20 to 43.37 |
| **3** | Singh *et al*., 2022 | L x T (7 x 3) | -12.84 to 36.72 | -14.50 to 44.72 |
| **4** | Sood, *et al*., 2022 | L x T (9 x 3) | -34.14 to 30.78 | -33.60 to 33.77 |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -53.84 to 38.39 | -9.02 to 73.58 |

## 2.4 Combining ability

Concepts of GCA and SCA was introduced by Sprague and Tatum in 1942. GCA about average performance of a parent in a cross combination and SCA about deviations of single crosses from average of parents. According to Sprague & Tatum, 1942, GCA & SCA are strong predictors of inbred potential for hybrid combinations. In which GCA is used for additive gene action estimation and SCA for non-additive, to estimate combining ability have been several techniques developed, among them poly cross test by (Tsydal *et al*., 1942), top cross (Jenkin & Bruson, 1932) and L x T analysis (Kempthrone 1957). Line × Tester analysis is a valuable tool for selecting parents for hybridization, building up a population, and determining the combining ability of both parents and crosses.

## Table 4. Review literature on combining ability and gene action in okra

### 1. First flowering node

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Raghuvanshi *et al*., 2011 | L x T (6 x 4) | -0.45 to 40 | -1.14 to 0.62 | |
| **2** | Reddy *et al*., 2013 | Half diallel (10 x 10) | -0.15 to 0.13 | -0.54 to -0.32 | $\sigma^2$gca = 0.030<br>$\sigma^2$sca=0.088 |
| **3** | Tiwari *et al*., 2016 | Diallel (5 x 5) | -3.93 to 3.30 | -4.57 to 4.83 | |
| **4** | Wakode *et al*., 2016 | Diallel (7x7) | -0.24 to 0.19 | -0.54 to -17 | $\sigma^2$gca =0.44<br>$\sigma^2$sca=0.44 |

### 2. First fruiting node

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Sharma *et al*., 2012 | L x T (6 x 4) | -0.20 to 0.15 | -0.55 to 0.66 | - |
| **2** | Reddy *et al*., 2013 | Half diallel | -0.54 to 0.32 | -0.54 to 0.03 | - |

3. **Days to first flowering**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Kishor *et al.*, 2013 | L x T (5 x 3) | -2.63 to 3.99 | -2.04 to 1.75 | $\sigma^2$gca =3.53<br>$\sigma^2$sca=2.16 |
| **2** | Bhatt *et al.*, 2015 | Half diallel (8 x 8) | -2.43 to 2.67 | -4.59 to 5.08 | $\sigma^2$gca =0.04<br>$\sigma^2$sca=0.42 |
| **3** | Tiwari *et al.*, 2016 | Diallel (5 x 5) | -3.39 to 3.30 | -4.57 to 4.83 | - |
| **4** | Wakode *et al.*, 2016 | Diallel (7 x 7) | -3.04 to 8.23 | -4.43 to 3.20 | $\sigma^2$gca =13.46<br>σ2sca=23.02 |
| **5** | Maurya *et al.*, 2022 | Diallel (10 x 10) | - | - | $\sigma^2$gca = 3.45* ± 1.27<br>$\sigma^2$sca= 14.54* ± 2.7 |

4. **Days to 50% flowering**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Anyaoha *et al.*, 2022 | Diallel (5 x 5) | -0.98 to 2.00 | -4.21 to 1.93 | |
| **2** | Maurya *et al.*, 2022 | Diallel (10 x 10) | - | - | $\sigma^2$gca = 6.85* ± 1.29<br>$\sigma^2$sca=15.43* ± 2.74 |
| **3** | Kharat *et al.*, 2022 | L x T (10 x 2) | -0.68 to 1.33 | -2.73 to 2.72 | |
| **4** | Shinde *et al.*, 2023 | L x T (11 x 3) | -2.52 to 2.98 | -3.38 to 4.17 | - |

5. **Days to first fruit harvest**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Verma *et al*., 2016 | Diallel (8 x 8) | -1.29 to 1.70 | -2.86 to 3.39 | - |
| **2** | Narkhede *et al*., 2021 | Half diallel (10 x 10) | -0.40 to 0.31 | -1.91 to 1.07 | - |
| **3** | Vekariya *et al*., 2020 | L x T (11 x 5) | - | - | $\sigma^2$gca =0.489<br>$\sigma^2$sca=0.993 |
| **4** | Kharat *et al*., 2022 | L x T (10 x 2) | -1.33 to 0.93 | -3.22 to 3.22 | - |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -2.58 to 2.92 | -3.32 to 4.14 | - |

6. **Plant height**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Anyaoha *et al*., 2022 | Diallel (5 x 5) | -6.36 to 8.29 | -52.82 to 24.89 | |
| | Kharat *et al*., 2022 | L x T (10 x 2) | -5.66 to 5.22 | -11.30 to 11.30 | - |
| **2** | Maurya *et al*., 2022 | Diallel (10 x 10) | - | - | $\sigma^2$gca = 0.12* ± 0.03<br>$\sigma^2$sca=0.53* ± 0.07 |
| **3** | Mundhe *et al*., 2023 | Half diallel (9 x 9) | -3.82 to 3.06 | -6.06 to 5.85 | - |
| **4** | Shinde *et al*., 2023 | L x T (11 x 3) | -18.42 to 15.25 | -17.78 to 18.10 | - |

## 7. Internodal length

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Anyaoha *et al*., 2022 | Diallel (5 x 5) | -1.25 to 1.09 | -2.89 to 3.51 | - |
| **2** | Kharat *et al*., 2022 | L x T (10 x 2) | -0.49 to 0.36 | -0.44 to 0.44 | - |
| **3** | Maurya *et al*., 2022 | Diallel (10 x 10) | - | - | $\sigma^2$gca = 0.14 ± 0.18<br>$\sigma^2$sca=1.64* ± 0.38 |
| **4** | Mundhe *et al*., 2023 | Half diallel (9 x 9) | -0.26 to 0.33 | -0.83 to 0.62 | - |
| **5** | Shinde *et al*., 2023 | L X T (11 x 3) | -1.10 to 1.27 | -0.96 to 0.98 | |

## 8. Number of nodes

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Vekariya *et al*., 2020 | L x T (11 x 5) | - | - | $\sigma^2$gca = 0.009<br>$\sigma^2$sca=0.047 |
| **2** | Narkhede *et al*., 2021 | Half diallel (10 x 10) | -0.52 to 0.40 | -1.86 to 2.14 | - |
| **3** | Kharat *et al*., 2022 | L x T (10 x 2) | -0.17 to 0.21 | -0.21 to o.21 | - |
| **4** | Mundhe *et al*., 2023 | Half diallel (9 x 9) | -0.19 to 0.12 | -0.51 to 0.76 | - |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -0.15 to 0.13 | -0.26 to 0.27 | - |

**9. Number of branches per plant**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Tiwari *et al*., 2016 | Diallel (5 x 5) | -0.403 to 0.474 | -0.480 to 0.485 | - |
| **2** | Satish *et al*., 2017 | L x T (10 x 5) | -0.20 to 0.14 | -0.40 to 0.50 | - |
| **3** | Hadiya *et al*., 2018 | Diallel (7 x 7) | - | -0.60 to 1.00 | - |
| **4** | Patel *et al*., 2021 | L x T (8 x 4) | -0.13 to 0.18 | -0.29 to 0.46 | - |

**10. Fruit length**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Anyaoha *et al*., 2022 | Diallel (5 x 5) | -1.13 to 1.87 | -3.32 to 3.74 | - |
| **2** | Kharat *et al*., 2022 | L x T (10 x 2) | -0.27 to 0.67 | -0.37 to 0.37 | - |
| **3** | Maurya *et al*., 2022 | Diallel (10 x 10) | - | - | $\sigma^2$gca = 0.23 ± 0.14<br>$\sigma^2$sca=1.55* ± 0.3 |
| **4** | Mundhe *et al*., 2023 | Half diallel (9 x 9) | -0.24 to 0.46 | -2.3 to 1.00 | - |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -2.01 to 1.82 | -2.12 to 3.13 | - |

**11. Fruit diameter**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Anyaoha *et al*., 2022 | Diallel (5 x 5) | -0.33 to 0.21 | -0.49 to 0.58 | |
| **2** | Kharat *et al*., 2022 | L x T (10 x 2) | -0.09 to 0.14 | -0.15 to 0.15 | - |
| **3** | Maurya *et al*., 2022 | Diallel (10 x 10) | - | - | $\sigma^2$gca = 0.01 ± 0.01<br>$\sigma^2$sca=0.08* ± 0.01 |
| **4** | Mundhe *et al*., 2023 | Half diallel (9 x 9) | -0.65 to 0.93 | -3.08 to 3.32 | - |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -0.12 to 0.09 | -0.28 to 0.21 | - |

**12. Number of ridges per fruit**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Gowda *et al*., 2018 | L X T (7 x 2) | -0.86 to 1.63 | -2.30 to 2.30 | - |
| **2** | Padadalli *et al*., 2019 | L x T (7 x 3) | -0.52 to 0.95 | -1.07 to 2.09 | - |
| **3** | Anyaoha *et al*., 2022 | Diallel (5 x 5) | -0.99 to 0.67 | -2.05 to 1.86 | - |
| **4** | Kharat *et al*., 2022 | L x T (10 x 2) | -0.15 to 0.35 | -0.45 to 0.45 | - |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -1.03 to 0.33 | -1.57 to 2.64 | - |

**13. Number of fruits per plant**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Shinde *et al.*, 2023 | L x T (11 x 3) | -1.03 to 0.33 | -1.57 to 2.64 | - |
| **2** | Kharat *et al.*, 2022 | L x T (10 x 2) | -4.41 to 2.24 | -2.41 to 2.41 | - |
| **3** | Maurya *et al.*, 2022 | Diallel (10 x 10) | - | - | $\sigma^2$gca = 1.96 ± 2.47 $\sigma^2$sca=45.15 ± 5.25 |
| **4** | Mundhe *et al.*, 2023 | Half diallel (9 x 9) | -0.48 to 0.55 | -1.18 to 3.64 | - |
| **5** | Shinde *et al.*, 2023 | L x T (11 x 3) | -1.96 to 1.89 | -2.13 to 3.29 | - |

**14. Number of marketable fruits**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Reddy *et al.*, 2012 | Half diallel (10 x 10) | -0.74 to 0.70 | -4.34 to 4.34 | $\sigma^2$gca =0.151 $\sigma^2$sca =1.820 |
| **2** | Reddy *et al.*, 2013 | Half diallel (10 x 10) | -0.42 to 0.42 | -2.22 to 2.22 | $\sigma^2$gca =0.039 $\sigma^2$sca =0.525 |
| **3** | Devi *et al.*, 2017 | Half diallel (8 x 8) | -1.35 to 0.81 | -0.71 to 1.14 | - |
| **4** | Palve *et al.*, 2021 | L x T (8 x 8) | - | -3.09 to 2.81 | - |

**15. Average fruit weight**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Narkhede *et al*., 2021 | Half diallel (10 x 10) | -0.72 to 0.45 | -1.58 to 1.83 | |
| **2** | Kharat *et al*., 2022 | L x T (10 x 2) | -1.01 to 0.61 | -0.97 to 0.97 | - |
| **3** | Maurya *et al*., 2022 | Diallel (10 x 10) | - | - | $\sigma^2$gca = 3.56 ± 5.55<br>$\sigma^2$sca=68.73 ± 11.82 |
| **4** | Mundhe *et al*., 2023 | Half diallel (9 x 9) | -0.23 to 0.41 | -2.72 to 1.27 | - |
| **5** | Shinde *et al*., 2023 | L x T (11 x 3) | -1.72 to 1.21 | -3.09 to 3.28 | - |

**16. Fruit yield per plant**

| S. No | References | Mating Design | GCA | SCA | Gene Action |
|---|---|---|---|---|---|
| **1** | Arvind *et al*., 2021 | Diallel (7 x 7) | -0.35 to 0.17 | -0.65 to 1.36 | - |
| **2** | Kousalya *et al*., 2021 | Full diallel (6 x 6) | -6.50 to 49.88 | -228.27 to 366.86 | $\sigma^2$gca = 415.866<br>$\sigma^2$sca=667.034 |
| **3** | Narkhede *et al*., 2021 | Half diallel (10 x10) | -3.90 to 10.82 | -52.71 to 36.29 | - |
| **4** | Palve *et al*., 2021 | L x T (8 x 8) | -0.45 to 0.34 | -66.73 to 69.12 | - |
| **5** | Chirag *et al*., 2023 | Half diallel (10 x 10) | -14.69 to 31.29 | -49.54 to 23.90 | - |

**2.5 Stability analysis**

Plant breeders have long recognized the existence of genetic differences in adaptability among plants, but they have often faced challenges in fully harnessing these differences in their breeding programs. This is because the expression of a plant's characteristics, or phenotype, is the outcome of the complex interaction between its genotype (genetic makeup) and the environment it grows in. Genotypic-environment interaction, accounts for the variations in plant development that arise from the lack of alignment between genetic factors and non-genetic environmental factors.

A stable plant variety or genotype is typically characterized as one that exhibits its maximum potential performance in the best-suited environment while demonstrating low G x E interaction, resulting in consistent better performance across numerous environments. The idea of "deviation from regression" was developed by Eberhart and Russell (1966) as an additional parameter for measuring stability in the field of plant breeding. They proposed that a variety exhibiting a regression coefficient *i.e.,* (bi-=1) close to unity and deviation from regression is near zero could be classified as stable, signifying its consistent high performance across diverse environmental conditions. This approach helps breeders identify and select varieties that maintain their performance consistently, regard less of changing conditions. Here is an overview of the stability okra data from several researchers.

**Jijabrao *et al*., (2015)** In the research involved an assessment of 55 genotypes, comprising 10 distinct lines and 4 testers, which resulted in the creation of 40 hybrid configurations with the mating design of a L x T. These hybrid varieties were subsequently grown in three different geographical locations to investigate their stability characteristics, specifically concentrating on fruit capsule production and its related characteristics. Furthermore, another hybrid, VIO 47672 x GAO – 5, demonstrated average stability across several important attributes, such as days to initial blooming, fruit output per plant, number of harvests, and total fruit yield. This suggests that while it may not excel in any single attribute like IC – 045796 x GAO – 5 did in fruit yield, it displayed reliability across multiple characteristics.

**Manubhai (2017)** The study involving stability parameters of 66 okra genotypes, consisting of 10 distinct lines, 5 testers, 50 hybrid combinations, and a check variety, yielded interesting findings highlighted the challenge of finding genotypes stable across all traits studied. However, it identified a subset of five hybrid combinations that demonstrated stability in capsule yield per plant, with JOL-08-7 crossed P. Kranti standing out as an excellent performer with consistent and reliable fruit yield across various environmental conditions.

**Vekariya *et al*., (2019)** In the research conducted during the *Kharif* season of 2018 at Navsari Agricultural University in Gujarat, involving a total of 72 genotypes stability using AMMI model. None of the parent or hybrid varieties displayed consistent stability across all observed characteristics. However, the parent GAO-5 and the hybrid AOL-16-04 × Arka Anamika emerged as particularly stable for fruit yield per plant, demonstrating average stability in this regard.

**Komolafe *et al*., (2022)** In this study, seventeen different accessions of okra were assessed in four different environments. The aim was to evaluate the interaction between genetics and the environment (G×E interaction) and to study the stability of these accessions. The AMMI analysis identified the accession NGB00378a as the most stable and highest-yielding among all accessions evaluated. NGB00355 showed the best yield compared to all other accessions, while it had significantly worse stability.

**Abdillah *et al*., (2023)** In this experiment different okra genotypes across four distinct environmental trials. RBD to evaluate the effects of 10 different okra genotypes as treatments. The experiments were conducted at the Leuwikopo Experimental Garden, IPB. Analysis using the AMMI-1, AMMI-2, and GGE biplot techniques provided insights into genotype stability and adaptability. It observed interaction between genotype and environment significantly influenced fruit yield, with the environment playing a predominant role. Notably, 'SWR01' exhibited the highest yield among the genotypes.

**Patel *et al*., (2023)** In 2019 research investigation was carried out at Navsari Agricultural University, located in the Zone I of southern Gujarat, India, known for its heavy rainfall agroclimatic conditions. which were systematically arranged in a RCBD and replicated three times across 4 diverse environments. Out of the chosen genotypes, two, specifically $H_{23}$ and $H_{10}$, exhibited significant potential. These genotypes not only consistently delivered high fruit yields but also demonstrated adaptability across a range of environmental conditions.

## 2.6 Characterization

The characterization of germplasm provides information on the characteristics possessed by each genotype, ensuring maximal use of the germplasm collection by end users. Morphological characters are the oldest and most used genetic markers and they may still be appropriate for certain germplasm management applications. Here is an overview of the characterization of okra data from several researchers.

**Matthew *et al*., (2018)** This study, conducted at the University of Benin, Benin City, Nigeria, aimed to explore the morphological distinctiveness among five varieties of okra. Various quantitative traits, including leaves, fruits, seeds, floral parts, and stems, were investigated. The results revealed significant variations among all five accessions in terms of stem length, petiole length, and leaf node.

**Oppong-Sekyere *et al*., (2020)** In this experiment, 25 accessions of okra collected in Ghana underwent evaluation for phenotypic identity and quality based on morphological characters. Qualitative characteristics were assessed and scored according to the standard international crop descriptor for okra. The study revealed the presence of distinct morphotypes within the Ghanaian okra germplasm, characterized by variations in petal colour, leaf and stem pubescence, fruit shape, and anthocyanin pigmentation.

**Teman *et al*., (2020)** In this study during the rainy season of 2019, an experiment was conducted at the Melkassa Research Center, evaluating 33 okra (*Abelmoschus esculentus* (L.) Moench) genotypes, which exhibited significant variation in growth habits, leaf morphology, fruit characteristics, flower attributes, and seed traits, particularly in qualitative aspects such as shape, color, and pubescence, the latter being a crucial determinant factor in consumer preference.

**Kumar *et al*., (2022)** The study, was conducted at the Research Farm of the Department of Vegetable Science, CCS HAU, Hisar, during the spring-summer season of 2012. The objective was to identify key diagnostic characters of the genotypes based on morphological descriptors. The study distinguished all 20 genotypes using key diagnostic features such as serration of the leaf blade margin, vein colour, intensity of colour between veins, depth of lobing, and petal base colour. These diagnostic characters are invaluable for plant breeders in trait-specific breeding programs.

*CHAPTER - 3*

# MATERIALS AND METHODS

A brief account of experiments conducted, entitled as "**Study on Phenotypic characterization along with $F_1$ okra hybrid analysis for heterosis, combining ability and stability"** was carried out information on Variability, Diversity, Heritability, Genetic Advancement, Heterosis, Combine Ability and Stability analysis. The experimental design utilized and the statistical methodologies employed in the current study are laid out below

3.1 Experimental site

3.2 Materials involved in experiment

3.3 Experimental details

3.4 Observations recorded

3.5 Statistical analysis

## 3.1 Experimental site

The experiments I, II and III were conducted at School of Agriculture, Lovely Professional University, Phagwara is located at latitude 31°13'28.27" N and longitude 75°46'25.93" E elevated to 248 m above MSL. The whole experiments were carried out during *Summer* 2022 to *Summer* 2023. Experimental site was sandy loam with pH 7.5.

**Table 5. Chronology of the experiments**

| Experiment | Purpose | Month & Year |
|---|---|---|
| Experiment- I | Characterization, genetic variability and diversity studies | March to June 2022 |
| Experiment-II | Parental selection and crossing block for L x T mating | July to October 2022 |
| Experiment-III | Research on combining ability, Heterosis and Stability | March to October 2023 |

### 3.2 Materials involved in experiment

This assay incorporates a total of fifty-five distinct genotypes of okra as the experimental material used for diversity studies, material collected from various geographical locations and are present in the table 6.

**Table.6 Fifty-five Genotypes and Source**

| Sl.no. | Name | Source | Sl.no. | Name | Source |
|---|---|---|---|---|---|
| 1 | EC169450 | NBPGR, New Delhi | 29 | IC045993 | NBPGR, New Delhi |
| 2 | EC169452 | NBPGR, New Delhi | 30 | IC045994 | NBPGR, New Delhi |
| 3 | EC169453 | NBPGR, New Delhi | 31 | IC049972 | NBPGR, New Delhi |
| 4 | EC169455 | NBPGR, New Delhi | 32 | IC049734 | NBPGR, New Delhi |
| 5 | EC169456 | NBPGR, New Delhi | 33 | IC049749 | NBPGR, New Delhi |
| 6 | EC169459 | NBPGR, New Delhi | 34 | IC052298 | NBPGR, New Delhi |
| 7 | EC169461 | NBPGR, New Delhi | 35 | IC052313 | NBPGR, New Delhi |
| 8 | IC052299 | NBPGR, New Delhi | 36 | IC052308 | NBPGR, New Delhi |
| 9 | IC052301 | NBPGR, New Delhi | 37 | IC052320 | NBPGR, New Delhi |
| 10 | IC052302 | NBPGR, New Delhi | 38 | IC052310 | NBPGR, New Delhi |
| 11 | IC052303 | NBPGR, New Delhi | 39 | Punjab 7 | PAU, Ludhiana |
| 12 | IC052312 | NBPGR, New Delhi | 40 | Hari Kranti | IIVR, Varanasi |
| 13 | IC052321 | NBPGR, New Delhi | 41 | Plamkomal | CSKHPKV |
| 14 | IC052322 | NBPGR, New Delhi | 42 | Anima | Bhiarvi bio-Sciences, |
| 15 | IC057733 | NBPGR, New Delhi | 43 | Pusa Makmali | IARI, New Delhi |
| 16 | IC058235 | NBPGR, New Delhi | 44 | VRO-4 | IIVR, Varanasi |
| 17 | IC058704 | NBPGR, New Delhi | 45 | Kashi Kranti | IIVR, Varanasi |
| 18 | IC058710 | NBPGR, New Delhi | 46 | Salkeerthi | KAU. Kerala |
| 19 | IC058712 | NBPGR, New Delhi | 47 | Hisar Naveen | CCSHAU, Hisar |
| 20 | IC058768 | NBPGR, New Delhi | 48 | Pusa Sawani | IARI, New Delhi |
| 21 | IC086008 | NBPGR, New Delhi | 49 | Arka Anamika | IARI, New Delhi |
| 22 | IC089712 | NBPGR, New Delhi | 50 | Kashi Pragati | IARI, New Delhi |
| 23 | IC089713 | NBPGR, New Delhi | 51 | Dhanvi66 | Dhanvi Seeds, |
| 24 | IC045995 | NBPGR, New Delhi | 52 | Hinarch | Manivk seeds, |
| 25 | IC050418 | NBPGR, New Delhi | 53 | GFS Gold | Gujarat Farm Seeds |
| 26 | IC046018 | NBPGR, New Delhi | 54 | Punjab 8 | PAU, Ludhiana |
| 27 | IC048281 | NBPGR, New Delhi | 55 | Kashi Mohini | IIVR, Varanasi |
| 28 | IC048948 | NBPGR, New Delhi | | | |

**Table 7. Crossing block genotypes for L×T mating**

<table>
<tr><th>S.No.</th><th>Selected parents</th><th>Code</th><th>S. No.</th><th>Selected parents</th><th>Code</th></tr>
<tr><td colspan="3">Lines</td><td colspan="2">Testers</td><td></td></tr>
<tr><td>1</td><td>IC058710</td><td>L1</td><td>11</td><td>EC169452</td><td>T1</td></tr>
<tr><td>2</td><td>IC045993</td><td>L2</td><td>12</td><td>IC052310</td><td>T2</td></tr>
<tr><td>3</td><td>Pusa Swami</td><td>L3</td><td>13</td><td>EC169459</td><td>T3</td></tr>
<tr><td>4</td><td>VRO-4</td><td>L4</td><td>14</td><td>Kashi Pragati</td><td>T4</td></tr>
<tr><td>5</td><td>IC052299</td><td>L5</td><td>15</td><td>IC052321</td><td>T5</td></tr>
<tr><td>6</td><td>Kashi Kranti</td><td colspan="4">Check</td></tr>
<tr><td>7</td><td>Salekeerthi</td><td>Check</td><td colspan="3">Sowmya $F_1$</td></tr>
<tr><td>8</td><td>IC058235</td><td colspan="4" rowspan="3"></td></tr>
<tr><td>9</td><td>Hisar Naveen</td></tr>
<tr><td>10</td><td>IC052302</td></tr>
</table>

**3.3 Experimental details:**

The materials used and statistical methods followed during the course of investigation are given below.

| | | | |
|---|---|---|---|
| 1 | Name of the experiment | : | Study on Phenotypic characterization along with $F_1$ okra hybrid analysis for heterosis, combining ability and stability |
| 2 | Seasons | : | *Summer*-2022<br>*Kharif* -2022<br>*Summer* -2023 |
| 3 | Environment | : | 2023 summer - early ($E_1$), timely ($E_2$) and late ($E_3$) |
| 4 | Diversity | : | 55 genotypes |

| | | | |
|---|---|---|---|
| 5 | Parents | : | 15 (10 Lines and 5 Testers) |
| 6 | Number of Genotype for evaluation | : | 66 (50 hybrids + 15 parents + 1 checks) |
| 7 | Experimental design | : | RBD |
| 8 | Number of replications | : | 3 |
| 9 | Spacing | : | 60 x 30 cm (crossing)<br>45 x 30 cm (Diversity and Evaluation) |
| 10 | Plant protection | : | As per requirement |

### 3.4 Observations recorded

### 3.4.1 Observations of quantitative data

The study followed the descriptor list developed by the International Plant Genetic Resources Institute (IPGRI) in 1991 specifically designed for okra. This list likely contained a set of standardized traits that could be used to describe and measure various characteristics of okra plants. A total of seventeen parameters related to yield and yield contribution were observed, maintaining border plants within each replication. Within every plot, five competitive plants were chosen at random and labelled for observational purposes. However, specific traits like days to first flowering, days to 50% flowering and days to first fruit harvest were recorded per plot basis.

#### 3.4.1.1: First flowering node

The node number at which the first flower appeared on each of the selected plants was counted. The node numbers for the first flower on the five plants were averaged to obtain the average first flowering node.

#### 3.4.1. 2: First fruiting node

Counted the node number where the initial fruit appeared on each of the chosen plants. The node numbers for the first fruit on the five plants were averaged to obtain the average first fruiting node.

#### 3.4.1.3: Days to first flowering

The duration from the planting date to the appearing of the first flower was noted.

### 3.6.1.4: Days to 50% flowering

The duration from the first planting to the point at which 50% of the plants reached the flowering stage was documented.

### 3.4.1.5: Days to first fruit harvest

The time elapsed from seed planting to the initial fruit picking was observed

### 3.4.1.6: Plant height (cm)

At the time of the last harvest, the height of the plant was measured from the ground up to the last bud. This was done in centimeters.

### 3.4.1.7: Internodal length (cm)

The internode length calculated across the 5$^{th}$ and 6$^{th}$ nodes during a last fruit harvest.

### 3.4.1.8: Number of branch count/ plant

A random selection of five plants was chosen during the final harvest, and the count of branches on each of these plants was recorded.

### 3.4.1.9: Number of nodes per plant

The cumulative tally of nodes situated on the primary shoot was documented at the final harvest.

### 3.4.1.10: Fruit length (cm)

The estimation of marketable fruit length was conducted through the measurement of the distance from the base of the fruit (with the exception the pedicel) to its tip at the time of harvest.

### 3.4.1.11. Fruit diameter (mm)

The vernier scale was utilized to measure the equatorial length of fruits at their midpoint. This measurement was conducted on five fruits randomly selected. It was expressed in millimetre.

#### 3.4.1.12: Number of ridges per fruit

Number of ridges per fruit recorded for randomly selected five fruitsfrom tagged plants and recorded.  Ridges are longitudinal ribs that run along the length of the okra pod.

#### 3.4.1.13: Number of marketable fruits per plant

It was done to determine the number of fruits suitable for sale, excluding those impacted by pest infestation, at every harvest and was summed up and an average was taken.

#### 3.4.1.14: Number of pickings per plant

A sample of five plants had the period of fruit harvest documented, with data collected every two days.

#### 3.4.1.15: Average fruit weight (g)

This process involved dividing the total fruit output from each specifically chosen plant by the respective plant's overall fruit count. The measured quantity was documented in grams.

#### 3.4.1.16: Number of fruits per plant

Every fruit, including those affected by borers, was counted during every harvest to determine the trait.

#### 3.4.1.17: Fruit yield per plant (g)

The cumulative weight of fruits collected from five specifically chosen plants was quantified throughout successive harvests, with the measurements being recorded in grams.

### 3.4.2 Observations of qualitative descriptors

Qualitative descriptors data were collected based on vegetative and reproductive characteristics that corresponded to the Distinctiveness, Uniformity and Stability (DUS) guideline descriptors of NBPGR (Mahajan *et al*., 2000), IPGRI (1991) and UPOV (1999). Plant vigour and architecture, whole plant pigmentation, pubescence and fruit traits were measured. Table 8 represents all 10 quantitative characters. The Royal Horticultural Society (RHS) colour chart (1986) was used to analyses colour qualities such as stem colour, mature leaf colour, and fruit colour.

**Table 8. Qualitative descriptors used in morphological characterization of okra**

| Sr. No. | Character measured | Descriptor states and codes | Type of Assessment |
|---|---|---|---|
| **1** | Stem colour | Green (G), Green with purple tinge (GPT), Purple (P) | VG |
| **2** | Plant habitat | Erect(E), Medium(M) Procumbent (PC) | VG |
| **3** | Petiole Colour | Cream (C), Yellow (Y), Purple (P) | VG |
| **4** | Fruit Surface between ridges | Concave (CC), Flat (F), Convex (CV) | VG |
| **5** | Maturate of fruit colour | Yellowish Green (YG), Green (G), Dark Green (DG), Red (R), Deep Red (DR) | VG |
| **6** | Fruit pubescence | Downy (D), Slightly rough (SR), Prickly (P) | VG |
| **7** | Fruit axis | Straight (S), Curved (C) | VG |
| **8** | Fruit type | Angular (AN), Round(R) | VG |
| **9** | Fruit shape | Broad Acute (BA), Narrow Acute (NA) Acute (A) | VG |
| **10** | Seed shape | Round (R), Kidney (K), Spherical (S) | VG |

**VG:** Visual assessment by a single observation of a group of plants or parts of plants

## Plate 1. Qualitative descriptors of the characters



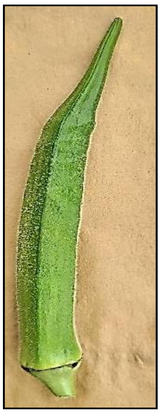
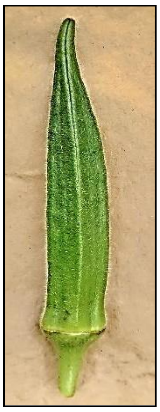
A. Shallow B. Medium C. Deep

**depth of leaf lobing**


A. Yellow B. Cream

**Petel Colors**




A. Yellowish green B. Green C. Dark green A. Narrow Acute B. Acute C. Broad Acute

**Mature fruit color** **Fruit shape apex**

**3.5 Statistical analysis**

3.6.1 Analysis of variance **(Panse and Sukhatme, 1985**)

3.6.2 Genetic variability **(Burton,1952)**

3.6.3 Heritability **(Hanson *et. al.*, 1956)**

3.6.4 Genetic advance (**Johnson *et. al.*, 1955)**

3.6.5 Genetic diversity ($D^2$ analysis) **(Mahalanobis, 1936)**

3.6.6 Heterosis **(Fonseca and Patterson,1968)**

3.6.7 Combining ability analysis **(Line x Tester analysis, Kempthorne,1957)**

3.6.8 Stability analysis **(Eberhart and Russell, 1966)**

**3.5.1 Analysis of variance**

Conducted a statistical analysis of the data on various crop characteristics using the appropriate method recommended by Panse and Sukhatme (1985). To assess the significance of differences between the treatments, we employed the analysis of variance (ANOVA) technique. The determination of significance relied on the F table values as outlined by Fisher and Yates (1967). We compared the calculated "F" value with the tabulated "F" values corresponding to both the 5% and 1% significance levels, taking into account the degrees of freedom associated with the error term.

**Table 9: ANOVA for randomized block design table**

| **Source of variation** | **d. f.** | **S.S.** | **M.S.S.** | **F value table** | |
|---|---|---|---|---|---|
| | | | | **Calculated** | **Table** |
| **Replication** | (r-1) | SSR | MSR | $\frac{MSR}{EMS}$ | |
| **Treatment/ Genotype** | (t-1) | SST | MST | $\frac{MST}{MSE}$ | |
| **Error** | (r-1) (t-1) | SSE | MSE | - | |
| **Total** | (rt-1) | SST | - | - | |

Where, r = Number of replications

t = Number of treatments

d.f = Degree of freedom

SSr= Replication sum of square

### 3.5.2 Genetic variability

**Mean:**

To calculate the mean or average, you sum up all the values of the observations and then divide this total by the count of observations. This can be expressed as $A = \Sigma X_i/N$, where A stands for the average (or mean), N represents the number of observations, and $X_i$ denotes the value of each individual observation

**Range:**

It can be calculated by taking the minimum and maximum values and subtracting both.

**Standard Error (SE):**

The standard error is the measure of uncontrolled variation within a sample. To calculate it, you divide the estimate of the standard deviation by the square root of the sample size

$$\text{Standard error} = \frac{s}{\sqrt{n}}$$

In this formula, S = Standard deviation

$\sqrt{n}$ = Total no. of observation

**Genotypic Variance:**

The genotypic variance is determined using the following formula:

$$V_G = \frac{MST - MSE}{r}$$

Where, $V_G$ = Genotypic variance

MST = Treatment means sum of square

MSE = Error mean sum of square

r = total number of replications

**Phenotypic Variance:**

The phenotypic variation can be expressed as the sum of the genetic variance, which is the variance in the effects of the genotype, and the environmental variance, which is the variance in the effects of the environment. In order to calculate phenotypic variation, the following formula should be used:

VP=VG+VE

Where, VP = Phenotypic variance

VG = Genotypic variance

**Coefficient of variation (CV %):**

The coefficient of variation was calculated in order to find the extent of variance present in each character. The formula derived by Burton and De Vane (1953) is presented as follows.

$$CV\% = \frac{SD}{N} X100$$

Where, SD= Standard deviation

N= Mean of character

**Phenotypic and genotypic coefficient of variances**

Burton and De Vane (1953) proposed a formula for computing both the phenotypic and genotypic coefficients of variation. These CV provide valuable insights into the relative variability of the trait within a specific population.

$$PCV\ (\%) = \frac{\sigma p}{\bar{x}} X100$$

$$GCV\ (\%) = \frac{\sigma g}{\bar{x}} X100$$

Were,

$\sigma p$ = phenotypic standard deviation

$\sigma g$ = genotypic standard deviation

$\bar{x}$ = general mean

**Table 10. Siva Subramanian and Menon were responsible for conducting the categorization of the scale for GCV and PCV**

| S.No | Range of GCV and PCV (%) | Scale |
|---|---|---|
| **1.** | 0 to 10 | Low |
| **2.** | 10 to 20 | Moderate |
| **3.** | >20 | High |

### 3.5.3 Heritability

Heritability is defined as the fraction of the variation in a trait's phenotype that can be attributed to genetic variation. The calculation of broad-sense heritability was conducted following the method introduced by Hanson *et al*. in 1956

$$H = \frac{\sigma g^2}{\sigma p^2} X100$$

$\sigma^2 g$ =Genotypic variance = $\frac{MST-MSE}{r}$

$\sigma^2 p$ =Phenotypic variance= $\sigma^2 g + \sigma^2 e$

**Table 11. Scale for Heritability were classified by Robinson *et al*., (1949)**

| Sr. No | Broad sense heritability | Scale |
|---|---|---|
| **1** | Low | Below 30 |
| **2** | Medium | 31 to 60 |
| **3** | High | Above 61 |

### 3.5.4 Genetic advance

The concept of genetic advancement relates to the mean genotypic value of chosen plants in comparison to the original parental population. The methodology proposed by Johnson *et al*. (1955).

$$GA = K \times \sigma^2 p \times h^2$$

Where,

K= Selection intensity, as determined by statistical analysis at a significance level of 5%, is 2.06.

$\sigma^2 p$ = Phenotypic level of standard deviation

$h^2$ = Heritability (BS) in fraction

### Genetic advance as percentage of mean

Genetic advance as percentage of mean was calculated by the following formula:

Genetic advance as percentage of mean = $\frac{GA}{\bar{x}} X100$

### 3.6.5 Genetic diversity using $D^2$ analysis

One of the most effective methods for determining genetic distance between genotypes using allelic frequencies at various loci is the Mahalanobis $D^2$ statistic, introduced in 1928.

This technique transforms the original variable means into uncorrelated variables through the pivotal condensation method of matrix inversion. The $D^2$ values between genotypes are then computed by summing the squares of the differences between these transformed variable values.

$$di = Yi^1 - Yi^2$$

Here, let's denote the transformed variables as Yi, where i represents a set of variables

(i = 1, 2, 3, 4, 5, ..., p).

$$D^2 = \sum (Yi^1 - Yi^2)^2$$

Rao, 1952 proposed by Tocher for the formation of clusters. According to this criteria, any two populations within the same cluster had to exhibit a smaller $D^2$ value when compared to populations belonging to different clusters.

### 3.6.5.1 Average intra-cluster and inter-cluster distances were measured as under:

Average intra cluster distance ($D = \sqrt{D^2}$)

$$D^2 = \frac{\sum D_i^2}{n}$$

Where,

$\sum D_i^2$= Sum of distance between all possible combinations of the two clusters populations in cluster

n = Number of populations in cluster

### 3.6.5.2Average distance between clusters ($D = \sqrt{D^2}$)

$$D^2 = \frac{\sum D_{ij}^2}{n_i \times n_j}$$

Where,

$D_{ij}^2$= Sum of distance between all possible combinations of the two clusters

$n_i$= Number of populations in cluster i

$n_j$ = Number of populations in cluster j

### 3.6.6 Estimation of heterosis

The estimation of heterosis was conducted using the mean of parents and $F_1$ hybrids, using the methodology proposed by Fonseca and Patterson (1968).

Heterobeltiosis (hii) = $F_1 - BP/BP\ X$ 100

Standard heterosis (siii) = $F_1 - SV/SV\ X$ 100

**Test of Significance**

The following method was used to figure out the standard error for heterosis:

$$\text{S.E. for MP} = \sqrt{3EMS2r}$$

$$\text{S.E. for MP and SV} = \sqrt{2EMSr}$$

$$\text{C.D.} = \text{S.E. for H x t}$$

Where,

EMS stands for Error Mean Square

R stands total Number of replications

't' value required depends on the significance level (usually 5% or 1%)

**Least significance differences (critical difference) for heterosis**

The CD represents the smallest difference between two values that needs to be exceeded for the disparity to be statistically significant. This approach enables researchers to establish whether the variation between the estimations of heterosis is statistically meaningful, considering the variability inherent in the data and the specific d.f associated with the statistical analysis.

CD = Sem x ‘t’ table value at degrees of freedom

**3.6.7 COMBINING ABILITY ANALYSIS**

The Line x Tester technique, originally introduced by Kempthorne in 1957, is a well-established method frequently applied in plant breeding and genetics. Its primary purpose is to evaluate the contributions of parental lines and specific crosses by assessing the combining ability effects. This technique proves invaluable in discerning the relative significance of two key factors: GCA and SCA in the inheritance patterns of various traits.

**Statistical model:**

The analysis was done based on the following statistical model:

$$Yi_{jk} = \mu + m_i\ f_j + S_{ij} + e_{ijk}$$

Whereas,

$\mu$= population mean

$m_i$ = gca effect of $i_{th}$ (male) parent

$f_j$ = gca effect of $j_{th}$ (female) parent

$S_{ij}$ = gca of (I x j) $^{th}$ cross

**Table 12. ANOVA table for L x T combining ability**

| Source of Variance | d.f | M.S. S | Expected M.S. S |
|---|---|---|---|
| Replications | (r-1) | - | - |
| Cross combinations (p) | (p-1) | - | |
| Females (x) | (x-1) | M1 | PE+rfm+rPm |
| Males (k) | (k-1) | M2 | PE + rPfm + rmPF |
| L *vs* T | (x-1) (k-1) | M3 | PE + rPfm |
| Error | (r-1) (fm-1) | M4 | PE |

Where,

r = no. of replications

x = no. of lines

p = crosses

k = no. of testers

Pm= GCA variance of males

PF= GCA variance of females

Pf m= SCA variance of males x females respectively

**3.6.7.1 Estimation of variance components**

Covariance estimation between full siblings and half-siblings was carried out using genetic probability-based mean squares analysis.

Cov. (F.S) = M1+M2+M3-3M+σr Cov. (H.S.)-r (l+t) Cov. (H.S.)/3r

Cov. (H.S) = M1+M2-2M3r (l+t)

The variances attributable to gca ($\sigma^2$sca) and specialized combining ability (σ2sca) were calculated based on the covariance of full siblings and the covariance of half siblings.

$\sigma^2$gca = Cov. (H. S.)

$\sigma^2$sca = Cov. (F. S.) – 2 Cov. (H. S.)

**3.6.7.2 The variances of GCA for lines and testers and SCA for hybrids were computed as follows:**

Variance of GCA for lines ($\sigma^2$GCA lines) = ($M_1$ - $M_3$) / (rt)

Variance of GCA for testers ($\sigma^2$GCA testers) = ($M_2$ - $M_3$) / (rl)

Variance of SCA for hybrids ($\sigma^2$SCA hybrids) = ($M_3$ - $M_4$) / r

### 3.6.7.3 Estimation of combining ability effects

The gca and sca effects were determined utilizing the prescribed methodology

$X_{ijk} = \mu + g_i + g_j + S_{ij} + e_{ijk}$

**Test of significant of combining ability**

Determined the variances of the estimations using the given formula. Subsequently, we calculated the standard errors of these estimations by taking the square roots of their respective variances

S.E. (gca for the line) = $(M_4/rt)1/2$

S.E. (gca for the tester) = $(M_4/rl)1/2$

S.E. (sca the effect) = $(M_4/r)1/2$

Where,

M4 represents the error variance.

r stands for the number of replications.

l refers to the lines.

t represents the testers.

### 3.6.7.4 Least significant differences between estimates:

Calculating the Least Significant Difference (LSD) is a statistical procedure used in the context of analysis of variance (ANOVA) to determine whether the differences between means in multiple groups are statistically significant.

S.E. (gi – gj) lines = $(2M_4/rt)^{1/2}$

S.E. (gi – gj) testers = $(2M_4/rl)^{1/2}$

S.E. ($S_{ij} - S_{kl}$) crosses = $(2M_4/r)^{1/2}$

**Analysis of additive and dominating variance**

We calculated additive and dominance variances using the method in both heterozygous (F=0) and homozygous (F=1) conditions.

$$\sigma^2 \text{ GCA} = [1+F/4]\ \sigma^2 \text{ A}$$

$$\sigma^2 \text{ A} = [4/1+F]\ \sigma^2 \text{ GCA}$$

$\sigma^2$ SCA = [1+$F$/4] $\sigma^2$ D

$\sigma^2$ D = $\sigma^2$ GCA [2. /1+$F$]$^2$

Where,

Inbreeding coefficient (F) and the variances associated with additive ($\sigma^2$A) and dominance ($\sigma^2$D) genetic effects.

### 3.6.8 REGRESSION MODEL (Eberhart and Russell, 1966)

The average values obtained for multiple attributes for both parents and their hybrids across three contexts were analysis of variance to assess phenotypic stability. Eberhart and Russell (1966) employed the subsequent model to explore genotype stability across different environments.

$$X_{ij}=p_i+b_{ij}+\delta_{ij}+e_{ij}$$

Whereas,

$X_{ij}$ = Mean performance of i$^{th}$ genotype at the j$^{th}$ environment.

$p_i$= Mean of the i$^{th}$ genotype pooled environments

$b_{ij}$ =Mean of genotypes by environment interaction

$e_{ij}$ = error $i^{th}$ genotype in the j$^{th}$ environment

According to the model proposed by Eberhart and Russell (1966), an optimal variety is characterized by a high average yield, a regression coefficient of unity (bi=1), and minimal variance from linear regression ($S^2$di=0).

**Table 13. ANOVA for Eberhart and Russell model**

| Source | D.f | SS | MS | 'F' Ratio |
|---|---|---|---|---|
| Total | gn-1 | $\sum_i \sum_j Y^2 ij - C.F.$ | $M_2$ | $\frac{M_2}{M_4}$ |
| Genotypes | g-1 | $\frac{1}{n}\sum_i Y^2 i - C.F.$ | | |
| Environments (Env) + Interaction (G x E) | g(n-1) | $\sum_i \sum_j Y^2 ij - \frac{\sum Y^2 i}{n}$ | | |
| Environment (linear) | 1 | $\frac{1}{g}(\sum_j YjIj)^2 / \sum \sum_j Ij^2$ | $M_3$ | $\frac{M_3}{M_4}$ |

| | | | | |
|---|---|---|---|---|
| Geno x Env. (linear) | g-1 | $\sum_i [(\sum_j Y_{ij} I_j)^2 / \sum_i I^2 j]$ –Env.. (linear) SS | | |
| Pooled deviation | g x (n-2) | $\sum_i \sum_j \delta^2 ij = [\sum_j Y^2 ij - {}^{Y} i^2 ] = \sum^2 \sum^2$ | $M_4$ | $\frac{M_4}{M_5}$ |
| Deviation for genotype 1 | n-2 | $[\sum_j Y^2 gi^{2\,Y} g_n = (\sum_j Y g_j I_j)^2 / \sum I^2 J$ | | |
| Deviation for genotype n | n-2 | - do - | $M_5 = M'e$ | |
| Pooled error | N(r-1) (g-1) | | | |

### 3.6.8.1 Computation of (bi) for each germplasm

bi = Σj ($Y_{ij}$ x Ij) / Σj (Ij^2)

Where,

bi=The regression coefficient for the i$^{th}$ genotype

Ij=The environmental index for the j$^{th}$ location.

Σj=S Summation over all locations.

$Y_{ij}$=The value of the response variable for the i$^{th}$ genotype at the j$^{th}$ location.

### 3.6.8.3 S²di is the mean square deviation from linear regression:

In regression analysis, it's common to decompose the total variance of the dependent variable (Y) into two components: the variance due to the linear relationship between the dependent and independent variable(s) (variance explained by the regression model) and the variance due to deviations from the regression line (variance explained by residuals or errors).

$\sigma^2 Y = \sigma^2$ (regression) + $\sigma^2$ (deviation from regression)

By subtracting the variance attributed to regression from the total variance (σ^2Y), we can isolate the variance caused by deviations from the regression line. This isolated variance becomes useful for estimating values related to s^2di. To quantify the variation of averages among different locations for specific genotypes, the following approach can be employed.

$\sigma^2$ gi = Σj (Yij - ($Yi^2$/g))

ij: This represents the mean value of a specific genotype in a particular site or location (i) and j might denote different genotypes.

Yi: This represents the total mean value of a variety across all locations, regardless of genotype.

The variability attributed to deviations from the regression line, denoted as Σiδij² for a specific genotype, can be expressed as follows: $\Sigma\delta_{ijj}$ = [Σ($Yij^2$) - ($Yi^2$ / gj)] - (Σ (Yij x Ij)) ² / Σ($Ij^2$)

ΣY2ij−Y2jig = variance associated with the dependent variable

$(\Sigma Yij-ijj)2(\Sigma ijj)2$=The variability due to regression

$S^2$di for each genotype is computed as follows:

$S^2$di = $\Sigma\delta^2{}_i j/e-2-(s2e/r)$

Mean square = Deviation from regression /degree of freedom for environment−Pooled error deviation /Number of replications, variance associated with genotypes, environments, and the combined error was determined using a similar approach as the division of the TSS into three distinct components in the pooled analysis of the dataset.

**3.8.2.4 Test of Significance:**

The combined deviation was employed to assess the MSS arising from germplasms and environments. Meanwhile, the mean sum of squares related to the G x E interaction was compared to the combined error. In cases where the combined deviation is not statistically significant, both linear components (Environment and G x E) are tested against the combined error. The mean sum of squares resulting from the combined deviations was then compared to the combined error, and the following significance tests were conducted.

1. To evaluate the significance of differences among genotype means, where the null hypothesis (Ho) assumes that all genotype means are equal (μ1 = μ2 = μ3 = ... = μn), you can perform an analysis of variance (ANOVA) test. In this context, you calculate an F-statistic,

which is the ratio of the MSS due to genotype (MS1) to the mean sum of squares due to pooled deviation (MS3).

$$F = MS3/MS1$$

2. To evaluate whether the genotypes exhibit similar regression patterns with respect to the environmental index (i.e., testing the null hypothesis Ho: b1 = b2 = b3 = ... = bn), the 'F' test was employed. This test involves comparing the mean sum of squares associated with the linear interaction between genotype and environment (denoted as MS2) to the mss due to pooled deviation ($MS_3$).

'F' statistic is calculated as follows:

$$F = MS_2/MS_3$$

3. To evaluate individual deviations from linear regression, a specific approach was employed. This approach involves calculating the 'F' statistic as follows

$$F = (\sum(\delta ij^2 S - 2)) \text{ pooled error}$$

4. In regression analysis, hypothesis tests are utilized to assess whether a regression coefficient significantly deviates from a predefined value, which can be either unity (1) or zero (0). The t-statistic is computed using the following formulas: $t = |b-0|SE(b)$ or $t = |b-1|SE(b)$ Here, SE(b) denotes the standard error associated with the coefficient estimate.

**3.6.8.5 Stable Genotype:**

Genotype stability is described by a regression coefficient (bi) close to 1, showing a consistent response to the independent variable, along with a mean square deviation ($S^2di$) that is statistically insignificant. To calculate the overall mean of these regression coefficients ($\bar{b}$), add up the individual bi values and divide by the total number of genotypes (g).

Mean and standard error of ‘b’

$$\text{Mean of } b = b = \sum_i bi/g$$

*CHAPTER - 4*

# RESULTS

The current investigation's experimental findings entitled “Study on Phenotypic characterization along with $F_1$ okra hybrid analysis for heterosis, combining ability and stability” are outlined under in the given headings

**I. Characterization, genetic variability and diversity of okra genotypes**

4.1 Genetic variability studies

4.2 Morphological diversity (Mahalanobis $D^2$)

4.3 Characterization of okra genotypes based on morphological descriptors

**II. Studies on combining ability and heterosis**

4.4 Analysis of variance

4.5 Mean performance

4.6 Magnitude and extent of heterosis

4.7 Estimation of combining ability effect and gene action

4.8 Proportional contribution of lines, testers and their interaction

**III. Validation of selected hybrids for stability (G x E) analysis**

4.9 Regression model (Eberhart and Russell, 1966)

**IV. Characterization of parents and their testers on morphological descriptor**

4.10 Characterization of okra parents and hybrids based on morphology

## 4.1 GENETIC VARIABILITY STUDIES

### 4.1.1 ANOVA

Table 14 displays the outcomes of the analysis of variance performed on the experiment's evaluated traits. Genetic variability was observed in seventeen characteristics across 55 entries. The ANOVA revealed a highly significant ($P>0.01$) impact of genotypes on all morphological characters, indicating their involvement in the observed variations. No significant variation was observed in replication, indicating minimal error attributable to the environment.

**Table 14. ANOVA for okra fruit yield and associated constituents**

| Source | Replication | Treatment | Error |
|---|---|---|---|
| **Degree of Freedom** | **2** | **54** | **108** |
| First flowering node | 0.124 | 0.490** | 0.077 |
| Frist fruiting node | 0.066 | 0.351** | 0.122 |
| Days to first flower | 0.236 | 5.109** | 0.638 |
| Days to 50% flowering | 0.115 | 6.450** | 0.807 |
| Days to first fruit harvest | 0.291 | 7.877** | 2.723 |
| Plant height (cm) | 52.156 | 161.483** | 7.843 |
| Internodal length (cm) | 0.041 | 0.541** | 0.201 |
| Number of branches per plant | 0.071 | 0.373** | 0.147 |
| Number of nodes per plant | 0.699 | 2.526** | 0.355 |
| Fruit length (cm) | 0.817 | 3.034** | 0.48 |
| Fruit diameter (mm) | 12.188 | 2.262** | 0.772 |
| No. of ridges per fruit | 0.026 | 0.077** | 0.035 |
| Number of fruits per plant | 0.452 | 61.295** | 0.889 |
| Number of marketable fruits per plant | 0.615 | 59.220** | 1.031 |
| Average fruit weight (g) | 1.837 | 2.608** | 0.336 |
| Number of pickings per plant | 0.947 | 11.596** | 0.896 |
| Fruit yield per plant (g) | 566.18 | 11966.897** | 143.941 |

*** and ** stand for levels of significance at 5% and 1%.**

### 4.1.2 MEAN PERFORMANCE OF GENOTYPES

The range and mean given in Table15 indicated greater variations for all seventeen evaluated traits for the current study, which addressed as the below given headings:

#### 4.1.2.1 First flowering node

First flowering node ranges from 3.73 (Pusa Makhmali) to 5.93 (EC169459) with a mean value of 4.60 and a CV of 6.03%.

#### 4.1.2.2 First fruiting node

The mean performance of the first fruiting node ranges from 4.60 (IC089713 and Hari Kranti) to 6.13 (EC169459) with a mean value of 5.11 and a CV of 6.83%.

#### 4.1.2.3 Days to first flowering

Days to first flowering ranges from 36 days (Hisar Naveen) to 41.33 days (IC052321) with a mean value of 38.31 days and a CV of 2.08%.

#### 4.1.2.4 Days to 50% flowering

The mean performance of days to 50% flowering ranges from 38.33 days (IC045993) to 45.00 days (IC052321) with mean value of 41.39 days and CV of 2.17%.

#### 4.1.2.5 Days to first fruit harvest

Days to first fruit harvest range between 45.33 days (Pusa Sawani) to 51 days (IC052321) mean value of 47.70 days and CV of 3.46%.

#### 4.1.2.6 Plant height (cm)

Plant height ranges from 69.29 cm (EC169459) to 100.24 cm (VRO-4) with a mean value of 86.01 cm and CV of 3.26%.

#### 4.1.2.7 Internodal length (cm)

In this character ranges from 4.59 cm (EC169453) to 6.53 cm (VRO-4) with a mean value of 5.54 cm and CV of 8.06%.

#### 4.1.2.8 Number of branches per plant

Mean performance ranges from 4.27 (EC169452 and IC058235) to 5.94 (IC052320) with average value of 5.56 and a CV of 8.06%.

#### 4.1.2.9 Number of nodes per plant

Number of nodes per plant ranges from 13.80 (EC169453) to 19.07 (Pusa Sawani) with mean value of 16.90 and a CV of 3.52%.

#### 4.1.2.10 Fruit length (cm)

The mean performance of fruit length ranges from 9.28 cm (IC52302) to 14.64 cm (Salkeerthi) with a mean value of 13.38 cm and a CV of 5.17%.

#### 4.1.2.11 Fruit diameter (mm)

The mean performance of the fruit diameter ranges from 13.61 mm (IC052302) to 18.18 mm (IC058710) with a mean value of 15.88 mm and a CV of 5.55%.

#### 4.1.2.12 Number of ridges per fruit

Number of ridges per fruit ranges between 5.00 (EC169459, Pusa Makmali and Hinarch) to 5.53 (GFS Gold) with a mean value of 5.22 and a CV of 3.25%.

#### 4.1.2.13 Number of fruits per plant

Number of fruits per plant mean ranges from 14.33 (EC169452) to 28.20 (Kashi Kranti) with a mean value of 22.33 and a CV of 4.23%.

#### 4.1.2.14 Number of marketable fruits per plant

No. of markable fruits per plant mean performance ranges from 13.53 (EC169452) to 26.20 (Kashi Kranti) with mean of 20.51 and a CV of 4.95%.

#### 4.1.2.15 Average fruit weight (g)

Average fruit weight mean range between 10.84 (IC089712) to 14.58 (Pusa Sawani) with a mean value of 12.49 g and CV of 4.63%.

#### 4.1.2.16 Number of pickings per plant

The mean performance of the number of pickings per plant ranges from 9.47 (IC045995) to 16.70 (IC058235) with mean of 14.08 and a CV of 6.74%.

#### 4.1.2.17 Fruit yield per plant (g)

Fruit yield per plant mean ranges from 173.57 (EC169452) to 374.23 (Kashi Kranti) with average value of 278.63 g and CV of 6.29%.

**Table 15. Mean performance for growth and yield characters of 55 okra genotypes**

| GEN/ CHR | FFN | FFRN | DF | D50F | DFFH | PH | INL | NB | NND | FL | FD | NRG | NFP | MFP | AFW | NPS | FYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC169450 | 4.80 | 5.20 | 39.33 | 43.33 | 49.33 | 73.47 | 5.32 | 5.27 | 14.80 | 13.40 | 15.96 | 5.07 | 22.60 | 20.87 | 11.96 | 13.47 | 269.70 |
| EC169452 | 4.93 | 5.27 | 40.00 | 44.33 | 48.67 | 76.79 | 5.32 | 4.27 | 12.53 | 10.28 | 17.01 | 5.27 | 14.33 | 13.53 | 11.33 | 10.80 | 173.57 |
| EC169453 | 4.07 | 4.80 | 41.00 | 44.33 | 49.00 | 72.22 | 4.59 | 5.33 | 16.33 | 12.31 | 17.38 | 5.07 | 16.53 | 14.27 | 13.06 | 10.60 | 215.47 |
| EC169455 | 4.33 | 4.73 | 39.33 | 43.67 | 48.33 | 77.63 | 6.00 | 5.33 | 17.00 | 13.59 | 16.35 | 5.27 | 22.27 | 20.20 | 12.29 | 13.87 | 273.20 |
| EC169456 | 5.13 | 5.80 | 39.67 | 44.00 | 49.33 | 72.38 | 5.82 | 5.07 | 17.60 | 13.98 | 15.11 | 5.47 | 15.87 | 13.60 | 11.11 | 11.27 | 176.13 |
| EC169459 | 5.93 | 6.13 | 38.67 | 41.33 | 48.67 | 69.29 | 5.13 | 5.20 | 16.20 | 13.51 | 17.23 | 5.00 | 20.53 | 18.33 | 13.07 | 13.67 | 268.13 |
| EC169461 | 4.33 | 4.73 | 39.33 | 42.67 | 49.00 | 81.64 | 5.78 | 5.67 | 17.73 | 12.45 | 15.37 | 5.07 | 23.13 | 20.63 | 12.30 | 13.93 | 284.37 |
| IC052299 | 4.73 | 5.20 | 39.67 | 42.67 | 50.00 | 77.60 | 6.04 | 4.87 | 17.20 | 14.59 | 16.40 | 5.20 | 24.20 | 21.80 | 12.83 | 14.37 | 310.00 |
| IC052301 | 4.40 | 5.00 | 39.00 | 42.33 | 49.00 | 79.80 | 6.15 | 5.67 | 16.13 | 12.12 | 17.37 | 5.47 | 18.67 | 17.13 | 10.92 | 13.70 | 203.73 |
| IC052302 | 4.93 | 5.07 | 37.00 | 40.33 | 44.33 | 92.47 | 5.97 | 5.53 | 17.13 | 9.28 | 13.61 | 5.07 | 22.93 | 20.13 | 12.87 | 14.33 | 295.13 |
| IC052303 | 4.27 | 4.73 | 37.67 | 41.33 | 47.00 | 90.77 | 5.38 | 5.13 | 18.53 | 12.99 | 15.19 | 5.13 | 19.67 | 17.73 | 11.88 | 12.40 | 233.37 |
| IC052312 | 4.93 | 5.20 | 40.33 | 44.00 | 50.33 | 90.03 | 5.48 | 5.13 | 17.67 | 14.64 | 15.28 | 5.20 | 21.27 | 19.07 | 12.07 | 14.33 | 256.50 |
| IC052321 | 4.73 | 5.13 | 41.33 | 45.00 | 51.00 | 75.95 | 6.23 | 5.27 | 15.40 | 13.87 | 15.25 | 5.20 | 25.53 | 23.07 | 12.27 | 15.77 | 312.77 |
| IC052322 | 5.20 | 5.53 | 38.00 | 42.00 | 48.67 | 84.80 | 5.94 | 5.13 | 16.53 | 13.17 | 14.92 | 5.20 | 21.80 | 19.47 | 12.24 | 12.27 | 266.83 |
| IC057733 | 5.40 | 5.80 | 37.00 | 41.33 | 47.33 | 84.53 | 6.39 | 5.00 | 17.60 | 13.35 | 15.50 | 5.20 | 20.67 | 19.07 | 13.29 | 12.37 | 273.73 |

*Table continues…*

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IC058235 | 4.80 | 5.13 | 38.33 | 42.00 | 49.00 | 93.80 | 5.90 | 4.27 | 17.07 | 13.44 | 16.62 | 5.33 | 25.20 | 23.27 | 12.68 | 16.70 | 319.40 |
| IC058704 | 4.87 | 5.07 | 39.00 | 42.33 | 48.33 | 85.40 | 5.07 | 4.73 | 15.73 | 13.21 | 16.65 | 5.13 | 18.80 | 17.67 | 11.41 | 13.10 | 214.33 |
| IC058710 | 4.27 | 4.87 | 37.00 | 40.67 | 47.00 | 72.48 | 5.58 | 4.93 | 15.13 | 14.51 | 18.18 | 5.53 | 27.93 | 26.47 | 12.32 | 17.33 | 343.83 |
| IC058712 | 5.07 | 5.40 | 37.00 | 41.00 | 46.67 | 83.66 | 6.33 | 4.80 | 16.67 | 12.73 | 16.54 | 5.40 | 18.67 | 16.67 | 12.47 | 13.87 | 232.67 |
| IC058768 | 5.00 | 5.73 | 38.00 | 41.00 | 46.67 | 80.44 | 5.29 | 5.60 | 17.07 | 11.22 | 16.24 | 5.27 | 12.93 | 11.67 | 12.77 | 10.40 | 165.33 |
| IC086008 | 4.20 | 4.87 | 37.67 | 40.67 | 48.00 | 79.50 | 5.30 | 5.13 | 16.27 | 12.71 | 16.79 | 5.27 | 15.00 | 13.60 | 14.52 | 12.97 | 218.00 |
| IC089712 | 4.60 | 5.13 | 37.00 | 41.00 | 47.00 | 77.60 | 5.07 | 4.93 | 16.33 | 10.81 | 15.42 | 5.00 | 15.60 | 13.57 | 10.84 | 10.57 | 169.00 |
| IC089713 | 4.00 | 4.60 | 36.00 | 39.33 | 46.67 | 78.90 | 5.23 | 5.20 | 16.60 | 12.27 | 16.17 | 5.40 | 16.33 | 15.67 | 13.68 | 10.97 | 223.27 |
| IC045995 | 4.07 | 4.80 | 37.67 | 40.67 | 47.00 | 85.93 | 5.12 | 5.60 | 17.07 | 12.60 | 15.23 | 5.13 | 13.53 | 12.57 | 12.49 | 9.47 | 168.53 |
| IC050418 | 4.47 | 5.07 | 38.00 | 40.67 | 47.33 | 88.17 | 5.11 | 5.20 | 17.53 | 13.89 | 15.45 | 5.20 | 25.47 | 23.33 | 12.82 | 15.27 | 326.30 |
| IC046018 | 4.60 | 5.13 | 38.67 | 41.33 | 47.33 | 81.71 | 5.44 | 5.53 | 16.00 | 13.97 | 15.39 | 5.20 | 25.90 | 23.27 | 13.32 | 16.13 | 345.00 |
| IC048281 | 4.80 | 5.40 | 38.33 | 41.33 | 47.00 | 83.81 | 5.69 | 4.93 | 16.20 | 13.45 | 16.82 | 5.07 | 22.07 | 19.87 | 13.09 | 13.30 | 288.71 |
| IC048948 | 4.33 | 4.80 | 36.67 | 39.33 | 46.33 | 96.09 | 5.47 | 4.93 | 17.60 | 13.67 | 15.76 | 5.47 | 17.93 | 16.67 | 11.84 | 11.40 | 212.46 |
| IC045993 | 4.33 | 5.20 | 36.33 | 38.33 | 46.67 | 82.10 | 5.28 | 5.27 | 16.13 | 12.49 | 17.40 | 5.40 | 22.47 | 20.07 | 12.08 | 15.20 | 270.87 |
| IC045994 | 5.00 | 5.47 | 36.67 | 39.67 | 47.00 | 92.37 | 5.68 | 5.13 | 17.60 | 14.24 | 15.45 | 5.20 | 25.27 | 22.60 | 11.58 | 14.63 | 292.67 |
| IC049972 | 4.93 | 5.40 | 39.33 | 42.00 | 46.00 | 90.30 | 5.41 | 5.80 | 17.27 | 13.42 | 15.24 | 5.13 | 18.07 | 15.87 | 11.34 | 12.27 | 204.86 |

*Table continues…*

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IC049734 | 4.67 | 5.33 | 40.00 | 43.00 | 49.67 | 91.17 | 5.83 | 4.87 | 17.53 | 13.02 | 15.41 | 5.07 | 24.80 | 22.80 | 11.55 | 16.27 | 286.13 |
| IC049749 | 5.13 | 5.07 | 39.00 | 40.67 | 49.33 | 93.78 | 5.66 | 5.13 | 16.40 | 14.48 | 18.18 | 5.07 | 26.87 | 24.67 | 11.41 | 15.27 | 306.67 |
| IC052298 | 5.07 | 5.20 | 39.00 | 41.00 | 49.00 | 98.13 | 5.79 | 5.20 | 17.13 | 13.11 | 15.74 | 5.33 | 26.73 | 25.53 | 10.89 | 16.47 | 291.00 |
| IC052313 | 4.53 | 5.00 | 36.67 | 39.67 | 46.00 | 89.43 | 5.45 | 5.47 | 17.00 | 13.72 | 15.00 | 5.07 | 25.73 | 24.33 | 11.12 | 16.37 | 285.80 |
| IC052308 | 4.53 | 4.67 | 37.67 | 40.00 | 48.00 | 85.45 | 5.23 | 5.53 | 16.87 | 14.56 | 15.39 | 5.33 | 25.07 | 23.40 | 12.16 | 13.03 | 304.83 |
| IC052320 | 4.60 | 5.33 | 39.67 | 43.00 | 47.67 | 89.65 | 5.15 | 5.94 | 16.73 | 13.60 | 15.35 | 5.20 | 16.33 | 14.67 | 11.55 | 12.80 | 188.60 |
| IC052310 | 4.47 | 4.73 | 39.00 | 41.33 | 49.33 | 92.93 | 5.04 | 5.27 | 17.47 | 13.95 | 16.07 | 5.00 | 25.13 | 23.60 | 11.76 | 14.67 | 295.18 |
| Punjab 7 | 3.80 | 4.80 | 37.00 | 40.33 | 47.00 | 95.61 | 5.90 | 5.20 | 17.60 | 13.49 | 16.88 | 5.07 | 27.73 | 25.73 | 11.59 | 16.13 | 321.27 |
| Hari Kranti | 4.00 | 4.60 | 38.00 | 40.33 | 48.00 | 88.78 | 4.85 | 5.47 | 16.87 | 14.30 | 15.15 | 5.47 | 25.93 | 24.60 | 13.29 | 14.97 | 344.67 |
| Palamkomal | 4.07 | 5.07 | 37.33 | 40.00 | 46.67 | 85.57 | 5.46 | 4.80 | 16.93 | 14.35 | 14.78 | 5.27 | 26.40 | 25.80 | 13.71 | 16.13 | 362.00 |
| Anima | 4.20 | 4.67 | 38.67 | 41.00 | 48.33 | 86.53 | 5.63 | 5.13 | 17.53 | 14.11 | 16.79 | 5.33 | 25.87 | 24.33 | 13.58 | 14.80 | 351.33 |
| Pusa Makhmali | 3.73 | 4.67 | 38.00 | 40.67 | 47.00 | 90.10 | 5.98 | 5.00 | 16.73 | 13.66 | 15.85 | 5.00 | 25.53 | 23.53 | 14.18 | 16.23 | 361.80 |
| VRO-4 | 4.60 | 5.07 | 38.33 | 40.33 | 41.33 | 100.24 | 6.53 | 5.60 | 18.87 | 14.03 | 15.23 | 5.40 | 25.67 | 23.13 | 12.22 | 15.57 | 313.77 |
| Kashi Kranti | 4.47 | 5.07 | 37.67 | 40.00 | 47.33 | 88.28 | 5.09 | 4.93 | 17.20 | 14.27 | 15.52 | 5.27 | 28.20 | 26.20 | 13.27 | 16.17 | 374.23 |
| Salkeerthi | 4.67 | 5.60 | 37.67 | 40.33 | 46.67 | 91.93 | 5.31 | 4.60 | 17.47 | 14.64 | 15.33 | 5.20 | 27.63 | 25.73 | 12.68 | 15.43 | 350.40 |

***Table continues…***

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hisar Naveen | 4.53 | 4.87 | 36.00 | 39.33 | 45.67 | 82.10 | 5.52 | 5.13 | 16.87 | 14.41 | 15.38 | 5.13 | 27.00 | 25.47 | 13.54 | 14.20 | 365.68 |
| Pusa Sawani | 4.53 | 4.93 | 40.33 | 42.67 | 45.33 | 98.07 | 5.58 | 4.73 | 19.07 | 13.61 | 15.74 | 5.22 | 24.73 | 23.33 | 14.58 | 13.57 | 359.67 |
| Arka Anamika | 4.67 | 5.47 | 39.00 | 41.67 | 48.33 | 87.27 | 6.07 | 5.20 | 16.53 | 14.54 | 15.09 | 5.13 | 26.00 | 23.13 | 12.94 | 14.87 | 335.87 |
| Kashi Pragati | 4.47 | 4.73 | 40.33 | 44.33 | 50.33 | 92.93 | 5.04 | 5.27 | 17.47 | 11.95 | 16.07 | 5.00 | 25.13 | 22.60 | 11.76 | 14.67 | 295.18 |
| Dhanvi66 | 4.80 | 5.27 | 39.00 | 41.33 | 48.33 | 92.49 | 5.27 | 5.07 | 17.40 | 12.95 | 15.07 | 5.33 | 15.80 | 13.73 | 14.36 | 14.87 | 212.15 |
| Hinarch | 4.60 | 5.40 | 37.67 | 41.00 | 48.33 | 88.40 | 5.23 | 5.07 | 18.60 | 13.85 | 17.53 | 5.00 | 24.07 | 22.40 | 12.50 | 14.90 | 300.53 |
| GFS Gold | 4.53 | 5.07 | 37.00 | 40.00 | 48.00 | 90.56 | 5.95 | 4.67 | 16.60 | 13.23 | 14.59 | 5.53 | 24.40 | 24.40 | 13.11 | 15.07 | 319.60 |
| Punjab 8 | 4.47 | 5.33 | 37.67 | 40.33 | 46.67 | 88.26 | 5.26 | 4.80 | 17.07 | 14.18 | 15.69 | 5.33 | 28.07 | 26.33 | 12.98 | 16.60 | 324.17 |
| Kashi Mohini | 4.60 | 5.13 | 38.00 | 40.33 | 47.33 | 91.50 | 5.45 | 5.20 | 17.07 | 13.91 | 16.65 | 5.33 | 18.33 | 16.27 | 13.40 | 14.52 | 266.03 |
| **Mean** | 4.60 | 5.12 | 38.32 | 41.39 | 47.70 | 86.01 | 5.54 | 5.15 | 16.90 | 13.35 | 15.92 | 5.22 | 22.33 | 20.50 | 12.49 | 14.08 | 278.63 |
| **Minimum** | 3.73 | 4.60 | 36.00 | 38.33 | 45.33 | 69.29 | 4.59 | 4.27 | 13.80 | 9.28 | 13.61 | 5.07 | 14.33 | 13.53 | 10.84 | 9.47 | 173.57 |
| **Maximum** | 5.93 | 6.13 | 41.33 | 45.00 | 51.00 | 100.24 | 6.53 | 5.94 | 19.07 | 14.64 | 18.18 | 5.53 | 28.20 | 26.20 | 14.58 | 16.70 | 374.23 |
| **CV%** | 6.03 | 6.83 | 2.08 | 2.17 | 3.46 | 3.26 | 8.06 | 7.46 | 3.52 | 5.17 | 5.55 | 3.57 | 4.23 | 4.95 | 4.63 | 6.74 | 6.29 |

**FFN:** First flowering node, **FFRN:** First fruiting node, **DFF:** Days to first flowering**, D50F:** Days to 50% flowering, **PH:** Plant height, **INL:** Inter nodal length, **NB:** Number of branches, **NON:** Number of nodes/plant, **FL:** Fruit length, **FD:** Fruit diameter, **NRG:** Number of ridges, **NFP:** Number of fruits/plant, **MFP:** Marketable fruits/plant, **AFW:** Average fruit weight, **NPS:** Number of pickings/plant, **FYP:** Fruit yield/plant.s

### 4.1.3 VARIABILITY, HAERITABILITY AND GENETIC ADVANCE

Biometric measurements like PCV, GCV, heritability, and genetic advancement can be used to discover variability. Table 16 includes estimates of variability parameters for all characters studied. The results have been categorised into the following headings.

#### 4.1.3.1 Genotypic and Phenotypic coefficients of variation

Higher estimates of GCV and PCV were observed in fruit yield per plant (22.46, 22.86), number of marketable fruits per plant (21.46, 22.03) and number of fruits per plant (20.13, 20.57). Moderate PCV and GCV were noted for number of pickings per plant (13.45, 15.04). Moderate PCV and low GCV for first flowering node (10.07,8.07) and internodal length (10.08,6.05), lower values of GCV and PCV were recorded for plant height (8.32, 8.93), average fruit weight (6.95, 8.35), fruit length (6.88, 8.61), first fruiting node (5.4, 8.7), number of nodes/ plant (5.02, 6.14), number of branches per plant (5.36, 9.19), fruit diameter (4.45, 7.11), days to 50% flowering (3.32,3.96), days to first flower (3.19, 3.81 ), days to first fruit harvest (2.75,4.41) and number of ridges per fruit (2.28, 4.24).

#### 4.1.3.2 Heritability

Heritability for broad sense was estimated for all the characters under study and observed range from 28.87% to 96.47%. High heritability (>60%) for fruit yield per plant (96.48), total fruits per plant (95.77), marketable fruits per plant (94.95),plant height (86.72), number of pickings per plant (79.92), days to first flowering (70.04), days to 50% flowering (69.99), average fruit weight (69.27), total nodes/plant (67.09), first flowering node (64.17), fruit length (63.97), and Moderate heritability (30-60%) recorded traits number of branches per plant (34.02), and fruit diameter (39.19), days to first fruit harvest (38.69), first fruiting node (38.47), internodal length (36.09). Low (<30) heritability number of ridges per fruit (28.87) recorded.

#### 4.1.3.3 Genetic Advance

The genetic advance % of the mean (at 5% selection intensity) observed range of 2.52 – 45.43. The fruit yield per plant (45.43), marketable fruits per plant (43.09), number of fruits per plant (40.58), and number of pickings per plant (24.76) exhibited high (>20) genetic advance as % of the mean. plant height (15.96), first flowering node (13.32), average fruit weight (11.91), fruit length (11.34) was moderate (10-20) GA % of the mean. Number of nodes per plant (8.48), internodal length

(7.49), first fruiting node (6.90), number of branches per plant (6.44), and their fruit diameter (5.73), days to 50% flowering (5.72), days to first flower (5.49), days to first fruit harvest (3.52) and total ridges per fruit (2.52) on the other hand, showed low (<10) genetic advance as % of the mean.

**Table 16. Genetic parameters of variation for 17 quantitative traits of 55 okra genotypes**

| Response Variable | GCV | PCV | Heritability | GA % Means |
|---|---|---|---|---|
| First flowering node | 8.07 | 10.07 | 64.17 | 13.32 |
| First fruiting node | 5.40 | 8.71 | 38.47 | 6.90 |
| Days to first flower | 3.19 | 3.81 | 70.04 | 5.49 |
| Days to 50% flowering | 3.32 | 3.96 | 69.99 | 5.72 |
| Days to first fruit harvest | 2.75 | 4.42 | 38.69 | 3.52 |
| Plant height (cm) | 8.32 | 8.94 | 86.72 | 15.96 |
| Inter nodal length (cm) | 6.05 | 10.08 | 36.09 | 7.49 |
| Number of branches per plant | 5.36 | 9.19 | 34.02 | 6.44 |
| Number of nodes per plant | 5.03 | 6.14 | 67.09 | 8.48 |
| Fruit length (cm) | 6.88 | 8.61 | 63.97 | 11.34 |
| Fruit diameter (mm) | 4.45 | 7.11 | 39.14 | 5.73 |
| No. of ridges per fruit | 2.28 | 4.24 | 28.87 | 2.52 |
| Number of fruits per plant | 20.13 | 20.57 | 95.77 | 40.58 |
| Number of marketable fruits per plant | 21.47 | 22.03 | 94.95 | 43.09 |
| Average fruit weight (g) | 6.95 | 8.35 | 69.27 | 11.91 |
| Number of pickings per plant | 13.45 | 15.04 | 79.92 | 24.76 |
| Fruit yield per plant (g) | 22.46 | 22.86 | 96.48 | 45.43 |

## 4.2 GENETIC DIVERGENCE

Plant breeders place significant importance on genetic divergence and diversity due to their crucial role in the development of a successful breeding program. Genetic divergence analysis is employed to assess a) the genetic variations among germplasms b) Assess the genetic variability of offspring from various parents to identify optimal recombinants and c) Determine the geographical origin of a clustering pattern.

### 4.2.1 Group constellations

Using Mahalanobis $D^2$ analysis, classified the samples into seven clusters, with the largest being cluster I, which compose 34 germplasm. Cluster III contain 16 germplasm, only one germplasm was found in Clusters II, IV, V, VI, and VII. Fig.1 and Table 17 show clustering arrangement different okra genotypes.

**Fig .1. Clustering 55 okra germplasm by tocher method**

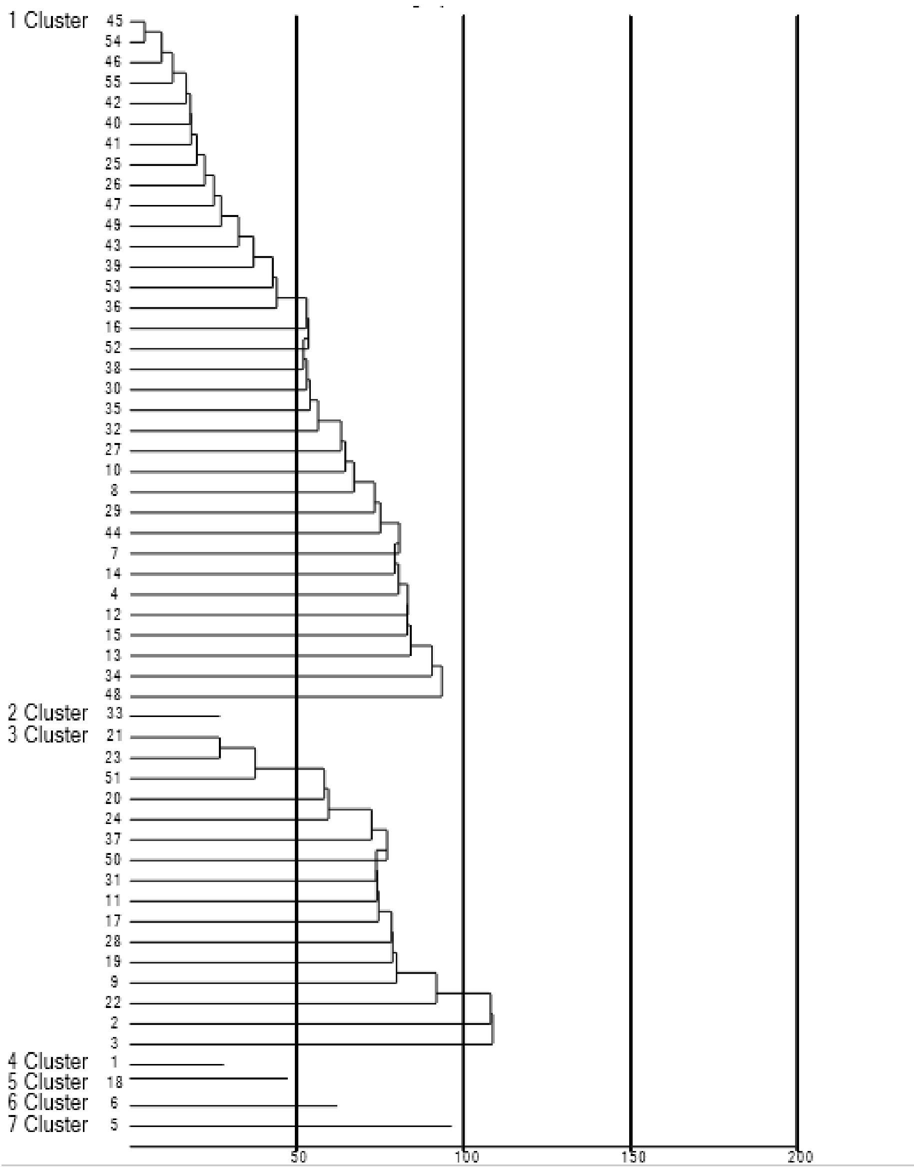


**Table 17. Showing clustering arrangement of 55 different okra genotypes**

| Clusters | No. of genotypes | Genotypes |
|---|---|---|
| **1** | 34 | Kashi Kranti, Punjab-8, Salekerthi, Kashi Mohini, Anima, Harikranti, Plamkomal,IC050418,IC046018,HisarNaveen,ArkaAnamika,PusaMakmali,P7,GFSGold,IC052308,IC058235,Hinarch,IC052310,IC045993,IC052313,IC049734,IC048281,IC052302,IC052299,IC045993,VRO4,EC169461,EC169456,IC052322,IC052312,IC057733,IC052321,IC052298,Pusa Sawani |
| **2** | 1 | IC049749 |
| **3** | 16 | IC086008, IC089712, Dhanvi 66, IC058768, IC045995, IC052320, Kashi Pragati, IC049972, IC052303, IC058704, IC048948, IC058710, IC052301, IC089712, EC169452, EC169453 |
| **4** | 1 | EC169450 |
| **5** | 1 | IC058710 |
| **6** | 1 | EC169459 |
| **7** | 1 | EC169456 |

### 4.2.2 Intra and inter clusters

The intra-cluster (same cluster) distance ranged between 0.00 to 9.64 and maximum differences among the genotypes were shown by cluster III (9.64) followed by cluster I (8.27), while cluster II, IV, V, VI and VIII showed no genetic variation within their specific genotypes, as demonstrated by a zero intra-cluster distance.

Inter cluster diverse from 7.89 to 20.22 inter-cluster distances (Table 18). The maximum distance shown between clusters II and VII (20.22), followed by cluster IV and V (19.75) clusters V and VII (19.65), clusters II and III (17.53). The clusters exhibited the shortest distance V and VI (7.89), followed by clusters IV and III (9.98).

**Table 18. Showing Inter cluster and Intra (bold) distance of 55 okra germplasm**

| Clusters | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 | Cluster 6 | Cluster 7 |
|---|---|---|---|---|---|---|---|
| **Cluster 1** | **8.27** | 9.98 | 15.61 | 9.96 | 10.4 | 12.51 | 17.22 |
| **Cluster 2** | | **0** | 17.53 | 11.48 | 11.94 | 13.91 | 20.22 |
| **Cluster 3** | | | **9.64** | 11.83 | 19.75 | 14.42 | 11.9 |
| **Cluster 4** | | | | **0** | 11.17 | 7.89 | 12.31 |
| **Cluster 5** | | | | | **0** | 12.27 | 19.65 |
| **Cluster 6** | | | | | | **0** | 11.61 |
| **Cluster 7** | | | | | | | **0** |

### 4.2.3 Cluster means

Cluster mean illustrate in Table 19. For the first flowering node, the cluster mean was minimum in cluster V (4.27) and maximum in cluster VI (5.93). With regards to first fruiting node cluster mean, the minimum was recorded in cluster V (3.60) and the maximum in cluster VIII (6.40). Cluster V had an early day to first flower cluster mean (37.00) and Cluster VII had a late day to first flower cluster mean (39.67). In the case of days to 50% flowering, early was recorded for cluster II &V (40.67) and late in cluster VIII (44.00). Cluster V (47.00) had the lowest cluster mean for days to first fruit harvest and Cluster II, IV and VII (49.33) had the highest recorded.

The minimum plant height cluster mean was observed in cluster VI (69.30 cm) and the maximum in cluster II (93.83 cm). With regards to internodal length, the lowest cluster mean was recorded in cluster VI (4.87 cm) and the highest in cluster IV (6.13 cm). Cluster mean for the number of branches per plant was found to be lowest in cluster V (4.93) and highest in cluster IV (5.27). The cluster mean for nodes per plant was lowest in cluster III (15.13) and highest in cluster VII (17.60).

The cluster mean of fruit length was a minimum for cluster III (12.39 cm) and a maximum for cluster II (14.50 cm). The fruit diameter was observed at a minimum in cluster VII (15.10) and a maximum in cluster II (17.20). The cluster mean for the number of ridges per fruit ranged from minimum (5.07) in cluster II & IV and maximum (5.67) in cluster IV & VII. In terms of the average number of fruits per plant, cluster VII (15.87) had the fewest fruits, while cluster V (27.93) had the most. The minimum cluster mean for the number of marketable fruits per plant was noted in cluster

VII (15.87) and maximum in cluster V (26.47). The average fruit weight cluster mean was lower for cluster VII (11.13) and higher for cluster VI (13.60). Cluster mean for number of pickings was the lowest in cluster VII (11.27) and the highest in cluster V (17.3). The lower most cluster mean for fruit yield per plant was recorded cluster VII (176.13 g) and the highest in cluster V (343.83 g).

**Table 19. Cluster mean for different quantitative traits of 55 okra germplasms**

| Traits & Clusters | FFN | FFRN | DFF | D50F | DFFH | PH | INL | NB | NON |
|---|---|---|---|---|---|---|---|---|---|
| **Cluster 1** | 4.57 | 5.10 | 38.21 | 41.13 | 47.57 | 88.15 | 5.65 | 5.12 | 17.17 |
| **Cluster 2** | 5.13 | 5.07 | 39.00 | 40.67 | 49.33 | 93.83 | 5.63 | 5.13 | 16.40 |
| **Cluster 3** | 4.53 | 5.05 | 38.42 | 41.67 | 47.69 | 84.49 | 5.41 | 5.16 | 16.72 |
| **Cluster 4** | 4.80 | 5.20 | 39.33 | 43.33 | 49.33 | 73.47 | 5.30 | 5.27 | 14.80 |
| **Cluster 5** | 4.27 | 4.87 | 37.00 | 40.67 | 47.00 | 72.47 | 5.57 | 4.93 | 15.13 |
| **Cluster 6** | 5.93 | 6.13 | 38.67 | 41.33 | 48.67 | 69.30 | 5.10 | 5.20 | 16.20 |
| **Cluster 7** | 5.13 | 5.80 | 39.67 | 44.00 | 49.33 | 72.37 | 5.80 | 5.07 | 17.60 |

| Traits & Clusters | FL | FD | NRG | NFP | MFP | AFW | NPS | FYP |
|---|---|---|---|---|---|---|---|---|
| **Cluster 1** | 13.79 | 15.7 | 5.2 | 25.01 | 23.11 | 12.71 | 15.01 | 317.75 |
| **Cluster 2** | 14.5 | 18.2 | 5.07 | 26.87 | 24.67 | 11.4 | 15.27 | 306.67 |
| **Cluster 3** | 12.39 | 16.01 | 5.24 | 16.37 | 14.86 | 12.31 | 11.93 | 200.27 |
| **Cluster 4** | 13.43 | 15.93 | 5.07 | 22.6 | 20.87 | 11.97 | 13.47 | 269.7 |
| **Cluster 5** | 14.5 | 16.07 | 5.53 | 27.93 | 26.47 | 12.33 | 17.33 | 343.83 |
| **Cluster 6** | 13.53 | 17.2 | 5.47 | 20.53 | 18.33 | 13.07 | 13.67 | 268.13 |
| **Cluster 7** | 13.97 | 15.1 | 5.47 | 15.87 | 13.6 | 11.13 | 11.27 | 176.13 |

### 4.2.4 Percent contribution of characters towards divergence

Table 20 presents the percentage contribution of each character to the overall divergence. Number of fruits per plant (49.63%) was found to be the most significant contributor to divergence, followed by Plant height (16.03%), average fruit weight (13.49%), number of nodes per plant (3.64%), days to first flower (2.96%), fruit yield per plant (2.49%), number of marketable fruits per plant (2.42%), fruit diameter (2.29%), number of pickings per plant (2.22%), first flowering node (1.55%), fruit length (0.74%), days to first fruit harvest (0.67%), days to 50% flowering (0.34%), number of ridges per fruit (0.34%), number of branches per plant (0.34%) and internodal length (0.34%).

**Table 20. Contribution of different quantitative characters towards genetic divergence**

| S.No | Source | Contribution | S.No | Source | Contribution | S.No | Source | Contribution |
|---|---|---|---|---|---|---|---|---|
| **1** | NFP | 49.63% | **7** | MFP | 2.42% | **13** | D50F | 0.34% |
| **2** | PH | 16.03% | **8** | FD | 2.29% | **14** | INL | 0.34% |
| **3** | AFW | 13.94% | **9** | NPS | 2.22% | **15** | NB | 0.34% |
| **4** | NON | 3.64% | **10** | FFN | 1.55% | **16** | NRG | 0.34% |
| **5** | DFF | 2.96% | **11** | FL | 0.74% | **17** | FFRN | 0.07% |
| **6** | FYP | 2.49% | **12** | DFFH | 0.67% | | | |

**FFN:** First flowering node, **FFRN:** First fruiting node, **DFF:** Days to first flowering**, D50F:** Days to 50% flowering**, PH:** Plant height**, INL:** Inter nodal length**, NB:** Number of branches**, NON:** Number of nodes/plant, **FL:** Fruit length**, FD:** Fruit diameter**, NRG:** Number of ridges**, NFP**: Number of fruits/plant, **MFP:** Marketable fruits/plant**, AFW:** Average fruit weight, **NPS:** Number of pickings/plant, **FYP:** Fruit yield/plant.

## 4.3 CHARACTERIZATION OKRA GENOTYPES BASED ON MORPHOLOGICAL DESCRIPTORS

The characterization of germplasm provides information on the characteristics possessed by each genotype, ensuring maximal use of the germplasm collection by end users. Morphological characters are the oldest and most used genetic markers and they may still be appropriate for certain germplasm management applications. Morphological characterization is the initial stage in the description, classification and arrangement of germplasm collections. Plant characterization identifies unique accessions required by gene bank curators and plant breeders. Landraces, germplasms, genotypes and local cultivars must be morphologically characterized by vegetable breeders seeking novel trait genes. The characterization of genetic resources is the means of selecting, differentiating, or distinguishing accessions depending on their character or quality (traits). Qualitative trait characterization of newly collected germplasm is necessary for crop improvement. It also gives information on genetic diversity for agricultural development, use of plant genetic resources and conservation. The genotypes of okra characterized upon 10 qualitative characters in this study and showed broad variation for most qualitative traits (Table 21), which allows for the identification of promising lines of okra.

### 4.3.1 Leaf characters:

In the study, the depth of leaf lobing was found to be 22.27 % shallow, 43.63% medium and 29.09% deep in genotypes.

### 4.3.2 Colouring of various plant parts:

In the present study, variation was expressed in all colour traits studied. The pigmentation of the vegetative (stem and leaf) and reproductive (flower and fruit) organs is remarkably diverse in this study. Stem colour was recorded as 47.27% green and 52.72 % green with a purple tinge for the genotypes, respectively. Petal colour was observed in the 45% cream and 55% yellow petals of the genotypes studied, respectively. Whereas in mature fruit colour 12.72 % of yellowish-green, 32.72 % of green and 54.54% of dark-green fruits were recorded for genotypes.

### 4.3.3 Pubescence (hairiness/spininess) of fruit:

In this study, diversity was expressed in pubescence traits fruit (hairiness). In fruit pubescence, 33.3% of genotypes were downy, 38.18% slightly rough and 25.15 % prickly.

### 4.34 Fruit characters:

In the study, fruit characteristics like surface between ridges, fruit axis, shape of apex and constriction of basal part expressed large diversity in genotypes. The fruit surface between the ridges of genotypes exhibited variation, with 63.63% showing a concave surface and 36.36% displaying a flat surface. The fruit axis varied, with 58.18% being straight and 23.63% curved. Shape of the fruit apex, comprising 40.0% narrow acute, 41.81% acute, and 18.18% broad acute types.

### 4.3.5 Plant habit and seed shape

In the study, plant habit and seed shape expressed large diversity in genotypes. Plant habit of genotypes varied between erect with 58.18%, medium with 30.19% and procumbent with 10.90. Plant habit can affect pest and disease susceptibility.

The seed shape varied greatly in the research with 58.18% straight and 23.63 % curved. In this study, the genotypes exhibited variability, with 38.18% being round, 36.36% spherical, and 10.90 % kidney shape.

**Table 21. Qualitative morphological characteristics of fifty-five okra genotypes**

| GENOTYPES | Plant habit | Depth of leaf lobing | Mature fruit colour | Fruit surface | Fruit axis | Fruit pubescence | Petel colour | Stem colour | Fruit shape | Seed shape |
|---|---|---|---|---|---|---|---|---|---|---|
| EC169450 | E | D | DG | CC | S | D | Y | G | BA | R |
| EC169452 | PC | M | YG | F | S | SR | C | GPT | A | R |
| EC169453 | PC | S | G | F | S | P | Y | G | BA | R |
| EC169455 | E | D | DG | F | S | D | C | G | NA | R |
| EC169456 | M | S | DG | CC | C | SR | Y | G | BA | S |
| EC169459 | E | M | G | F | S | SR | C | G | A | R |
| EC169461 | M | M | G | CC | S | P | Y | G | A | R |
| IC052299 | M | D | DG | F | S | SR | Y | GPT | BA | R |
| IC052301 | PC | D | G | CC | C | SR | Y | G | NA | K |
| IC052302 | M | M | DG | CC | S | SR | Y | G | NA | S |
| IC052303 | E | M | DG | CC | S | SR | Y | G | NA | K |
| IC052312 | PC | D | DG | F | S | SR | Y | G | A | S |
| IC052321 | E | S | DG | CC | C | D | C | G | NA | K |
| IC052322 | E | S | DG | CC | S | D | C | G | A | S |
| IC057733 | M | M | DG | CC | C | D | C | GPT | NA | K |
| IC058235 | E | D | G | F | S | P | C | GPT | NA | K |
| IC058704 | PC | M | DG | CC | S | P | C | GPT | A | K |
| IC058710 | E | M | DG | CC | C | P | C | GPT | BA | K |
| IC058712 | E | S | YG | CC | S | SR | Y | G | A | S |
| IC058768 | E | S | YG | CC | S | SR | C | G | A | S |
| IC086008 | E | M | DG | F | S | SR | Y | GPT | NA | S |
| IC089712 | M | D | YG | F | S | P | Y | GPT | NA | K |
| IC089712 | M | M | G | F | C | SR | Y | G | A | S |
| IC045995 | E | M | YG | CC | C | P | Y | G | A | R |

***Table continues…...***

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| IC050418 | E | S | G | F | S | D | Y | GPT | NA | S |
| IC046018 | E | D | DG | F | C | P | Y | GPT | A | S |
| IC048281 | PC | S | DG | CC | S | P | C | G | NA | K |
| IC048948 | E | D | DG | CC | S | P | Y | G | NA | S |
| IC045993 | E | M | G | F | S | D | C | GPT | BA | R |
| IC045994 | E | M | DG | F | S | D | C | G | A | R |
| IC049972 | E | M | DG | F | S | SR | C | G | BA | S |
| IC049734 | E | D | G | CC | C | P | Y | GPT | NA | R |
| IC049749 | E | M | YG | F | S | SR | C | GPT | NA | S |
| IC052298 | M | M | G | CC | S | SR | Y | G | A | R |
| IC052313 | M | M | DG | CC | S | D | Y | G | BA | R |
| IC052308 | M | S | DG | F | C | D | C | G | NA | K |
| IC052320 | E | S | G | CC | S | D | C | G | A | S |
| IC052310 | M | D | G | F | S | D | C | GPT | NA | R |
| Punjab 7 | M | S | DG | CC | C | D | Y | G | NA | R |
| Hari Kranti | E | S | G | CC | S | SR | Y | G | A | S |
| Palamkomal | M | M | DG | CC | S | D | C | GPT | NA | R |
| Anima | M | S | DG | CC | S | D | C | G | A | S |
| Pusa Makhmali | E | M | G | CC | S | SR | Y | G | BA | R |
| VRO-4 | M | D | DG | F | S | SR | Y | G | NA | S |
| Kashi Kranti | E | S | DG | CC | S | D | C | GPT | BA | K |
| Salkeerthi | M | M | G | CC | S | SR | Y | G | A | K |
| Hisar Naveen | E | D | DG | CC | C | P | Y | GPT | NA | R |
| Pusa Sawani | E | M | YG | CC | S | SR | Y | G | A | R |
| Arka Anamika | E | D | DG | F | C | D | Y | G | NA | R |
| Kashi Pragati | E | S | G | CC | S | P | C | GPT | A | S |
| Dhanvi66 | E | M | G | CC | S | D | Y | G | A | S |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…...*** | | | | | | | | | | |
| Hinarch | M | M | DG | CC | S | D | C | G | A | K |
| GFS Gold | E | D | G | CC | S | D | C | G | A | K |
| Punjab 8 | E | D | DG | CC | S | P | Y | G | NA | S |
| Sowmya | E | M | DG | CC | S | SR | C | GPT | A | R |
| **Descriptor** | **E** | **M** | **DG** | **CC** | **S** | **D** | **Y** | **G** | **A** | **R** |
| **No. of cultivars** | 32 | 24 | 30 | 35 | 32 | 20 | 30 | 26 | 23 | 21 |
| **Percent of cultivars** | 58.18 | 43.63 | 54.54 | 63.63 | 58.18 | 36.36 | 55 | 47.27 | 41.81 | 38.18 |
| **Descriptor** | **M** | **D** | **G** | **F** | **C** | **SR** | **C** | **GPT** | **NA** | **S** |
| **No. of cultivars** | 17 | 16 | 18 | 20 | 13 | 21 | 25 | 29 | 22 | 20 |
| **Percent of cultivars** | 30.19 | 29.09 | 32.72 | 36.36 | 23.63 | 38.18 | 45 | 25.72 | 40 | 36.36 |
| **Descriptor** | **PC** | **S** | **YG** | **-** | **-** | **P** | **-** | **-** | **BA** | **K** |
| **No. of cultivars** | 6 | 15 | 7 | - | - | 14 | - | - | 10 | 14 |
| **Percent of cultivars** | 10.9 | 27.27 | 12.72 | - | - | 25.15 | - | - | 18.18 | 25.45 |

**E:** Erect, **M**; Medium, **PC**: Procumbent, **D**: Deep, **M**: Medium, **S**: Shallow, **DG**: Dark Green, **YG**; Yellow Green, **G**: Green, **CC**: Concave, **F**: Flat, **S**: Stright, **C**: Curve, **D**: Downy, **SR:** Slightly rough, **P:** Prickly **Y:** Yellow, **C**: cream, **GPT:** Green with Purple Tinge ,**BA**: Broad Acute, **NA**: Narrow Acute, **A**: Acute, **K**: Kidney, **R**: Round, **S:** Spherical

## II. STUDIES HETEROSIS AND ON COMBINING ABILITY

The assessment was conducted on the genotypes resulting from the crossing of 15 parents (Table 7), which included 50 $F_1$ hybrids and one check. The gathered data were further examined to determine the average performance, combining ability, and heterosis. Below, the important findings for each feature that was evaluated are given.

## 4.4 ANALYSIS OF VARIANCE

The ANOVA for the setup implicated significant treatment variations for all seventeen, results showed MSS owning to treatments recorded significant for every trait studied in all of the environmental and also Pooled conditions (Table 22). In crosses mean sum of square of all the seventeen traits were significance in all the environments and pooled analysis. All the three environments fruit yield per plant was found significant for replicates. Parent *vs* Crosses in all the three environments, days to first flowering and internodal length are significance, in Pooled analysis all seventeen traits are significance except average fruit weight, variations in the performance of both parents and hybrids substantiated the existence of heterosis across the majority of the studied traits.

**Table 22. ANOVA for okra fruit yield and associated traits**

| Source of variation | d.f. | First flowering node | | | | First fruiting node | | | | Days to first flowering | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 0.015 | 0.08 | 0.05 | 0.054 | 0.062 | 0.14 | 0.2 | 0.23 | 1.00 | 0.31 | 0.65 | 0.87 |
| Treatments | 64 | 0.46** | 0.33** | 0.46** | 0.61** | 0.32** | 0.35** | 0.30** | 0.46** | 4.00** | 3.5** | 2.1** | 5.31** |
| Parents | 14 | 0.045 | 0.0629 | 0.29** | 0.14 | 0.12 | 0.31** | 0.21* | 0.25** | 5.59** | 2.26** | 2.14** | 6.80** |
| Line | 9 | 0.039 | 0.0302 | 0.11 | 0.05 | 0.13 | 0.26* | 0.16 | 0.17 | 1.144 | 1.10 | 2.09** | 1.90** |
| Testers | 4 | 0.071 | 0.136 | 0.44** | 0.24 | 0.10 | 0.29* | 0.30* | 0.23 | 5.27** | 2.2* | 2.23* | 7.7** |
| (L vs T) | 1 | 0.002 | 0.064 | 1.30** | 0.61* | 0.13 | 0.75* | 0.35 | 1.10** | 46.94** | 12.84** | 2.18 | 47.29** |
| P vs C | 1 | 7.74** | 5.22** | 0.50 | 11.11** | 5.12** | 1.81** | 0.07 | 5.01** | 6.77** | 40.20** | 7.25** | 13.02** |
| Crosses | 49 | 0.43** | 0.31** | 0.50** | 0.53** | 0.28** | 0.33** | 0.33** | 0.43** | 3.49** | 3.12** | 2.04** | 4.72* |
| Error | 128 | 0.090 | 0.09 | 0.12 | 0.10 | 0.138 | 0.11 | 0.10 | 0.12 | 0.708 | 0.89 | 0.71 | 0.77 |

| Source of variation | d.f. | Days to 50 % flowering | | | | Days to first picking | | | | Plant height | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 0.27 | 1.144 | 3.92* | 1.57 | 5.93* | 0.60 | 2.27 | 6.78** | 27.047 | 51.32 | 40.66 | 14.019 |
| Treatments | 64 | 4.24** | 6.93** | 3.59** | 8.96 ** | 6.74** | 6.34** | 3.16** | 7.70** | 99.08** | 91.4** | 73.91** | 141.09** |
| Parents | 14 | 5.78** | 6.18** | 4.04** | 10.85** | 1.803 | 3.77** | 1.66* | 3.37** | 160.73** | 103.49** | 69.70** | 169.31** |
| Line | 9 | 1.48 | 6.7** | 2.85** | 6.96** | 1.763 | 2.98** | 0.73 | 2.15* | 68.67** | 28.82 | 39.30 | 68.05** |
| Testers | 4 | 4.07** | 6.57** | 5.4** | 13.41** | 2.067 | 6.1** | 4.07** | 6.72** | 207.07** | 69.39** | 155.48** | 156.24** |
| (L vs T) | 1 | 51.38** | 0.011 | 9.34** | 35.57** | 1.111 | 1.60 | 0.40 | 0.948 | 803.83** | 912.02** | 0.06 | 1132.9** |
| P vs C | 1 | 20.46** | 53.03** | 0.03 | 47.81** | 139.07** | 87.14** | 2.59 | 127.01** | 55.32* | 639.95** | 0.61 | 374.37** |
| Crosses | 49 | 3.47** | 6.21** | 3.53** | 7.63** | 5.45** | 5.43** | 3.61** | 6.50** | 82.36** | 76.76** | 76.60** | 128.27** |
| Error | 128 | 0.90 | 1.34 | 1.10 | 1.11 | 1.501 | 0.90 | 0.85 | 1.08 | 13.02 | 17.85 | 21.50 | 17.46 |

| Source of variation | d.f. | Internodal length | | | | Number of branches/plant | | | | Number of nodes per plant | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 0.30 | 0.101 | 1.10** | 1.05** | 0.052 | 0.05 | 0.03 | 0.004 | 1.287 | 1.17 | 1.28 | 11.98** |
| Treatments | 64 | 0.97** | 0.66** | 0.40** | 0.93** | 0.78** | 0.46** | 0.36* | 0.90** | 5.74** | 1.46** | 5.74** | 3.96** |
| Parents | 14 | 0.09 | 0.42** | 0.23 | 0.33* | 0.141 | 0.37* | 0.27* | 0.48** | 3.08* | 0.62 | 3.08* | 2.89** |
| Line | 9 | 0.032 | 0.13 | 0.30* | 0.18 | 0.101 | 0.46* | 0.37* | 0.55** | 2.425 | 0.19 | 2.42 | 1.34 |
| Testers | 4 | 0.12 | 0.98** | 0.11 | 0.51* | 0.236* | 0.140 | 0.11 | 0.28 | 1.130 | 1.06 | 1.13 | 2.12 |
| (L vs T) | 1 | 0.484 | 0.77* | 0.05 | 1.07* | 0.114 | 0.04 | 0.05 | 0.19 | 16.81** | 2.79 | 16.81** | 19.88** |
| P vs C | 1 | 23.35** | 5.79** | 0.66* | 21.60** | 14.21** | 0.95* | 0.46 | 9.79** | 62.18** | 6.60 | 62.18** | 37.73** |
| Crosses | 49 | 0.77** | 0.63** | 0.44** | 0.69** | 0.68** | 0.48** | 0.39** | 0.85** | 5.36** | 1.60 | 5.35** | 3.58** |
| Error | 128 | 0.27 | 0.174 | 0.13 | 0.19 | 0.095 | 0.183 | 0.15 | 0.14 | 1.60 | 0.55 | 1.60 | 1.01 |

| Source of variation | d.f. | Fruit length | | | | Fruit diameter | | | | Number of ridges per fruit | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 0.27 | 0.15 | 1.12 | 0.62 | 0.88 | 2.39* | 0.31 | 0.54 | 0.016 | 0.095 | 0.02 | 0.012 |
| Treatments | 64 | 3.75** | 2.83** | 1.31** | 5.06** | 4.03** | 2.99** | 2.58** | 5.06** | 0.31** | 0.13** | 0.07** | 0.24** |
| Parents | 14 | 4.27** | 5.06** | 1.83** | 8.58** | 2.52** | 2.28** | 1.63* | 4.04** | 0.08 | 0.035 | 0.07** | 0.09** |
| Line | 9 | 1.72** | 0.77 | 0.55 | 0.80 | 1.80** | 0.401 | 0.52 | 1.40* | 0.05 | 0.028 | 0.10 | 0.08* |
| Testers | 4 | 8.77** | 11.88** | 2.62** | 19.39** | 3.76** | 5.8** | 4.29 | 10.90** | 0.14 | 0.042 | 0.01 | 0.12* |
| (L vs T) | 1 | 9.21** | 16.43** | 10.20** | 35.25** | 4.02* | 4.93** | 0.91 | 0.457 | 0.16 | 0.07 | 0.04 | 0.07 |
| P vs C | 1 | 80.90** | 21.19** | 1.20 | 71.98** | 86.19** | 1.15 | 0.03 | 34.57** | 4.88** | 0.23* | 0.046 | 2.80** |
| Crosses | 49 | 2.03** | 1.82** | 1.16** | 2.69** | 2.79** | 3.22** | 2.91** | 4.75** | 0.28** | 0.15** | 0.07** | 0.23** |
| Error | 128 | 0.570 | 0.71 | 0.44 | 0.58 | 0.634 | 0.65 | 0.91 | 0.73 | 0.06 | 0.037 | 0.030 | 0.04 |

| Source of variation | d.f. | Number of fruits/plant | | | | Number of marketable fruits/plant | | | | Average fruit weight | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 3.393 | 3.82 | 10.09** | 0.33 | 2.87 | 0.28 | 5.51* | 0.27 | 1.29 | 4.08 | 0.03 | 0.72 |
| Treatments | 64 | 19.64** | 21.38** | 17.13** | 47.96** | 19.96** | 1.95** | 17.50** | 47.50** | 2.74** | 18.24** | 1.75** | 3.44 |
| Parents | 14 | 39.19** | 50.79** | 48.63** | 134.74** | 37.22** | 0.56 | 47.91** | 125.19** | 2.26** | 44.57** | 1.20** | 2.86** |
| Line | 9 | 4.79** | 2.57 | 1.90 | 5.66** | 5.11** | 0.17 | 2.68 | 5.41** | 0.549 | 2.61 | 0.63 | 0.83 |
| Testers | 4 | 45.35** | 55.81** | 78.42** | 175.92** | 49.40** | 1.30* | 68.91** | 158.49** | 3.92** | 42.54** | 0.23 | 3.36** |
| (L vs T) | 1 | 324.14** | 464.67** | 350.07** | 1131.81 ** | 277.38** | 1.156 | 370.88** | 1070.02** | 11.08** | 430.33** | 10.15** | 19.21** |
| P vs C | 1 | 63.88** | 94.95** | 65.37** | 222.26** | 80.56** | 0.41 | 89.13** | 332.18** | 2.84* | 172.96** | 0.88 | 1.32 |
| Crosses | 49 | 13.15** | 11.47** | 7.15** | 19.60** | 13.79** | 2.39** | 7.35** | 19.49** | 2.88** | 7.56** | 1.92** | 3.64** |
| Error | 128 | 1.484 | 1.602 | 1.44 | 1.51 | 1.62 | 0.4362 | 1.50 | 1.69 | 0.626 | 1.95 | 0.357 | 0.47 |

| Source of variation | d.f. | Number of pickings/plant | | | | Fruit yield/plant | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 8.06** | 2.56 | 5.01 | 6.93** | 1368.24** | 1819.40** | 1625.0** | 602.83 |
| Treatments | 64 | 9.40** | 4.39** | 4.43** | 13.85** | 3897.29** | 3678.75** | 4593.56** | 11312.45** |
| Parents | 14 | 11.38** | 8.42** | 5.01** | 22.95** | 10619.16** | 10526.74** | 11287.27** | 31992.15** |
| Line | 9 | 3.62** | 2.52** | 1.69 | 6.16** | 532.26** | 441.85* | 249.13** | 1129.5** |
| Testers | 4 | 8.62** | 8.83** | 2.86 | 18.71** | 12213.62** | 12213.62** | 13791.34** | 37781.56** |
| (L vs T) | 1 | 92.21** | 59.86** | 43.54** | 191.01** | 95023.49** | 94543.20** | 100614.27** | 286598.4** |
| P vs C | 1 | 4.71 | 13.79** | 9.08* | 26.36** | 17108.04** | 10886.90** | 15597.22** | 51082.81** |
| Crosses | 49 | 8.94** | 3.047** | 4.16** | 10.99** | 1707.14** | 1575.08** | 2456.5** | 4592.32** |
| Error | 128 | 1.312 | 0.88 | 1.74 | 1.30 | 169.142 | 203.75 | 298.1 | 229.04 |

### 4.5 MEAN PERFORMANCE OF PARENTS AND THEIR HYBRIDS

The mean performance of both parents and their hybrids is provided for three environments, as well as pooled environment is given in tables 23 -31.

#### 4.5.1 First flowering node

In E1 first flowering node exhibit ranges from 3.53 to 5.13, with a general mean of 4.27. Among the parents, IC045993 (4.47) and in crosses Kashi Kranti x EC169452, Kashi Kranti x IC052310 (3.47) recorded desirable (lower) mean, Whereas in E2 exhibit ranges from 3.40 to 5.13, with a general mean of 4.23. While in parents, IC052321 (4.33) and in the crosses Salkeerthi x IC052321 (3.40), recorded desirable (lower) mean. Where in E3 exhibit range from 3.87 to 5.53, with a general mean of 4.61. Among the parents, Pusa Sawani (4.33) and crosses Kranti x Kashi Pragati (3.87), recorded desirable (lower) mean, while in Pooled analysis exhibit ranges from 3.80 to 4.96, with a general mean of 4.37. Among the parents, Pusa Sawani (4.47) observed a desirable (low) mean, and in cross VRO-4 x Kashi Pragati (3.80) recorded desirable (lower) mean.

#### 4.5.2 First fruiting node

In E1 first fruiting node exhibit ranges from 4.00 to 6.00, with a general mean of 4.88. Among the parents, IC052299 (4.67) and in hybrids Kashi Kranti x IC052310 (4.00), had a desirable (low). Whereas in E2 exhibit ranges from 4.33 to 6.00, with a general mean of 5.04. Among the parents, IC052299 (4.67) and while, in hybrids VRO-4 x Kashi Pragati and Kashi Kranti x Kashi Pragati (4.40), had a desirable (low) mean. Where in E3 exhibit ranges from 4.27 to 5.60, with a general mean of 4.93. Among the parents, Salkeerthi, IC058235 (4.67) and in crosses VRO-4 x EC169452 (4.27), recorded desirable (lower) mean, while in Pooled analysis its ranges from 4.31 to 5.47, with a general mean of 4.95. Among the parents, IC052299 (4.6) observed a desirable (low) mean, and in crosses Kashi Kranti x Kashi Pragati (4.31) recorded desirable (low) mean.

#### 4.5.3 Days to first flowering

In E1 Days to 1$^{st}$ flowering ranges from 36.0 to 41.0 with the general mean of (38.08). Among the parents Pusa Sawani, Hisar Naveen, IC052302 (37.00) and while in crosses IC052299 x EC169459 (36.00), observed a least mean. Whereas in E2 ranges from 35.67 to 40.67 with the general mean of 38.15. Among the parents Hisar Naveen (37.33) and while in crosses Kashi Kranti x Kashi Pragati (35.67), observed a least (desirable) mean.

**Table 23. Mean performance of parents and hybrids across different environments and pooled in okra for first flowering node and first fruit node**

| S.No. | Genotype | First flowering node | | | | First fruiting node | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| | **PARENTS** | | | | | | | | |
| **1** | IC058710 | 4.60 | 4.47 | 4.67 | 4.58 | 5.20 | 4.80 | 5.07 | 5.02 |
| **2** | IC045993 | 4.47 | 4.53 | 4.80 | 4.60 | 4.80 | 5.13 | 4.93 | 4.96 |
| **3** | Pusa Sawani | 4.67 | 4.40 | 4.33 | 4.47 | 5.60 | 4.93 | 5.00 | 5.18 |
| **4** | VRO-4 | 4.80 | 4.53 | 4.73 | 4.69 | 5.20 | 5.33 | 5.00 | 5.18 |
| **5** | IC052299 | 4.67 | 4.53 | 4.67 | 4.62 | 4.67 | 4.67 | 4.73 | 4.60 |
| **6** | Kashi Kranti | 4.53 | 4.67 | 4.80 | 4.67 | 4.80 | 5.73 | 5.40 | 5.31 |
| **7** | Salkeerthi | 4.73 | 4.67 | 4.40 | 4.60 | 5.00 | 5.20 | 4.67 | 4.96 |
| **8** | IC058235 | 4.80 | 4.40 | 4.27 | 4.49 | 5.20 | 5.07 | 4.67 | 4.98 |
| **9** | Hisar Naveen | 4.60 | 4.47 | 4.60 | 4.56 | 5.60 | 5.13 | 4.73 | 5.13 |
| **10** | IC052302 | 4.53 | 4.40 | 4.60 | 4.51 | 4.60 | 5.27 | 4.93 | 4.93 |
| **11** | EC169452 | 4.47 | 4.87 | 5.13 | 4.82 | 5.20 | 5.60 | 5.20 | 5.33 |
| **12** | IC052310 | 4.60 | 4.73 | 5.53 | 4.96 | 5.00 | 5.80 | 5.60 | 5.47 |
| **13** | EC169459 | 4.67 | 4.53 | 4.73 | 4.64 | 4.80 | 5.40 | 4.93 | 5.04 |
| **14** | Kashi Pragati | 4.53 | 4.47 | 4.73 | 4.58 | 6.00 | 5.13 | 4.87 | 5.33 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continuess….*** | | | | | | | | | |
| **15** | IC052321 | 4.87 | 4.33 | 4.60 | 4.60 | 5.60 | 5.07 | 4.87 | 5.18 |
| **HYBRIDS** | | | | | | | | | |
| **16** | IC058710 x EC169452 | 3.93 | 3.93 | 4.33 | 4.07 | 4.40 | 4.47 | 4.53 | 4.47 |
| **17** | IC058710 x IC052310 | 4.73 | 4.73 | 4.87 | 4.78 | 4.80 | 5.33 | 5.13 | 5.09 |
| **18** | IC058710 x EC169459 | 4.67 | 4.27 | 5.13 | 4.69 | 4.80 | 6.00 | 5.27 | 5.36 |
| **19** | IC058710 x Kashi Pragati | 4.60 | 4.20 | 4.40 | 4.40 | 4.80 | 4.47 | 4.73 | 4.67 |
| **20** | IC058710 x IC052321 | 4.00 | 3.93 | 4.40 | 4.11 | 4.40 | 4.87 | 4.67 | 4.64 |
| **21** | IC045993 x EC169452 | 3.93 | 4.13 | 4.33 | 4.13 | 4.80 | 5.07 | 4.67 | 4.84 |
| **22** | IC045993 x IC052310 | 4.80 | 4.40 | 4.60 | 4.60 | 5.40 | 5.00 | 4.87 | 5.09 |
| **23** | IC045993 x EC169459 | 4.80 | 4.60 | 4.20 | 4.53 | 5.60 | 4.73 | 4.53 | 4.96 |
| **24** | IC045993 x Kashi Pragati | 4.87 | 4.20 | 4.47 | 4.51 | 5.00 | 5.00 | 4.93 | 4.98 |
| **25** | IC045993 x IC052321 | 4.07 | 3.93 | 4.87 | 4.29 | 4.60 | 5.40 | 5.13 | 5.04 |
| **26** | Pusa Sawani x EC169452 | 4.33 | 4.43 | 4.60 | 4.46 | 5.00 | 5.40 | 4.80 | 5.07 |
| **27** | Pusa Sawani x IC052310 | 5.13 | 5.13 | 4.33 | 4.87 | 6.00 | 4.60 | 4.73 | 5.11 |
| **28** | Pusa Sawani x EC169459 | 3.73 | 4.00 | 5.33 | 4.36 | 4.80 | 5.07 | 5.40 | 5.09 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **29** | Pusa Sawani x Kashi Pragati | 4.33 | 4.33 | 4.20 | 4.29 | 4.80 | 5.40 | 5.27 | 5.16 |
| **30** | Pusa Sawani x IC052321 | 4.20 | 4.00 | 4.73 | 4.31 | 4.80 | 5.20 | 5.00 | 5.00 |
| **31** | VRO-4 x EC169452 | 4.07 | 4.00 | 4.07 | 4.04 | 4.60 | 4.33 | 4.27 | 4.40 |
| **32** | VRO-4 x IC052310 | 4.33 | 3.80 | 4.40 | 4.18 | 4.60 | 4.93 | 4.73 | 4.76 |
| **33** | VRO-4 x EC169459 | 4.13 | 3.87 | 4.53 | 4.18 | 5.40 | 5.53 | 4.73 | 5.22 |
| **34** | VRO-4 x Kashi Pragati | 3.87 | 3.60 | 3.93 | 3.80 | 5.00 | 4.40 | 4.33 | 4.58 |
| **35** | VRO-4 x IC052321 | 3.80 | 3.67 | 4.13 | 3.87 | 5.20 | 4.73 | 4.40 | 4.78 |
| **36** | IC052299 x EC169452 | 4.13 | 4.20 | 5.13 | 4.49 | 5.40 | 5.07 | 5.20 | 5.22 |
| **37** | IC052299 x IC052310 | 4.40 | 4.40 | 5.07 | 4.62 | 5.60 | 4.80 | 5.20 | 5.20 |
| **38** | IC052299 x EC169459 | 4.20 | 4.20 | 4.67 | 4.36 | 4.20 | 5.07 | 4.93 | 4.73 |
| **39** | IC052299 x Kashi Pragati | 4.13 | 3.87 | 4.00 | 4.00 | 4.80 | 4.47 | 4.80 | 4.69 |
| **40** | IC052299 x IC052321 | 4.27 | 4.07 | 4.73 | 4.36 | 4.40 | 5.27 | 5.00 | 4.89 |
| **41** | Kashi Kranti x EC169452 | 3.47 | 4.80 | 5.00 | 4.42 | 4.20 | 5.07 | 5.27 | 4.84 |
| **42** | Kashi Kranti x IC052310 | 3.47 | 4.27 | 5.00 | 4.24 | 4.00 | 5.27 | 5.27 | 4.84 |
| **43** | Kashi Kranti x EC169459 | 3.73 | 4.20 | 4.67 | 4.20 | 4.80 | 5.00 | 5.13 | 4.98 |

| *Table continues…* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **44** | Kashi Kranti x Kashi Pragati | 3.87 | 3.87 | 3.87 | 3.87 | 4.20 | 4.40 | 4.33 | 4.31 |
| **45** | Kashi Kranti x IC052321 | 4.00 | 3.93 | 4.73 | 4.22 | 4.20 | 5.13 | 4.93 | 4.76 |
| **46** | Salkeerthi x EC169452 | 4.07 | 3.73 | 5.40 | 4.40 | 4.60 | 5.00 | 5.60 | 5.07 |
| **47** | Salkeerthi x IC052310 | 4.20 | 4.00 | 5.00 | 4.40 | 4.60 | 5.27 | 5.40 | 5.09 |
| **48** | Salkeerthi x EC169459 | 4.20 | 4.00 | 5.07 | 4.42 | 4.60 | 5.07 | 5.33 | 5.00 |
| **49** | Salkeerthi x Kashi Pragati | 4.13 | 3.80 | 4.20 | 4.04 | 5.00 | 4.73 | 5.13 | 4.96 |
| **50** | Salkeerthi x IC052321 | 4.33 | 3.40 | 4.27 | 4.00 | 4.60 | 5.07 | 4.47 | 4.71 |
| **51** | IC058235 x EC169452 | 4.33 | 4.33 | 4.93 | 4.53 | 5.20 | 4.80 | 5.07 | 5.02 |
| **52** | IC058235 x IC052310 | 3.53 | 4.27 | 5.33 | 4.38 | 4.60 | 5.13 | 5.53 | 5.09 |
| **53** | IC058235 x EC169459 | 4.13 | 4.27 | 4.80 | 4.40 | 5.20 | 5.27 | 5.13 | 5.20 |
| **54** | IC058235 x Kashi Pragati | 4.07 | 4.07 | 4.07 | 4.07 | 5.00 | 4.87 | 4.87 | 4.91 |
| **55** | IC058235 x IC052321 | 4.67 | 3.87 | 5.13 | 4.56 | 5.00 | 5.53 | 5.27 | 5.27 |
| **56** | Hisar Naveen x EC169452 | 4.67 | 4.67 | 4.53 | 4.62 | 5.20 | 5.00 | 4.60 | 4.93 |
| **57** | Hisar Naveen x IC052310 | 4.53 | 4.53 | 4.33 | 4.47 | 5.00 | 5.00 | 4.60 | 4.87 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **58** | Hisar Naveen x EC169459 | 4.20 | 4.20 | 5.13 | 4.51 | 4.60 | 5.07 | 5.33 | 5.00 |
| **59** | Hisar Naveen x Kashi Pragati | 4.33 | 3.93 | 4.20 | 4.16 | 4.80 | 4.87 | 5.13 | 4.93 |
| **60** | Hisar Naveen x IC052321 | 3.93 | 4.07 | 4.67 | 4.22 | 4.60 | 5.13 | 5.00 | 4.91 |
| **61** | IC052302 x EC169452 | 3.80 | 4.27 | 4.07 | 4.04 | 4.60 | 4.67 | 4.53 | 4.60 |
| **62** | IC052302 x IC052310 | 3.87 | 4.40 | 4.53 | 4.27 | 4.60 | 5.00 | 4.73 | 4.78 |
| **63** | IC052302 x EC169459 | 3.73 | 4.27 | 4.40 | 4.13 | 5.00 | 4.73 | 4.60 | 4.78 |
| **64** | IC052302 x Kashi Pragati | 3.73 | 4.20 | 3.93 | 3.96 | 4.60 | 4.73 | 4.73 | 4.69 |
| **65** | IC052302 x IC052321 | 3.67 | 4.00 | 4.60 | 4.09 | 4.60 | 5.07 | 4.87 | 4.84 |
| Check | | 4.20 | 4.27 | 4.44 | 4.36 | 5.40 | 5.07 | 5.13 | 5.4 |
| **Range** | | 3.53-5.13 | 3.40-5.13 | 3.87-5.53 | 3.80-4.96 | 4.00-6.00 | 4.33-6.00 | 4.27-5.60 | 4.31-5.47 |
| **General mean** | | 4.27 | 4.23 | 4.61 | 4.37 | 4.89 | 5.04 | 4.93 | 4.95 |
| **Parent mean** | | 4.64 | 4.53 | 4.71 | 4.63 | 5.13 | 5.22 | 4.97 | 5.11 |
| **Hybrid mean** | | 4.16 | 4.14 | 4.59 | 4.30 | 4.81 | 4.99 | 4.92 | 4.91 |

Where in E3 exhibit ranges from 38.00 to 42.33, with a general mean of 40.64. Among the parents, IC052302 (38.00) and in crosses IC045993 x Kashi Pragati and Kashi Kranti x Kashi Pragati (39.00) recorded desirable (lower) mean, while in Pooled analysis its ranges from 37.00 to 41.00, with a general mean of 38.96. Among the parents, IC052302 (38.00) observed a desirable (low) mean, and in crosses Kashi Kranti x Kashi Pragati (37.00) recorded desirable (lower) mean.

#### 4.5.4 Days to 50 % flowering

In E1 exhibit ranges from 38.33 to 43.33 with the general mean of (40.49). Among the parents Hisar Naveen (39.33) with desirable (low) mean, and in crosses VRO-4 x Kashi Pragati and Kashi Kranti x Kashi Pragati (38.33), observed a least mean. Whereas in E2 ranges from 39.00 to 45.33 with the general mean of 42.75. Among the parents Pusa Sawani (41.33) recorded a desirable (low) mean and while in crosses Kashi Kranti x Kashi Pragati (39.00), observed a least mean. Where in E3 ranges from 40.33 to 45.00, with a general mean of 42.93. Among the parents, IC045993 (41.00) observed a desirable (low) mean and in crosses Kashi Kranti x Kashi Pragati (40.33) recorded desirable (lower) mean, while in Pooled analysis its exhibit ranges from 39.22 to 44.56, with a general mean of 42.06. Among the parents, Pusa Sawani (41.11) observed a desirable (low) mean, and in crosses Kashi Kranti x Kashi Pragati (39.22) recorded desirable (lower) mean.

#### 4.5.5 Days to first fruit harvest

In E1 Days to 1$^{st}$ fruit harvest ranges from 43.0 to 49.0 with the general mean of (46.63). Among the parents VRO-4 (46.67) with low desirable (low) mean and in crosses Kashi Kranti x Kashi Pragati (43.00), observed a desirable (least) mean. Whereas in E2 ranges from 45.33 to 52.00 with the general mean (48.04). Among the parents Pusa Sawani (47.66) and among the crosses Hisar Naveen x IC052321 (45.33), observed a least mean. Where in E3 ranges from 45.67 to 51.00 with a general mean of 42.93. In parents Kashi Pragati (46.33) and in crosses Kashi Kranti x EC169459 (45.67) observed a least mean, while in Pooled analysis its exhibit ranges from 45.00 to 49.89, with a general mean of 47.57. Among the parents, Kashi Pragati (47.56) and in crosses Kashi Kranti x Kashi Pragati (45.00) recorded desirable (lower) mean.

**Table 24. Mean value of parents and their hybrids across and pooled in okra for days to first flowering and days to 50% flowering respectively**

| S.No. | Genotype | Days to first flowering | | | | Days to 50% flowering | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| | **PARENTS** | | | | | | | | |
| **1** | IC058710 | 38.33 | 39.33 | 40.67 | 39.67 | 41.00 | 45.33 | 43.00 | 43.11 |
| **2** | IC045993 | 37.67 | 38.67 | 40.33 | 38.89 | 40.33 | 42.33 | 41.00 | 41.22 |
| **3** | Pusa Sawani | 37.00 | 39.00 | 40.67 | 38.89 | 40.00 | 41.33 | 42.00 | 41.11 |
| **4** | VRO-4 | 37.67 | 39.00 | 40.33 | 39.00 | 40.00 | 42.33 | 42.00 | 41.44 |
| **5** | IC052299 | 38.00 | 38.33 | 41.00 | 39.11 | 39.67 | 43.67 | 43.33 | 42.22 |
| **6** | Kashi Kranti | 37.67 | 38.33 | 40.33 | 38.78 | 41.67 | 44.67 | 43.67 | 43.33 |
| **7** | Salkeerthi | 38.00 | 39.00 | 39.67 | 38.89 | 40.33 | 45.33 | 43.33 | 43.00 |
| **8** | IC058235 | 38.00 | 38.00 | 40.00 | 38.67 | 41.00 | 45.00 | 43.67 | 43.22 |
| **9** | Hisar Naveen | 37.00 | 37.33 | 40.33 | 38.22 | 39.33 | 42.33 | 43.00 | 41.56 |
| **10** | IC052302 | 37.00 | 39.00 | 38.00 | 38.00 | 40.00 | 44.67 | 41.33 | 42.00 |
| **11** | EC169452 | 40.33 | 40.00 | 41.67 | 40.67 | 43.33 | 45.33 | 45.00 | 44.56 |
| **12** | IC052310 | 41.00 | 40.67 | 41.33 | 41.00 | 43.33 | 44.33 | 44.67 | 44.11 |
| **13** | EC169459 | 39.67 | 38.67 | 40.00 | 39.44 | 42.33 | 42.00 | 41.67 | 42.00 |
| **14** | Kashi Pragati | 37.67 | 39.00 | 39.67 | 38.78 | 40.67 | 42.33 | 43.00 | 42.00 |
| **15** | IC052321 | 40.67 | 40.33 | 40.33 | 40.44 | 43.33 | 44.67 | 43.67 | 43.89 |
| **HYBRIDS** | | | | | | | | | |

| Table continues… | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **16** | IC058710 x EC169452 | 39.00 | 39.33 | 39.33 | 39.22 | 41.00 | 42.67 | 42.67 | 42.11 |
| **17** | IC058710 x IC052310 | 39.33 | 37.67 | 41.33 | 39.44 | 41.67 | 43.67 | 44.00 | 43.11 |
| **18** | IC058710 x EC169459 | 38.67 | 38.33 | 39.67 | 38.89 | 40.00 | 43.33 | 43.33 | 42.22 |
| **19** | IC058710 x Kashi Pragati | 37.67 | 36.67 | 42.00 | 38.78 | 39.33 | 41.33 | 43.67 | 41.44 |
| **20** | IC058710 x IC052321 | 39.33 | 38.67 | 39.33 | 39.11 | 40.00 | 43.00 | 40.67 | 41.22 |
| **21** | IC045993 x EC169452 | 38.67 | 38.33 | 40.00 | 39.00 | 40.67 | 41.33 | 42.33 | 41.44 |
| **22** | IC045993 x IC052310 | 39.33 | 40.00 | 41.67 | 40.33 | 42.33 | 41.33 | 43.33 | 42.33 |
| **23** | IC045993 x EC169459 | 39.67 | 39.67 | 40.00 | 39.78 | 42.00 | 41.67 | 42.00 | 41.89 |
| **24** | IC045993 x Kashi Pragati | 38.00 | 37.00 | 39.00 | 38.00 | 39.67 | 43.00 | 41.33 | 41.33 |
| **25** | IC045993 x IC052321 | 37.00 | 39.00 | 40.00 | 38.67 | 39.33 | 44.00 | 42.00 | 41.78 |
| **26** | Pusa Sawani x EC169452 | 36.67 | 40.00 | 41.33 | 39.33 | 38.67 | 41.33 | 43.67 | 41.22 |
| **27** | Pusa Sawani x IC052310 | 36.67 | 37.33 | 41.00 | 38.33 | 39.67 | 41.33 | 43.33 | 41.44 |
| **28** | Pusa Sawani x EC169459 | 37.67 | 38.33 | 41.67 | 39.22 | 39.67 | 44.00 | 44.33 | 42.67 |
| **29** | Pusa Sawani x Kashi Pragati | 37.33 | 37.33 | 39.33 | 37.89 | 39.00 | 41.00 | 42.67 | 40.89 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **30** | Pusa Sawani x IC052321 | 37.00 | 37.00 | 40.00 | 38.00 | 39.67 | 42.33 | 43.67 | 41.89 |
| **31** | VRO-4 x EC169452 | 37.33 | 37.00 | 41.33 | 38.56 | 39.33 | 44.33 | 44.00 | 42.56 |
| **32** | VRO-4 x IC052310 | 39.00 | 39.00 | 41.00 | 39.67 | 42.00 | 42.33 | 42.33 | 42.22 |
| **33** | VRO-4 x EC169459 | 37.00 | 37.67 | 41.67 | 38.78 | 39.00 | 41.33 | 44.33 | 41.56 |
| **34** | VRO-4 x Kashi Pragati | 37.00 | 37.00 | 39.67 | 37.89 | 38.33 | 40.33 | 40.67 | 39.78 |
| **35** | VRO-4 x IC052321 | 38.00 | 38.00 | 41.00 | 39.00 | 40.00 | 44.33 | 43.67 | 42.67 |
| **36** | IC052299 x EC169452 | 37.67 | 37.67 | 41.33 | 38.89 | 39.67 | 41.67 | 42.33 | 41.22 |
| **37** | IC052299 x IC052310 | 37.00 | 37.00 | 40.33 | 38.11 | 39.67 | 43.00 | 41.67 | 41.44 |
| **38** | IC052299 x EC169459 | 36.00 | 36.00 | 41.67 | 37.89 | 39.33 | 40.00 | 42.67 | 40.67 |
| **39** | IC052299 x Kashi Pragati | 37.67 | 37.33 | 40.67 | 38.56 | 40.00 | 41.33 | 42.67 | 41.33 |
| **40** | IC052299 x IC052321 | 38.00 | 38.00 | 41.00 | 39.00 | 40.67 | 43.67 | 44.33 | 42.89 |
| **41** | Kashi Kranti x EC169452 | 38.67 | 38.67 | 42.33 | 39.89 | 40.67 | 41.00 | 44.33 | 42.00 |
| **42** | Kashi Kranti x IC052310 | 38.33 | 38.33 | 41.33 | 39.33 | 41.33 | 44.33 | 42.67 | 42.78 |
| **43** | Kashi Kranti x EC169459 | 36.33 | 37.00 | 40.33 | 37.89 | 39.00 | 41.00 | 41.67 | 40.56 |
| **44** | Kashi Kranti x Kashi Pragati | 36.33 | 35.67 | 39.00 | 37.00 | 38.33 | 39.00 | 40.33 | 39.22 |

| Table continues… | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **45** | Kashi Kranti x IC052321 | 36.67 | 37.33 | 40.33 | 38.11 | 39.67 | 42.33 | 42.00 | 41.33 |
| **46** | Salkeerthi x EC169452 | 39.33 | 39.00 | 41.33 | 39.89 | 41.00 | 44.33 | 43.67 | 43.00 |
| **47** | Salkeerthi x IC052310 | 40.00 | 40.00 | 41.00 | 40.33 | 42.00 | 43.00 | 44.00 | 43.00 |
| **48** | Salkeerthi x EC169459 | 38.67 | 37.67 | 40.67 | 39.00 | 41.00 | 41.67 | 42.00 | 41.56 |
| **49** | Salkeerthi x Kashi Pragati | 37.00 | 37.00 | 40.00 | 38.00 | 40.00 | 42.00 | 41.67 | 41.22 |
| **50** | Salkeerthi x IC052321 | 36.67 | 36.67 | 40.33 | 37.89 | 39.67 | 42.00 | 41.67 | 41.11 |
| **51** | IC058235 x EC169452 | 37.67 | 37.67 | 41.33 | 38.89 | 39.67 | 42.00 | 44.00 | 41.89 |
| **52** | IC058235 x IC052310 | 38.00 | 38.00 | 41.33 | 39.11 | 41.67 | 44.33 | 43.67 | 43.22 |
| **53** | IC058235 x EC169459 | 38.33 | 38.33 | 41.00 | 39.22 | 40.33 | 43.33 | 42.33 | 42.00 |
| **54** | IC058235 x Kashi Pragati | 38.67 | 37.00 | 40.67 | 38.78 | 41.00 | 44.33 | 43.00 | 42.78 |
| **55** | IC058235 x IC052321 | 38.00 | 37.67 | 40.67 | 38.78 | 41.00 | 43.67 | 42.33 | 42.33 |
| **56** | Hisar Naveen x EC169452 | 37.33 | 37.33 | 42.00 | 38.89 | 40.33 | 43.00 | 44.00 | 42.44 |
| **57** | Hisar Naveen x IC052310 | 38.67 | 38.67 | 41.67 | 39.67 | 41.67 | 42.67 | 43.00 | 42.44 |
| **58** | Hisar Naveen x EC169459 | 38.33 | 37.67 | 41.33 | 39.11 | 41.00 | 41.67 | 42.33 | 41.67 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **59** | Hisar Naveen x Kashi Pragati | 38.33 | 37.33 | 41.00 | 38.89 | 40.67 | 44.33 | 43.33 | 42.78 |
| **60** | Hisar Naveen x IC052321 | 37.67 | 37.67 | 40.67 | 38.67 | 39.67 | 42.33 | 43.33 | 41.78 |
| **61** | IC052302 x EC169452 | 37.67 | 37.33 | 40.33 | 38.44 | 40.00 | 40.67 | 42.67 | 41.11 |
| **62** | IC052302 x IC052310 | 36.33 | 37.33 | 41.33 | 38.33 | 39.67 | 40.67 | 44.67 | 41.67 |
| **63** | IC052302 x EC169459 | 40.33 | 38.67 | 40.33 | 39.78 | 42.00 | 41.67 | 43.33 | 42.33 |
| **64** | IC052302 x Kashi Pragati | 39.00 | 37.67 | 41.00 | 39.22 | 41.33 | 45.33 | 43.67 | 43.44 |
| **65** | IC052302 x IC052321 | 40.00 | 40.00 | 41.00 | 40.33 | 42.67 | 45.33 | 45.00 | 44.33 |
| Check | | 40.00 | 39.0 | 41.00 | 41.69 | 41.00 | 43.33 | 44.33 | 42.88 |
| **Range** | | 36.0-41.0 | 35.67-40.67 | 38.00-42.33 | 37.00-41.0 | 38.33-43.33 | 39.00-45.33 | 40.33-45.00 | 39.32-44.56 |
| **General mean** | | 4.27 | 38.08 | 38.15 | 40.65 | 38.96 | 40.50 | 42.76 | 42.93 |
| **Parent mean** | | 4.64 | 38.42 | 38.98 | 40.29 | 39.23 | 41.09 | 43.71 | 42.96 |
| **Hybrid mean** | | 4.16 | 37.98 | 37.90 | 40.75 | 38.88 | 40.32 | 42.47 | 42.93 |

### 4.5.6 Plant height (cm)

In E1 Plant height exhibit ranges from 76.10 cm to 104.33 cm with the general mean (92.55cm). Among the parents IC058235 (100.24 cm) and in cross combinations VRO-4 x Kashi Pragati (104.33 cm), observed a high mean. Whereas in E2 ranges from 77.60 to 105.58 with the general mean (93.97 cm). Among the parents VRO-4 (99.23 cm) and while in crosses IC052302 x IC052321 (105.58 cm), observed a high mean. Whereas in E3 ranges from 78.77 cm to 99.13 cm with the general mean (88.51 cm). Among the parents VRO-4 (93.80 cm) and in crosses IC052302 x EC169452 (99.13 cm) observed a high mean, while in Pooled analysis its exhibit ranges from 81.54 cm to 100.26 cm with the general mean (91.76 cm). Among the parents VRO-4 (97.35 cm) and in crosses Kashi Kranti x Kashi Pragati (100.26 cm) observed a high mean.

### 4.5.7 Internodal length (cm)

In E1 Internodal length exhibit ranges from 4.93 cm to 7.25 cm with the general mean (5.98 cm). Among the parents IC052299 (5.57 cm) and whereas cross combinations IC045993 x EC169459 (7.25 cm) observed a high mean. Whereas in E2 ranges from 4.02 cm to 6.53 cm with the general mean (5.72 cm). Among the parents IC052302 (5.72 cm) and in crosses Hisar Naveen x Kashi Pragati (6.53 cm), observed a high mean. Where in E3 ranges from 4.95 cm to 6.72 cm with the general mean (5.66 cm). Among the parents VRO-4 (6.19 cm) and in crosses Kashi Kranti x Kashi Pragati (6.72 cm) observed a high mean, while in Pooled analysis its exhibit ranges from 4.84 cm to 6.65 cm with the general mean (6.59 cm). Among the parents VRO-4 (5.65 cm), and in crosses Kashi Kranti x Kashi Pragati (6.65 cm) observed a high mean value.

### 4.5.8 Number of branches per plant

In E1 number of branches per plant exhibit ranges from 3.40 to 5.33 with the general mean (4.35). Among the parents IC058710 (4.13) and in cross combinations Kashi Kranti x Kashi Pragati (5.33) recorded a high mean. Whereas in E2 ranges from 4.07 to 5.93 with the general mean (4.35). Among the parents Kashi Kranti (5.86) and while in crosses IC058235 x IC052310 (5.93) observed a high mean. Where in E3 ranges from 4.27 to 5.93 with the general mean (5.10). Among the parents Kashi Kranti (5.86) with high mean and in crosses IC058235 x IC052310 (5.93) observed a high mean, while in Pooled analysis its exhibit ranges from 4.20 to 5.47 with the general mean (4.86). Among the parents Kashi Kranti (5.18) in crosses IC045993 x Kashi Pragati (5.47) observed a high mean.

**Table.25 Mean value of parents and their hybrids diverse and pooled environments in okra for days to first fruit harvest and plant height**

| S.No. | Genotype | Days to first fruit harvest | | | | Plant height | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| | **PARENTS** | | | | | | | | |
| **1** | IC058710 | 48.33 | 48.67 | 47.67 | 48.22 | 94.50 | 92.37 | 81.80 | 89.55 |
| **2** | IC045993 | 49.00 | 48.33 | 48.00 | 48.44 | 95.47 | 90.90 | 89.90 | 92.09 |
| **3** | Pusa Sawani | 48.00 | 47.67 | 48.67 | 48.11 | 97.20 | 94.86 | 91.13 | 94.40 |
| **4** | VRO-4 | 46.67 | 49.00 | 47.67 | 47.78 | 99.01 | 99.23 | 93.80 | 97.35 |
| **5** | IC052299 | 47.33 | 49.67 | 48.33 | 48.44 | 95.56 | 98.13 | 84.13 | 92.61 |
| **6** | Kashi Kranti | 47.33 | 49.33 | 47.33 | 48.00 | 97.42 | 89.43 | 87.83 | 91.56 |
| **7** | Salkeerthi | 49.00 | 50.33 | 47.33 | 48.89 | 90.42 | 92.70 | 86.77 | 89.96 |
| **8** | IC058235 | 48.33 | 49.00 | 48.00 | 48.44 | 100.24 | 92.29 | 90.97 | 94.50 |
| **9** | Hisar Naveen | 48.00 | 48.33 | 47.67 | 48.00 | 83.93 | 92.93 | 86.80 | 87.89 |
| **10** | IC052302 | 48.67 | 51.00 | 48.67 | 49.44 | 91.93 | 95.61 | 90.67 | 92.74 |
| **11** | EC169452 | 48.33 | 52.00 | 49.33 | 49.89 | 76.10 | 77.60 | 97.73 | 83.81 |
| **12** | IC052310 | 48.67 | 49.00 | 48.33 | 48.67 | 77.85 | 81.61 | 85.17 | 81.54 |
| **13** | EC169459 | 49.00 | 48.33 | 47.00 | 48.11 | 87.27 | 86.53 | 86.23 | 86.68 |
| **14** | Kashi Pragati | 47.00 | 49.33 | 46.33 | 47.56 | 94.29 | 90.10 | 93.60 | 92.66 |
| **15** | IC052321 | 49.00 | 49.00 | 47.67 | 48.56 | 92.49 | 85.63 | 79.57 | 85.90 |
| **HYBRIDS** | | | | | | | | | |
| **16** | IC058710 x EC169452 | 47.33 | 48.67 | 47.33 | 47.78 | 95.71 | 97.66 | 93.23 | 95.53 |
| **17** | IC058710 x IC052310 | 46.67 | 48.67 | 48.33 | 47.89 | 97.11 | 86.63 | 93.80 | 92.51 |

***Table continues…***

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **18** | IC058710 x EC169459 | 46.33 | 49.00 | 46.67 | 47.33 | 97.13 | 96.30 | 90.03 | 94.49 |
| **19** | IC058710 x Kashi Pragati | 46.33 | 46.00 | 48.67 | 47.00 | 93.25 | 96.55 | 90.17 | 93.32 |
| **20** | IC058710 x IC052321 | 48.00 | 48.67 | 47.67 | 48.11 | 91.15 | 90.29 | 81.40 | 87.61 |
| **21** | IC045993 x EC169452 | 47.33 | 48.00 | 49.67 | 48.33 | 93.63 | 97.11 | 88.37 | 93.04 |
| **22** | IC045993 x IC052310 | 48.33 | 48.00 | 47.67 | 48.00 | 95.91 | 87.47 | 86.63 | 90.01 |
| **23** | IC045993 x EC169459 | 46.00 | 45.67 | 46.33 | 46.00 | 100.83 | 97.09 | 93.40 | 97.10 |
| **24** | IC045993 x Kashi Pragati | 45.00 | 46.33 | 46.00 | 45.67 | 96.89 | 99.47 | 93.23 | 96.53 |
| **25** | IC045993 x IC052321 | 45.33 | 49.67 | 48.00 | 47.67 | 90.46 | 101.72 | 90.33 | 94.17 |
| **26** | Pusa Sawani x EC169452 | 45.33 | 48.33 | 51.00 | 48.22 | 94.61 | 94.90 | 98.12 | 95.88 |
| **27** | Pusa Sawani x IC052310 | 43.67 | 48.33 | 48.67 | 46.89 | 89.01 | 87.43 | 83.91 | 86.78 |
| **28** | Pusa Sawani x EC169459 | 45.33 | 46.67 | 48.00 | 46.67 | 95.86 | 97.98 | 81.55 | 91.80 |
| **29** | Pusa Sawani x Kashi Pragati | 47.67 | 47.33 | 48.33 | 47.78 | 92.32 | 93.47 | 93.49 | 93.09 |
| **30** | Pusa Sawani x IC052321 | 47.00 | 48.67 | 47.67 | 47.78 | 96.70 | 99.04 | 93.80 | 96.51 |
| **31** | VRO-4 x EC169452 | 45.33 | 46.00 | 46.33 | 45.89 | 99.36 | 99.27 | 94.80 | 97.81 |
| **32** | VRO-4 x IC052310 | 46.33 | 45.67 | 47.00 | 46.33 | 94.35 | 103.73 | 92.27 | 96.78 |
| **33** | VRO-4 x EC169459 | 45.33 | 45.67 | 48.00 | 46.33 | 96.67 | 95.43 | 86.57 | 92.89 |
| **34** | VRO-4 x Kashi Pragati | 46.67 | 45.67 | 48.00 | 46.78 | 104.33 | 95.18 | 96.27 | 98.59 |
| **35** | VRO-4 x IC052321 | 46.67 | 47.67 | 48.33 | 47.56 | 95.00 | 99.19 | 88.63 | 94.28 |
| **36** | IC052299 x EC169452 | 46.67 | 50.00 | 48.00 | 48.22 | 90.27 | 95.15 | 89.33 | 91.58 |
| **37** | IC052299 x IC052310 | 46.67 | 48.67 | 47.00 | 47.44 | 92.06 | 91.49 | 91.10 | 91.55 |

***Table continues…***

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **38** | IC052299 x EC169459 | 43.67 | 48.00 | 47.67 | 46.44 | 100.65 | 96.65 | 88.50 | 95.27 |
| **39** | IC052299 x Kashi Pragati | 46.00 | 46.00 | 48.33 | 46.78 | 90.52 | 98.83 | 88.63 | 92.66 |
| **40** | IC052299 x IC052321 | 47.00 | 48.33 | 49.33 | 48.22 | 94.27 | 94.23 | 88.27 | 92.26 |
| **41** | Kashi Kranti x EC169452 | 45.67 | 50.00 | 48.67 | 48.11 | 88.21 | 99.33 | 87.40 | 91.65 |
| **42** | Kashi Kranti x IC052310 | 44.67 | 49.67 | 48.00 | 47.44 | 82.87 | 94.30 | 89.03 | 88.73 |
| **43** | Kashi Kranti x EC169459 | 44.00 | 48.67 | 45.67 | 46.11 | 100.60 | 93.45 | 90.90 | 94.98 |
| **44** | Kashi Kranti x Kashi Pragati | 43.00 | 46.00 | 46.00 | 45.00 | 103.59 | 100.59 | 96.60 | 100.26 |
| **45** | Kashi Kranti x IC052321 | 46.67 | 48.33 | 48.00 | 47.67 | 99.75 | 95.71 | 85.33 | 93.60 |
| **46** | Salkeerthi x EC169452 | 45.67 | 49.67 | 50.00 | 48.44 | 87.78 | 96.70 | 85.13 | 89.87 |
| **47** | Salkeerthi x IC052310 | 48.00 | 49.00 | 48.00 | 48.33 | 86.41 | 95.21 | 78.77 | 86.80 |
| **48** | Salkeerthi x EC169459 | 45.33 | 48.33 | 48.67 | 47.44 | 86.13 | 98.99 | 96.20 | 93.77 |
| **49** | Salkeerthi x Kashi Pragati | 44.00 | 46.67 | 48.33 | 46.33 | 96.51 | 95.53 | 86.17 | 92.74 |
| **50** | Salkeerthi x IC052321 | 45.33 | 47.67 | 48.67 | 47.22 | 90.90 | 99.23 | 90.53 | 93.56 |
| **51** | IC058235 x EC169452 | 44.67 | 49.00 | 48.33 | 47.33 | 91.19 | 92.53 | 83.47 | 89.06 |
| **52** | IC058235 x IC052310 | 46.67 | 49.33 | 49.00 | 48.33 | 92.79 | 99.23 | 85.47 | 92.49 |
| **53** | IC058235 x EC169459 | 46.67 | 47.67 | 48.33 | 47.56 | 92.92 | 100.10 | 83.50 | 92.17 |
| **54** | IC058235 x Kashi Pragati | 48.00 | 47.33 | 48.67 | 48.00 | 90.58 | 95.10 | 86.57 | 90.75 |
| **55** | IC058235 x IC052321 | 47.00 | 47.33 | 48.00 | 47.44 | 89.13 | 90.47 | 79.77 | 86.46 |
| **56** | Hisar Naveen x EC169452 | 46.33 | 46.00 | 50.33 | 47.56 | 81.07 | 90.43 | 82.10 | 84.53 |

*Table continues…*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **57** | Hisar Naveen x IC052310 | 48.33 | 48.00 | 49.33 | 48.56 | 91.01 | 86.81 | 82.43 | 86.75 |
| **58** | Hisar Naveen x EC169459 | 45.67 | 46.00 | 47.33 | 46.33 | 87.89 | 90.76 | 87.37 | 88.67 |
| **59** | Hisar Naveen x Kashi Pragati | 49.00 | 46.67 | 48.00 | 47.89 | 91.76 | 92.91 | 94.53 | 93.07 |
| **60** | Hisar Naveen x IC052321 | 45.67 | 45.33 | 49.00 | 46.67 | 85.01 | 85.01 | 84.50 | 84.84 |
| **61** | IC052302 x EC169452 | 45.67 | 46.67 | 47.67 | 46.67 | 86.24 | 87.81 | 99.13 | 91.06 |
| **62** | IC052302 x IC052310 | 45.33 | 46.00 | 49.33 | 46.89 | 84.73 | 85.22 | 82.63 | 84.20 |
| **63** | IC052302 x EC169459 | 45.33 | 47.67 | 48.67 | 47.22 | 86.37 | 83.81 | 87.73 | 85.97 |
| **64** | IC052302 x Kashi Pragati | 48.33 | 48.67 | 49.33 | 48.78 | 95.35 | 101.05 | 85.40 | 93.94 |
| **65** | IC052302 x IC052321 | 47.67 | 48.67 | 48.00 | 48.11 | 95.26 | 105.58 | 80.43 | 93.76 |
| Check | | 47.67 | 47.67 | 49.33 | 48.22 | 96.00 | 98.10 | 84.56 | 92.80 |
| **Range** | | 43.0-49.0 | 45.33-52.00 | 45.67-51.00 | 45.00-49.89 | 76.10-104.33 | 77.60-105.58 | 78.77-99.13 | 81.54-100.26 |
| **General mean** | | 46.64 | 48.05 | 48.08 | 47.59 | 92.55 | 93.97 | 88.51 | 91.68 |
| **Parent mean** | | 48.18 | 49.27 | 47.87 | 48.44 | 91.58 | 90.66 | 88.41 | 90.22 |
| **Hybrid mean** | | 46.17 | 47.68 | 48.14 | 47.33 | 92.84 | 94.96 | 88.54 | 92.11 |

**Table 26. Mean performance of parents and their hybrids diverse and pooled environments in okra for internodal length and number of branches/plants respectively**

| S.No. | Genotype | Internodal length | | | | Number of branches per plant | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | EN1 | EN2 | EN3 | Pooled | EN1 | EN2 | EN3 | Pooled |
| | **PARENTS** | | | | | | | | |
| **1** | IC058710 | 5.25 | 5.27 | 5.38 | 5.30 | 4.13 | 5.07 | 5.07 | 4.76 |
| **2** | IC045993 | 5.39 | 5.23 | 5.49 | 5.37 | 3.93 | 5.00 | 5.07 | 4.67 |
| **3** | Pusa Sawani | 5.55 | 5.13 | 5.57 | 5.42 | 3.80 | 4.47 | 4.67 | 4.31 |
| **4** | VRO-4 | 5.51 | 5.26 | 6.19 | 5.65 | 3.73 | 4.67 | 4.80 | 4.40 |
| **5** | IC052299 | 5.57 | 5.45 | 5.68 | 5.57 | 3.53 | 5.00 | 5.20 | 4.58 |
| **6** | Kashi Kranti | 5.50 | 4.97 | 5.47 | 5.32 | 3.80 | 5.86 | 5.87 | 5.18 |
| **7** | Salkeerthi | 5.43 | 5.24 | 4.95 | 5.21 | 4.07 | 4.60 | 4.67 | 4.44 |
| **8** | IC058235 | 5.40 | 5.52 | 5.79 | 5.57 | 3.87 | 5.13 | 5.13 | 4.71 |
| **9** | Hisar Naveen | 5.34 | 5.27 | 5.74 | 5.45 | 4.00 | 4.93 | 4.93 | 4.62 |
| **10** | IC052302 | 5.35 | 5.72 | 5.49 | 5.52 | 4.07 | 5.20 | 5.20 | 4.82 |
| **11** | EC169452 | 5.05 | 4.02 | 5.45 | 4.84 | 4.07 | 5.27 | 5.27 | 4.87 |
| **12** | IC052310 | 5.29 | 5.29 | 5.25 | 5.28 | 3.87 | 4.93 | 5.00 | 4.60 |
| **13** | EC169459 | 5.35 | 5.41 | 5.49 | 5.42 | 4.00 | 4.67 | 4.73 | 4.47 |
| **14** | Kashi Pragati | 4.94 | 5.18 | 5.78 | 5.30 | 3.40 | 4.93 | 5.00 | 4.44 |
| **15** | IC052321 | 5.41 | 5.25 | 5.56 | 5.41 | 3.60 | 4.87 | 4.93 | 4.47 |
| **HYBRIDS** | | | | | | | | | |
| 16 | IC058710 x EC169452 | 5.37 | 5.53 | 5.57 | 5.49 | 4.13 | 5.27 | 5.27 | 4.89 |

***Table continues…***

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **17** | IC058710 x IC052310 | 5.54 | 5.36 | 5.74 | 5.55 | 4.20 | 4.27 | 4.27 | 4.24 |
| **18** | IC058710 x EC169459 | 6.63 | 4.68 | 5.63 | 5.65 | 4.40 | 5.33 | 5.33 | 5.02 |
| **19** | IC058710 x Kashi Pragati | 5.96 | 6.00 | 5.44 | 5.80 | 3.93 | 5.33 | 5.33 | 4.87 |
| **20** | IC058710 x IC052321 | 5.31 | 5.82 | 5.40 | 5.51 | 4.20 | 5.07 | 5.07 | 4.78 |
| **21** | IC045993 x EC169452 | 5.71 | 6.08 | 5.59 | 5.80 | 3.80 | 5.20 | 5.20 | 4.73 |
| **22** | IC045993 x IC052310 | 5.59 | 6.27 | 5.93 | 5.93 | 4.33 | 5.80 | 5.67 | 5.27 |
| **23** | IC045993 x EC169459 | 7.25 | 6.04 | 6.47 | 6.59 | 4.87 | 4.87 | 4.87 | 4.87 |
| **24** | IC045993 x Kashi Pragati | 5.56 | 6.15 | 5.74 | 5.82 | 5.07 | 5.67 | 5.67 | 5.47 |
| **25** | IC045993 x IC052321 | 6.47 | 5.97 | 5.38 | 5.94 | 5.20 | 5.53 | 5.53 | 5.42 |
| **26** | Pusa Sawani x EC169452 | 5.85 | 5.38 | 5.80 | 5.68 | 5.00 | 5.13 | 5.13 | 5.09 |
| **27** | Pusa Sawani x IC052310 | 6.12 | 5.48 | 5.47 | 5.69 | 5.13 | 5.13 | 5.13 | 5.13 |
| **28** | Pusa Sawani x EC169459 | 6.53 | 6.23 | 5.39 | 6.05 | 5.07 | 5.67 | 5.27 | 5.33 |
| **29** | Pusa Sawani x Kashi Pragati | 5.41 | 5.94 | 5.85 | 5.73 | 5.20 | 5.13 | 5.13 | 5.16 |
| **30** | Pusa Sawani x IC052321 | 6.79 | 6.39 | 5.74 | 6.31 | 5.07 | 5.00 | 5.00 | 5.02 |
| **31** | VRO-4 x EC169452 | 6.05 | 5.90 | 4.97 | 5.64 | 4.27 | 4.07 | 4.27 | 4.20 |
| **32** | VRO-4 x IC052310 | 6.89 | 5.07 | 5.39 | 5.78 | 4.40 | 4.73 | 4.73 | 4.62 |
| **33** | VRO-4 x EC169459 | 6.49 | 5.34 | 5.25 | 5.70 | 4.87 | 4.93 | 4.93 | 4.91 |
| **34** | VRO-4 x Kashi Pragati | 6.69 | 5.67 | 6.23 | 6.20 | 3.80 | 4.80 | 4.80 | 4.47 |
| **35** | VRO-4 x IC052321 | 6.51 | 5.29 | 6.01 | 5.94 | 4.00 | 5.60 | 5.60 | 5.07 |
| **36** | IC052299 x EC169452 | 5.63 | 5.30 | 5.10 | 5.34 | 4.60 | 5.13 | 5.13 | 4.96 |

*Table continues…*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **37** | IC052299 x IC052310 | 5.85 | 5.07 | 6.54 | 5.82 | 4.20 | 4.93 | 4.93 | 4.69 |
| **38** | IC052299 x EC169459 | 6.77 | 5.23 | 5.84 | 5.95 | 4.53 | 5.20 | 5.20 | 4.98 |
| **39** | IC052299 x Kashi Pragati | 6.00 | 6.45 | 5.47 | 5.97 | 4.33 | 5.60 | 5.60 | 5.18 |
| **40** | IC052299 x IC052321 | 6.16 | 5.42 | 5.78 | 5.79 | 4.47 | 5.20 | 5.20 | 4.96 |
| **41** | Kashi Kranti x EC169452 | 6.87 | 5.44 | 5.63 | 5.98 | 5.07 | 4.87 | 5.53 | 5.16 |
| **42** | Kashi Kranti x IC052310 | 6.28 | 5.69 | 5.83 | 5.93 | 5.07 | 4.87 | 4.93 | 4.96 |
| **43** | Kashi Kranti x EC169459 | 6.81 | 5.47 | 5.83 | 6.04 | 5.07 | 5.07 | 4.93 | 5.02 |
| **44** | Kashi Kranti x Kashi Pragati | 6.98 | 6.26 | 6.72 | 6.65 | 5.33 | 5.47 | 5.27 | 5.36 |
| **45** | Kashi Kranti x IC052321 | 6.44 | 5.40 | 5.76 | 5.87 | 5.20 | 5.13 | 5.13 | 5.16 |
| **46** | Salkeerthi x EC169452 | 6.18 | 5.41 | 6.57 | 6.05 | 4.33 | 5.80 | 5.80 | 5.31 |
| **47** | Salkeerthi x IC052310 | 6.42 | 5.65 | 6.01 | 6.03 | 4.60 | 4.80 | 4.87 | 4.76 |
| **48** | Salkeerthi x EC169459 | 6.12 | 5.50 | 5.57 | 5.73 | 5.20 | 5.13 | 5.13 | 5.16 |
| **49** | Salkeerthi x Kashi Pragati | 6.01 | 6.34 | 5.52 | 5.96 | 3.80 | 5.20 | 5.20 | 4.73 |
| **50** | Salkeerthi x IC052321 | 6.03 | 5.45 | 5.46 | 5.65 | 4.00 | 5.87 | 5.47 | 5.11 |
| **51** | IC058235 x EC169452 | 6.00 | 5.23 | 6.01 | 5.75 | 4.00 | 5.53 | 5.53 | 5.02 |
| **52** | IC058235 x IC052310 | 6.28 | 6.33 | 5.34 | 5.98 | 4.40 | 5.93 | 5.93 | 5.42 |
| **53** | IC058235 x EC169459 | 6.69 | 5.04 | 5.58 | 5.77 | 4.67 | 5.27 | 5.27 | 5.07 |
| **54** | IC058235 x Kashi Pragati | 6.41 | 5.90 | 5.11 | 5.81 | 3.80 | 5.20 | 5.20 | 4.73 |
| **55** | IC058235 x IC052321 | 5.70 | 4.85 | 4.97 | 5.17 | 5.13 | 5.27 | 5.47 | 5.29 |
| **56** | Hisar Naveen x EC169452 | 6.87 | 5.29 | 5.43 | 5.86 | 3.67 | 4.73 | 4.80 | 4.40 |
| **57** | Hisar Naveen x IC052310 | 6.17 | 5.63 | 5.81 | 5.87 | 4.27 | 5.00 | 5.13 | 4.80 |

***Table continues…***

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **58** | Hisar Naveen x EC169459 | 6.73 | 5.05 | 5.69 | 5.82 | 4.40 | 4.87 | 5.00 | 4.76 |
| **59** | Hisar Naveen x Kashi Pragati | 6.15 | 6.53 | 5.69 | 6.12 | 4.13 | 5.60 | 5.60 | 5.11 |
| **60** | Hisar Naveen x IC052321 | 5.87 | 5.09 | 5.98 | 5.64 | 4.00 | 4.73 | 4.93 | 4.56 |
| **61** | IC052302 x EC169452 | 6.17 | 5.31 | 5.57 | 5.68 | 4.33 | 4.60 | 4.60 | 4.51 |
| **62** | IC052302 x IC052310 | 5.61 | 5.52 | 5.47 | 5.53 | 4.27 | 5.13 | 5.13 | 4.84 |
| **63** | IC052302 x EC169459 | 6.32 | 5.53 | 5.49 | 5.78 | 4.80 | 4.73 | 4.73 | 4.76 |
| **64** | IC052302 x Kashi Pragati | 5.69 | 6.07 | 6.21 | 5.99 | 4.33 | 5.13 | 5.20 | 4.89 |
| **65** | IC052302 x IC052321 | 4.93 | 5.15 | 5.54 | 5.21 | 4.00 | 4.40 | 4.47 | 4.29 |
| Check | | 5.97 | 5.37 | 6.03 | 5.97 | 4.20 | 5.13 | 5.00 | 4.78 |
| **Range** | | 4.93-7.25 | 4.02-6.53 | 4.95-6.72 | 4.84-6.65 | 3.40-5.33 | 4.07-5.93 | 4.27-5.93 | 4.20-5.47 |
| **General mean** | | 5.99 | 5.53 | 5.66 | 5.73 | 4.35 | 5.10 | 5.12 | 4.86 |
| **Parent mean** | | 5.36 | 5.21 | 5.55 | 5.37 | 3.86 | 4.97 | 5.04 | 4.62 |
| **Hybrid mean** | | 6.18 | 5.62 | 5.69 | 5.83 | 4.50 | 5.14 | 5.15 | 4.93 |

### 4.5.9 Number of nodes per plant

In E1 exhibit ranges from 13.37 to 19.34 with the general mean (16.30). Among the parents Pusa Sawani (16.80) with high mean, and in crosses VRO-4 x Kashi Pragati (19.34) observed a high mean. Whereas in E2 ranges from ranges from 14.80 to 18.47 with the general mean (16.26). Among the parents Kashi Kranti (16.40) and while in crosses VRO-4 x IC052310 (18.47) observed a high mean. Where in E3 ranges from 14.90 to 18.81 with the general mean (16.47). Among the parents IC058235 (17.23) and while in crosses VRO-4 x EC169459 (18.81) observed a high mean, in Pooled analysis its exhibit ranges from 14.90 to 18.81 with the general mean (16.29). Among the parents IC052302 (16.44) and in crosses Pusa Sawani x EC169452 (17.71) observed a high mean.

### 4.5.10 Fruit length (cm)

In E1 fruit length ranges from 9.07 to 15.89 with the general mean (13.85 cm). Among the parents VRO-4 (14.00) and in crosses Kashi Kranti x EC169459 (15.89 cm) observed high mean. Whereas in E2 ranges from 9.02 to 15.85 with the general mean (13.98). Among the parents IC058235 (14.52) and while in crosses Kashi Kranti x EC169459 (15.85 cm) observed a top mean. Where in E3 ranges from 12.15 to 15.71 with the general mean (14.01). Among the parents IC058710 (14.61) and in crosses VRO-4 x IC052310 (15.71) observed a high mean, while in Pooled analysis its exhibit ranges from 10.09 to 15.55 with the general mean (13.95). Among the parents VRO-4 (14.18) and in crosses Kashi Kranti x Kashi Pragati (15.55), observed a high mean.

### 4.5.11 Fruit diameter (nm)

E1 fruit diameter exhibit ranges from 13.24 nm to 18.37 nm with the general mean (16.05 nm). Among the parents VRO-4 (16.13 nm), and in crosses, Salkeerthi x Kashi Pragati (18.37 nm) recorded a high mean. Whereas in E2 ranges from 14.02 nm to 18.67 nm with the general mean (15.57 nm). Among the parents IC052310 (16.23) and while in cross combinations Salkeerthi x EC169459 (18.67 nm) observed a high mean. Where in E3 ranges from 13.60 nm to 17.91nm with the general mean (15.12 nm). Among the parents IC052310 (17.09 nm) and in cross combinations Salkeerthi x EC169459 (17.91 nm) observed a high mean, while in Pooled analysis its exhibit ranges from 14.16 nm to 18.18 nm with the general mean (15.58 nm). Among the parents IC052310 (16.37 nm), while in crosses Salkeerthi x EC169459 (18.18 nm) observed a high mean.

**Table 27. Mean value of parents and their hybrids diverse and pooled environments in okra for number of nodes/plant and fruit length respectively**

| S.No. | Genotype | Number of nodes | | | | Fruit length | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| | **PARENTS** | | | | | | | | |
| 1 | IC058710 | 14.74 | 15.86 | 15.26 | 15.28 | 12.64 | 13.47 | 14.61 | 13.57 |
| 2 | IC045993 | 15.85 | 16.20 | 16.31 | 16.12 | 13.42 | 13.90 | 14.22 | 13.85 |
| 3 | Pusa Sawani | 16.80 | 16.33 | 15.97 | 16.37 | 12.65 | 14.39 | 14.58 | 13.87 |
| 4 | VRO-4 | 16.38 | 15.91 | 16.19 | 16.16 | 14.00 | 14.19 | 14.34 | 14.18 |
| 5 | IC052299 | 15.93 | 16.07 | 17.23 | 16.41 | 13.45 | 13.90 | 14.37 | 13.91 |
| 6 | Kashi Kranti | 14.74 | 16.40 | 17.37 | 16.17 | 12.86 | 13.67 | 13.68 | 13.40 |
| 7 | Salkeerthi | 14.33 | 15.93 | 16.35 | 15.54 | 13.97 | 13.97 | 13.52 | 13.82 |
| 8 | IC058235 | 15.47 | 15.99 | 17.60 | 16.35 | 11.59 | 14.52 | 14.62 | 13.58 |
| 9 | Hisar Naveen | 14.54 | 16.53 | 17.23 | 16.10 | 13.17 | 13.17 | 13.64 | 13.32 |
| 10 | IC052302 | 16.53 | 15.80 | 16.99 | 16.44 | 12.27 | 12.95 | 14.48 | 13.23 |
| 11 | EC169452 | 13.37 | 14.80 | 15.57 | 14.58 | 9.07 | 9.02 | 12.15 | 10.09 |
| 12 | IC052310 | 13.88 | 15.27 | 15.86 | 15.00 | 12.18 | 12.93 | 12.50 | 12.54 |
| 13 | EC169459 | 14.73 | 16.13 | 16.03 | 15.63 | 13.26 | 13.47 | 13.38 | 13.37 |
| 14 | Kashi Pragati | 14.83 | 16.20 | 16.23 | 15.76 | 12.97 | 13.07 | 13.40 | 13.14 |
| 15 | IC052321 | 14.37 | 15.47 | 16.47 | 15.43 | 12.74 | 14.12 | 14.55 | 13.80 |
| **HYBRIDS** | | | | | | | | | |
| 16 | IC058710 x EC169452 | 16.77 | 15.94 | 16.33 | 16.35 | 12.66 | 13.56 | 14.00 | 13.40 |
| 17 | IC058710 x IC052310 | 14.30 | 16.07 | 15.65 | 15.34 | 14.04 | 14.26 | 13.41 | 13.90 |
| 18 | IC058710 x EC169459 | 16.87 | 15.70 | 16.21 | 16.26 | 13.85 | 13.08 | 13.56 | 13.50 |
| 19 | IC058710 x Kashi Pragati | 15.84 | 16.73 | 16.50 | 16.36 | 13.49 | 14.84 | 12.43 | 13.59 |
| 20 | IC058710 x IC052321 | 15.13 | 16.20 | 16.69 | 16.01 | 13.73 | 14.10 | 14.12 | 13.98 |
| 21 | IC045993 x EC169452 | 16.53 | 15.88 | 17.10 | 16.50 | 12.96 | 13.29 | 14.29 | 13.51 |
| 22 | IC045993 x IC052310 | 14.53 | 15.80 | 15.47 | 15.27 | 14.38 | 14.38 | 13.06 | 13.94 |
| 23 | IC045993 x EC169459 | 18.57 | 16.24 | 15.67 | 16.82 | 14.76 | 15.32 | 13.69 | 14.59 |
| 24 | IC045993 x Kashi Pragati | 16.47 | 16.47 | 16.48 | 16.47 | 14.61 | 14.61 | 13.45 | 14.22 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| 25 | IC045993 x IC052321 | 15.47 | 15.36 | 17.50 | 16.11 | 14.28 | 13.83 | 14.26 | 14.12 |
| 26 | Pusa Sawani x EC169452 | 18.77 | 17.60 | 16.77 | 17.71 | 14.78 | 14.78 | 13.83 | 14.46 |
| 27 | Pusa Sawani x IC052310 | 15.67 | 15.67 | 16.29 | 15.87 | 14.38 | 15.08 | 14.46 | 14.64 |
| 28 | Pusa Sawani x EC169459 | 18.17 | 17.34 | 16.20 | 17.23 | 13.84 | 13.93 | 13.42 | 13.73 |
| 29 | Pusa Sawani x Kashi Pragati | 14.79 | 17.68 | 17.53 | 16.67 | 14.95 | 14.41 | 13.29 | 14.22 |
| 30 | Pusa Sawani x IC052321 | 16.63 | 16.33 | 16.63 | 16.53 | 13.41 | 12.31 | 14.33 | 13.35 |
| 31 | VRO-4 x EC169452 | 18.70 | 16.17 | 17.67 | 17.51 | 14.43 | 14.43 | 14.08 | 14.31 |
| 32 | VRO-4 x IC052310 | 15.87 | 18.47 | 14.90 | 16.41 | 14.39 | 13.66 | 15.71 | 14.59 |
| 33 | VRO-4 x EC169459 | 17.56 | 16.27 | 18.81 | 17.55 | 14.73 | 14.73 | 14.07 | 14.51 |
| 34 | VRO-4 x Kashi Pragati | 19.34 | 17.20 | 15.28 | 17.27 | 15.14 | 14.44 | 15.67 | 15.08 |
| 35 | VRO-4 x IC052321 | 16.47 | 16.50 | 16.89 | 16.62 | 14.59 | 14.59 | 14.73 | 14.63 |
| 36 | IC052299 x EC169452 | 17.95 | 15.53 | 16.05 | 16.51 | 14.04 | 13.25 | 13.54 | 13.61 |
| 37 | IC052299 x IC052310 | 15.41 | 16.14 | 16.80 | 16.12 | 14.64 | 15.07 | 14.38 | 14.70 |
| 38 | IC052299 x EC169459 | 18.02 | 16.29 | 16.83 | 17.05 | 15.58 | 14.23 | 13.70 | 14.50 |
| 39 | IC052299 x Kashi Pragati | 17.15 | 15.94 | 16.40 | 16.49 | 14.62 | 13.43 | 13.64 | 13.90 |
| 40 | IC052299 x IC052321 | 16.58 | 16.07 | 16.13 | 16.26 | 15.20 | 14.23 | 13.98 | 14.47 |
| 41 | Kashi Kranti x EC169452 | 16.84 | 17.19 | 17.23 | 17.09 | 13.42 | 13.56 | 14.92 | 13.97 |
| 42 | Kashi Kranti x IC052310 | 16.47 | 17.36 | 18.24 | 17.36 | 13.50 | 14.11 | 14.67 | 14.09 |
| 43 | Kashi Kranti x EC169459 | 17.80 | 17.25 | 16.93 | 17.33 | 15.89 | 15.83 | 14.63 | 15.47 |
| 44 | Kashi Kranti x Kashi Pragati | 17.40 | 17.74 | 17.60 | 17.58 | 15.33 | 15.68 | 15.62 | 15.55 |
| 45 | Kashi Kranti x IC052321 | 18.24 | 16.53 | 17.27 | 17.35 | 15.58 | 14.85 | 14.01 | 14.81 |
| 46 | Salkeerthi x EC169452 | 17.25 | 15.22 | 16.89 | 16.45 | 12.68 | 13.88 | 13.71 | 13.42 |
| 47 | Salkeerthi x IC052310 | 14.61 | 15.70 | 16.37 | 15.56 | 14.80 | 13.97 | 13.81 | 14.19 |
| 48 | Salkeerthi x EC169459 | 16.50 | 15.95 | 16.26 | 16.24 | 14.05 | 14.77 | 14.63 | 14.48 |
| 49 | Salkeerthi x Kashi Pragati | 15.73 | 16.40 | 15.51 | 15.88 | 15.01 | 15.01 | 14.40 | 14.81 |
| 50 | Salkeerthi x IC052321 | 15.47 | 15.41 | 17.00 | 15.96 | 13.15 | 14.05 | 13.95 | 13.72 |
| 51 | IC058235 x EC169452 | 15.18 | 17.15 | 16.17 | 16.17 | 15.23 | 14.11 | 14.36 | 14.56 |
| 52 | IC058235 x IC052310 | 14.80 | 16.36 | 16.63 | 15.93 | 12.56 | 13.16 | 13.93 | 13.22 |

***Table continues…***

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 53 | IC058235 x EC169459 | 18.66 | 17.33 | 15.45 | 17.15 | 13.88 | 13.88 | 14.09 | 13.95 |
| 54 | IC058235 x Kashi Pragati | 15.20 | 16.75 | 16.20 | 16.05 | 13.54 | 13.28 | 13.64 | 13.49 |
| 55 | IC058235 x IC052321 | 14.81 | 17.13 | 15.95 | 15.96 | 14.87 | 14.15 | 13.87 | 14.30 |
| 56 | Hisar Naveen x EC169452 | 16.40 | 15.14 | 15.75 | 15.76 | 14.47 | 15.05 | 13.53 | 14.35 |
| 57 | Hisar Naveen x IC052310 | 15.34 | 15.87 | 17.70 | 16.30 | 14.42 | 14.42 | 13.48 | 14.11 |
| 58 | Hisar Naveen x EC169459 | 17.06 | 15.74 | 15.15 | 15.98 | 13.71 | 13.44 | 13.83 | 13.66 |
| 59 | Hisar Naveen x Kashi Pragati | 15.61 | 16.07 | 16.26 | 15.98 | 13.85 | 13.85 | 14.37 | 14.03 |
| 60 | Hisar Naveen x IC052321 | 14.23 | 16.00 | 15.90 | 15.38 | 14.87 | 14.43 | 13.50 | 14.27 |
| 61 | IC052302 x EC169452 | 17.32 | 15.60 | 17.03 | 16.65 | 12.39 | 12.99 | 14.07 | 13.15 |
| 62 | IC052302 x IC052310 | 15.90 | 16.40 | 16.28 | 16.19 | 13.65 | 15.35 | 14.24 | 14.41 |
| 63 | IC052302 x EC169459 | 17.10 | 16.00 | 15.68 | 16.26 | 14.29 | 12.41 | 14.14 | 13.61 |
| 64 | IC052302 x Kashi Pragati | 16.20 | 16.33 | 15.61 | 16.05 | 14.37 | 14.75 | 14.51 | 14.54 |
| 65 | IC052302 x IC052321 | 14.33 | 15.93 | 15.90 | 15.39 | 13.51 | 13.51 | 13.79 | 13.60 |
| Check | | 16.70 | 16.90 | 16.20 | 16.60 | 14.46 | 14.32 | 14.02 | 14.20 |
| **Range** | | 13.37-19.34 | 14.80-18.47 | 14.90-18.81 | 14.58-17.71 | 9.07-15.89 | 9.02-15.83 | 12.15-15.71 | 10.09-15.55 |
| **General mean** | | 16.13 | 16.26 | 16.47 | 16.29 | 13.86 | 13.99 | 14.01 | 13.95 |
| **Parent mean** | | 15.10 | 15.93 | 16.44 | 15.82 | 12.68 | 13.39 | 13.87 | 13.31 |
| **Hybrid mean** | | 16.44 | 16.36 | 16.47 | 16.43 | 14.21 | 14.17 | 14.06 | 14.14 |

#### 4.5.12 Number of ridges per fruit

In E1 number of ridges per fruit ranges from 4.60 to 6.07 with the general mean (5.34). Among the parents VRO-4 (5.40), while in crosses VRO-4 x Kashi Pragati (6.07) observed a high mean. Whereas in E2 ranges from 4.80-5.86 with the general mean (5.17). Among the parents IC052302 (5.33) in crosses IC058235 x IC052321 (5.86) observed a high mean. Where in E3 ranges exhibit ranges from 5.00 to 5.87 with the general mean (5.21). Among the parents Pusa Sawani (5.53) in cross combinations IC052299 x EC169459 (5.87) observed a high mean, while in Pooled analysis its exhibit ranges from 4.89 to 5.73 with the general mean (5.24). Among the VRO-4 IC052299 (5.29) and in crosses VRO-4 x Kashi Pragati (5.73) observed a high mean.

#### 4.5.13 Number of fruits per plant

In E1 number of fruits per plant exhibit ranges from 15.67 to 29.20 with the general mean (29.20). Among the parents Kashi Kranti (28.13), and in crosses IC058235 x EC169459 (29.20) recorded a high mean. Whereas in E2 ranges from 14.80 to 29.97 with the general mean (25.53). Among the parents Kashi Kranti (28.13) and while in crosses Kashi Kranti x IC052321 (29.97) observed a high mean. Where in E3 exhibit ranges from 14.27 to 29.80 with the general mean (25.08). Among the parents IC052299 (26.76) and in crosses Kashi Kranti x Kashi Pragati (29.80) observed a high mean, while in Pooled analysis its exhibit ranges from 14.91 to 28.98 with the general mean (25.26). Among the parents Kashi Kranti (27.64) and in crosses Kranti x Kashi Pragati (28.98) observed a high mean.

#### 4.5.14 Number of marketable fruits per plant

In E1 no. of marketable fruits/ plant exhibit ranges from 14.20 to 27.93 with the general mean (23.42). Among the parents IC052299 (25.83) and in crosses IC058235 x EC169459 (27.93) recorded a high mean. Whereas in E2 ranges from 13.70 to 29.13 with the general mean (24.25). Among the parents Kashi Kranti (26.07) and while in crosses Kashi Kranti x IC052321 (29.13) observed a high mean. Where in E3 exhibit ranges from 12.87 to 28.50 with the general mean (23.53). Among the parents IC058710 (25.26) and in crosses Kashi Kranti x Kashi Pragati (28.50) observed a high mean, while in Pooled analysis its exhibit ranges from 13.59 to 27.69 with the general mean (23.78). Among the parents IC052299 (25.67) and in crosses Kranti x Kashi Pragati (27.69) observed a high mean.

**Table 28. Mean performance of parents and their hybrids diverse and pooled environments in okra for fruit diameter and number of ridges/ fruits respectively**

| S.No. | Genotype | Fruit diameter | | | | Number of ridges per fruit | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| | **PARENTS** | | | | | | | | |
| 1 | IC058710 | 15.00 | 15.06 | 15.17 | 15.07 | 5.13 | 5.13 | 5.33 | 5.20 |
| 2 | IC045993 | 15.82 | 15.95 | 15.37 | 15.72 | 4.93 | 5.07 | 5.00 | 5.00 |
| 3 | Pusa Sawani | 14.50 | 14.92 | 14.36 | 14.59 | 5.13 | 5.00 | 5.53 | 5.22 |
| 4 | VRO-4 | 16.13 | 15.41 | 15.52 | 15.69 | 5.40 | 5.13 | 5.33 | 5.29 |
| 5 | IC052299 | 15.03 | 15.58 | 14.98 | 15.20 | 5.00 | 5.13 | 5.00 | 5.04 |
| 6 | Kashi Kranti | 14.56 | 14.85 | 14.55 | 14.65 | 5.00 | 5.13 | 5.07 | 5.07 |
| 7 | Salkeerthi | 15.80 | 14.80 | 14.68 | 15.09 | 5.20 | 5.27 | 5.13 | 5.20 |
| 8 | IC058235 | 13.58 | 15.18 | 15.62 | 14.79 | 5.07 | 5.13 | 5.00 | 5.07 |
| 9 | Hisar Naveen | 15.48 | 15.27 | 15.24 | 15.33 | 5.00 | 5.07 | 5.13 | 5.07 |
| 10 | IC052302 | 14.65 | 14.98 | 14.94 | 14.86 | 5.13 | 5.33 | 5.07 | 5.18 |
| 11 | EC169452 | 13.24 | 15.36 | 13.88 | 14.16 | 5.13 | 5.20 | 5.20 | 5.18 |
| 12 | IC052310 | 15.81 | 16.23 | 17.09 | 16.37 | 4.60 | 4.93 | 5.13 | 4.89 |
| 13 | EC169459 | 15.31 | 14.51 | 14.95 | 14.92 | 5.00 | 5.07 | 5.27 | 5.11 |
| 14 | Kashi Pragati | 13.50 | 15.60 | 15.34 | 14.81 | 5.00 | 4.93 | 5.33 | 5.09 |
| 15 | IC052321 | 14.23 | 15.83 | 15.38 | 15.15 | 5.13 | 5.13 | 5.20 | 5.16 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **HYBRIDS** | | | | | | | | | |
| 16 | IC058710 x EC169452 | 16.82 | 15.83 | 15.23 | 15.96 | 5.07 | 5.20 | 5.07 | 5.11 |
| 17 | IC058710 x IC052310 | 15.86 | 15.22 | 15.15 | 15.41 | 5.20 | 5.13 | 5.27 | 5.20 |
| 18 | IC058710 x EC169459 | 16.70 | 16.58 | 16.48 | 16.58 | 5.00 | 5.27 | 5.07 | 5.11 |
| 19 | IC058710 x Kashi Pragati | 16.61 | 15.20 | 13.74 | 15.18 | 5.13 | 5.00 | 5.27 | 5.13 |
| 20 | IC058710 x IC052321 | 16.53 | 14.19 | 14.61 | 15.11 | 5.27 | 5.13 | 5.47 | 5.29 |
| 21 | IC045993 x EC169452 | 16.59 | 15.24 | 15.14 | 15.66 | 5.93 | 5.07 | 5.47 | 5.49 |
| 22 | IC045993 x IC052310 | 15.87 | 15.16 | 15.08 | 15.37 | 5.93 | 5.40 | 5.33 | 5.44 |
| 23 | IC045993 x EC169459 | 16.20 | 15.54 | 15.12 | 15.62 | 5.27 | 5.33 | 5.20 | 5.27 |
| 24 | IC045993 x Kashi Pragati | 17.51 | 17.41 | 17.19 | 17.37 | 5.47 | 5.33 | 5.47 | 5.42 |
| 25 | IC045993 x IC052321 | 15.70 | 15.68 | 14.82 | 15.40 | 5.27 | 5.20 | 5.07 | 5.18 |
| 26 | Pusa Sawani x EC169452 | 15.05 | 15.21 | 15.32 | 15.19 | 5.07 | 4.80 | 5.00 | 4.96 |
| 27 | Pusa Sawani x IC052310 | 15.22 | 15.78 | 14.84 | 15.28 | 5.87 | 5.33 | 5.20 | 5.47 |
| 28 | Pusa Sawani x EC169459 | 16.08 | 15.14 | 14.53 | 15.25 | 5.13 | 5.07 | 5.80 | 5.13 |
| 29 | Pusa Sawani x Kashi Pragati | 14.77 | 15.56 | 14.43 | 14.92 | 5.20 | 5.67 | 5.20 | 5.36 |
| 30 | Pusa Sawani x IC052321 | 16.77 | 17.04 | 13.60 | 15.80 | 5.13 | 4.93 | 5.20 | 5.09 |
| 31 | VRO-4 x EC169452 | 16.29 | 15.08 | 16.58 | 15.98 | 5.73 | 5.07 | 5.33 | 5.38 |
| 32 | VRO-4 x IC052310 | 17.93 | 15.09 | 16.64 | 16.55 | 5.60 | 5.07 | 5.13 | 5.27 |

***Table continues…***

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 33 | VRO-4 x EC169459 | 17.24 | 14.88 | 16.12 | 16.08 | 5.93 | 5.00 | 5.53 | 5.49 |
| 34 | VRO-4 x Kashi Pragati | 17.57 | 15.51 | 16.55 | 16.54 | 6.07 | 5.73 | 5.40 | 5.73 |
| 35 | VRO-4 x IC052321 | 17.32 | 15.52 | 15.87 | 16.24 | 5.47 | 5.07 | 5.27 | 5.27 |
| 36 | IC052299 x EC169452 | 16.00 | 18.10 | 16.28 | 16.79 | 5.20 | 5.13 | 5.27 | 5.20 |
| 37 | IC052299 x IC052310 | 16.28 | 14.69 | 15.31 | 15.42 | 5.33 | 5.13 | 5.70 | 5.16 |
| 38 | IC052299 x EC169459 | 17.98 | 15.56 | 14.98 | 16.17 | 5.53 | 4.93 | 5.87 | 5.29 |
| 39 | IC052299 x Kashi Pragati | 15.13 | 15.18 | 15.38 | 15.23 | 5.73 | 5.27 | 5.13 | 5.38 |
| 40 | IC052299 x IC052321 | 15.86 | 14.70 | 14.72 | 15.09 | 5.53 | 5.00 | 5.20 | 5.24 |
| 41 | Kashi Kranti x EC169452 | 16.18 | 15.24 | 14.76 | 15.39 | 5.67 | 5.20 | 5.20 | 5.36 |
| 42 | Kashi Kranti x IC052310 | 15.46 | 18.42 | 16.59 | 16.82 | 5.60 | 5.20 | 5.07 | 5.29 |
| 43 | Kashi Kranti x EC169459 | 17.66 | 15.13 | 14.50 | 15.76 | 5.40 | 5.20 | 5.47 | 5.36 |
| 44 | Kashi Kranti x Kashi Pragati | 17.97 | 17.25 | 16.97 | 17.40 | 5.93 | 5.20 | 5.80 | 5.51 |
| 45 | Kashi Kranti x IC052321 | 16.95 | 15.09 | 14.32 | 15.45 | 5.87 | 5.13 | 5.20 | 5.40 |
| 46 | Salkeerthi x EC169452 | 17.13 | 14.48 | 14.11 | 15.24 | 5.00 | 5.07 | 5.00 | 5.02 |
| 47 | Salkeerthi x IC052310 | 17.64 | 14.02 | 14.57 | 15.41 | 5.07 | 5.20 | 5.07 | 5.11 |
| 48 | Salkeerthi x EC169459 | 17.96 | 18.67 | 17.91 | 18.18 | 5.00 | 5.13 | 5.07 | 5.07 |
| 49 | Salkeerthi x Kashi Pragati | 18.37 | 14.52 | 14.33 | 15.74 | 5.80 | 5.00 | 5.33 | 5.38 |
| 50 | Salkeerthi x IC052321 | 17.24 | 15.72 | 13.83 | 15.60 | 5.73 | 5.07 | 5.07 | 5.29 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 51 | IC058235 x EC169452 | 16.82 | 14.91 | 14.43 | 15.39 | 5.53 | 5.13 | 5.33 | 5.33 |
| 52 | IC058235 x IC052310 | 14.78 | 15.27 | 14.18 | 14.75 | 5.40 | 5.07 | 5.47 | 5.31 |
| 53 | IC058235 x EC169459 | 17.72 | 15.71 | 14.77 | 16.07 | 5.13 | 5.13 | 5.00 | 5.09 |
| 54 | IC058235 x Kashi Pragati | 16.04 | 18.03 | 16.56 | 16.88 | 5.60 | 5.20 | 5.07 | 5.29 |
| 55 | IC058235 x IC052321 | 16.25 | 14.62 | 14.57 | 15.15 | 5.33 | 5.87 | 5.47 | 5.56 |
| 56 | Hisar Naveen x EC169452 | 14.65 | 15.17 | 14.52 | 14.78 | 5.20 | 5.20 | 5.27 | 5.22 |
| 57 | Hisar Naveen x IC052310 | 16.23 | 15.17 | 14.42 | 15.27 | 5.33 | 5.80 | 5.33 | 5.49 |
| 58 | Hisar Naveen x EC169459 | 15.82 | 15.14 | 14.32 | 15.09 | 5.20 | 5.13 | 5.70 | 5.11 |
| 59 | Hisar Naveen x Kashi Pragati | 15.60 | 15.76 | 14.32 | 15.23 | 5.87 | 5.40 | 5.40 | 5.56 |
| 60 | Hisar Naveen x IC052321 | 15.36 | 15.76 | 15.45 | 15.52 | 5.13 | 5.00 | 5.27 | 5.13 |
| 61 | IC052302 x EC169452 | 16.20 | 15.21 | 14.59 | 15.33 | 5.20 | 5.13 | 5.20 | 5.18 |
| 62 | IC052302 x IC052310 | 15.99 | 15.29 | 14.85 | 15.38 | 5.13 | 5.00 | 5.13 | 5.09 |
| 63 | IC052302 x EC169459 | 16.33 | 15.40 | 14.41 | 15.38 | 5.20 | 5.67 | 5.00 | 5.29 |
| 64 | IC052302 x Kashi Pragati | 14.90 | 15.80 | 14.58 | 15.09 | 5.53 | 5.13 | 5.13 | 5.27 |
| 65 | IC052302 x IC052321 | 15.87 | 15.96 | 14.22 | 15.35 | 5.73 | 5.07 | 5.20 | 5.33 |
| Check | | 16.77 | 16.12 | 15.74 | 16.21 | 5.33 | 5.20 | 5.27 | 5.2 |
| **Range** | | 13.24-18.37 | 14.02-18.67 | 13.60-17.91 | 14.16-18.18 | 4.60-6.07 | 4.80-5.87 | 5.00-5.87 | 4.89-5.73 |
| **General mean** | | 16.06 | 15.57 | 15.12 | 15.58 | 5.35 | 5.17 | 5.26 | 5.24 |
| **Parent mean** | | 14.84 | 15.43 | 15.14 | 15.14 | 5.06 | 5.11 | 5.18 | 5.12 |
| **Hybrid mean** | | 16.42 | 15.62 | 15.12 | 15.72 | 5.43 | 5.19 | 5.28 | 5.28 |

**Table.29 Mean value of parents and their hybrids diverse and pooled environments for number of fruits/plant and number of marketable fruits respectively**

| S.No. | Genotype | Number of fruits/plant | | | | Marketable fruits/plant | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| | **PARENTS** | | | | | | | | |
| 1 | IC058710 | 25.03 | 25.33 | 26.40 | 25.59 | 23.87 | 23.87 | 25.27 | 24.33 |
| 2 | IC045993 | 25.73 | 27.53 | 24.87 | 26.04 | 23.37 | 25.67 | 22.83 | 23.96 |
| 3 | Pusa Sawani | 25.90 | 26.40 | 25.80 | 26.03 | 23.63 | 24.47 | 24.07 | 24.06 |
| 4 | VRO-4 | 26.07 | 26.80 | 25.93 | 26.27 | 24.13 | 25.37 | 23.97 | 24.49 |
| 5 | IC052299 | 27.67 | 27.60 | 26.90 | 27.39 | 25.83 | 25.93 | 25.23 | 25.67 |
| 6 | Kashi Kranti | 28.13 | 28.03 | 26.77 | 27.64 | 24.90 | 26.07 | 25.20 | 25.39 |
| 7 | Salkeerthi | 26.60 | 26.00 | 25.53 | 26.04 | 25.17 | 24.20 | 23.70 | 24.36 |
| 8 | IC058235 | 24.33 | 26.00 | 24.73 | 25.02 | 22.50 | 23.70 | 23.00 | 23.07 |
| 9 | Hisar Naveen | 26.33 | 25.93 | 26.03 | 26.10 | 25.03 | 23.97 | 24.87 | 24.62 |
| 10 | IC052302 | 24.33 | 25.60 | 27.00 | 25.64 | 21.57 | 23.97 | 25.17 | 23.57 |
| 11 | EC169452 | 16.67 | 15.27 | 14.80 | 15.58 | 14.47 | 14.47 | 13.20 | 14.04 |
| 12 | IC052310 | 15.67 | 14.80 | 14.27 | 14.91 | 14.20 | 13.70 | 12.87 | 13.59 |
| 13 | EC169459 | 24.33 | 23.67 | 24.40 | 24.13 | 22.60 | 21.57 | 22.07 | 22.08 |
| 14 | Kashi Pragati | 22.20 | 22.87 | 24.27 | 23.11 | 21.23 | 20.93 | 22.33 | 21.50 |
| 15 | IC052321 | 22.73 | 21.93 | 22.67 | 22.44 | 21.17 | 20.13 | 20.73 | 20.68 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **HYBRIDS** | | | | | | | | | |
| 16 | IC058710 x EC169452 | 23.87 | 24.00 | 24.00 | 23.96 | 23.13 | 23.50 | 22.13 | 22.92 |
| 17 | IC058710 x IC052310 | 25.13 | 25.40 | 23.87 | 24.80 | 23.50 | 24.60 | 21.87 | 23.32 |
| 18 | IC058710 x EC169459 | 27.33 | 23.20 | 25.83 | 25.46 | 25.90 | 21.53 | 24.00 | 23.81 |
| 19 | IC058710 x Kashi Pragati | 24.03 | 25.87 | 26.13 | 25.34 | 21.97 | 24.07 | 24.73 | 23.59 |
| 20 | IC058710 x IC052321 | 26.00 | 26.53 | 25.27 | 25.93 | 23.63 | 25.23 | 23.90 | 24.26 |
| 21 | IC045993 x EC169452 | 25.00 | 28.37 | 26.13 | 26.50 | 24.50 | 25.23 | 24.57 | 24.77 |
| 22 | IC045993 x IC052310 | 26.83 | 25.10 | 26.87 | 26.27 | 25.67 | 24.07 | 24.87 | 24.87 |
| 23 | IC045993 x EC169459 | 26.23 | 28.37 | 24.87 | 26.49 | 24.83 | 26.70 | 23.80 | 25.11 |
| 24 | IC045993 x Kashi Pragati | 28.50 | 26.87 | 25.80 | 27.06 | 26.13 | 25.73 | 24.40 | 25.42 |
| 25 | IC045993 x IC052321 | 27.77 | 26.87 | 24.87 | 26.50 | 25.90 | 24.87 | 23.27 | 24.68 |
| 26 | Pusa Sawani x EC169452 | 23.73 | 23.70 | 23.33 | 23.59 | 22.30 | 22.53 | 21.80 | 22.21 |
| 27 | Pusa Sawani x IC052310 | 25.73 | 26.23 | 23.80 | 25.26 | 24.13 | 25.67 | 22.60 | 24.13 |
| 28 | Pusa Sawani x EC169459 | 24.67 | 26.57 | 26.40 | 25.88 | 22.70 | 25.67 | 24.93 | 24.43 |
| 29 | Pusa Sawani x Kashi Pragati | 24.57 | 21.63 | 26.20 | 24.13 | 22.93 | 21.90 | 24.47 | 23.10 |
| 30 | Pusa Sawani x IC052321 | 21.67 | 24.83 | 23.27 | 23.26 | 21.20 | 23.30 | 21.80 | 22.10 |
| 31 | VRO-4 x EC169452 | 26.40 | 23.27 | 21.80 | 23.82 | 19.40 | 22.53 | 20.43 | 20.79 |
| 32 | VRO-4 x IC052310 | 23.53 | 24.37 | 24.93 | 24.28 | 24.43 | 24.27 | 23.20 | 23.97 |
| 33 | VRO-4 x EC169459 | 28.13 | 28.87 | 25.87 | 27.62 | 25.10 | 26.67 | 24.70 | 25.49 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 34 | VRO-4 x Kashi Pragati | 25.43 | 27.47 | 23.50 | 25.47 | 24.23 | 25.60 | 22.40 | 24.08 |
| 35 | VRO-4 x IC052321 | 27.77 | 26.93 | 24.40 | 26.37 | 26.73 | 26.53 | 22.83 | 25.37 |
| 36 | IC052299 x EC169452 | 27.73 | 24.70 | 24.20 | 25.54 | 25.53 | 24.80 | 23.00 | 24.44 |
| 37 | IC052299 x IC052310 | 28.40 | 25.80 | 23.27 | 25.82 | 25.23 | 23.80 | 21.90 | 23.64 |
| 38 | IC052299 x EC169459 | 28.40 | 27.80 | 26.07 | 27.42 | 25.47 | 26.00 | 24.07 | 25.18 |
| 39 | IC052299 x Kashi Pragati | 23.20 | 26.93 | 26.53 | 25.56 | 21.97 | 25.70 | 25.07 | 24.24 |
| 40 | IC052299 x IC052321 | 22.97 | 23.03 | 25.60 | 23.87 | 21.07 | 22.27 | 23.80 | 22.38 |
| 41 | Kashi Kranti x EC169452 | 25.67 | 26.20 | 25.20 | 25.69 | 24.77 | 25.40 | 23.57 | 24.58 |
| 42 | Kashi Kranti x IC052310 | 26.60 | 27.47 | 27.10 | 27.06 | 25.37 | 26.30 | 26.10 | 25.92 |
| 43 | Kashi Kranti x EC169459 | 28.07 | 28.60 | 28.13 | 28.27 | 26.80 | 27.53 | 27.17 | 27.17 |
| 44 | Kashi Kranti x Kashi Pragati | 28.67 | 28.47 | 29.80 | 28.98 | 27.23 | 27.33 | 28.50 | 27.69 |
| 45 | Kashi Kranti x IC052321 | 27.60 | 29.97 | 28.70 | 28.76 | 26.63 | 29.13 | 26.33 | 27.37 |
| 46 | Salkeerthi x EC169452 | 24.40 | 28.30 | 24.87 | 25.86 | 22.60 | 25.53 | 23.33 | 23.82 |
| 47 | Salkeerthi x IC052310 | 23.43 | 23.83 | 23.27 | 23.51 | 20.77 | 21.47 | 21.83 | 21.36 |
| 48 | Salkeerthi x EC169459 | 28.07 | 25.93 | 26.93 | 26.98 | 25.97 | 24.20 | 24.93 | 25.03 |
| 49 | Salkeerthi x Kashi Pragati | 25.17 | 29.43 | 27.60 | 27.40 | 23.90 | 25.73 | 26.47 | 25.37 |
| 50 | Salkeerthi x IC052321 | 25.27 | 25.83 | 23.57 | 24.89 | 23.90 | 24.33 | 21.77 | 23.33 |
| 51 | IC058235 x EC169452 | 20.47 | 25.07 | 25.90 | 23.81 | 17.87 | 24.07 | 23.67 | 21.87 |
| 52 | IC058235 x IC052310 | 22.40 | 24.87 | 24.27 | 23.84 | 20.67 | 23.67 | 22.80 | 22.38 |

*Continues….*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 53 | IC058235 x EC169459 | 29.20 | 26.60 | 26.27 | 27.36 | 27.93 | 25.33 | 24.63 | 25.97 |
| 54 | IC058235 x Kashi Pragati | 24.67 | 27.57 | 26.23 | 26.16 | 23.67 | 26.33 | 25.43 | 25.14 |
| 55 | IC058235 x IC052321 | 24.47 | 27.27 | 26.53 | 26.09 | 23.17 | 26.07 | 25.43 | 24.89 |
| 56 | Hisar Naveen x EC169452 | 23.80 | 24.67 | 25.07 | 24.51 | 22.43 | 23.53 | 23.60 | 23.19 |
| 57 | Hisar Naveen x IC052310 | 25.13 | 22.13 | 24.93 | 24.07 | 24.17 | 23.23 | 23.87 | 23.76 |
| 58 | Hisar Naveen x EC169459 | 27.57 | 25.03 | 26.13 | 26.24 | 25.67 | 25.00 | 25.33 | 25.33 |
| 59 | Hisar Naveen x Kashi Pragati | 26.70 | 26.67 | 26.47 | 26.61 | 24.83 | 25.73 | 24.67 | 25.08 |
| 60 | Hisar Naveen x IC052321 | 23.87 | 25.60 | 24.80 | 24.76 | 21.80 | 24.87 | 23.73 | 23.47 |
| 61 | IC052302 x EC169452 | 22.87 | 25.93 | 25.07 | 24.62 | 21.57 | 25.27 | 23.73 | 23.52 |
| 62 | IC052302 x IC052310 | 21.73 | 21.47 | 23.00 | 22.07 | 20.43 | 22.53 | 21.47 | 21.48 |
| 63 | IC052302 x EC169459 | 25.47 | 25.03 | 26.20 | 25.57 | 23.40 | 24.33 | 24.60 | 24.11 |
| 64 | IC052302 x Kashi Pragati | 25.47 | 25.40 | 25.93 | 25.60 | 23.80 | 24.00 | 24.20 | 24.00 |
| 65 | IC052302 x IC052321 | 23.93 | 25.33 | 25.17 | 24.81 | 21.57 | 24.73 | 23.53 | 23.28 |
| Check | | 26.30 | 26.68 | 26.0 | 25.66 | 24.12 | 25.41 | 24.53 | 24.65 |
| **Range** | | 15.67-29.20 | 14.80-29.97 | 14.27-29.80 | 14.91-28.98 | 14.20-27.93 | 13.70-29.13 | 12.87-28.50 | 13.59-27.69 |
| **General mean** | | 25.16 | 25.53 | 25.08 | 25.26 | 23.42 | 24.25 | 23.53 | 23.78 |
| **Parent mean** | | 24.12 | 24.25 | 24.02 | 24.13 | 22.24 | 22.53 | 22.30 | 22.36 |
| **Hybrid mean** | | 25.47 | 25.91 | 25.40 | 25.59 | 23.77 | 24.77 | 23.90 | 24.15 |

#### 4.5.15 Average fruit weight

In E1 average fruit weight ranges from 11.32 to 15.94 with the general mean (13.62). Among the parents IC058235 (14.69) with high mean and in crosses IC052299 x Kashi Pragati (15.94) recorded a high mean. Whereas in E2 ranges from 12.13 to 15.54 with the general mean (15.54). Among the parents Kashi Pragati (13.99 gm) recorded high mean and among the crosses IC058710 x EC169459 (15.54) observed a high. Where in E3 exhibit ranges from 11.92 to 15.26 with the general mean (13.49). Among the parents IC058235 (14.44) with high mean and in crosses VRO-4 x Kashi Pragati (15.26) observed a high mean, while in Pooled analysis its exhibit ranges from 12.12 to 14.74 with the general mean (13.47). Among the parents IC058235 (14.30) with high mean, and in the crosses Pusa Sawani x Kashi Pragati (14.74) observed a high mean.

#### 4.5.16 Number of pickings per plant

In E1 number of pickings per plant exhibit ranges from 10.53 to 19.00 with the general mean (14.92). Among the parents Hisar Naveen (17.20) and cross combinations Kashi Kranti x Kashi Pragati (19.00) recorded a high mean. Whereas in E2 ranges from 10.47 to 17.17 with the general mean (14.42). Among the parents Kashi Kranti (16.87) and in cross combinations Kashi Kranti x Kashi Pragati (17.17) observed a high mean. Where in E3 exhibit ranges 11.60 to 17.80 with the general mean (14.59). Among the parents Kashi Kranti (16.06) in crosses Kashi Kranti x Kashi Pragati (17.80) observed a high mean, while in Pooled analysis its exhibit ranges from 11.02 to 17.99 with the general mean (14.65). Among the parents Kashi Kranti (16.67) and in crosses Kashi Kranti x Kashi Pragati (17.99) observed a high mean.

#### 4.5.17 Fruit yield per plant (g)

In E1 Fruit yield per plant (g) ranges from 188.60 to 402.30, with the general mean (341.96). Among the parents, Kashi Kranti (385.27 g) and in crosses, Kashi Kranti x Kashi Pragati (402.23 g) recorded a high mean. Whereas in E2 express range from 184.10 to 409.87 with the general mean (341.96). Among the parents Kashi Kranti (380.47) and while in cross combinations Kashi Kranti x EC169459 (409.86) observed a high mean. Where in E3 exhibit ranges from 178.60 to 386.03 with the general mean (338.15). Among the parents Kashi Kranti (372.40 g) and in crosses Kashi Kranti x Kashi Pragati (386.03) observed a high mean, while in Pooled analysis its express ranges from 186.68 to 399.38 with the general mean (14.65). Among the parents Kashi Kranti (379.38 g) and in crosses Kashi Kranti x Kashi Pragati (399.38) observed a high mean.

**Table 30. Mean performance of parents and their hybrids diverse and pooled environments in okra for average fruit weight and number of pickings**

| S.No. | Genotype | Average fruit weight | | | | Number of pickings per plant | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| | **PARENTS** | | | | | | | | |
| **1** | IC058710 | 13.77 | 13.61 | 13.88 | 13.76 | 14.87 | 14.33 | 14.40 | 14.53 |
| **2** | IC045993 | 14.06 | 13.14 | 13.88 | 13.69 | 16.27 | 13.93 | 15.67 | 15.29 |
| **3** | Pusa Sawani | 13.58 | 13.31 | 13.82 | 13.57 | 15.40 | 14.53 | 14.33 | 14.76 |
| **4** | VRO-4 | 13.89 | 13.50 | 13.84 | 13.74 | 16.30 | 14.40 | 15.60 | 15.43 |
| **5** | IC052299 | 13.21 | 13.48 | 13.06 | 13.25 | 14.90 | 14.87 | 14.53 | 14.77 |
| **6** | Kashi Kranti | 13.70 | 13.44 | 13.91 | 13.68 | 17.07 | 16.87 | 16.06 | 16.67 |
| **7** | Salkeerthi | 13.20 | 13.49 | 13.55 | 13.41 | 16.10 | 14.33 | 14.80 | 15.08 |
| **8** | IC058235 | 14.69 | 13.75 | 14.44 | 14.30 | 14.27 | 14.60 | 14.13 | 14.33 |
| **9** | Hisar Naveen | 13.68 | 13.89 | 13.82 | 13.80 | 17.20 | 15.80 | 15.53 | 16.18 |
| **10** | IC052302 | 13.82 | 13.16 | 12.82 | 13.27 | 14.13 | 13.87 | 13.93 | 13.98 |
| **11** | EC169452 | 11.32 | 12.36 | 12.68 | 12.12 | 11.00 | 10.47 | 11.60 | 11.02 |
| **12** | IC052310 | 12.34 | 13.02 | 12.52 | 12.63 | 10.53 | 10.60 | 11.93 | 11.02 |
| **13** | EC169459 | 12.35 | 12.71 | 13.01 | 12.69 | 13.93 | 14.27 | 13.53 | 13.91 |
| **14** | Kashi Pragati | 14.40 | 13.99 | 12.93 | 13.77 | 13.73 | 12.67 | 13.27 | 13.22 |
| **15** | IC052321 | 13.13 | 13.60 | 12.34 | 13.02 | 13.87 | 13.53 | 13.73 | 13.71 |
| **HYBRIDS** | | | | | | | | | |
| **16** | IC058710 x EC169452 | 13.18 | 12.70 | 12.74 | 12.87 | 13.80 | 13.53 | 14.07 | 13.80 |
| **17** | IC058710 x IC052310 | 12.62 | 13.19 | 12.78 | 12.86 | 15.60 | 14.00 | 15.20 | 14.93 |
| **18** | IC058710 x EC169459 | 13.19 | 15.54 | 14.30 | 14.34 | 16.07 | 15.10 | 15.07 | 15.41 |
| **19** | IC058710 x Kashi Pragati | 14.63 | 12.94 | 14.16 | 13.91 | 14.13 | 15.00 | 14.33 | 14.49 |
| **20** | IC058710 x IC052321 | 12.86 | 12.60 | 13.73 | 13.06 | 15.20 | 15.13 | 15.77 | 15.37 |
| **21** | IC045993 x EC169452 | 13.53 | 12.19 | 12.90 | 12.87 | 14.53 | 14.13 | 14.40 | 14.36 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **22** | IC045993 x IC052310 | 12.79 | 13.49 | 12.94 | 13.07 | 15.23 | 13.20 | 15.67 | 14.70 |
| **23** | IC045993 x EC169459 | 14.04 | 12.97 | 14.48 | 13.83 | 17.17 | 16.60 | 15.73 | 16.50 |
| **24** | IC045993 x Kashi Pragati | 12.77 | 12.96 | 14.03 | 13.25 | 16.47 | 14.80 | 16.53 | 15.93 |
| **25** | IC045993 x IC052321 | 11.96 | 12.36 | 12.37 | 12.23 | 14.87 | 14.40 | 14.60 | 14.62 |
| **26** | Pusa Sawani x EC169452 | 12.23 | 12.25 | 12.87 | 12.45 | 15.30 | 13.13 | 14.53 | 14.32 |
| **27** | Pusa Sawani x IC052310 | 13.77 | 12.74 | 13.61 | 13.37 | 15.47 | 14.63 | 15.07 | 15.06 |
| **28** | Pusa Sawani x EC169459 | 14.45 | 13.12 | 13.61 | 13.73 | 16.27 | 13.27 | 15.80 | 15.11 |
| **29** | Pusa Sawani x Kashi Pragati | 14.68 | 15.53 | 14.01 | 14.74 | 12.27 | 13.93 | 14.27 | 13.49 |
| **30** | Pusa Sawani x IC052321 | 15.12 | 13.19 | 15.23 | 14.51 | 13.00 | 13.60 | 14.07 | 13.56 |
| **31** | VRO-4 x EC169452 | 13.10 | 12.86 | 14.17 | 13.37 | 16.70 | 14.07 | 13.20 | 14.66 |
| **32** | VRO-4 x IC052310 | 14.03 | 13.40 | 13.70 | 13.71 | 14.40 | 13.97 | 15.03 | 14.47 |
| **33** | VRO-4 x EC169459 | 13.11 | 12.30 | 14.01 | 13.14 | 16.97 | 15.27 | 16.47 | 16.23 |
| **34** | VRO-4 x Kashi Pragati | 14.38 | 14.01 | 15.26 | 14.55 | 16.67 | 15.87 | 16.10 | 16.21 |
| **35** | VRO-4 x IC052321 | 13.21 | 13.40 | 14.16 | 13.59 | 15.73 | 14.63 | 16.53 | 15.63 |
| **36** | IC052299 x EC169452 | 11.77 | 12.44 | 12.18 | 12.13 | 14.07 | 15.10 | 15.00 | 14.72 |
| **37** | IC052299 x IC052310 | 11.63 | 12.81 | 12.81 | 12.42 | 15.47 | 14.73 | 14.47 | 14.89 |
| **38** | IC052299 x EC169459 | 13.10 | 13.11 | 14.04 | 13.42 | 17.70 | 15.50 | 16.60 | 16.60 |
| **39** | IC052299 x Kashi Pragati | 15.94 | 12.69 | 13.67 | 14.10 | 14.40 | 14.60 | 14.67 | 14.56 |
| **40** | IC052299 x IC052321 | 15.18 | 15.09 | 13.76 | 14.68 | 13.27 | 15.10 | 13.33 | 13.90 |
| **41** | Kashi Kranti x EC169452 | 14.96 | 13.22 | 14.78 | 14.32 | 16.13 | 14.13 | 15.00 | 15.09 |
| **42** | Kashi Kranti x IC052310 | 13.43 | 12.95 | 13.84 | 13.41 | 15.67 | 15.53 | 14.60 | 15.27 |
| **43** | Kashi Kranti x EC169459 | 14.05 | 13.40 | 13.52 | 13.66 | 17.93 | 16.20 | 15.63 | 16.59 |
| **44** | Kashi Kranti x Kashi Pragati | 14.03 | 14.41 | 12.96 | 13.80 | 19.00 | 17.17 | 17.80 | 17.99 |

***Table continues…***

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **45** | Kashi Kranti x IC052321 | 13.50 | 12.43 | 13.23 | 13.05 | 18.47 | 16.03 | 14.87 | 16.46 |
| **46** | Salkeerthi x EC169452 | 14.23 | 12.38 | 11.93 | 12.85 | 14.87 | 15.63 | 14.00 | 14.83 |
| **47** | Salkeerthi x IC052310 | 14.74 | 15.33 | 12.49 | 14.19 | 16.67 | 13.67 | 14.63 | 14.99 |
| **48** | Salkeerthi x EC169459 | 13.16 | 14.21 | 13.79 | 13.72 | 15.27 | 14.40 | 15.27 | 14.98 |
| **49** | Salkeerthi x Kashi Pragati | 14.53 | 12.22 | 13.41 | 13.39 | 16.27 | 16.57 | 14.57 | 15.80 |
| **50** | Salkeerthi x IC052321 | 14.13 | 13.77 | 15.01 | 14.31 | 13.87 | 14.13 | 14.63 | 14.21 |
| **51** | IC058235 x EC169452 | 14.59 | 12.13 | 14.13 | 13.62 | 11.80 | 16.67 | 12.60 | 13.69 |
| **52** | IC058235 x IC052310 | 13.76 | 12.33 | 12.77 | 12.95 | 12.07 | 13.33 | 12.87 | 12.76 |
| **53** | IC058235 x EC169459 | 12.31 | 13.56 | 13.85 | 13.24 | 14.93 | 14.27 | 15.00 | 14.73 |
| **54** | IC058235 x Kashi Pragati | 14.51 | 12.55 | 13.57 | 13.54 | 13.53 | 13.67 | 14.57 | 13.92 |
| **55** | IC058235 x IC052321 | 14.33 | 12.84 | 13.50 | 13.56 | 13.60 | 15.07 | 13.47 | 14.04 |
| **56** | Hisar Naveen x EC169452 | 13.93 | 13.31 | 12.83 | 13.36 | 13.40 | 14.37 | 13.73 | 13.83 |
| **57** | Hisar Naveen x IC052310 | 12.08 | 12.40 | 12.67 | 12.38 | 14.80 | 13.33 | 14.27 | 14.13 |
| **58** | Hisar Naveen x EC169459 | 13.25 | 14.22 | 14.54 | 14.00 | 16.47 | 14.27 | 16.27 | 15.67 |
| **59** | Hisar Naveen x Kashi Pragati | 13.82 | 13.88 | 13.62 | 13.77 | 15.93 | 13.93 | 15.97 | 15.28 |
| **60** | Hisar Naveen x IC052321 | 14.35 | 13.36 | 12.67 | 13.46 | 12.07 | 13.73 | 12.60 | 12.80 |
| **61** | IC052302 x EC169452 | 14.79 | 13.03 | 11.92 | 13.25 | 12.53 | 14.00 | 13.33 | 13.29 |
| **62** | IC052302 x IC052310 | 14.86 | 15.00 | 12.70 | 14.18 | 12.60 | 13.33 | 12.40 | 12.78 |
| **63** | IC052302 x EC169459 | 12.43 | 12.77 | 13.32 | 12.84 | 13.73 | 14.07 | 13.27 | 13.69 |
| **64** | IC052302 x Kashi Pragati | 13.65 | 13.81 | 13.67 | 13.71 | 15.20 | 13.87 | 14.87 | 14.64 |
| **65** | IC052302 x IC052321 | 14.12 | 13.36 | 14.13 | 13.87 | 12.80 | 13.73 | 13.13 | 13.22 |
| Check | | 12.76 | 13.33 | 13.01 | 130.3 | 14.60 | 15.23 | 15.12 | 14.98 |
| **Range** | | 11.32-15.94 | 12.13-15.54 | 11.92-15.26 | 12.12-14.74 | 10.53-19.00 | 10.47-17.23 | 11.60-17.80 | 11.02-17.99 |
| **General mean** | | 13.63 | 13.28 | 13.49 | 13.47 | 14.92 | 14.42 | 14.60 | 14.65 |
| **Parent mean** | | 13.41 | 13.36 | 13.37 | 13.38 | 14.64 | 13.94 | 14.20 | 14.26 |
| **Hybrid mean** | | 13.70 | 13.25 | 13.53 | 13.49 | 15.01 | 14.57 | 14.72 | 14.76 |

**Table.31 Mean performance of parents and their hybrids diverse and pooled environments in okra for fruit yield/plant**

| S.NO. | GENOTYPES | Fruit yield/plant | | | |
|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled |
| | **PARENTS** | | | | |
| **1** | IC058710 | 344.67 | 336.13 | 366.27 | 349.02 |
| **2** | IC045993 | 362.00 | 355.40 | 344.47 | 353.96 |
| **3** | Pusa Sawani | 351.33 | 348.33 | 356.20 | 351.96 |
| **4** | VRO-4 | 361.80 | 355.37 | 358.73 | 358.63 |
| **5** | IC052299 | 365.33 | 365.33 | 351.27 | 360.64 |
| **6** | Kashi Kranti | 385.27 | 380.47 | 372.40 | 379.38 |
| **7** | Salkeerthi | 350.40 | 342.47 | 345.53 | 346.13 |
| **8** | IC058235 | 357.27 | 351.67 | 355.80 | 354.91 |
| **9** | Hisar Naveen | 359.67 | 351.10 | 359.47 | 356.74 |
| **10** | IC052302 | 335.87 | 325.43 | 346.53 | 335.94 |
| **11** | EC169452 | 188.60 | 184.10 | 187.33 | 186.68 |
| **12** | IC052310 | 192.60 | 190.43 | 178.60 | 187.21 |
| **13** | EC169459 | 300.53 | 291.80 | 317.40 | 303.24 |
| **14** | Kashi Pragati | 319.60 | 322.44 | 314.00 | 318.68 |
| **15** | IC052321 | 298.07 | 289.90 | 279.47 | 289.14 |
| **HYBRIDS** | | | | | |
| **16** | IC058710 x EC169452 | 314.30 | 304.57 | 305.73 | 308.20 |
| **17** | IC058710 x IC052310 | 317.47 | 334.30 | 305.53 | 319.10 |
| **18** | IC058710 x EC169459 | 360.53 | 360.53 | 369.03 | 363.37 |
| **19** | IC058710 x Kashi Pragati | 351.57 | 334.80 | 370.00 | 352.12 |
| **20** | IC058710 x IC052321 | 333.97 | 333.97 | 346.70 | 338.21 |
| **21** | IC045993 x EC169452 | 337.70 | 345.73 | 334.43 | 339.29 |
| **22** | IC045993 x IC052310 | 342.97 | 338.60 | 347.87 | 343.14 |

| *Table continues…* | | | | | |
|---|---|---|---|---|---|
| **23** | IC045993 x EC169459 | 367.93 | 367.93 | 359.80 | 365.22 |
| **24** | IC045993 x Kashi Pragati | 363.43 | 346.90 | 361.77 | 357.37 |
| **25** | IC045993 x IC052321 | 331.80 | 331.80 | 307.53 | 323.71 |
| **26** | Pusa Sawani x EC169452 | 290.33 | 290.33 | 300.13 | 293.60 |
| **27** | Pusa Sawani x IC052310 | 353.50 | 333.87 | 323.70 | 337.02 |
| **28** | Pusa Sawani x EC169459 | 356.30 | 348.47 | 359.27 | 354.68 |
| **29** | Pusa Sawani x Kashi Pragati | 360.50 | 335.93 | 366.93 | 354.46 |
| **30** | Pusa Sawani x IC052321 | 327.13 | 319.97 | 353.20 | 333.43 |
| **31** | VRO-4 x EC169452 | 345.73 | 309.70 | 307.87 | 321.10 |
| **32** | VRO-4 x IC052310 | 329.67 | 325.27 | 341.47 | 332.13 |
| **33** | VRO-4 x EC169459 | 368.33 | 354.93 | 362.13 | 361.80 |
| **34** | VRO-4 x Kashi Pragati | 365.43 | 357.20 | 357.73 | 360.12 |
| **35** | VRO-4 x IC052321 | 366.17 | 360.33 | 345.73 | 357.41 |
| **36** | IC052299 x EC169452 | 326.53 | 307.23 | 294.87 | 309.54 |
| **37** | IC052299 x IC052310 | 330.07 | 330.07 | 297.60 | 319.24 |
| **38** | IC052299 x EC169459 | 371.80 | 364.47 | 365.60 | 367.29 |
| **39** | IC052299 x Kashi Pragati | 369.57 | 341.93 | 362.60 | 358.03 |
| **40** | IC052299 x IC052321 | 347.67 | 347.67 | 351.30 | 348.88 |
| **41** | Kashi Kranti x EC169452 | 383.83 | 346.33 | 372.30 | 367.49 |
| **42** | Kashi Kranti x IC052310 | 355.13 | 355.13 | 375.00 | 361.76 |
| **43** | Kashi Kranti x EC169459 | 394.33 | 381.47 | 379.27 | 385.02 |
| **44** | Kashi Kranti x Kashi Pragati | 402.23 | 409.87 | 386.03 | 399.38 |
| **45** | Kashi Kranti x IC052321 | 372.33 | 372.20 | 379.13 | 374.56 |
| **46** | Salkeerthi x EC169452 | 347.20 | 350.10 | 296.73 | 331.34 |
| **47** | Salkeerthi x IC052310 | 343.00 | 365.40 | 291.93 | 333.44 |
| **48** | Salkeerthi x EC169459 | 369.30 | 368.73 | 371.53 | 369.86 |
| **49** | Salkeerthi x Kashi Pragati | 365.20 | 359.57 | 370.13 | 364.97 |

| *Table continues…* | | | | | |
|---|---|---|---|---|---|
| **50** | Salkeerthi x IC052321 | 355.40 | 355.40 | 353.47 | 354.76 |
| **51** | IC058235 x EC169452 | 298.70 | 303.67 | 365.93 | 322.77 |
| **52** | IC058235 x IC052310 | 306.33 | 306.33 | 311.07 | 307.91 |
| **53** | IC058235 x EC169459 | 359.20 | 360.50 | 363.73 | 361.14 |
| **54** | IC058235 x Kashi Pragati | 357.53 | 345.90 | 355.93 | 353.12 |
| **55** | IC058235 x IC052321 | 349.47 | 349.47 | 358.23 | 352.39 |
| **56** | Hisar Naveen x EC169452 | 331.13 | 326.40 | 322.27 | 326.60 |
| **57** | Hisar Naveen x IC052310 | 303.37 | 305.87 | 315.87 | 308.37 |
| **58** | Hisar Naveen x EC169459 | 362.80 | 355.93 | 380.00 | 366.24 |
| **59** | Hisar Naveen x Kashi Pragati | 368.87 | 368.87 | 360.73 | 366.16 |
| **60** | Hisar Naveen x IC052321 | 342.07 | 342.07 | 314.87 | 333.00 |
| **61** | IC052302 x EC169452 | 337.47 | 337.47 | 298.80 | 324.58 |
| **62** | IC052302 x IC052310 | 320.97 | 320.97 | 292.47 | 311.47 |
| **63** | IC052302 x EC169459 | 315.13 | 319.50 | 349.00 | 327.88 |
| **64** | IC052302 x Kashi Pragati | 346.47 | 349.73 | 354.33 | 350.18 |
| **65** | IC052302 x IC052321 | 337.03 | 338.47 | 355.60 | 343.70 |
| Check | | 369.5 | 368.10 | 359.53 | 363.88 |
| **Range** | | 188.60-402.3 | 184.10-409.87 | 178.60-386.03 | 186.68-399.38 |
| **General mean** | | 341.97 | 337.11 | 338.56 | 339.21 |
| **Parent mean** | | 324.87 | 319.36 | 322.23 | 322.15 |
| **Hybrid mean** | | 347.10 | 342.44 | 343.46 | 344.33 |

## 4.6. MAGNITUDE AND EXTENT OF HETEROSIS

An analysis was conducted on 50 hybrids to assess heterobeltiosis and standard heterosis across 17 specific features, three environments and pooled analysis as outlined in table 32-48

### 4.6.1 First flowering node

In E1, twenty cross combinations over better parent and four crosses over standard check recorded significant and negative heterosis for first flowering node. Heterosis over better parent ranges from -23.53 % (Kashi Kranti x IC052310) to 8.96 % (IC045993 x Kashi Pragati), while heterosis over standard check ranges from -17.46% (Kashi Kranti x EC169452, Kashi Kranti x IC052310) to 22.22 % (Pusa Sawani x IC052310). Top significantly and negative heterobeltiosis was observed in the cross-combination Kashi Kranti x IC052310 (-23.53%) followed by Kashi Kranti x EC169452 (-22.39%) and IC058235 x IC052310 (-23.19%). Cross combinations Kashi Kranti x EC169452, Kashi Kranti x IC052310 (-17.46%), IC058235 x IC052310 (-15.87%) and IC052302 x IC052321 (12.70%) were three most best hybrids for significant and desirable standard heterosis.

In E2, twelve cross combinations over better parent and three crosses over standard check recorded significant and negative heterosis for first flowering node. Heterosis over better parent ranged from -19.40 % (VRO-4 x Kashi Pragati) to 16.67 % (Pusa Sawani x IC052310), while heterosis over standard check ranges from -15.63% (VRO-4 x Kashi Pragati, Salekerthi x IC052321) to 20.31% (Pusa Sawani x IC052310). Top significantly and negative heterobeltiosis was observed in the cross-combination VRO-4 x Kashi Pragati (-19.40%) followed by VRO-4 x IC052310 (-16.18%) and VRO-4 x IC052321 (-15.38%). Cross combinations VRO-4 x Kashi Pragati, Salkeerthi x IC052321 (-15.63%) and VRO-4 x IC052321 (-14.06 %) were best hybrids for significant and negative (desirable) standard heterosis.

In E3, six cross combinations over better parent and three hybrids over standard check exhibited significant and negative heterosis for first flowering node. Heterobeltiosis ranges from -18.31% (Kashi Kranti x Kashi Pragati) to 12.68 % (IC058235 x IC052310), while heterosis over standard check ranges from -15.94% (Kashi Kranti x Kashi Pragati) to 15.94 % (IC058235 x IC052310). Top significantly and negative heterobeltiosis was observed in the cross-combination Kashi Kranti x Kashi Pragati (-18.31%) followed by VRO-4 x Kashi Pragati (-16.90%) and IC052302 x Kashi Pragati (-14.49%).

**Table 32. Magnitude of heterosis for diverse and pooled environments for first flowering node**

| Crosses | First flowering node | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -11.94* | -6.35 | -11.94* | -7.81 | -7.14 | -5.80 | -11.17* | -6.63 |
| IC058710 x IC052310 | 2.90 | 12.70** | 5.97 | 10.94 | 2.86 | 4.35 | 3.88 | 9.18 |
| IC058710 x EC169459 | 1.45 | 11.11 | -4.48 | 0.00 | 10.00 | 11.59 | 2.43 | 7.65 |
| IC058710 x Kashi Pragati | 1.47 | 9.52 | -5.97 | -1.56 | -5.71 | -4.35 | -3.88 | 1.02 |
| IC058710 x IC052321 | -13.04* | -4.76 | -9.23 | -7.81 | -5.71 | -4.35 | -10.19 | -5.61 |
| IC045993 x EC169452 | -11.94* | -6.35 | -8.82 | -3.12 | -9.72 | -5.80 | -10.14 | -5.10 |
| IC045993 x IC052310 | 7.46 | 14.29* | -2.94 | 3.13 | -4.17 | 0.2 | 0.00 | 5.61 |
| IC045993 x EC169459 | 7.46 | 14.29* | 1.47 | 7.81 | -11.27 | -8.70 | -1.45 | 4.08 |
| IC045993 x Kashi Pragati | 8.96 | 15.87** | -5.97 | -1.56 | -5.63 | -2.90 | -1.46 | 3.57 |
| IC045993 x IC052321 | -8.96 | -3.17 | -9.23 | -7.81 | 4.29 | 5.80 | -6.76 | -1.53 |
| Pusa Sawani x EC169452 | -2.99 | 3.17 | 0.76 | 3.91 | -11.11 | -7.25 | -6.01 | -0.26 |
| Pusa Sawani x IC052310 | 11.59* | 22.22** | 16.67** | 20.31** | -9.72 | -5.80 | 5.29 | 11.73* |
| Pusa Sawani x EC169459 | -20.00** | -11.11 | -9.09 | -6.25 | -5.63 | -2.90 | -12.02* | -6.63 |
| Pusa Sawani x Kashi Pragati | -4.41 | 3.17 | -1.52 | 1.56 | -11.27 | -8.70 | -6.31 | -1.53 |
| Pusa Sawani x IC052321 | -10.00 | 0.00 | -7.69 | -6.25 | 1.43 | 2.90 | -6.28 | -1.02 |
| VRO-4 x EC169452 | -8.96 | -3.17 | -11.76* | -6.25 | -14.08* | -11.59 | -13.74* | -7.14 |
| VRO-4 x IC052310 | -5.80 | 3.17 | -16.18** | -10.94 | -7.04 | -4.35 | -10.90* | -4.08 |
| VRO-4 x EC169459 | -11.43* | -1.59 | -14.71** | -9.38 | -4.23 | -1.45 | -10.05 | -4.08 |
| VRO-4 x Kashi Pragati | -14.71** | -7.94 | -19.40** | -15.63** | -16.90** | -14.49* | -16.99** | -12.76* |
| VRO-4 x IC052321 | -20.83** | -9.52 | -15.38** | -14.06* | -11.43 | -10.14 | -15.94** | -11.22* |
| IC052299 x EC169452 | -7.46 | -1.59 | -7.35 | -1.56 | 8.57 | 10.14 | -3.37 | 2.55 |
| IC052299 x IC052310 | -4.35 | 4.76 | -2.94 | 3.13 | 8.57 | 10.14 | 0.00 | 6.12 |
| IC052299 x EC169459 | -10.00 | 0.2 | -7.35 | -1.56 | 0.03 | 1.45 | -5.77 | 0.04 |
| IC052299 x Kashi Pragati | -8.82 | -1.59 | -13.43* | -9.38 | -14.29* | -13.04* | -12.62* | -8.16 |
| IC052299 x IC052321 | -8.57 | 1.59 | -6.15 | -4.69 | 1.43 | 2.90 | -5.31 | 0.00 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | -22.39** | -17.46** | 2.86 | 12.50** | -4.17 | 0.00 | -8.10 | -1.53 |
| Kashi Kranti x IC052310 | -23.53** | -17.46** | -8.57 | 0.00 | -6.94 | -2.90 | -12.86* | -6.63 |
| Kashi Kranti x EC169459 | -17.65** | -11.11 | -7.35 | -1.56 | -1.41 | 1.45 | -9.57 | -3.57 |
| Kashi Kranti x Kashi Pragati | -14.71** | -7.94 | -13.43* | -9.38 | -18.31** | -15.94* | -15.53** | -11.22* |
| Kashi Kranti x IC052321 | -11.76* | -4.76 | -9.23 | -7.81 | 1.43 | 2.90 | -8.21 | -3.06 |
| Salkeerthi x EC169452 | -8.96 | -3.17 | -12.86* | -4.69 | 8.57 | 10.14 | -9.48 | -2.55 |
| Salkeerthi x IC052310 | -8.70 | 0.00 | -10.00 | -1.56 | 7.14 | 8.70 | -3.79 | 3.57 |
| Salkeerthi x EC169459 | -10.00 | 0.00 | -8.82 | -3.12 | 1.43 | 2.90 | -6.70 | -0.51 |
| Salkeerthi x Kashi Pragati | -8.82 | -1.59 | -14.93** | -10.94 | -7.14 | -5.80 | -12.62* | -8.16 |
| Salkeerthi x IC052321 | -8.45 | 3.17 | -16.92** | -15.63** | 0.00 | 1.45 | -6.76 | -1.53 |
| IC058235 x EC169452 | -2.99 | 3.17 | -1.52 | 1.56 | 4.23 | 7.25 | -2.39 | 4.08 |
| IC058235 x IC052310 | -23.19** | -15.87** | -3.03 | 0.2 | 12.68* | 15.94* | -5.74 | 0.51 |
| IC058235 x EC169459 | -11.43* | -1.59 | -3.03 | 0.4 | 1.41 | 4.35 | -5.26 | 1.02 |
| IC058235 x Kashi Pragati | -10.29 | -3.17 | -7.58 | -4.69 | -14.08* | -11.59 | -11.17* | -6.63 |
| IC058235 x IC052321 | -2.78 | 11.11 | -10.77 | -9.38 | 10.00 | 11.59 | -0.97 | 4.59 |
| Hisar Naveen x EC169452 | 4.48 | 11.11 | 4.48 | 9.38 | -1.45 | -1.45 | 1.46 | 6.12 |
| Hisar Naveen x IC052310 | -1.45 | 7.94 | 1.49 | 6.25 | -5.80 | -5.80 | -1.95 | 2.55 |
| Hisar Naveen x EC169459 | -8.70 | 0.00 | -5.97 | -1.56 | 11.59 | 11.59 | -0.98 | 3.57 |
| Hisar Naveen x Kashi Pragati | -4.41 | 3.17 | -11.94* | -7.81 | -8.70 | -8.70 | -8.78 | -4.59 |
| Hisar Naveen x IC052321 | -14.49** | -6.35 | -6.15 | -4.69 | 1.45 | 1.45 | -7.32 | -3.06 |
| IC052302 x EC169452 | -14.93** | -9.52 | -3.03 | 0.00 | -11.59 | -11.59 | -10.34 | -7.14 |
| IC052302 x IC052310 | -14.71** | -7.94 | 0.00 | 3.12 | -1.45 | -1.45 | -5.42 | -2.04 |
| IC052302 x EC169459 | -17.65** | -11.11 | -3.03 | 0.00 | -4.35 | -4.35 | -8.37 | -5.10 |
| IC052302 x Kashi Pragati | -17.65** | -11.11 | -4.55 | -1.56 | -14.49* | -14.49* | -12.32* | -9.18 |
| IC052302 x IC052321 | -19.12** | -12.70* | -7.69 | -6.25 | 0.00 | 0.00 | -9.36 | -6.12 |
| **Positive significance crosses** | 1 | 5 | 1 | 2 | 1 | 1 | 0 | 1 |
| **Negative significance crosses** | 20 | 4 | 12 | 3 | 6 | 3 | 12 | 3 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly. HB**:** Heterobeltiosis, **SH;** Standard Heterosis

Combinations Kashi Kranti x Kashi Pragati (-15.94 %), IC052302 x Kashi Pragati, VRO-4 x Kashi Pragati (-14.49 %), and IC052299 x Kashi Pragati (-13.04%) were best hybrids for significant and desirable (negative) economic heterosis for first flowering node.

In Pooled analysis, twelve hybrids over better parent and three hybrids over standard check exhibit significant and negative heterosis for first flowering node. Heterosis over better parent ranged from -16.99% (VRO-4 x Kashi Pragati) to 3.88 % (IC058710 x IC052310), while heterosis over standard check ranges from -12.76 % (VRO-4 x Kashi Pragati) to 9.18 % (IC058710 x IC052310). Top significantly and negative heterobeltiosis was observed in the cross-combination VRO-4 x Kashi Pragati (-16.99 %) followed by VRO-4 x IC052321 (-15.94%) and Kashi Kranti x Kashi Pragati (-15.53 %). Cross combinations VRO-4 x Kashi Pragati (-16.99 %), VRO-4 x IC052321 (-15.94 %) and Kahi Kranti x Kashi Pragati (-15.53 %) were best hybrids for significant and desirable (negative) economic heterosis for first flowering node.

**4.6.2 First fruiting node**

In E1, five cross combinations over better parent and four hybrids over standard check exhibited significant and negative heterosis for first fruiting node. Heterobeltiosis ranges from -18.75 % (VRO-4 x EC169452) to 25.00 % (IC058710 x EC169459), while heterosis over standard check ranges from -18.70 % (VRO-4 x EC169452) to 12.5 % (IC058710 x EC169459). Top significantly and negative heterobeltiosis was observed in the cross-combination VRO-4 x EC169452 (-18.75 %) followed by VRO-4 x Kashi Pragati, Kashi Kranti x Kashi Pragati (-14.29 %) and IC052302 x EC169452 (-11.39 %). Cross combinations VRO-4 x EC169452 (-18.70 %), VRO-4 x Kashi Pragati (-17.25 %) and Kashi Kranti x Kashi Pragati (-17.0%) were best cross combinations for significant and negative economic heterosis for first fruiting node.

In E2, six cross combinations over better parent and six hybrids over standard check exhibited significant and negative heterosis for first fruiting node. Heterobeltiosis ranges from -18.75% (VRO-4 x EC169452) to 25.00% (IC058710 x EC169459), while heterosis over standard check ranges from -15.03% (VRO-4 x EC169452) to 17.65% (IC058710 x EC169459). Top significantly and negative heterobeltiosis was observed in the cross-combination VRO-4 x EC169452 (-18.75%) followed by VRO-4 x Kashi Pragati, Kashi Kranti x Kashi Pragati (-14.29%) and IC052302 x EC169452 (-11.39%). Cross combinations

VRO-4 x EC169452 (-15.03%), VRO-4 x Kashi Pragati, Kashi Kranti x Kashi Pragati (-13.73%) and IC052299 x Kashi Pragati (-12.42 %) were best hybrids for significant and negative standard heterosis for first fruiting node.

In E3, four cross combinations over heterobeltiosis and seven crosses over standard check exhibit significant and negative heterosis for first fruiting node. Heterobeltiosis ranges from -14.67% (VRO-4 x EC169452) to 22.86 (Salkeerthi x EC169452), while heterosis over standard check ranges from -16.34% (VRO-4 x EC169452) to 12.42% (Salkeerthi x EC169452). Top significantly and negative heterobeltiosis was observed in the cross-combination VRO-4 x EC169452 (-14.67%) followed by VRO-4 x Kashi Pragati, Kashi Kranti x Kashi Pragati (-10.96%) and IC058710 x EC169452 (-10.53%). Cross combinations VRO-4 x EC169452 (-16.34), Kashi Kranti x Kashi Pragati, VRO-4 x Kashi Pragati (15.03%) and VRO-4 x IC052321 (13.73%) were top hybrids for significant and negative standard heterosis for first fruiting node.

In Pooled analysis, ten crosses over heterobeltiosis and twenty-two crosses over standard check exhibit significant and negative heterosis for first fruiting node. Heterobeltiosis ranges from -15.83 % (VRO-4 x EC169452) to 10.46 % (IC058710 x EC169459). While heterosis over standard check ranges from -19.14% (VRO-4 x Kashi Pragati) to 2.94 % (IC058710 x EC169459). Top significantly and negative heterobeltiosis was observed in the cross-combination VRO-4 x EC169452 (-15.83 %) followed by VRO-4 x Kashi Pragati (-14.02%) and Kashi Kranti x Kashi Pragati (-13.57%). Cross combinations VRO-4 x Kashi Pragati (-19.14), Kashi Kranti x Kashi Pragati (-18.71%) and VRO-4 x EC169452 (-18.42%) were top hybrids for significant and negative (desirable) economic heterosis for first fruiting node.

**Table 33. Magnitude of heterosis for diverse and pooled environments first fruiting node**

| Crosses | First fruiting node | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -6.94 | -16.25** | -6.94 | -12.42* | -10.53* | -11.11* | -9.54** | -15.7** |
| IC058710 x IC052310 | 3.9 | 0.12 | 11.11* | 4.58 | 1.32 | 0.65 | 5.54 | -1.65 |
| IC058710 x EC169459 | 25* | 12.5* | 25** | 17.65** | 6.76 | 3.27 | 10.46** | 2.94 |
| IC058710 x Kashi Pragati | -6.94 | -16.25** | -6.94 | -12.42* | -2.74 | -7.19 | -5.85 | -12.26** |
| IC058710 x IC052321 | 1.39 | -8.75 | 1.39 | -4.58 | -4.11 | -8.5 | -5.54 | -11.97** |
| IC045993 x EC169452 | -1.3 | -5 | -1.3 | -0.65 | -5.41 | -8.5 | -5.45 | -10.54** |
| IC045993 x IC052310 | -2.6 | -6.25 | -2.6 | -1.96 | -1.35 | -4.58 | -1.36 | -6.67 |
| IC045993 x EC169459 | -7.79 | -11.25** | -7.79 | -7.19 | -8.11 | -11.11* | -5.91 | -10.97** |
| IC045993 x Kashi Pragati | -2.6 | -6.25 | -2.6 | -1.96 | 1.37 | -3.27 | -0.91 | -6.81 |
| IC045993 x IC052321 | 6.58 | 1.25 | 6.58 | 5.88 | 5.48 | 0.65 | 1.99 | -4.37 |
| Pusa Sawani x EC169452 | 9.46 | 1.25 | 9.46 | 5.88 | -4 | -5.88 | 1.77 | -5.45 |
| Pusa Sawani x IC052310 | -6.76 | -13.75** | -6.76 | -9.8 | -5.33 | -7.19 | -1.39 | -8.39* |
| Pusa Sawani x EC169459 | 2.7 | -5 | 2.7 | -0.65 | 9.46 | 5.88 | 2.93 | -4.37 |
| Pusa Sawani x Kashi Pragati | 9.46 | 1.25 | 9.46 | 5.88 | 8.22 | 3.27 | 3.86 | -3.51 |
| Pusa Sawani x IC052321 | 5.41 | -2.5 | 5.41 | 1.96 | 2.74 | -1.96 | 0.77 | -6.38 |
| VRO-4 x EC169452 | -18.75** | -18.7** | -18.75** | -15.03** | -14.67** | -16.34** | -15.83** | -18.42** |
| VRO-4 x IC052310 | -7.5 | -7.5 | -7.5 | -3.27 | -5.33 | -7.19 | -7.84* | -10.68** |
| VRO-4 x EC169459 | 3.75 | 3.75 | 3.75 | 8.5 | -4.05 | -7.19 | -3.56 | -6.81 |
| VRO-4 x Kashi Pragati | -14.29** | -17.5** | -14.29** | -13.73** | -10.96* | -15.03** | -14.02** | -19.14** |
| VRO-4 x IC052321 | -6.58 | -11.25** | -6.58 | -7.19 | -9.59 | -13.73** | -10.55** | -16.13** |
| IC052299 x EC169452 | 8.57 | -5 | 8.57 | -0.65 | 9.86 | 1.96 | 5.23 | -4.8 |
| IC052299 x IC052310 | 2.86 | -10* | 2.86 | -5.88 | 9.86 | 1.96 | 4.28 | -5.66 |
| IC052299 x EC169459 | 8.57 | -5 | 8.57 | -0.65 | 4.23 | -3.27 | 2.38 | -7.38 |
| IC052299 x Kashi Pragati | -4.29 | -16.25** | -4.29 | -12.42* | 1.41 | -5.88 | -5.39 | -14.41** |
| IC052299 x IC052321 | 12.86* | -1.25 | 12.86* | 3.27 | 5.63 | -1.96 | 4.28 | -5.66 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | -9.52 | -5 | -9.52* | -0.65 | 1.28 | 3.27 | -5.55 | -4.8 |
| Kashi Kranti x IC052310 | -8.14 | -1.25 | -8.14 | 3.27 | -2.47 | 3.27 | -8.16* | -6.38 |
| Kashi Kranti x EC169459 | -7.41 | -6.25 | -7.41 | -1.96 | 4.05 | 0.65 | -4.3 | -7.53 |
| Kashi Kranti x Kashi Pragati | -14.29** | -17** | -14.29** | -13.73** | -10.96* | -15.03** | -13.57** | -18.71** |
| Kashi Kranti x IC052321 | 1.32 | -3.75 | 1.32 | 0.65 | 1.37 | -3.27 | -1.68 | -7.81 |
| Salkeerthi x EC169452 | -3.85 | -6.25 | -6.41 | -4.58 | 22.86** | 12.42* | 0.4 | -6.67 |
| Salkeerthi x IC052310 | 1.28 | -1.25 | 3.85 | 5.88 | 17.14** | 7.19 | 5.07 | -1.94 |
| Salkeerthi x EC169459 | -2.56 | -5 | -6.41 | -4.58 | 12.86* | 3.27 | 1.08 | -5.66 |
| Salkeerthi x Kashi Pragati | -7.79 | -11.25** | -7.79 | -7.19 | 4.29 | -4.58 | -5.68 | -11.97** |
| Salkeerthi x IC052321 | 0 | -5 | 6.58 | 5.88 | 2.86 | -5.88 | -0.92 | -7.5 |
| IC058235 x EC169452 | -5.26 | -10* | -5.26 | -5.88 | 8.57 | -0.65 | 1.25 | -7.1 |
| IC058235 x IC052310 | 1.32 | -3.75 | 1.32 | 0.65 | 18.57** | 8.5 | 5.78 | -2.94 |
| IC058235 x EC169459 | 3.95 | -1.25 | 3.95 | 3.27 | 10 | 0.65 | 4.06 | -4.52 |
| IC058235 x Kashi Pragati | -3.95 | -8.75 | -3.95 | -4.58 | 4.29 | -4.58 | -2.97 | -10.97** |
| IC058235 x IC052321 | 9.21 | 3.75 | 9.21 | 8.5 | 12.86* | 3.27 | 7.97* | -0.93 |
| Hisar Naveen x EC169452 | -2.6 | -6.25 | -2.6 | -1.96 | -1.43 | -9.8 | -0.93 | -8.24* |
| Hisar Naveen x IC052310 | -2.6 | -6.25 | -2.6 | -1.96 | -1.43 | -9.8 | -2.01 | -9.25** |
| Hisar Naveen x EC169459 | -1.3 | -5 | -1.3 | -0.65 | 14.29* | 4.58 | 3.87 | -3.8 |
| Hisar Naveen x Kashi Pragati | -5.19 | -8.75 | -5.19 | -4.58 | 10 | 0.65 | -1.39 | -8.67** |
| Hisar Naveen x IC052321 | 1.32 | -3.75 | 1.32 | 0.65 | 7.14 | -1.96 | 0 | -7.38 |
| IC052302 x EC169452 | -11.39* | -12.5** | -11.39* | -8.5 | -8.11 | -11.11* | -9.97** | -14.55** |
| IC052302 x IC052310 | -5.06 | -6.25 | -5.06 | -1.96 | -4.05 | -7.19 | -4.83 | -9.68** |
| IC052302 x EC169459 | -10.13* | -11.25* | -10.13* | -7.19 | -6.76 | -9.8 | -8.46* | -13.12** |
| IC052302 x Kashi Pragati | -7.79 | -11.25* | -7.79 | -7.19 | -2.74 | -7.19 | -7.93* | -13.41** |
| IC052302 x IC052321 | 0 | -5 | 0.3 | -0.65 | 0 | -4.58 | -3.52 | -9.53** |
| **Positive significance crosses** | 2 | 1 | 3 | 1 | 6 | 1 | 2 | 0 |
| **Negative significance crosses** | 5 | 15 | 6 | 6 | 4 | 7 | 10 | 22 |

*, ** denote significance levels of 5% and 1%, accordingly. **HB:** Heterobeltiosis, **SH:** Standard Heterosis

### 4.6.3 Days to first flowering

In E1 three crosses over better parent and thirty hybrids over standard check exhibits for significant and negative heterosis for days to first flowering. Heterobeltiosis ranged from -13.27% (VRO-4 x Kashi Pragati) to 9.01% (IC052302 x EC169459), while heterosis over standard check ranges from -17.65% (Kashi Kranti x Kashi Pragati) to 1.68% (IC052302 x EC169459). Top significantly and negative heterobeltiosis was observed in the cross-combination VRO-4 x Kashi Pragati (-13.45%) followed by VRO-4 x EC169459 (-8.85%) and IC052299 x EC169459 (-5.26%). Cross combinations Kashi Kranti x Kashi Pragati (-17.65%), VRO-4 x EC169459 (-13.27%) and IC052299 x EC169459 (-9.24%) were top hybrids for significant and negative standard heterosis for days to first flowering

In E2 fourteen crosses over better parent and twenty hybrids over standard check exhibits for significant and negative heterosis for days to first flowering. Heterobeltiosis ranges from -6.96 (Kashi Kranti x Kashi Pragati) to 3.57 (Hisar Naveen x IC052310), while heterosis over standard check ranges from -8.55% (Kashi Kranti x Kashi Pragati) to 2.63% (IC052302 x IC052321). Top significantly and negative heterobeltiosis was observed in the cross-combination Kashi Kranti x Kashi Pragati (-6.96%) followed by IC052299 x EC169459 (-6.09%) and IC058710 x Kashi Pragati (-5.98%). Cross combinations Kashi Kranti x Kashi Pragati (-8.55%), IC052299 x EC169459 (-7.69%) and IC058710 x Kashi Pragati (-5.98%) were top hybrids for significant and negative standard heterosis for days to first flowering.

In E3 three crosses over better parent and twenty-three hybrids over standard check exhibits for significant and negative heterosis for days to first flowering. Heterobeltiosis ranges from -13.93% (Pusa Sawani x EC169452) to 7.89% (IC052302 x IC052310 and IC052302 x IC052321), while heterosis over standard check ranges from -16.67% (Pusa Sawani x EC169452) to 0.2% (Hisar Naveen x EC169452). Top significantly and negative heterobeltiosis was observed in the cross-combination Pusa Sawani x EC169452 (-13.93%) followed by Kashi Kranti x EC169452 (-9.09%) and IC058710 x IC052321 (-7.44%). Cross combinations Pusa Sawani x EC169452 (-16.67%), IC058710 x IC052321 (-11.11%) and Pusa Sawani x Kashi Pragati, Kashi Kranti x Kashi Pragati (-7.14%) were top hybrids for significant and desirable economic heterosis for days to first flowering.

**Table 34. Magnitude of heterosis for diverse and pooled environments for days to first flowering**

| Crosses | Day to first flowering | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -1.71 | -3.36 | 0 | 0.85 | -3.28 | -6.35** | -1.12 | -4.59 |
| IC058710 x IC052310 | 0.85 | -0.84 | -4.24* | -3.42 | 1.64 | -1.59 | -0.56 | -4.05 |
| IC058710 x EC169459 | -0.85 | -2.52 | -0.86 | -1.71 | -0.83 | -5.56** | -1.41 | -5.41 |
| IC058710 x Kashi Pragati | 0 | -5.04** | -5.98** | -5.98** | 5.88** | 0 | 0 | -5.68 |
| IC058710 x IC052321 | 0.85 | -0.84 | -1.69 | -0.85 | -7.44** | -11.11** | -1.4 | -4.86 |
| IC045993 x EC169452 | 2.65 | -2.52 | -0.86 | -1.71 | -0.83 | -4.76** | 0.29 | -5.14 |
| IC045993 x IC052310 | 4.42* | -0.84 | 3.45 | 2.56 | 3.31 | -0.79 | 3.71 | -1.89 |
| IC045993 x EC169459 | 5.31** | 0 | 2.59 | 1.71 | 0 | -4.76** | 2.29 | -3.24 |
| IC045993 x Kashi Pragati | 0.88 | -4.2* | -4.31* | -5.13* | -1.68 | -7.14** | -2.01 | -7.57* |
| IC045993 x IC052321 | -1.77 | -6.72** | 0.86 | 0 | -0.83 | -4.76** | -0.57 | -5.95 |
| Pusa Sawani x EC169452 | -0.9 | -7.56** | 2.56 | 2.56 | -13.93** | -16.67** | 1.14 | -4.32 |
| Pusa Sawani x IC052310 | -0.9 | -7.56** | -4.27* | -4.27* | 0.82 | -2.38 | -1.43 | -6.76 |
| Pusa Sawani x EC169459 | 1.8 | -5.04** | -0.86 | -1.71 | 4.17* | -0.79 | 0.86 | -4.59 |
| Pusa Sawani x Kashi Pragati | 0.9 | -5.88** | -4.27* | -4.27* | -1.68 | -7.14** | -2.29 | -7.84* |
| Pusa Sawani x IC052321 | 0 | -6.72** | -5.13* | -5.13* | -0.83 | -4.76** | -2.29 | -7.57* |
| VRO-4 x EC169452 | -0.88 | -5.88** | -5.13* | -5.13* | 2.48 | -1.59 | -1.14 | -6.22 |
| VRO-4 x IC052310 | 3.54 | -1.68 | 0 | 0 | 1.65 | -2.38 | 1.71 | -3.51 |
| VRO-4 x EC169459 | -8.85** | -13.45** | -2.59 | -3.42 | 4.17* | -0.79 | -0.57 | -5.68 |
| VRO-4 x Kashi Pragati | -13.27** | -17.65** | -5.13* | -5.13* | 0 | -5.56** | -2.29 | -7.84* |
| VRO-4 x IC052321 | 0.88 | -4.2* | -2.56 | -2.56 | 1.65 | -2.38 | 0 | -5.14 |
| IC052299 x EC169452 | -0.88 | -5.04** | -1.74 | -3.42 | 0.81 | -1.59 | -9.66* | -14.05** |
| IC052299 x IC052310 | -2.63 | -6.72** | -3.48 | -5.13* | -1.63 | -3.97* | -2.56 | -7.3 |
| IC052299 x EC169459 | -5.26** | -9.24** | -6.09** | -7.69** | 4.17* | -0.79 | -3.13 | -7.84* |
| IC052299 x Kashi Pragati | 0 | -5.04** | -2.61 | -4.27* | 2.52 | -3.17 | -0.57 | -6.22 |
| IC052299 x IC052321 | 0 | -4.2* | -0.87 | -2.56 | 1.65 | -2.38 | -0.28 | -5.14 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | 2.65 | -2.52 | 0.87 | -0.85 | -9.09** | -4.76** | 2.87 | -2.97 |
| Kashi Kranti x IC052310 | 1.77 | -3.36 | 0 | -1.71 | -3.23 | -4.76** | -18.44** | -23.06** |
| Kashi Kranti x EC169459 | -3.54 | -8.4** | -3.48 | -5.13* | 0 | -4.76** | -2.29 | -7.84* |
| Kashi Kranti x Kashi Pragati | -3.54 | -8.4** | -6.96** | -8.55** | -1.68 | -7.14** | -4.58 | -10** |
| Kashi Kranti x IC052321 | -2.65 | -7.56** | -2.61 | -4.27* | 0 | -3.97* | -1.72 | -7.3 |
| Salkeerthi x EC169452 | 2.63 | -1.68 | 0 | 0 | 5.88** | 0.17 | -10.86** | -15.68** |
| Salkeerthi x IC052310 | 4.39* | 0 | 1.71 | 1.71 | 3.36 | -2.38 | 4 | -1.62 |
| Salkeerthi x EC169459 | 0 | -4.2* | -2.59 | -3.42 | 1.68 | -3.97* | 0.57 | -4.86 |
| Salkeerthi x Kashi Pragati | -0.88 | -5.88** | -4.27* | -4.27* | 1.68 | -3.97* | -1.43 | -7.03 |
| Salkeerthi x IC052321 | -2.63 | -6.72** | -5.13* | -5.13* | 1.68 | -3.97* | -2.29 | -7.57* |
| IC058235 x EC169452 | -0.88 | -5.04** | -0.88 | -3.42 | 3.33 | -1.59 | -8.62* | -14.05** |
| IC058235 x IC052310 | 0 | -4.2* | 0 | -2.56 | 3.33 | -1.59 | 1.15 | -4.86 |
| IC058235 x EC169459 | 0.88 | -3.36 | 0.88 | -1.71 | 2.5 | -2.38 | 1.44 | -4.59 |
| IC058235 x Kashi Pragati | 2.65 | -2.52 | -2.63 | -5.13* | 2.52 | -3.17 | 0.29 | -5.68 |
| IC058235 x IC052321 | 0 | -4.2* | -0.88 | -3.42 | 1.67 | -3.17 | 0.29 | -5.68 |
| Hisar Naveen x EC169452 | 0.9 | -5.88** | 0 | -4.27* | 4.13* | 0.2 | 1.74 | -5.41 |
| Hisar Naveen x IC052310 | 4.5* | -2.52 | 3.57 | -0.85 | 3.31 | -0.79 | 3.78 | -3.51 |
| Hisar Naveen x EC169459 | 3.6 | -3.36 | 0.89 | -3.42 | 3.33 | -1.59 | 2.33 | -4.86 |
| Hisar Naveen x Kashi Pragati | 3.6 | -3.36 | 0 | -4.27* | 3.36 | -2.38 | 1.74 | -5.41 |
| Hisar Naveen x IC052321 | 1.8 | -5.04** | 0.89 | -3.42 | 0.83 | -3.17 | 1.16 | -5.95 |
| IC052302 x EC169452 | 1.8 | -5.04** | -4.27* | -4.27* | 5.26** | -4.76** | 1.17 | -6.49 |
| IC052302 x IC052310 | -1.8 | -8.4** | -4.27* | -4.27* | 7.89** | -2.38 | 0.88 | -6.76 |
| IC052302 x EC169459 | 9.01** | 1.68 | 0 | -0.85 | 5.26** | -4.76** | 4.68 | -3.24 |
| IC052302 x Kashi Pragati | 5.41** | -1.68 | -3.42 | -3.42 | 6.14** | -3.97* | 3.22 | -4.59 |
| IC052302 x IC052321 | 0 | 0.84 | 2.63 | 2.56 | 7.89** | -2.38 | 6.14 | -1.89 |
| **Positive significance crosses** | 6 | 0 | 0 | 0 | 11 | 0 | 0 | 0 |
| **Negative significance crosses** | 3 | 30 | 14 | 20 | 3 | 23 | 4 | 12 |

*, ** denote significance levels of 5% and 1%, accordingly. **HB:** Heterobeltiosis**, SH:** Standard Heterosis

In pooled analysis four crosses over better parent and twelve hybrids over standard check exhibits for significant and negative heterosis for days to first flowering. Heterosis over better parent ranges from -18.44% (Kashi Kranti x IC052310) to 16.67% (Pusa Sawani x EC169459). Top significantly and negative heterobeltiosis was observed in the cross-combination Kashi Kranti x IC052310 (-18.44%) followed by Salkeerthi x EC169452 (-10.86%) and IC052299 x EC169452 (-9.66%). Cross combinations Kashi Kranti x IC052310 (-23.06), Salkeerthi x EC169452 (-15.68%) and IC052299 x EC169452 (-14.05%) were top hybrids for significant and negative standard heterosis for days to first flowering.

#### 4.6.4 Days to 50 % flowering

In E1 four crosses over better parent and ten hybrids over standard check exhibits for significant and negative heterosis for days to 50 % first flowering. Heterobeltiosis ranged from -6.40% (Kashi Kranti x EC169459) to 6.67% (IC052302 x IC052321), while heterosis over standard check ranges from -6.50% (Kashi Kranti x Kashi Pragati) to 4.07% (IC052302 x IC052321). Top significantly and negative heterobeltiosis was observed in the cross-combination Kashi Kranti x EC169459 (-6.40%) followed by Kashi Kranti x Kashi Pragati (-5.74%) and Kashi Kranti x IC052321 (-4.80%). Cross combinations Kashi Kranti x Kashi Pragati (-6.50%), VRO-4 x Kashi Pragati (-6.45%) and Pusa Sawani x EC169452 (-5.69%) were top hybrids for significant and negative standard heterosis for days to 50% flowering.

In E2 eleven crosses over better parent and fifteen hybrids over standard check exhibits for significant and negative heterosis for days to 50 % first flowering. Heterobeltiosis ranged from -8.96 % (IC052302 x EC169452) to 7.09 (IC052302 x Kashi Pragati), while heterosis over standard check ranges from -10.00 % (Kashi Kranti x Kashi Pragati) to 4.62% (IC052302 x IC052321, IC052302 x Kashi Pragati). Top significantly and negative heterobeltiosis was observed in the cross-combination IC052302 x EC169452 (-8.96 %) followed by IC052302 x IC052310 (-8.27 %) and Kashi Kranti x EC169452 (-8.21%). Cross combinations Kashi Kranti x Kashi Pragati (-10.00%), IC052299 x EC169459 (-7.69%) and VRO-4 x Kashi Pragati (-6.92%) were top hybrids for significant and negative standard heterosis for days to 50% flowering.

**Table 35. Magnitude of heterosis for diverse and pooled environments for days to 50% flowering**

| Crosses | Days 50 % flowering | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | 0.00 | 0.00 | -5.88* | -1.54 | -0.78 | -3.76 | -2.32 | -1.81 |
| IC058710 x IC052310 | 1.63 | 1.63 | 3.15 | 0.77 | 7.32** | -0.75 | 4.58** | 0.52 |
| IC058710 x EC169459 | -2.44 | -2.44 | 3.17 | 0.00 | 4 | -2.26 | 0.53 | -1.55 |
| IC058710 x Kashi Pragati | -3.28 | -4.07* | -2.36 | -4.62* | 1.55 | -1.5 | -1.32 | -3.36 |
| IC058710 x IC052321 | -2.44 | -2.44 | -3.73 | -0.77 | -5.43** | -8.27** | -4.38** | -3.88 |
| IC045993 x EC169452 | 0.83 | -0.81 | -2.36 | -4.62* | 3.25 | -4.51** | 0.54 | -3.36 |
| IC045993 x IC052310 | 4.96* | 3.25 | -2.36 | -4.62* | 5.69** | -2.26 | 2.7 | -1.29 |
| IC045993 x EC169459 | 4.13* | 2.44 | -0.79 | -3.85 | 2.44 | -5.26** | 1.62 | -2.33 |
| IC045993 x Kashi Pragati | -1.65 | -3.25 | 1.57 | -0.77 | 0.81 | -6.77** | 0.27 | -3.62 |
| IC045993 x IC052321 | -2.48 | -4.07* | 3.94 | 1.54 | 2.44 | -5.26 | 1.35 | -2.59 |
| Pusa Sawani x EC169452 | -3.33 | -5.69* | 0 | -4.62* | 3.97 | -1.5 | 0.27 | -3.88 |
| Pusa Sawani x IC052310 | -0.83 | -3.25 | 0 | -4.62* | 3.17 | -2.26 | 0.81 | -3.36 |
| Pusa Sawani x EC169459 | -0.83 | -3.25 | 6.45* | 1.54 | 6.4** | 0 | 3.78 | -0.51 |
| Pusa Sawani x Kashi Pragati | -2.50 | -4.88* | -0.81 | -5.38* | 1.59 | -3.76 | -0.54 | -4.66** |
| Pusa Sawani x IC052321 | -0.83 | -3.25 | 2.42 | -2.31 | 3.97 | -1.5 | 1.89 | -2.33 |
| VRO-4 x EC169452 | -1.67 | -4.07* | 4.72* | 2.31 | 4.76** | -0.75 | 2.68 | -0.77 |
| VRO-4 x IC052310 | 5.00* | 2.44 | 0 | -2.31 | 0.79 | -4.51* | 1.88 | -1.55 |
| VRO-4 x EC169459 | -2.50 | -4.88* | -1.59 | -4.62* | 6.4* | 0 | 0.27 | -3.10 |
| VRO-4 x Kashi Pragati | -4.17* | -6.50* | -4.72* | -6.92* | -3.17 | -8.2** | -4.02* | -7.25** |
| VRO-4 x IC052321 | 0.00 | -2.44 | 4.72* | 2.31 | 3.97 | -1.5 | 2.95 | -0.51 |
| IC052299 x EC169452 | 0.00 | -3.25 | -4.58* | -3.85 | -2.31 | -4.51* | -2.37 | -3.88 |
| IC052299 x IC052310 | 0.00 | -3.25 | -1.53 | -0.77 | -3.85 | -6.02** | -1.84 | -3.36 |
| IC052299 x EC169459 | -0.84 | -4.07* | -4.76* | -7.69* | 2.4 | -3.76 | -3.17 | -5.18** |
| IC052299 x Kashi Pragati | 0.84 | -2.44 | -2.36 | -4.62* | -0.78 | -3.76 | -1.59 | -3.62 |
| IC052299 x IC052321 | 2.52 | -0.81 | 0 | 0.77 | 2.31 | 0 | 1.58 | 0.01 |
| Kashi Kranti x EC169452 | -2.40 | -0.81 | -8.21** | -5.38* | 1.53 | 0.4 | -3.08 | -2.07 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x IC052310 | -0.80 | 0.81 | 0 | 2.31 | -2.29 | -3.76 | -1.28 | -0.25 |
| Kashi Kranti x EC169459 | -6.40** | -4.88* | -2.38 | -5.38* | 0 | -6.02* | -3.44 | -5.44* |
| Kashi Kranti x Kashi Pragati | -5.74** | -6.50* | -7.87** | -10.00** | -6.2** | -9.02** | -6.61** | -8.54** |
| Kashi Kranti x IC052321 | -4.80** | -3.25 | -5.22* | -2.31 | -3.82 | -5.26** | -4.62** | -3.62 |
| Salkeerthi x EC169452 | 1.65 | 0.00 | -2.21 | 2.31 | 0.77 | -1.5 | 0 | 0.26 |
| Salkeerthi x IC052310 | 5.79* | 4.07* | -3.01 | -0.77 | 1.54 | -0.75 | 0 | 0.26 |
| Salkeerthi x EC169459 | 0.00 | -1.63 | -0.79 | -3.85 | 0.8 | -5.26 | -1.06 | -3.10 |
| Salkeerthi x Kashi Pragati | 0.00 | -1.63 | -0.79 | -3.08 | -3.1 | -6.02** | -1.85 | -3.88 |
| Salkeerthi x IC052321 | -1.65 | -3.25 | -5.97** | -3.08 | -3.85 | -6.02** | -4.39** | -4.14** |
| IC058235 x EC169452 | -3.25 | -3.25 | -6.67** | -3.08 | 0.76 | -0.75 | -3.08 | -2.33 |
| IC058235 x IC052310 | 1.63 | 1.63 | 0 | 2.31 | 0 | -1.5 | 0 | 0.78 |
| IC058235 x EC169459 | -1.63 | -1.63 | 3.17 | 0.00 | 1.6 | -4.51* | 0 | -2.07 |
| IC058235 x Kashi Pragati | 0.82 | 0.00 | 4.72* | 2.31 | 0 | -3.01 | 1.85 | -0.25 |
| IC058235 x IC052321 | 0.00 | 0.00 | -2.24 | 0.77 | -3.05 | -4.51 | -2.06 | -1.29 |
| Hisar Naveen x EC169452 | 2.54 | -1.63 | 1.57 | -0.77 | 2.33 | -0.75 | 2.14 | -1.03 |
| Hisar Naveen x IC052310 | 5.93* | 1.63 | 0.79 | -1.54 | 0 | -3.01 | 2.14 | -1.03 |
| Hisar Naveen x EC169459 | 4.24* | 0.00 | -0.79 | -3.85 | 1.6 | -4.51* | 0.27 | -2.84 |
| Hisar Naveen x Kashi Pragati | 3.39 | -0.81 | 4.72* | 2.31 | 0.78 | -2.26 | 2.94 | -0.25 |
| Hisar Naveen x IC052321 | 0.85 | -3.25 | 0 | -2.31 | 0.78 | -2.26 | 0.53 | -2.59 |
| IC052302 x EC169452 | 0.00 | -2.44 | -8.96** | -6.15** | 3.23 | -3.76 | -2.12 | -4.14** |
| IC052302 x IC052310 | -0.83 | -3.25 | -8.27** | -6.15** | 8.06** | 0.75 | -0.79 | -2.84 |
| IC052302 x EC169459 | 5.00* | 2.44 | -0.79 | -3.85 | 4.84 | -2.26 | 0.79 | -1.29 |
| IC052302 x Kashi Pragati | 3.33 | 0.81 | 7.09** | 4.62 | 5.65** | -1.5 | 3.44 | 1.30 |
| IC052302 x IC052321 | 6.67* | 4.07* | 1.49 | 4.62 | 3.05 | 1.5 | 1.01 | 3.37 |
| **Positive significance crosses** | 8 | 2 | 6 | 0 | 2 | 0 | 1 | 0 |
| **Negative significance crosses** | 4 | 2 | 11 | 15 | 7 | 15 | 5 | 7 |

*, ** denote significance levels of 5% and 1%, accordingly. **HB: Heterobeltiosis, SH: Standard Heteros**

In E3 two cross combinations over better parent and fifteen hybrids over standard check exhibits for significant and negative heterosis for days to 50 % first flowering. Heterobeltiosis ranged from -6.2 % (Kashi Kranti x Kashi Pragati) to 8.06 % (IC052302 x IC052310), while heterosis over standard check ranges from -9.02 % (Kashi Kranti x Kashi Pragati) to 0.4 % (Kashi Kranti x EC169452). Top significantly and negative heterobeltiosis was observed in the cross-combination Kashi Kranti x Kashi Pragati (-6.20%) and IC058710 x IC052321 (-5.43%). Cross combinations Kashi Kranti x Kashi Pragati (-9.02%), IC058710 x IC052321 (-8.27%). and VRO-4 x Kashi Pragati (-8.2%) were top hybrids for significant and negative (desirable) economic heterosis for days to 50% flowering.

In pooled analysis five crosses over better parent and seven hybrids over standard check exhibits for significant and negative heterosis for days to 50 % first flowering. Heterobeltiosis ranged from -6.61% (Kashi Kranti x Kashi Pragati) to 4.58% (IC058710 x IC052310), while heterosis over standard check ranges from -8.54% (Kashi Kranti x Kashi Pragati) to 3.37 % (IC052302 x IC052321). Top significantly and negative heterobeltiosis was observed in the cross-combination Kashi Kranti x Kashi Pragati (-6.61%) followed by Kashi Kranti x IC052321 (-4.62%) and Salkeerthi x IC052321 (-4.39%). Cross combinations Kashi Kranti x Kashi Pragati (-8.54%), VRO-4 x Kashi Pragati (-7.25 %) and IC052299 x Kashi Pragati (-5.18%) were top hybrids for significant and negative standard heterosis for days to first flowering.

### 4.6.5 Days to first fruit harvest

In E1 eighteen crosses over better parent and fifteen hybrids over standard check exhibits for significant and negative heterosis for days to first fruit harvest. Heterobeltiosis ranged from -9.03% (Pusa Sawani x IC052310) to 4.26% (Hisar Naveen x Kashi Pragati), while heterosis over standard check ranges from - 9.79 % (Kashi Kranti x Kashi Pragati) to 2.8% (Hisar Naveen x Kashi Pragati). Top significantly and negative heterobeltiosis was observed in the cross-combination Pusa Sawani x IC052310 (-9.03%) followed by Kashi Kranti x Kashi Pragati (-8.51%) and IC052299 x EC169459 (-7.75%). Cross combinations Kashi Kranti x Kashi Pragati (-9.79%), Pusa Sawani x IC052310 (-8.39%) and IC052299 x EC169459 (-8.21 %) were top hybrids for significant and negative standard heterosis for days to first fruit harvest.

In E2 eighteen crosses over better parent and five hybrids over standard check exhibits for significant and negative heterosis for days to first fruit harvest. Heterobeltiosis ranges from -8.50% (IC052302 x EC169452) to 2.76% (IC045993 x IC052321). Heterobeltiosis ranges from -8.50% (IC052302 x EC169452) to 2.76% (IC045993 x IC052321), while heterosis over standard check ranges from -4.23% (Hisar Naveen x IC052321) to 5.63% (IC052299 x EC169452). Top significantly and negative heterobeltiosis was observed in the cross-combinations IC052302 x EC169452 (-8.50%) followed by VRO-4 x IC052310, VRO-4 x Kashi Pragati (-6.80%) and IC052299 x Kashi Pragati (-6.76%). Cross combinations Hisar Naveen x IC052321 (-4.23), VRO-4 x IC052310 (-3.86) and VRO-4 x Kashi Pragati (-3.52%) were top hybrids for significant and negative standard heterosis for days to first fruit harvest.

In E3 three crosses over better parent and eleven crosses over standard check exhibits for significant and negative heterosis for days to first fruit harvest. Heterobeltiosis ranges from -6.9% (Kashi Kranti x IC052310) to 14.18% (Pusa Sawani x EC169452), while heterosis over standard check ranges from -12.24% (IC052302 x EC169452 to 0.2% (Hisar Naveen x EC169452). Top significantly and negative heterobeltiosis was observed in the cross-combination Kashi Kranti x IC052310 (-6.9%) followed by VRO-4 x IC052310 (-4.90%) and IC052302 x EC169452 (-3.73%). Cross combinations IC052302 x EC169452 (-12.24%), IC052299 x IC052310 (-8.16%) and VRO-4 x IC052310 (-7.48%) were top hybrids for significant and negative standard heterosis for days to first fruit harvest.

In pooled analysis five crosses over better parent and five crosses over standard check exhibits for significant and negative heterosis for days to first fruit harvest. Heterobeltiosis ranges from -25.08% (Kashi Kranti x IC052310) to 2.57% (IC052302 x Kashi Pragati), while heterosis over standard check ranges from -26.44% (Kashi Kranti x IC052310) to -0.23% (IC052302 x Kashi Pragati). Top significantly and negative heterobeltiosis was observed in the cross-combination Kashi Kranti x IC052310 (-25.08%) followed by IC058235 x IC052321 (-15.37%) and IC052299 x IC052321 (-13.3%). Cross combinations Kashi Kranti x IC052310 (-26.44 %), IC058235 x IC052321 (-16.14%) and IC052299 x IC052321, Kashi Kranti x Kashi Pragati (-14.09%) were top hybrids for significant and negative standard for days to first fruit harvest.

**Table 36. Magnitude of heterosis for diverse and pooled environments for days to first fruit harvesting**

| Crosses | Days to first harvesting | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -2.07 | -0.7 | 0 | 2.82 | 5.97** | -3.4* | -0.92 | -2.27 |
| IC058710 x IC052310 | -3.45 | -2.1 | 0.2 | 2.82 | 5.07** | -1.36 | -0.69 | -2.05 |
| IC058710 x EC169459 | -4.14 | -2.8 | 1.38 | 3.52* | 1.45 | -4.76** | -1.62 | -3.18 |
| IC058710 x Kashi Pragati | -1.42 | -2.8 | -5.48** | -2.82 | 5.8 | -0.68 | -1.17 | -3.86 |
| IC058710 x IC052321 | -0.69 | 0.7 | 0 | 2.82 | 3.62* | -2.72 | -0.23 | -1.59 |
| IC045993 x EC169452 | -2.07 | -0.7 | -0.69 | 1.41 | 11.19** | 1.36 | -0.23 | -1.14 |
| IC045993 x IC052310 | -0.68 | 1.4 | -0.69 | 1.41 | -0.69 | -2.72 | -0.92 | -1.82 |
| IC045993 x EC169459 | -6.12** | -3.5 | -5.52** | -3.52* | -1.42 | -5.44** | -4.39 | -5.91 |
| IC045993 x Kashi Pragati | -4.26 | -5.59* | -4.14* | -2.11 | -1.44 | -6.8** | -3.97 | -6.59 |
| IC045993 x IC052321 | -7.48** | -4.9* | 2.76 | 4.93** | 0.7 | -2.04 | -1.61 | -2.5 |
| Pusa Sawani x EC169452 | -5.56* | -4.9* | 1.4 | 2.11 | 14.18** | 4.08* | 0.23 | -1.36 |
| Pusa Sawani x IC052310 | -9.03** | -8.39** | 1.4 | 2.11 | 0.69 | -0.68 | -2.54 | -4.09 |
| Pusa Sawani x EC169459 | -5.56* | -4.9* | -2.1 | -1.41 | 2.13 | -2.04 | -3 | -4.55 |
| Pusa Sawani x Kashi Pragati | 1.42 | 0 | -0.7 | 0 | 4.32* | -1.36 | 0.47 | -2.27 |
| Pusa Sawani x IC052321 | -2.08 | -1.4 | 2.1 | 2.82 | 0 | -2.72 | -0.69 | -2.27 |
| VRO-4 x EC169452 | -2.86 | -4.9* | -6.12** | -2.82 | 3.73* | -5.44** | -3.95 | -6.14 |
| VRO-4 x IC052310 | -0.71 | -2.8 | -6.8** | -3.86* | -4.9** | -7.48** | -3.02 | -5.23 |
| VRO-4 x EC169459 | -2.86 | -4.9* | -5.52** | -3.45* | 2.13 | -2.04 | -3.02 | -5.23 |
| VRO-4 x Kashi Pragati | 0.2 | -2.1 | -6.8** | -3.52* | 3.6* | -2.04 | -1.64 | -4.32 |
| VRO-4 x IC052321 | 0 | -2.2 | -2.72 | 0.7 | 1.4 | -1.36 | -0.47 | -2.73 |
| IC052299 x EC169452 | -1.41 | -1.1 | 0.67 | 5.63** | 7.46** | -2.04 | -0.46 | -1.36 |
| IC052299 x IC052310 | -1.41 | -2.4 | -0.68 | 2.82 | -6.9** | -8.16** | -2.06 | -2.95 |
| IC052299 x EC169459 | -7.75** | -8.21** | -0.69 | 1.41 | 1.42 | -2.72 | -3.46 | -5 |
| IC052299 x Kashi Pragati | -2.13 | -3.5 | -6.76** | -2.82 | 4.32* | -1.36 | -1.64 | -4.32 |
| IC052299 x IC052321 | -0.7 | -1.4 | -1.36 | 2.11 | 3.5* | 0.68 | -13.3** | -14.09** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | -3.52 | -4.2 | 1.35 | 5.63** | 8.96** | -0.68 | 0.23 | -1.59 |
| Kashi Kranti x IC052310 | -5.63* | -6.29** | 1.36 | 4.93** | 1.41 | -2.04 | -25.08** | -26.44** |
| Kashi Kranti x EC169459 | -7.04** | -7.69** | 0.69 | 2.82 | -2.84 | -6.8** | -3.94 | -5.68 |
| Kashi Kranti x Kashi Pragati | -8.51** | -9.79** | -6.76** | -2.82 | -0.72 | -6.12** | -11.68** | -14.09** |
| Kashi Kranti x IC052321 | -1.41 | -2.1 | -1.36 | 2.11 | 1.41 | -2.04 | -0.69 | -2.5 |
| Salkeerthi x EC169452 | -4.83* | -3.5 | -1.32 | 4.93** | 11.94** | 2.04 | -2.05 | -2.05 |
| Salkeerthi x IC052310 | -1.37 | 0.7 | 0 | 3.52* | 1.41 | -2.04 | 0 | -0.45 |
| Salkeerthi x EC169459 | -7.48** | -4.9* | -2.07 | 0.2 | 3.55 | -0.68 | -1.62 | -3.18 |
| Salkeerthi x Kashi Pragati | -1.42 | -2.8 | -4.05* | 0 | 4.32* | -1.36 | -2.34 | -5 |
| Salkeerthi x IC052321 | -6.12** | -3.5 | -2.04 | 1.41 | 2.82 | -0.68 | -12.81** | -13.41** |
| IC058235 x EC169452 | -7.59** | -6.29** | 0 | 3.52* | 8.21** | -1.36 | -2.29 | -3.18 |
| IC058235 x IC052310 | -3.45 | -2.1 | 0.68 | 4.23* | 2.08 | 0 | -0.23 | -1.14 |
| IC058235 x EC169459 | -3.45 | -2.1 | -1.38 | 0.7 | 2.84 | -1.36 | -1.15 | -2.73 |
| IC058235 x Kashi Pragati | 2.13 | 0.7 | -3.4* | 0 | 5.04** | -0.68 | 0.93 | -1.82 |
| IC058235 x IC052321 | -2.76 | -1.4 | -3.4* | 0.1 | 0.7 | -2.04 | -15.37** | -16.14** |
| Hisar Naveen x EC169452 | -3.47 | -2.8 | -4.83** | -2.82 | 12.69** | 2.72 | -0.93 | -2.73 |
| Hisar Naveen x IC052310 | 0.69 | 1.4 | -0.69 | 1.41 | 3.5 | 0.68 | 1.16 | -0.68 |
| Hisar Naveen x EC169459 | -4.86* | -4.2 | -4.83** | -2.82 | 0.71 | -3.4* | -3.47 | -5.23 |
| Hisar Naveen x Kashi Pragati | 4.26 | 2.8 | -3.45* | -1.41 | 3.6* | -2.04 | 0.7 | -2.05 |
| Hisar Naveen x IC052321 | -4.86* | -4.2 | -6.21** | -4.23* | 2.8 | 0 | -2.78 | -4.55 |
| IC052302 x EC169452 | -5.52* | -4.2 | -8.5** | -1.41 | -3.73* | -12.24** | -5.62 | -4.55 |
| IC052302 x IC052310 | -6.85** | -4.9* | -6.12** | -2.82 | 2.07 | 0.68 | -3.65 | -4.09 |
| IC052302 x EC169459 | -6.85** | -4.9* | -1.38 | 0.7 | 3.55 | -0.68 | -1.85 | -3.41 |
| IC052302 x Kashi Pragati | 2.84 | 1.4 | -1.35 | 2.82 | 6.47** | 0.68 | 2.57 | -0.23 |
| IC052302 x IC052321 | -2.05 | 0 | -0.68 | 2.82 | 0.7 | -2.04 | -0.92 | -1.59 |
| **Positive significance crosses** | 0 | 0 | 0 | 9 | 19 | 1 | 0 | 0 |
| **Negative significance crosses** | 18 | 15 | 18 | 5 | 3 | 11 | 5 | 5 |

The signs *, ** represent significance levels of 5% and 1% accordingly

**4.6.6 Plant height**

In E1 four crosses over better parent and ten cross combinations over standard check exhibits for significant and positive heterosis for plant height. Heterobeltiosis ranged from -14.94% (Kashi Kranti x IC052310) to 11.14 % (IC058710 x EC169459), while heterosis over standard check ranges from -12.19% (Hisar Naveen x EC169452) to 13.75% (IC058710 x EC169459.Top significantly and positive heterobeltiosis was observed in the cross-combinations of IC058710 x EC169459 (11.14%) followed by Hisar Naveen x IC052310 (8.43%) and IC058710 x EC169452 (7.23%). Cross combinations IC058710 x EC169459 (13.75%) VRO-4 x Kashi Pragati (13.00%) and Kashi Kranti x Kashi Pragati (12.19%) were top hybrids for significant and positive standard (economic) heterosis for plant height.

In E2 eight hybrids over better parent and seven cross combinations over standard check exhibit for significant and positive heterosis for plant height. Heterobeltiosis ranged from -12.35% (IC052302 x EC169459) to 11.64% (Kashi Kranti x Kashi Pragati), while heterosis over standard check ranges from -9.89% (IC052302 x EC169459) to 13.53% (IC052302 x IC052321). Top significantly and positive heterobeltiosis was observed in the cross-combinations of Kashi Kranti x Kashi Pragati (11.64%) followed by IC045993 x IC052321 (11.9%) and Kashi Kranti x EC169452 (11.7 %). Cross combinations IC052302 x IC052321 (13.53%), VRO-4 x IC052310 (11.53%) and IC045993 x IC052321 (9.38%) were top hybrids for significant and positive standard heterosis for plant height.

In E3 two crosses over better parent and six hybrids over standard check exhibits for significant and positive heterosis for plant height. Heterobeltiosis ranged from -12.93% (Salkeerthi x EC169452) to 10.14 % (IC058710 x IC052310), while heterosis over standard check ranges from -9.01% (IC058235 x IC052321) to 13.08% (IC052302 x EC169452). Top significantly and positive heterobeltiosis was observed in the cross-combination to IC058710 x IC052310 (10.14%) and Pusa Sawani x IC052321 (8.63%). Cross combinations IC052302 x EC169452 (13.08%), Pusa Sawani x Kashi Pragati (12.93%) and Pusa Sawani x IC052321 (12.19%) were top hybrids for significant and positive economic heterosis for plant height

## Table.37 Magnitude of heterosis for diverse and pooled environments for plant height

| Crosses | Plant height | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | 7.23* | 9.75** | 5.73 | 5.01 | -4.6 | 6.35 | 12.63* | 13.41* |
| IC058710 x IC052310 | 2.76 | 5.17 | -6.21 | -6.85 | 10.14* | 7.0 | 15.3* | 16.09* |
| IC058710 x EC169459 | 11.14** | 13.75** | 4.26 | 3.55 | 4.41 | 2.7 | 15.31* | 16.1* |
| IC058710 x Kashi Pragati | -1.32 | 0.99 | 4.53 | 3.82 | -3.67 | 2.85 | 0.71 | 7.27 |
| IC058710 x IC052321 | -3.55 | -1.29 | -2.24 | -2.91 | -0.49 | -7.15 | 0.02 | 0.7 |
| IC045993 x EC169452 | -1.93 | 1.4 | 6.84 | 4.42 | -9.58* | 0.8 | 11.49 | 6.94 |
| IC045993 x IC052310 | 0.47 | 3.88 | -3.77 | -5.94 | -3.63 | -1.18 | 10.38 | 3.46 |
| IC045993 x EC169459 | 5.61 | 9.2** | 6.81 | 4.39 | 3.89 | 6.54 | 12.03 | 11.61 |
| IC045993 x Kashi Pragati | 1.49 | 4.94 | 9.42* | 6.95 | -0.39 | 6.35 | 4.18 | 10.96 |
| IC045993 x IC052321 | -5.24 | -2.03 | 11.9** | 9.38* | 0.48 | 3.04 | 9.63 | 8.24 |
| Pusa Sawani x EC169452 | -2.66 | 2.47 | 0.04 | 2.04 | 0.4 | 11.92** | 4.88 | 13.79* |
| Pusa Sawani x IC052310 | -8.43** | -3.6 | -7.84* | -5.99 | -7.93 | -4.29 | -8.07 | -0.25 |
| Pusa Sawani x EC169459 | -1.38 | 3.82 | 3.29 | 5.35 | -10.51* | -6.97 | -2.75 | 5.51 |
| Pusa Sawani x Kashi Pragati | -5.02 | -0.01 | -1.47 | 0.5 | 5.77 | 12.93** | -1.38 | 7 |
| Pusa Sawani x IC052321 | 3.91 | 9.39** | 4.41 | 6.49 | 8.63* | 12.19** | 2.24 | 10.93 |
| VRO-4 x EC169452 | 0.36 | 7.61* | 0.03 | 6.74 | -3 | 8.14 | 0.47 | 12.42 |
| VRO-4 x IC052310 | -4.7 | 2.19 | 4.53 | 11.53** | -1.63 | 5.25 | -0.58 | 11.24 |
| VRO-4 x EC169459 | -2.36 | 4.69 | -3.83 | 2.62 | -7.71 | -1.25 | -4.58 | 6.77 |
| VRO-4 x Kashi Pragati | 5.38 | 13** | -4.08 | 2.34 | 2.63 | 9.81* | 1.28 | 13.33* |
| VRO-4 x IC052321 | -4.04 | 2.89 | -0.04 | 6.66 | -5.51 | 1.1 | -3.15 | 8.36 |
| IC052299 x EC169452 | -5.54 | -2.24 | -3.04 | 2.32 | -8.59* | 1.9 | -1.11 | 5.27 |
| IC052299 x IC052310 | -3.66 | -0.3 | -6.77 | -1.62 | 6.97 | 3.92 | -1.14 | 5.23 |
| IC052299 x EC169459 | 5.33 | 9.01** | -1.51 | 3.93 | 2.63 | 0.95 | 2.87 | 9.5 |
| IC052299 x Kashi Pragati | -5.27 | -1.96 | 0.71 | 6.27 | -5.31 | 1.1 | 0 | 6.51 |
| IC052299 x IC052321 | -1.35 | 2.1 | -3.97 | 1.33 | 4.91 | 0.68 | -0.38 | 6.04 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | -9.46** | -4.47 | 11.07** | 6.81 | -10.57** | -0.3 | 0.09 | 5.34 |
| Kashi Kranti x IC052310 | -14.94** | -10.25** | 5.44 | 1.4 | 1.37 | 1.56 | -31.88** | -28.31** |
| Kashi Kranti x EC169459 | 3.26 | 8.95** | 4.49 | 0.48 | 3.49 | 3.69 | 3.74 | 9.17 |
| Kashi Kranti x Kashi Pragati | 6.33* | 12.19** | 11.64** | 8.16* | 3.21 | 10.19* | 8.2 | 15.24* |
| Kashi Kranti x IC052321 | 2.39 | 8.03* | 7.02 | 2.92 | -2.85 | -2.66 | 2.22 | 7.58 |
| Salkeerthi x EC169452 | 0.25 | -1.83 | 3.39 | 3.06 | -12.93** | -2.93 | -0.72 | 2.66 |
| Salkeerthi x IC052310 | -1.4 | -3.45 | 4.22 | 3.89 | -3.73 | -4.71 | -1.04 | 2.33 |
| Salkeerthi x EC169459 | -1.79 | -3.83 | 7.88* | 7.53* | 6.22 | 5.13 | -0.47 | 2.92 |
| Salkeerthi x Kashi Pragati | 1.99 | 4.14 | 5.05 | 4.71 | -11.15** | -5.13 | 0.23 | 6.75 |
| Salkeerthi x IC052321 | -1.14 | -0.97 | 6.3 | 5.96 | 0.54 | -0.49 | 0.01 | 3.41 |
| IC058235 x EC169452 | -9.03** | -1.24 | 0.25 | -0.51 | -14.6** | -4.79 | -5.76 | 2.37 |
| IC058235 x IC052310 | -7.44* | 0.49 | 7.51* | 6.7 | -6.05 | -2.51 | -2.12 | 6.31 |
| IC058235 x EC169459 | -7.3* | 0.64 | 8.46* | 7.63* | -8.21 | -4.75 | -2.46 | 5.95 |
| IC058235 x Kashi Pragati | -9.64** | -1.9 | 3.04 | 2.26 | -7.51 | -1.25 | -3.97 | 4.31 |
| IC058235 x IC052321 | -11.08** | -3.47 | -1.97 | -2.72 | -12.31** | -9.01* | -8.51 | -0.62 |
| Hisar Naveen x EC169452 | -3.41 | -12.19** | -2.69 | -2.77 | -16** | -6.35 | -3.82 | -2.84 |
| Hisar Naveen x IC052310 | 8.43* | -1.44 | -6.58 | -6.66 | -5.03 | -5.97 | -1.29 | -0.29 |
| Hisar Naveen x EC169459 | 0.71 | -4.81 | -2.33 | -2.41 | 0.65 | -0.34 | 0.9 | 1.92 |
| Hisar Naveen x Kashi Pragati | -2.68 | -0.62 | -0.02 | -0.1 | 1 | 7.83 | 0.44 | 6.97 |
| Hisar Naveen x IC052321 | -8.09* | -7.94* | -8.52* | -8.59* | -2.65 | -3.61 | -3.47 | -2.49 |
| IC052302 x EC169452 | -6.19 | -6.6* | -8.16* | -5.58 | 1.43 | 13.08** | -1.81 | 4.67 |
| IC052302 x IC052310 | -7.83* | -8.23* | -10.87** | -8.37* | -8.86* | -5.74 | -9.21 | -3.22 |
| IC052302 x EC169459 | -6.05 | -6.46* | -12.35** | -9.89** | -3.24 | 0.08 | -7.3 | -1.19 |
| IC052302 x Kashi Pragati | 1.13 | 3.27 | 5.69 | 8.66* | -8.76* | -2.59 | 9.29 | 16.5* |
| IC052302 x IC052321 | 2.99 | 3.17 | 10.42** | 13.53** | -11.29** | -8.25 | 1.0 | 7.66 |
| **Positive significance crosses** | 4 | 10 | 8 | 7 | 2 | 6 | 3 | 7 |
| **Negative significance crosses** | 10 | 5 | 4 | 2 | 10 | 1 | 1 | 1 |

**HB**: Heterobeltiosis, **SH**: Standard Heterosis The signs *, ** represent significance levels of 5% and 1% accordingly

In pooled analysis three cross combinations over better parent and seven crosses over standard check exhibits for significant and positive heterosis for plant height. Heterobeltiosis ranged from -31.88% (Kashi Kranti x IC052310) to 15.31% (IC058710 x EC169459), while heterosis over standard check ranges from - 28.31% (Kashi Kranti x IC052310) to 16.50% (IC052302 x Kashi Pragati). Top significantly and positive (desirable) heterobeltiosis was observed in the cross-combination of IC058710 x EC169459 (15.31%), IC058710 x IC052310 (15.30%) and IC058710 x EC169452 (12.63%). Cross combinations IC052302 x Kashi Pragati (16.50%), IC058710 x EC169459 (16.10%) and IC058710 x IC052310 (16.09 %) were top hybrids for significant and positive economic heterosis for plant height.

**4.6.7 Internodal length**

In E1 twenty-four crosses over better parent and five hybrids over standard check exhibits for significant and positive heterosis for internodal length. Heterobeltiosis ranges from -18.64 % (Pusa Sawani x Kashi Pragati) to 34.59 % (IC045993 x EC169459), while heterosis over standard check ranges from -17.32 % (IC052302 x IC052321) to 21.51% (IC045993 x EC169459). Top significantly and positive heterobeltiosis was observed in the cross-combination to IC045993 x EC169459 (34.59) followed by Hisar Naveen x EC169452 (28.71%) and Kashi Kranti x Kashi Pragati (26.97%). Cross combination of IC045993 x EC169459 (21.51%), Kashi Kranti x Kashi Pragati (17.04%) and VRO-4 x IC052310 (15.42%) were top hybrids for significant and positive economic heterosis for internodal length.

In E2 thirteen crosses over better parent and eleven hybrids over standard check exhibit for significant and positive heterosis for internodal length. Heterobeltiosis ranges from -13.55% (IC058710 x EC169459) to 23.83% (Hisar Naveen x Kashi Pragati), while heterosis over standard check ranges from -12.8% (IC058710 x EC169459) to 21.68% (Hisar Naveen x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of Hisar Naveen x Kashi Pragati (23.83%) followed by Pusa Sawani x IC052321 (21.7%) and Salkeerthi x Kashi Pragati (21.37%). Cross combinations Hisar Naveen x Kashi Pragati (21.68), IC052299 x Kashi Pragati (20.12%) and Pusa Sawani x IC052321 (19.13%) were top hybrids for significant and positive economic heterosis for internodal length.

**Table 38. Magnitude of heterosis for diverse and pooled environments for internodal length**

| Crosses | Internodal length | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | 2.29 | -10.06 | 5.06 | 3.11 | 2.2 | -1.76 | 3.61 | 6.93 |
| IC058710 x IC052310 | 4.66 | -7.15 | 1.39 | -0.12 | 6.69 | 1.29 | 4.7 | 8.05 |
| IC058710 x EC169459 | 23.79** | 11.06 | -13.55* | -12.8* | 2.55 | -0.59 | 4.18 | 10 |
| IC058710 x Kashi Pragati | 13.66 | -0.06 | 13.92* | 11.8 | -5.88 | -4 | 9.45 | 13.01 |
| IC058710 x IC052321 | -1.73 | -10.95 | 10.51 | 8.45 | -2.88 | -4.71 | 1.93 | 7.36 |
| IC045993 x EC169452 | 6.06 | -4.25 | 16.33* | 13.29* | 1.82 | -1.29 | 7.95 | 12.9 |
| IC045993 x IC052310 | 3.71 | -6.37 | 18.54** | 16.77** | 8.01 | 4.71 | 10.43 | 15.5* |
| IC045993 x EC169459 | 34.59** | 21.51** | 11.58 | 12.55 | 17.84** | 14.24** | 21.55** | 28.33** |
| IC045993 x Kashi Pragati | 3.22 | -6.82 | 17.6** | 14.53* | -0.69 | 1.29 | 8.32 | 13.29 |
| IC045993 x IC052321 | 19.73* | 8.49 | 13.71* | 11.3 | -3.24 | -5.06 | 9.91 | 15.76* |
| Pusa Sawani x EC169452 | 5.4 | -1.9 | 4.81 | 0.25 | 4.07 | 2.35 | 4.76 | 10.61 |
| Pusa Sawani x IC052310 | 10.2 | 2.57 | 3.72 | 2.17 | -1.91 | -3.53 | 4.98 | 10.84 |
| Pusa Sawani x EC169459 | 17.53* | 9.39 | 15.09* | 16.09* | -3.23 | -4.82 | 11.62 | 17.86* |
| Pusa Sawani x Kashi Pragati | -18.64* | -9.39 | 14.67* | 10.68 | 1.27 | 3.29 | 5.78 | 11.69 |
| Pusa Sawani x IC052321 | 22.21** | 13.74 | 21.7** | 19.13** | 2.93 | 1.24 | 16.34* | 22.84** |
| VRO-4 x EC169452 | 9.81 | 1.34 | 12.17 | 9.94 | -19.72** | -12.35* | -0.24 | 9.83 |
| VRO-4 x IC052310 | 25.06** | 15.42* | -4.04 | -5.47 | -12.93** | -4.94 | 2.32 | 12.64 |
| VRO-4 x EC169459 | 17.92* | 8.83 | -1.29 | -0.43 | -15.09** | -7.29 | 0.81 | 10.97 |
| VRO-4 x Kashi Pragati | 21.55** | 12.18 | 7.73 | 5.59 | 0.75 | 10 | 9.67 | 20.74** |
| VRO-4 x IC052321 | 18.28* | 9.16 | 0.51 | -1.49 | -2.8 | 6.12 | 5.07 | 15.67* |
| IC052299 x EC169452 | 1.08 | -5.59 | -2.81 | -1.24 | -10.21 | -10 | -4.03 | 4.11 |
| IC052299 x IC052310 | 5.02 | -1.9 | -7.09 | -5.59 | 15.14** | 15.41** | 4.51 | 13.38 |
| IC052299 x EC169459 | 21.41** | 13.41 | -4.03 | -2.48 | 2.82 | 3.06 | 6.78 | 15.84* |
| IC052299 x Kashi Pragati | 7.66 | 0.56 | 18.22** | 20.12** | -5.31 | -3.41 | 7.26 | 16.36* |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| IC052299 x IC052321 | 10.53 | 3.24 | -0.61 | 0.99 | 1.76 | 2 | 3.91 | 12.73 |
| Kashi Kranti x EC169452 | 24.85** | 15.08* | 9.38 | 1.37 | 2.92 | -0.59 | 12.5 | 16.49* |
| Kashi Kranti x IC052310 | 14.18 | 5.25 | 7.57 | 5.96 | 6.46 | 2.82 | 26.09** | 30.56** |
| Kashi Kranti x EC169459 | 23.76** | 14.08 | 0.99 | 1.86 | 6.19 | 2.94 | 11.36 | 17.58* |
| Kashi Kranti x Kashi Pragati | 26.97** | 17.04* | 20.85** | 16.65** | 16.26** | 18.59** | 25.19** | 29.63** |
| Kashi Kranti x IC052321 | 17.03* | 7.88 | 2.79 | 0.62 | 3.6 | 1.65 | 8.49 | 14.26 |
| Salkeerthi x EC169452 | 15.58* | 5.25 | 4.45 | 1.99 | 19.28** | 14.65** | 12.59 | 14.24 |
| Salkeerthi x IC052310 | 15.95* | 5.59 | 7.69 | 6.09 | 9.91 | 1.76 | 10.03 | 13.07 |
| Salkeerthi x EC169459 | 17.06* | 6.59 | 1.35 | 2.24 | 1.94 | -1.18 | 5.78 | 11.69 |
| Salkeerthi x Kashi Pragati | 9.45 | -0.34 | 21.37** | 18.51** | -6.81 | -4.94 | 9.85 | 13.42 |
| Salkeerthi x IC052321 | 15.83* | 5.47 | -3.81 | -5.84 | -5.64 | -7.41 | 1.48 | 6.88 |
| IC058235 x EC169452 | -11.11* | 0.56 | -5.19 | -2.48 | 3.68 | 6 | 3.15 | 11.95 |
| IC058235 x IC052310 | 16.36* | 5.31 | 14.61* | 17.89** | -7.83 | -5.76 | 7.4 | 16.56* |
| IC058235 x EC169459 | 23.89** | 12.12 | -8.7 | -6.09 | -3.68 | -1.53 | 3.57 | 12.4 |
| IC058235 x Kashi Pragati | 18.77* | 7.49 | 6.94 | 10 | -11.74* | -9.76 | 4.29 | 13.18 |
| IC058235 x IC052321 | 5.43 | -4.47 | -12.2 | -9.69 | -14.15** | -12.24* | -7.14 | 0.78 |
| Hisar Naveen x EC169452 | 28.71** | 15.2* | 0.38 | -1.37 | -5.46 | -4.24 | 7.58 | 14.24 |
| Hisar Naveen x IC052310 | 15.61 | 3.46 | 6.56 | 4.97 | 1.16 | 2.47 | 7.7 | 14.37 |
| Hisar Naveen x EC169459 | 25.78** | 12.85 | -6.77 | -5.96 | -0.81 | 0.47 | 6.85 | 13.46 |
| Hisar Naveen x Kashi Pragati | 15.11 | 3.02 | 23.83** | 21.68** | -1.61 | 0.35 | 12.29 | 19.24** |
| Hisar Naveen x IC052321 | 8.51 | -1.68 | -3.54 | -5.22 | 4.18 | 5.53 | 3.55 | 9.96 |
| IC052302 x EC169452 | 15.19 | 3.35 | -7.23 | -1.12 | 1.46 | -1.76 | 2.9 | 10.65 |
| IC052302 x IC052310 | 4.73 | -6.03 | -3.5 | 2.86 | -0.36 | -3.53 | 0.2 | 7.75 |
| IC052302 x EC169459 | 18.06* | 5.92 | -3.38 | 2.98 | 0 | -3.06 | 4.71 | 12.6 |
| IC052302 x Kashi Pragati | 6.23 | -4.69 | 6.12 | 13.11* | 7.5 | 9.65 | 8.51 | 16.69* |
| IC052302 x IC052321 | -8.75 | -17.32* | -10.02 | -4.1 | -0.42 | -2.29 | -5.7 | 1.41 |
| **Positive significance crosses** | 24 | 5 | 13 | 11 | 4 | 4 | 4 | 16 |
| **Negative significance crosses** | 2 | 1 | 1 | 0 | 5 | 1 | 0 | 0 |

**HB**: Heterobeltiosis, **SH**: Standard Heterosis The signs *, ** represent significance levels of 5% and 1% accordingly

In E3 four cross combinations over better parent and four hybrids over standard check exhibit for significant and positive (desirable) heterosis for internodal length. Heterobeltiosis ranges from -19.72% (VRO-4 x EC169452) to 19.28% (Salkeerthi x EC169452), while heterosis over standard check ranges from -12.35% (VRO-4 x EC169452) to 18.59% (Kashi Kranti x Kashi Pragati).Top significantly and positive heterobeltiosis was observed in the cross-combination of Salkeerthi x EC169452 (19.28) followed by Kashi Kranti x IC052310 (26.90%) and Kashi Kranti x Kashi Pragati (25.19%).Cross combinations Kashi Kranti x Kashi Pragati (18.59), IC052299 x IC052310 (15.41%) and Salkeerthi x EC169452 (14.65%) were top hybrids for significant and positive standard heterosis for internodal length.

In pooled analysis four crosses over better parent and sixteen hybrids over standard check exhibit for significant and positive heterosis for internodal length. Heterobeltiosis ranges from -7.41% (IC058235 x IC052321 to 26.09 (Kashi Kranti x IC052310), while heterosis over standard check ranges from 0.78% (IC058235 x IC052321) to 30.56% (Kashi Kranti x IC052310). Top significantly and positive heterobeltiosis was observed in the cross-combination of Kashi Kranti x IC052310 (26.09%) followed by Kashi Kranti x Kashi Pragati (25.19%) and IC045993 x EC169459 (21.55%). Cross combinations Kashi Kranti x IC052310 (30.56%), Kashi Kranti x Kashi Pragati (29.63%) and IC045993 x EC169459 (28.33%) were top hybrids for significant and positive economic heterosis for internodal length.

**4.6.8 Number of branches per plant**

In E1 twenty-five crosses over better parent and eighteen hybrids over standard check exhibits for significant and positive heterosis for number of branches/ plant. Heterobeltiosis ranges from -9.84% (Hisar Naveen x EC169452) to 40.35% (Kashi Kranti x Kashi Pragati), while heterosis over standard check ranges from -12.7% (Hisar Naveen x EC169452) to 26.98% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination to Kashi Kranti x Kashi Pragati (40.35) followed by Kashi Kranti x IC052321 (36.84%) and Pusa Sawani x IC052321 (33.33%). Cross combinations of Kashi Kranti x Kashi Pragati (26.96%), Kashi Kranti x IC052321 (23.81%) and IC045993 x IC052321 (23.10), were top hybrids for significant and positive economic heterosis for number of branches/plant.

In E2 four crosses over better parent and ten hybrids over standard check exhibits for significant and positive heterosis for number of branches/ plant. Heterobeltiosis ranges from -22.78% (VRO-4 x EC169452) to 21.43% (Pusa Sawani x EC169459), while heterosis over standard check ranges from -14.69% (VRO-4 x EC169452) to 24.68% (Salkeerthi x EC169452). Top significantly and positive heterobeltiosis was observed in the cross-combination to Pusa Sawani x EC169459 (21.43%) followed by IC045993 x IC052310 (16.00%) and IC058235 x IC052310 (15.58%). Cross combinations of Salkeerthi x EC169452 (24.68%), IC058235 x IC052310 (24.48%) and IC045993 x IC052310 (21.68%) were top hybrids for significant and positive economic heterosis for number of branches/plant.

In E3 six cross combinations over better parent and four hybrids over standard check exhibits for significant and desirable heterosis for number of branches/ plant. Heterobeltiosis ranges from -18.99% (VRO-4 x EC169452) to 19.74% (IC045993 x Kashi Pragati), while heterosis over standard check ranges from -13.51% (IC058710 x IC052310) to 22.97% (IC045993 x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination to IC045993 x Kashi Pragati (19.74%) followed by IC045993 x IC052310 (18.42%) and IC058235 x IC052310 (15.58%). Cross combinations of IC045993 x Kashi Pragati (22.97%), IC045993 x IC052310 (21.62%) and Salkeerthi x EC169452 (20.27%) and were top hybrids for significant and positive standard heterosis for number of branches/plant.

In pooled analysis eleven crosses over better parent and eleven hybrids over standard check exhibits for significant and positive heterosis for number of branches/ plant. Heterobeltiosis ranges from -13.7% (VRO-4 x EC169452) to 19.40% (Pusa Sawani x EC169459), while heterosis over standard check ranges from -8.7% (VRO-4 x EC169452) to 18.84% (IC045993 x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of Pusa Sawani x EC169459 (19.40%) followed by IC045993 x Kashi Pragati (17.14%) and Salkeerthi x EC169459 (16.42%). Cross combinations of IC045993 x Kashi Pragati (18.84%), IC045993 x IC052321 (17.87%) and Kashi Kranti x Kashi Pragati (16.43%) and were top hybrids for significant and positive economic heterosis for number of branches/plant.

**Table 39. Magnitude of heterosis for diverse and pooled environments for number of branches/plant**

| Crosses | Number of branches/plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | 0.1 | -1.59 | 0.3 | 10.49 | 0 | 6.76 | 0.46 | 6.28 |
| IC058710 x IC052310 | 1.61 | 0 | -15.79* | -10.49 | -15.79** | -13.51* | -10.75 | -7.73 |
| IC058710 x EC169459 | 6.45 | 4.76 | 5.26 | 11.89 | 5.26 | 8.11 | 5.61 | 9.18 |
| IC058710 x Kashi Pragati | -4.84 | -6.35 | 5.26 | 11.89 | 5.26 | 8.11 | 2.34 | 5.8 |
| IC058710 x IC052321 | 1.61 | 0.3 | 0 | 6.29 | 0.2 | 2.7 | 0.47 | 3.86 |
| IC045993 x EC169452 | -6.56 | -9.52 | -1.27 | 9.09 | -1.27 | 5.41 | -2.74 | 2.9 |
| IC045993 x IC052310 | 10.17 | 3.17 | 16* | 21.68** | 18.42** | 21.62** | 12.86* | 14.49* |
| IC045993 x EC169459 | 21.67** | 15.87* | -2.67 | 2.1 | -3.95 | -1.35 | 4.29 | 5.8 |
| IC045993 x Kashi Pragati | 28.81** | 20.63** | 13.33 | 18.88* | 19.74** | 22.97** | 17.14** | 18.84** |
| IC045993 x IC052321 | 32.2** | 23.10** | 10.67 | 16.08* | 9.21 | 12.16* | 16.19** | 17.87** |
| Pusa Sawani x EC169452 | 22.95** | 19.05** | -2.53 | 7.69 | -2.53 | 4.05 | 4.57 | 10.63 |
| Pusa Sawani x IC052310 | 32.76** | 22.22** | 4.05 | 7.69 | 2.67 | 4.05 | 11.59 | 11.59 |
| Pusa Sawani x EC169459 | 26.67** | 20.63** | 21.43** | 18.88* | 11.27 | 6.76 | 19.4** | 15.94* |
| Pusa Sawani x Kashi Pragati | 36.84** | 23.81** | 4.05 | 7.69 | 2.67 | 4.05 | 16* | 12.08 |
| Pusa Sawani x IC052321 | 33.33** | 20.63** | 2.74 | 4.9 | 1.35 | 1.35 | 12.44 | 9.18 |
| VRO-4 x EC169452 | 4.92 | 1.59 | -22.78** | -14.69 | -18.99** | -13.51* | -13.7* | -8.7 |
| VRO-4 x IC052310 | 13.79* | 4.76 | -4.05 | -0.7 | -5.33 | -4.05 | 0.48 | 0.48 |
| VRO-4 x EC169459 | 21.67** | 15.87* | 5.71 | 3.5 | 2.78 | 0 | 9.95 | 6.76 |
| VRO-4 x Kashi Pragati | 1.79 | -9.52 | -2.7 | 0.7 | -4 | -2.7 | 0.5 | -2.9 |
| VRO-4 x IC052321 | 7.14 | -4.76 | 15.07* | 17.48* | 13.51* | 13.51* | 13.43* | 10.14 |
| IC052299 x EC169452 | 13.11* | 9.52 | -2.53 | 7.69 | -2.53 | 4.05 | 1.83 | 7.73 |
| IC052299 x IC052310 | 8.62 | 0 | -1.33 | 3.5 | -5.13 | 0 | 1.93 | 1.93 |
| IC052299 x EC169459 | 13.33* | 7.94 | 4 | 9.09 | 0 | 5.41 | 8.74 | 8.21 |
| IC052299 x Kashi Pragati | 22.64** | 3.17 | 12 | 17.48* | 7.69 | 13.51* | 13.11* | 12.56* |
| IC052299 x IC052321 | 24.07** | 6.35 | 4 | 9.09 | 0 | 5.41 | 8.25 | 7.73 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | 24.59** | 20.3** | -17.05** | 2.1 | -5.68 | 12.16* | -0.43 | 12.08 |
| Kashi Kranti x IC052310 | 31.03** | 20** | -17.05** | 2.1 | -15.91** | 0.2 | 3 | 15.94* |
| Kashi Kranti x EC169459 | 26.67** | 20.63** | -13.64* | 6.29 | -15.91** | 0 | -3 | 9.18 |
| Kashi Kranti x Kashi Pragati | 40.35** | 26.98** | -6.82 | 14.69 | -10.23* | 6.76 | 3.43 | 16.43** |
| Kashi Kranti x IC052321 | 36.84** | 23.81** | -12.5* | 7.69 | -12.5* | 4.05 | -0.43 | 12.08 |
| Salkeerthi x EC169452 | 8.2 | 4.76 | 12.66 | 24.68** | 12.66* | 20.27** | 7.31 | 13.53* |
| Salkeerthi x IC052310 | 16.39* | 12.7* | 10.81 | 14.69 | 9.33 | 10.81 | 11.11 | 11.11 |
| Salkeerthi x EC169459 | 18.03** | 14.29* | 10 | 7.69 | 8.45 | 4.05 | 16.42* | 13.04* |
| Salkeerthi x Kashi Pragati | -8.2 | -11.11 | 6.76 | 10.49 | 5.33 | 6.76 | 6.5 | 2.9 |
| Salkeerthi x IC052321 | 9.84 | 6.35 | 9.59 | 11.89 | 8.11 | 8.11 | 14.43* | 11.11 |
| IC058235 x EC169452 | -1.64 | -4.76 | 5.06 | 16.08* | 5.06 | 12.16* | 3.2 | 9.18 |
| IC058235 x IC052310 | 13.79* | 4.76 | 15.58* | 24.48** | 15.58** | 20.27** | 15.09* | 17.48** |
| IC058235 x EC169459 | 16.67* | 11.11 | 2.6 | 10.49 | 2.6 | 6.76 | 7.55 | 10.14 |
| IC058235 x Kashi Pragati | -1.72 | -9.52 | 1.3 | 9.09 | 1.3 | 5.41 | 0.47 | 2.9 |
| IC058235 x IC052321 | 32.76** | 22.22** | 2.6 | 10.49 | 6.49 | 10.81 | 12.26* | 14.98* |
| Hisar Naveen x EC169452 | -9.84 | -12.7* | -10.13 | -0.7 | -8.86 | -2.7 | -9.59 | -4.35 |
| Hisar Naveen x IC052310 | 6.67 | 1.59 | 1.35 | 4.9 | 2.67 | 4.05 | 3.85 | 4.35 |
| Hisar Naveen x EC169459 | 10 | 4.76 | -1.35 | 2.1 | 1.35 | 1.35 | 2.88 | 3.38 |
| Hisar Naveen x Kashi Pragati | 3.33 | -1.59 | 13.51 | 17.48* | 12* | 13.51* | 10.58 | 11.11 |
| Hisar Naveen x IC052321 | 0 | -4.76 | -4.05 | -0.7 | 0 | 0 | -1.44 | -0.97 |
| IC052302 x EC169452 | 6.56 | 3.17 | -12.66 | -3.5 | -12.66* | -6.76 | -7.31 | -1.93 |
| IC052302 x IC052310 | 4.92 | 1.59 | -1.28 | 7.69 | -1.28 | 4.05 | 0.46 | 5.31 |
| IC052302 x EC169459 | 18.03** | 14.29* | -8.97 | -0.7 | -8.97 | -4.05 | -1.38 | 3.38 |
| IC052302 x Kashi Pragati | 6.56 | 3.17 | -1.28 | 7.69 | 0 | 5.41 | 1.38 | 6.28 |
| IC052302 x IC052321 | -1.64 | -4.76 | -15.38* | -7.69 | -14.1* | -9.46 | -11.06 | -6.76 |
| **Positive significance crosses** | 25 | 18 | 4 | 10 | 6 | 4 | 11 | 11 |
| **Negative significance crosses** | 0 | 1 | 6 | 0 | 7 | 1 | 0 | 0 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly. **HB:** Heterobeltiosis, **SH:** Standard Heterosis

### 4.6.9 Number of nodes per plant

In E1 thirteen crosses over better parent and seven hybrids over standard check exhibits for significant and positive heterosis for number of nodes/ plant. Heterobeltiosis ranges from -13.31% (IC052302 x IC052321 to 23.74% (Kashi Kranti x IC052321), while heterosis over standard check ranges from -11.41% (Hisar Naveen x IC052321) to 20.37% (VRO-4 x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of Kashi Kranti x IC052321 (23.74%) followed by Kashi Kranti x EC169459 (20.74%) and IC058235 x EC169459 (20.62%). Cross combinations of VRO-4 x Kashi Pragati (20.37), Pusa Sawani x EC169452 (16.80%) and VRO-4 x EC169452 (16.39%) were top hybrids for significant and positive standard heterosis for number of nodes/plant.

In E2 seven crosses over better parent and thirteen hybrids over standard check exhibits for significant and positive heterosis for number of nodes/ plant. Heterobeltiosis ranges from -8.43% (Hisar Naveen x EC169452) to 17.28% (IC058235 x Kashi Pragati), while heterosis over standard check ranges from -3.36% (Hisar Naveen x EC169452) to 21.28% (IC058235 x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC058235 x Kashi Pragati (17.28%) followed by VRO-4 x IC052310 (16.05%) and IC058235 x IC052321 (14.68%). Cross combinations of IC058235 x Kashi Pragati (21.28%), VRO-4 x IC052310 (17.87%) and IC058235 x IC052321 (17.02%) were top hybrids for significant and positive standard heterosis for number of nodes/plant.

In E3 three crosses over better parent and ten hybrids over standard check exhibits for significant and positive heterosis for number of nodes/ plant. Heterobeltiosis ranges from -12.22% (IC058235 x EC169459) to 21.46% (Pusa Sawani x IC052321), while heterosis over standard check ranges from -5.7% (VRO-4 x IC052310) to 26.58% (Pusa Sawani x IC052321). Top significantly and positive heterobeltiosis was observed in the cross-combination of Pusa Sawani x IC052321 (21.46%) followed by VRO-4 x EC169459 (16.23%) and Pusa Sawani x EC169452 (14.82%). Cross combinations of Pusa Sawani x IC052321 (26.58%), VRO-4 x EC169459 (19.07%) and Pusa Sawani x EC169452 (16.03%) were top hybrids for significant and positive economic heterosis for number of nodes/plant.

**Table 40. Magnitude of heterosis for diverse and pooled environments for number of nodes/plant**

| Crosses | Number of nodes/plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | 13.78 | 4.36 | 0.55 | 1.77 | 4.93 | 3.38 | 6.96 | 5.47 |
| IC058710 x IC052310 | -2.96 | -11 | 1.32 | 2.55 | -1.35 | -0.97 | 0.35 | -1.05 |
| IC058710 x EC169459 | 14.45* | 4.98 | -2.69 | 0.21 | 1.08 | 2.57 | 3.99 | 4.89 |
| IC058710 x Kashi Pragati | 6.79 | -1.41 | 3.29 | 6.81 | 2.67 | 5.49 | 3.82 | 5.53 |
| IC058710 x IC052321 | 2.69 | -5.81 | 2.17 | 3.4 | 1.34 | 5.61 | 3.71 | 3.27 |
| IC045993 x EC169452 | 4.31 | 2.9 | -1.98 | 1.36 | 7.73 | 11.18* | 2.39 | 6.48 |
| IC045993 x IC052310 | -8.31 | -9.54 | -2.47 | 0.85 | -5.15 | -2.11 | -5.29 | -1.51 |
| IC045993 x EC169459 | 17.14** | 15.56* | 0.25 | 3.66 | -3.92 | -0.84 | 4.38 | 8.54 |
| IC045993 x Kashi Pragati | 3.91 | 2.51 | 1.65 | 5.11 | 1.04 | 4.28 | 2.19 | 6.27 |
| IC045993 x IC052321 | -2.38 | -3.69 | -5.19 | -1.96 | 6.28 | 10.76* | 17.87** | 22.58** |
| Pusa Sawani x EC169452 | 11.71 | 16.8** | 7.76* | 12.34** | 14.82** | 16.03** | 8.21 | 14.27** |
| Pusa Sawani x IC052310 | -6.75 | -2.49 | -4.08 | 0 | 2 | 3.08 | -3.01 | 2.41 |
| Pusa Sawani x EC169459 | 8.13 | 13.07* | 6.14 | 10.66** | 1.04 | 2.53 | 5.3 | 11.19* |
| Pusa Sawani x Kashi Pragati | -11.96 | -7.95 | 8.27* | 12.87** | 8.01 | 10.97* | 1.85 | 7.54 |
| Pusa Sawani x IC052321 | -0.99 | 3.53 | -0.02 | 4.23 | 21.46** | 26.58** | 1.01 | 6.66 |
| VRO-4 x EC169452 | 14.16* | 16.39* | 1.63 | 3.23 | 9.14 | 11.81* | 8.37 | 12.99** |
| VRO-4 x IC052310 | -3.13 | -1.24 | 16.05** | 17.87** | -7.95 | -5.7 | 1.55 | 5.88 |
| VRO-4 x EC169459 | 7.22 | 9.32 | 0.85 | 3.85 | 16.23** | 19.07** | 8.59 | 13.22** |
| VRO-4 x Kashi Pragati | 18.07** | 20.37** | 6.17 | 9.79* | -5.87 | -3.29 | 6.89 | 11.44* |
| VRO-4 x IC052321 | 0.53 | 2.49 | 3.71 | 5.34 | 2.55 | 6.88 | 2.84 | 7.22 |
| IC052299 x EC169452 | 12.66 | 11.72 | -3.32 | -0.85 | -6.89 | 1.56 | 0.6 | 6.52 |
| IC052299 x IC052310 | -3.31 | -4.11 | 0.48 | 3.04 | -2.51 | 6.33 | 5.62 | 11.83* |
| IC052299 x EC169459 | 13.12* | 12.18 | 0.95 | 3.96 | -2.32 | 6.54 | 15.78** | 22.50** |
| IC052299 x Kashi Pragati | 7.62 | 6.72 | -1.63 | 1.72 | -4.84 | 3.8 | 9.68* | 16.13** |
| IC052299 x IC052321 | 4.08 | 3.22 | 0 | 2.55 | -6.38 | 2.11 | -0.91 | 4.91 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | 14.27* | 4.83 | 4.82 | 9.72* | -0.77 | 9.07 | 5.69 | 10.25* |
| Kashi Kranti x IC052310 | 11.71 | 2.49 | 5.85 | 10.81** | 5.03 | 15.44** | 2.93 | 7.37 |
| Kashi Kranti x EC169459 | 20.74** | 10.77 | 5.16 | 10.09* | -2.5 | 7.17 | 7.15 | 11.78* |
| Kashi Kranti x Kashi Pragati | 17.3* | 8.3 | 8.17* | 13.23** | 1.34 | 11.39* | 8.73 | 13.42** |
| Kashi Kranti x IC052321 | 23.74** | 13.53* | 0.81 | 5.53 | -0.58 | 9.28 | 7.28 | 11.91* |
| Salkeerthi x EC169452 | 16.23* | 3.69 | -1.05 | 0.64 | 2.57 | 6.12 | 4.35 | 4.6 |
| Salkeerthi x IC052310 | 2.33 | -8.71 | 0.42 | 2.13 | 0.53 | 4.01 | 0.69 | 0.94 |
| Salkeerthi x EC169459 | 16.92* | 7.22 | 2.56 | 5.62 | -2.2 | 1.18 | 2.13 | 3.01 |
| Salkeerthi x Kashi Pragati | -1.12 | -8.71 | -0.76 | 2.62 | -1.1 | 2.32 | 2.26 | 3.94 |
| Salkeerthi x IC052321 | 7.7 | -3.69 | 0.84 | 2.55 | -1.74 | 2.41 | 0.46 | 0.71 |
| IC058235 x EC169452 | -1.87 | -5.5 | 7.26 | 9.45* | -8.14 | 2.32 | -1.15 | 4.29 |
| IC058235 x IC052310 | -4.37 | -7.9 | 2.34 | 4.43 | -5.49 | 5.27 | -2.59 | 2.77 |
| IC058235 x EC169459 | 20.62** | 16.16* | 11.16** | 14.47** | -12.2** | -2.19 | 4.87 | 10.65* |
| IC058235 x Kashi Pragati | -1.77 | -5.39 | 17.28** | 21.28** | -7.95 | 2.53 | -1.85 | 3.56 |
| IC058235 x IC052321 | -4.31 | -7.84 | 14.68** | 17.02** | -9.39* | 0.93 | -2.39 | 2.98 |
| Hisar Naveen x EC169452 | 12.79 | 2.07 | -8.43* | -3.36 | -8.63 | -0.34 | -2.11 | 1.69 |
| Hisar Naveen x IC052310 | 5.5 | -4.52 | -4.03 | 1.28 | 2.71 | 12.03* | 1.24 | 5.18 |
| Hisar Naveen x EC169459 | 15.77* | 6.16 | -4.8 | 0.47 | -12.07** | -4.09 | -0.74 | 3.12 |
| Hisar Naveen x Kashi Pragati | 5.21 | -2.86 | -2.82 | 2.55 | -5.65 | 2.91 | -0.77 | 3.08 |
| Hisar Naveen x IC052321 | -2.11 | -11.41 | -3.23 | 2.13 | -7.74 | 0.63 | -4.5 | -0.79 |
| IC052302 x EC169452 | 4.74 | 7.78 | -1.24 | -0.4 | 0.27 | 7.81 | 1.28 | 7.43 |
| IC052302 x IC052310 | -3.83 | -1.04 | 3.8 | 4.68 | -4.16 | 3.04 | -1.5 | 4.47 |
| IC052302 x EC169459 | 3.43 | 6.43 | -0.83 | 2.13 | -7.69 | -0.76 | -1.09 | 4.9 |
| IC052302 x Kashi Pragati | -2.02 | 0.83 | 0.82 | 4.26 | -8.12 | -1.22 | -2.39 | 3.53 |
| IC052302 x IC052321 | -13.31* | -10.79 | 0.84 | 1.7 | -6.4 | 0.63 | -6.39 | -0.72 |
| **Positive significance crosses** | 13 | 7 | 7 | 13 | 3 | 10 | 3 | 14 |
| **Negative significance crosses** | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 |

The signs *, ** represent significance levels of 5% and 1%. **HB:** Heterobeltiosis, **SH:** Standard Heterosis

In pooled analysis three crosses over better parent and fourteen hybrids over standard check exhibits for significant and positive heterosis for number of nodes/ plant. Heterobeltiosis ranges from -6.39% (IC052302 x IC052321) to 17.87% (IC045993 x IC052321), while heterosis over standard check ranges from -1.05% (IC058710 x IC052310) to 22.58% (IC045993 x IC052321). Top significantly and positive heterobeltiosis was observed in the cross-combinations IC045993 x IC052321 (17.87%) followed by IC052299 x EC16945 (15.78%) and IC052299 x Kashi Pragati (9.68%). Cross combinations of IC045993 x IC052321 (22.58), IC052299 x EC169459 (22.50%) and IC052299 x Kashi Pragati (16.13%) were top hybrids for significant and positive standard heterosis for number of nodes/plant.

#### 4.6.10 Fruit length

In E1 sixteen crosses over better parent and six hybrids over standard check exhibits for significant and positive heterosis for fruit length. Heterobeltiosis ranges from -5.44% (Salkeerthi x EC169452) to 31.38% (IC058235 x EC169452), while heterosis over standard check ranges from -10.95% (IC052302 x EC169452 to 14.26% (Kashi Kranti x EC169459). Top significantly and positive heterobeltiosis was observed in the cross-combination IC058235 x EC169452 (31.38%) followed by Kashi Kranti x IC052321 (21.16%) and Kashi Kranti x EC169459 (19.89%). Cross combinations of Kashi Kranti x Kashi Pragati (14.26%), IC052299 x EC169459 (12.01%) and Kashi Kranti x IC052321 (11.98%) were top hybrids for significant and positive standard heterosis for fruit length.

In E2 seven crosses over better parent and seven hybrids over standard check exhibits for significant and positive heterosis for fruit length. Heterobeltiosis ranges from -14.41 (Pusa Sawani x IC052321) to 18.48 (IC052302 x IC052310), while heterosis over standard check ranges from -4.95 (IC052302 x EC169452) to 16.29 (Kashi Kranti x EC169459). Top significantly and positive heterobeltiosis was observed in the cross-combination to IC052302 x IC052310 (18.48) followed by Kashi Kranti x EC169459 (16.24%) Kashi Kranti x Kashi Pragati (14.7%). Cross combinations of Kashi Kranti x EC169459 (16.29), Kashi Kranti x Kashi Pragati (14.76%) and IC052302 x IC052310 (12.29) were top hybrids for significant and positive economic heterosis for fruit length.

In E3 five cross combinations over better parent and three hybrids over standard check exhibits for significant and desirable (positive) heterosis for fruit length.

Heterobeltiosis ranges from -14.88 % (IC058710 x Kashi Pragati) to 14.15 % (Kashi Kranti x Kashi Pragati), while heterosis over standard check ranges from -11.36% (IC058710 x Kashi Pragati) to 12.02% (VRO-4 x IC052310). Top significantly and positive heterobeltiosis was observed in the cross-combination to Kashi Kranti x Kashi Pragati (14.15%) followed by VRO-4 x IC052310 (9.6%) and VRO-4 x Kashi Pragati (9.28%). Cross combinations of VRO-4 x IC052310 (12.02%), VRO-4 x Kashi Pragati (11.69%) and Kashi Kranti x Kashi Pragati (11.36%) were top hybrids for significant and positive standard heterosis for fruit length.

In pooled analysis four crosses over better parent and sixteen hybrids over standard check exhibits for significant and positive heterosis for fruit length. Heterobeltiosis ranges from -3.76% (Pusa Sawani x IC052321) to 15.97% (Kashi Kranti x Kashi Pragati), while heterosis over standard check ranges from 1.15% (IC052302 x EC169452) to 19.58% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination to Kashi Kranti x Kashi Pragati (15.97%) followed by Kashi Kranti x EC169459 (15.43%) and IC052302 x Kashi Pragati (9.88%). Cross combinations of combination Kashi Kranti x Kashi Pragati (19.58), Kashi Kranti x EC169459 (19.02%) and Kashi Kranti x IC052321 (13.94%) were top hybrids for significant and positive economic heterosis for fruit length.

### 4.6.11 Fruit diameter

In E1 twenty crosses over better parent and eleven hybrids over standard check exhibits for significant and positive (desirable) heterosis for fruit diameter. Heterobeltiosis ranges from -6.53 % (IC058235 x IC052310) to 23.89 % (IC058235 x EC169452), while heterosis over standard check ranges from -6.8 % (Pusa Sawani x EC169459) to 13.46% (IC052299 x EC169459). Top significantly and positive heterobeltiosis was observed in the cross-combination IC058235 x EC169452 (23.89 %) followed by Kashi Kranti x Kashi Pragati (23.43%) and IC058235 x Kashi Pragati (18.15%). Cross combinations of IC052299 x EC169459 (13.46%), Kashi Kranti x Kashi Pragati (13.38 %) and VRO-4 x IC052310 (13.09%) were top hybrids for significant and positive economic heterosis for fruit diameter.

**Table 41. Magnitude of heterosis for diverse and pooled environments for fruit length**

| Crosses | Fruit length | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | 0.16 | -8.99 | 0.67 | -0.8 | -4.18 | -0.21 | -1.23 | 3.11 |
| IC058710 x IC052310 | 11.08* | 0.93 | 5.89 | 4.34 | -8.22* | -4.42 | 2.44 | 6.94 |
| IC058710 x EC169459 | 4.5 | -0.41 | -2.9 | -4.32 | -7.17 | -3.33 | -0.55 | 3.82 |
| IC058710 x Kashi Pragati | 4.01 | -3.04 | 10.2* | 8.59 | -14.88** | -11.36** | 0.11 | 4.51 |
| IC058710 x IC052321 | 7.77 | -1.29 | -0.14 | 3.17 | -3.33 | 0.67 | 1.3 | 7.56 |
| IC045993 x EC169452 | -3.48 | -6.85 | -4.41 | -2.78 | 0.52 | 1.9 | -2.42 | 3.94 |
| IC045993 x IC052310 | 7.13 | 3.38 | 3.45 | 5.22 | -8.16* | -6.89 | 0.67 | 7.23 |
| IC045993 x EC169459 | 9.96* | 6.11 | 10.22* | 12.1* | -3.7 | -2.38 | 5.37 | 12.24** |
| IC045993 x Kashi Pragati | 8.87 | 5.06 | 5.13 | 6.93 | -5.44 | -4.13 | 2.72 | 9.42 |
| IC045993 x IC052321 | 6.41 | 2.68 | -2.08 | 1.17 | -2.04 | 1.64 | 1.98 | 8.63 |
| Pusa Sawani x EC169452 | 16.87** | 6.25 | 2.73 | 8.15 | -5.12 | -1.38 | 4.28 | 11.26 |
| Pusa Sawani x IC052310 | 13.71** | 3.38 | 4.84 | 10.37* | -0.82 | 3.09 | 5.55 | 12.62** |
| Pusa Sawani x EC169459 | 4.43 | -0.48 | -3.2 | 1.9 | -7.96* | -4.33 | -1.02 | 5.62 |
| Pusa Sawani x Kashi Pragati | 15.32** | 7.5 | 0.14 | 5.41 | -8.87* | -5.28 | 2.48 | 9.35 |
| Pusa Sawani x IC052321 | 5.26 | -3.59 | -14.41** | -9.9* | -1.74 | 2.14 | -3.76 | 2.69 |
| VRO-4 x EC169452 | 3.02 | 3.71 | 1.69 | 5.56 | -1.79 | 0.38 | 0.96 | 10.09* |
| VRO-4 x IC052310 | 2.74 | 3.43 | -3.74 | -0.07 | 9.6* | 12.02** | 2.89 | 12.2** |
| VRO-4 x EC169459 | 5.21 | 5.92 | 3.85 | 7.8 | -1.84 | 0.33 | 2.38 | 11.64** |
| VRO-4 x Kashi Pragati | 8.12 | 8.84 | 1.81 | 5.68 | 9.28* | 11.69** | 6.4 | 16.03** |
| VRO-4 x IC052321 | 4.17 | 4.86 | 2.82 | 6.73 | 1.19 | 4.99 | 3.23 | 12.56** |
| IC052299 x EC169452 | 4.39 | 0.91 | -4.65 | -3.02 | -5.8 | -3.47 | -2.13 | 4.69 |
| IC052299 x IC052310 | 8.87 | 5.25 | 8.42 | 10.27* | 0.05 | 2.52 | 5.68 | 13.05** |
| IC052299 x EC169459 | 15.87** | 12.01* | 2.37 | 4.12 | -4.68 | -2.33 | 4.29 | 11.56* |
| IC052299 x Kashi Pragati | 8.7 | 5.08 | -3.36 | -1.71 | -5.1 | -2.76 | -0.07 | 6.9 |
| IC052299 x IC052321 | 13.06** | 9.3* | 0.76 | 4.1 | -3.94 | -0.33 | 4.05 | 11.31* |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | 4.41 | -3.5 | -0.83 | -0.78 | 9.06* | 6.39 | 4.21 | 7.45 |
| Kashi Kranti x IC052310 | 5.03 | -2.92 | 3.17 | 3.22 | 7.24 | 4.61 | 7.92 | 11.27 |
| Kashi Kranti x EC169459 | 19.89** | 14.26** | 16.24** | 16.29** | 6.92 | 4.3 | 15.43** | 19.02** |
| Kashi Kranti x Kashi Pragati | 18.25** | 10.23* | 14.7** | 14.76** | 14.15** | 11.36** | 15.97** | 19.58** |
| Kashi Kranti x IC052321 | 21.16** | 11.98* | 5.19 | 8.68 | -3.76 | -0.14 | 7.3 | 13.94** |
| Salkeerthi x EC169452 | -5.44 | -5.01 | -2.77 | -0.59 | 3.67 | -0.05 | -1.33 | 4.91 |
| Salkeerthi x IC052310 | 0.57 | 1.03 | -4.46 | -2.32 | 3.43 | -0.29 | 2.98 | 9.5 |
| Salkeerthi x EC169459 | -1.91 | -1.46 | -1.86 | 0.34 | 8.45* | 4.56 | 3.48 | 10.03 |
| Salkeerthi x Kashi Pragati | 2.22 | 2.68 | 5.2 | 7.56 | 6.33 | 2.52 | 5.3 | 11.97** |
| Salkeerthi x IC052321 | -3.72 | -3.28 | 1.7 | 5.07 | -2.29 | 1.38 | -0.97 | 5.3 |
| IC058235 x EC169452 | 31.38** | 9.47* | -2.85 | 3.22 | -1.78 | 2.38 | 7.28 | 12.03** |
| IC058235 x IC052310 | 3.12 | -9.73* | -9.39* | -3.73 | -4.7 | -0.67 | -2.66 | 1.66 |
| IC058235 x EC169459 | 4.73 | -0.19 | -4.41 | 1.56 | -3.6 | 0.48 | 2.77 | 7.32 |
| IC058235 x Kashi Pragati | 4.4 | -2.68 | -8.52 | -2.8 | -6.7 | -2.76 | -0.66 | 3.74 |
| IC058235 x IC052321 | 16.72** | 6.9 | -2.55 | 3.54 | -5.15 | -1.14 | 3.56 | 9.97 |
| Hisar Naveen x EC169452 | 9.92* | 4.05 | 14.28** | 10.1* | -0.81 | -3.56 | 7.7 | 10.38 |
| Hisar Naveen x IC052310 | 9.54 | 3.69 | 9.54 | 5.54 | -1.15 | -3.9 | 5.9 | 8.53 |
| Hisar Naveen x EC169459 | 3.39 | -1.46 | -0.2 | -1.66 | 1.44 | -1.38 | 2.19 | 5.08 |
| Hisar Naveen x Kashi Pragati | 5.22 | -0.41 | 5.22 | 1.37 | 5.4 | 2.47 | 5.28 | 7.9 |
| Hisar Naveen x IC052321 | 12.91** | 6.88 | 2.22 | 5.61 | -7.24 | -3.75 | 3.35 | 9.74 |
| IC052302 x EC169452 | 0.98 | -10.95* | 0.28 | -4.95 | -2.81 | 0.33 | -0.63 | 1.15 |
| IC052302 x IC052310 | 11.3* | -1.85 | 18.48** | 12.29* | -1.66 | 1.52 | 8.92* | 10.87 |
| IC052302 x EC169459 | 7.79 | 2.73 | -7.85 | -9.2 | -2.35 | 0.81 | 1.84 | 4.72 |
| IC052302 x Kashi Pragati | 10.8* | 3.28 | 12.86* | 7.9 | 0.21 | 3.45 | 9.88* | 11.85** |
| IC052302 x IC052321 | 6.02 | -2.9 | -4.34 | -1.17 | -5.27 | -1.71 | -1.48 | 4.62 |
| **Positive significance crosses** | 16 | 6 | 7 | 7 | 5 | 3 | 4 | 16 |
| **Negative significance crosses** | 0 | 2 | 2 | 1 | 5 | 1 | 0 | 0 |

The signs *, ** represent significance levels of 5% and 1%. **HB:** Heterobeltiosis, **SH:** Standard Heterosis

In E2 six crosses over better parent and six hybrids over standard check exhibits for significant and positive heterosis for fruit diameter. Heterobeltiosis ranges from -14.06% (IC058710 x Kashi Pragati) to 20.29% (Kashi Kranti x Kashi Pragati), while heterosis over standard check ranges from -14.51% (IC058710 x Kashi Pragati) to 14.77% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination Kashi Kranti x Kashi Pragati (20.29%) followed by Salkeerthi x EC169459 (18.69%) and IC058710 x EC169459 (14.69%). Cross combinations of Kashi Kranti x Kashi Pragati (14.77%), IC058710 x EC169459 (14.04 %) and IC045993 x Kashi Pragati (12.09%) were top hybrids for significant and positive standard (economic) heterosis for fruit diameter.

In E3 five crosses over better parent and six hybrids over standard check exhibits for significant and positive heterosis for fruit diameter. Heterobeltiosis ranges from -17.5% (IC058235 x IC052310) to 16.45% (IC058710 x EC169452), while heterosis over standard check ranges from -10.55% (Pusa Sawani x IC052321) to 16.50% (Salkeerthi x IC052321). Top significantly and positive heterobeltiosis was observed in the cross-combination IC058710 x EC169452 (16.45%) followed by Salkeerthi x IC052321 (14.89%) and IC045993 x Kashi Pragati (11.85%). Cross combinations of Salkeerthi x IC052321 (16.50%), IC058710 x EC169452 (16.23%) and IC045993 x Kashi Pragati (13.12%) were top hybrids for significant and positive desirable economic heterosis for fruit diameter.

In pooled analysis six crosses over better parent and five hybrids over standard check exhibits for significant and positive heterosis for fruit diameter. Heterobeltiosis ranges from -13.66 (IC058235 x IC052310) to 17.46% (Kashi Kranti x Kashi Pragati), while heterosis over standard check ranges from - 4.12% (IC058235 x IC052310) to 13.12% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination Kashi Kranti x Kashi Pragati (17.46%) followed by IC058235 x Kashi Pragati (13.94%) and Salkeerthi x EC169459 (13.51%). Cross combinations of Kashi Kranti x Kashi Pragati (13.12%), IC045993 x Kashi Pragati (12.93%) and Salkeerthi x EC169459 (11.41%) were top hybrids for significant and positive standard heterosis for fruit diameter.

## Table 42. Magnitude of heterosis for diverse and pooled environments for fruit diameter

| Crosses | Fruit diameter | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | 12.16** | 6.11 | -4.79 | -5.29 | 16.45** | 16.23** | 5.86 | 3.76 |
| IC058710 x IC052310 | 0.27 | 0.05 | -5.25 | -5.75 | -11.85** | -0.31 | -9.77* | 0.18 |
| IC058710 x EC169459 | 9.05* | 5.34 | 14.64** | 14.04** | 8.63 | 8.42 | 10.02* | 7.83 |
| IC058710 x Kashi Pragati | 10.78* | 4.81 | -14.06** | -14.51** | -10.39* | -9.57 | 0.73 | -1.27 |
| IC058710 x IC052321 | 10.21* | 4.27 | -8.67 | -9.14 | -5.01 | -3.9 | -0.25 | -1.77 |
| IC045993 x EC169452 | 4.86 | 4.69 | -4.89 | -5.82 | -1.51 | -0.39 | -0.38 | 1.8 |
| IC045993 x IC052310 | 0.27 | 0.11 | -5.48 | -6.23 | -12.3** | -0.82 | -10.02* | -0.08 |
| IC045993 x EC169459 | 2.41 | 2.24 | -5.02 | -5.95 | -1.64 | -0.53 | -0.6 | 1.57 |
| IC045993 x Kashi Pragati | 10.63* | 10.45* | 13.18** | 12.08* | 11.85* | 13.12* | 10.51* | 12.93** |
| IC045993 x IC052321 | -0.75 | -0.92 | -6.93 | -7.84 | -3.65 | -2.52 | -2.01 | 0.13 |
| Pusa Sawani x EC169452 | 3.8 | -5.06 | 6.65 | -4.71 | 6.65 | 0.78 | 4.1 | -1.23 |
| Pusa Sawani x IC052310 | -3.73 | -3.95 | -6.96 | -7.70 | -13.67** | -2.37 | -10.52* | -0.65 |
| Pusa Sawani x EC169459 | 5.04 | 1.47 | -2.86 | -9.65* | -2.86 | -4.44 | 2.19 | -0.84 |
| Pusa Sawani x Kashi Pragati | 1.9 | -6.8 | -5.92 | -10.24* | -5.92 | -5.06 | 0.73 | -2.99 |
| Pusa Sawani x IC052321 | 15.66** | 5.78 | -7.58 | -11.60* | -11.58* | -10.55* | 4.31 | 2.73 |
| VRO-4 x EC169452 | 0.96 | 2.75 | 8.36 | 3.14 | 6.83 | 9.09 | 1.89 | 3.92 |
| VRO-4 x IC052310 | 11.12** | 13.09** | 11.02* | 10.14* | -3.2 | 9.47 | -3.08 | 7.62 |
| VRO-4 x EC169459 | 6.85 | 8.75* | 5.31 | 0.25 | 3.83 | 6.03 | 2.49 | 4.54 |
| VRO-4 x Kashi Pragati | 8.92* | 10.85* | 7.87 | 2.92 | 6.6 | 8.86 | 5.45 | 7.56 |
| VRO-4 x IC052321 | 7.39 | 9.29* | 3.18 | -1.30 | 2.23 | 4.39 | 3.5 | 5.56 |
| IC052299 x EC169452 | 6.41 | 0.93 | 8.64 | 1.26 | 8.64 | 7.11 | 10.47* | 9.18* |
| IC052299 x IC052310 | 2.92 | 2.69 | -4.03 | -4.79 | -10.95* | 0.71 | -9.68* | 0.29 |
| IC052299 x EC169459 | 17.45** | 13.46** | -0.04 | -6.83 | -0.04 | -1.46 | 6.39 | 5.15 |
| IC052299 x Kashi Pragati | 0.65 | -4.54 | 0.26 | -4.34 | 0.26 | 1.18 | 0.19 | -0.97 |
| IC052299 x IC052321 | 5.48 | 0.04 | -4.25 | -8.41 | -4.25 | -3.13 | -0.71 | -1.86 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | 11.11* | 2.06 | 1.44 | -8.21 | 1.44 | -2.92 | 5.05 | 0.07 |
| Kashi Kranti x IC052310 | -2.26 | -2.48 | 4.02 | 3.20 | -1.59 | 11.29* | -7.74 | 2.45 |
| Kashi Kranti x EC169459 | 15.34** | 11.42** | -3.03 | -9.81* | -3.03 | -4.61 | 5.62 | 2.49 |
| Kashi Kranti x Kashi Pragati | 23.43** | 13.38** | 20.29** | 14.77** | 10.66* | 11.67* | 17.46** | 13.12** |
| Kashi Kranti x IC052321 | 16.4** | 6.92 | -6.85 | -10.91* | -6.85 | -5.77 | 2.04 | 0.49 |
| Salkeerthi x EC169452 | 6.88 | 6.54 | -0.99 | -9.57* | -0.99 | -4.36 | 1.68 | -0.21 |
| Salkeerthi x IC052310 | 7.57 | 7.33 | -7.36 | -8.09 | -14.04** | -2.79 | -10.53* | -0.66 |
| Salkeerthi x EC169459 | 12.14** | 11.79** | 18.69** | 10.39* | 10.04 | 8.25 | 13.52** | 11.41* |
| Salkeerthi x Kashi Pragati | 11.24* | 10.89* | 3.80 | -0.96 | 3.8 | 4.75 | 9.2 | 7.17 |
| Salkeerthi x IC052321 | 5.55 | 5.22 | -8.94 | -12.90** | 14.89** | 16.50** | 4.61 | 3.02 |
| IC058235 x EC169452 | 23.89** | 6.14 | -7.60 | -10.25* | -7.6 | -5.07 | 4.03 | 0.04 |
| IC058235 x IC052310 | -6.53 | -6.74 | -11.09* | -11.79* | -17.5** | -6.7 | -13.66** | -4.12 |
| IC058235 x EC169459 | 15.71** | 11.77** | -5.42 | -8.13 | -5.42 | -2.83 | 7.66 | 4.46 |
| IC058235 x Kashi Pragati | 18.15** | 1.22 | 11.53* | 8.33 | 6.03 | 8.93 | 13.94** | 9.74* |
| IC058235 x IC052321 | 14.19** | 2.54 | -6.69 | -9.36 | -6.69 | -4.13 | 0.02 | -1.5 |
| Hisar Naveen x EC169452 | -5.34 | -7.56 | -4.73 | -9.70 | -4.73 | -4.49 | -3.59 | -3.9 |
| Hisar Naveen x IC052310 | 2.66 | 2.42 | -9.58* | -10.30* | -16.1** | -5.12 | -10.56* | -0.69 |
| Hisar Naveen x EC169459 | 2.22 | -0.18 | -6.02 | -10.92* | -6.02 | -5.79 | -1.54 | -1.85 |
| Hisar Naveen x Kashi Pragati | 0.76 | -1.6 | -6.64 | -10.92* | -6.64 | -5.79 | -0.68 | -1 |
| Hisar Naveen x IC052321 | -0.79 | -3.12 | 0.44 | -3.93 | 0.44 | 1.61 | 1.25 | 0.92 |
| IC052302 x EC169452 | 10.61* | 2.22 | -2.36 | -9.25 | -2.36 | -4.02 | 3.23 | -0.29 |
| IC052302 x IC052310 | 1.13 | 0.9 | -6.88 | -7.61 | -13.59** | -2.29 | -9.94* | 0 |
| IC052302 x EC169459 | 6.62 | 3 | -3.65 | -10.39* | -3.65 | -5.22 | 3.05 | -0.01 |
| IC052302 x Kashi Pragati | 1.73 | -5.99 | -4.94 | -9.30 | 10.83* | 11.84* | 1.6 | -1.86 |
| IC052302 x IC052321 | 8.32 | 0.11 | -7.50 | -11.53* | -0.29 | 0.88 | 1.34 | -0.2 |
| **Positive significance crosses** | 20 | 11 | 6 | 6 | 5 | 6 | 6 | 5 |
| **Negative significance crosses** | 0 | 0 | 1 | 14 | 9 | 1 | 3 | 0 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly. **HB:** Heterobeltiosis, **SH:** Standard Heterosis

### 4.6.12 Number of ridges/ fruits

In E1 twenty cross combination over better parent and eleven hybrids over standard check exhibits for significant and positive heterosis for number of ridges/fruit. Heterobeltiosis ranges from -6.41% (Salkeerthi x EC169459) to 20.27% (IC045993 x IC052310), while heterosis over standard check ranges from -8.75% IC058235 x EC169459 to 13.75% (VRO-4 x Kashi Pragati). Top significantly and positive (desirable) heterobeltiosis was observed in the cross-combinations IC045993 x IC052310 (20.27%) followed by Kashi Kranti x Kashi Pragati (18.67%) and Hisar Naveen x Kashi Pragati (17.33%). Cross combinations of IC052299 x EC169459 (13.75%), IC045993 x EC169452 (12.25 %) and VRO-4 x EC169459 (12.04%) were top hybrids for significant and positive economic heterosis for number of ridges/fruit.

In E2 eight cross combinations over better parent and five hybrids over standard check exhibits for significant and positive heterosis for number of ridges/fruit. Heterobeltiosis ranges from -7.69% (Pusa Sawani x EC169452 to 14.47% (Hisar Naveen x IC052310), while heterosis over standard check ranges from -7.69% (Pusa Sawani x EC169452) to 12.82% (IC058235 x IC052321). Top significantly and positive heterobeltiosis was observed in the cross-combination Hisar Naveen x IC052310 (14.47) followed by IC058235 x IC052321 (14.29%) and Pusa Sawani x Kashi Pragati (13.33%). Cross combinations of IC058235 x IC052321 (12.82%), Hisar Naveen x IC052310 (11.54%) and VRO-4 x Kashi Pragati (10.26%) were top hybrids for significant and positive economic heterosis for number of ridges/fruit.

In E3 six cross combinations over better parent and fifteen hybrids over economic heterosis exhibits for significant and positive heterosis for number of ridges/fruit. Heterobeltiosis ranges from -9.64% (Pusa Sawani x EC169452) to 18.75% (Kashi Kranti x Kashi Pragati), while heterosis over standard check ranges from -2.36 (IC058235 x EC169459) to 25% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination Kashi Kranti x Kashi Pragati (18.75%) followed by Kashi Kranti x IC052310 (16.88%) and Kashi Kranti x IC052321 (15.38%). Cross combinations of Kashi Kranti x Kashi Pragati (25.00%), Kashi Kranti x IC052321 (18.42%) and Kashi Kranti x IC052310 (18.22%) were top hybrids for significant and positive economic heterosis for number of ridges/fruit.

**Table 43. Magnitude of heterosis for diverse and pooled environments for number of ridges/fruit**

| Crosses | Number of ridges/fruit | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -1.3 | -5 | 0 | 0 | -5 | 0 | -1.71 | 2.22 |
| IC058710 x IC052310 | 1.3 | -2.5 | 0 | -1.28 | -1.25 | 3.95 | 0 | 4 |
| IC058710 x EC169459 | -2.6 | -6.25 | 2.6 | 1.28 | -5 | 0 | -1.71 | 2.22 |
| IC058710 x Kashi Pragati | 0 | -3.75 | -2.6 | -3.85 | -1.25 | 3.95 | -1.28 | 2.67 |
| IC058710 x IC052321 | 2.6 | -1.25 | 0 | -1.28 | 2.5 | 7.89* | 1.71 | 5.78 |
| IC045993 x EC169452 | 15.58** | 12.25** | -2.56 | -2.56 | 5.13 | 7.89* | 6.01 | 9.78* |
| IC045993 x IC052310 | 20.27** | 11.25** | 6.58* | 3.85 | -2.6 | -1.32 | 8.89* | 8.89* |
| IC045993 x EC169459 | 5.33 | -1.25 | 5.26 | 2.56 | -1.27 | 2.63 | 3.04 | 5.33 |
| IC045993 x Kashi Pragati | 9.33* | 2.5 | 5.26 | 2.56 | 2.5 | 7.89* | 6.55 | 8.44* |
| IC045993 x IC052321 | 2.6 | -1.25 | 1.3 | 0.1 | -2.56 | 0 | 0.43 | 3.56 |
| Pusa Sawani x EC169452 | -1.3 | -5 | -7.69* | -7.69* | -9.64** | -1.32 | -5.11 | -0.89 |
| Pusa Sawani x IC052310 | 14.29** | 10** | 6.67* | 2.56 | -6.02* | 2.63 | 4.68 | 9.33* |
| Pusa Sawani x EC169459 | 0 | -3.75 | 0 | -2.56 | -6.02* | 2.63 | -1.7 | 2.67 |
| Pusa Sawani x Kashi Pragati | 1.3 | -2.5 | 13.33** | 8.97** | -6.02* | 2.63 | 2.55 | 7.11 |
| Pusa Sawani x IC052321 | 0 | -3.75 | -3.9 | -5.13 | -6.02* | 2.63 | -2.55 | 1.78 |
| VRO-4 x EC169452 | 6.17 | 7.5* | -2.56 | -2.56 | 0 | 5.26 | 1.68 | 7.56 |
| VRO-4 x IC052310 | 3.7 | 5 | -1.3 | -2.56 | -3.75 | 1.32 | -0.42 | 5.33 |
| VRO-4 x EC169459 | 9.88** | 12.04** | -2.6 | -3.85 | 3.75 | 9.21** | 3.78 | 9.78* |
| VRO-4 x Kashi Pragati | 12.35** | 13.75** | 11.69** | 10.26** | 1.25 | 6.58* | 8.4* | 14.67** |
| VRO-4 x IC052321 | 1.23 | 2.5 | -1.3 | -2.56 | -1.25 | 3.95 | -0.42 | 5.33 |
| IC052299 x EC169452 | 1.3 | -2.5 | -1.28 | -1.28 | 1.28 | 3.95 | 0.43 | 4 |
| IC052299 x IC052310 | 6.67 | 0 | 0 | -1.28 | -2.6 | -1.32 | 2.2 | 3.11 |
| IC052299 x EC169459 | 10.67** | 3.75 | -3.9 | -5.13 | 2.53 | 6.58* | 3.48 | 5.78 |
| IC052299 x Kashi Pragati | 14.67** | 7.5* | 2.6 | 1.28 | -3.75 | 1.32 | 5.68 | 7.56 |
| IC052299 x IC052321 | 7.79* | 3.75 | -2.6 | -3.85 | 0 | 2.63 | 1.72 | 4.89 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | 10.39** | 6.25 | 0 | 0.1 | 5.13 | 7.89* | 3.43 | 7.11 |
| Kashi Kranti x IC052310 | 12** | 5 | 1.3 | 0 | 16.88** | 18.22** | 16.23** | 17.78** |
| Kashi Kranti x EC169459 | 8* | 1.25 | 1.3 | 0.2 | 3.8 | 7.89* | 4.78 | 7.11 |
| Kashi Kranti x Kashi Pragati | 18.67** | 11.25** | 1.3 | 0 | 18.75** | 25** | 8.3* | 10.22* |
| Kashi Kranti x IC052321 | 14.29** | 10** | 0 | -1.28 | 15.38** | 18.42** | 4.74 | 8 |
| Salkeerthi x EC169452 | -2.56 | -5 | -3.8 | -2.56 | -2.56 | 0 | -1.28 | 2.67 |
| Salkeerthi x IC052310 | -2.56 | -5 | -1.27 | 0 | 1.3 | 2.63 | 0.85 | 4.89 |
| Salkeerthi x EC169459 | -6.41 | -8.75* | -1.27 | 0.2 | -3.8 | 0 | -2.99 | 0.89 |
| Salkeerthi x Kashi Pragati | 12.82** | 10** | -5.06 | -3.85 | -1.25 | 3.95 | 1.71 | 5.78 |
| Salkeerthi x IC052321 | 8.97* | 6.25 | 2.53 | 3.85 | 0 | 2.63 | 4.27 | 8.44* |
| IC058235 x EC169452 | 7.79* | 3.75 | -1.28 | -1.28 | 15.38** | 18.42** | 3 | 6.67 |
| IC058235 x IC052310 | 6.58 | 1.25 | -1.3 | -2.56 | 6.49* | 7.89* | 4.82 | 6.22 |
| IC058235 x EC169459 | 1.32 | -3.75 | 0 | -1.28 | -5.06 | -2.36 | -0.43 | 1.78 |
| IC058235 x Kashi Pragati | 10.53** | 5 | 1.3 | 0 | -5 | 0.1 | 3.93 | 5.78 |
| IC058235 x IC052321 | 3.9 | 0 | 14.29** | 12.82** | 5.13 | 7.89* | 7.76 | 11.11** |
| Hisar Naveen x EC169452 | 1.3 | -2.5 | 0 | 0 | 1.28 | 3.95 | 0.86 | 4.44 |
| Hisar Naveen x IC052310 | 6.67 | 0 | 14.47** | 11.54** | 3.9 | 5.26 | 8.33* | 9.78* |
| Hisar Naveen x EC169459 | 4 | -2.5 | 1.32 | -1.28 | -5.06 | -1.32 | 0 | 2.22 |
| Hisar Naveen x Kashi Pragati | 17.33** | 10** | 6.58* | 3.85 | 1.25 | 6.58* | 9.17* | 11.11** |
| Hisar Naveen x IC052321 | 0 | -3.75 | -2.6 | -3.85 | 1.28 | 3.95 | -0.43 | 2.67 |
| IC052302 x EC169452 | 1.3 | -2.5 | -3.75 | -1.28 | 2.56 | 5.26 | 0 | 3.56 |
| IC052302 x IC052310 | 0 | -3.75 | -6.25* | -3.85 | 0 | 1.32 | -1.72 | 1.78 |
| IC052302 x EC169459 | 1.3 | -2.5 | 6.25* | 8.97** | 13.92** | 18.42** | 2.15 | 5.78 |
| IC052302 x Kashi Pragati | 7.79* | 3.75 | -3.75 | -1.28 | -3.75 | 1.32 | 1.72 | 5.33 |
| IC052302 x IC052321 | 11.69** | 7.5* | -5 | -2.56 | 0 | 2.63 | 3 | 6.67 |
| **Positive significance crosses** | 12 | 11 | 8 | 5 | 6 | 16 | 6 | 12 |
| **Negative significance crosses** | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly. **HB:** Heterobeltiosis, **SH:** Standard Heterosis

In pooled analysis six crosses over better parent and twelve hybrids over standard check exhibits for significant and positive heterosis for number of ridges/fruit. Heterobeltiosis ranges from -5.11% (Pusa Sawani x EC169452) to 16.23% (Kashi Kranti x IC052310), while heterosis over standard check ranges from -0.89% (Pusa Sawani x EC169452) to 17.78% (Kashi Kranti x IC052310). Top significantly and positive heterobeltiosis was observed in the cross-combination Kashi Kranti x IC052310 (16.23%) followed by Hisar Naveen x Kashi Pragati (9.17%) and IC045993 x IC052310 (8.89%). Cross combinations of Kashi Kranti x IC052310 (17.78%), VRO-4 x Kashi Pragati (14.67%) and IC058235 x IC052321 (11.11%) were top cross combinations for significant and positive economic heterosis for number of ridges/fruit.

**4.6.13 Number of fruits per plant**

In E1 six crosses over better parent and eleven hybrids over standard check exhibits for significant and positive heterosis for number fruits/ plant. Heterobeltiosis ranges from -16.99% (IC052299 x IC052321) to 20.00% (IC058235 x EC169459), while heterosis over standard check ranges from -19.21% (IC058235 x EC169452) to 15.26% (IC058235 x EC169459). Top significantly and positive heterobeltiosis was observed in the cross-combination IC058235 x EC169459 (20.00%) followed by IC045993 x Kashi Pragati (10.75%) and IC058710 x EC169459 (9.19%). Cross combinations of IC058235 x EC169459 (15.26), Salkeerthi x EC169459 (13.95) and Kashi Kranti x Kashi Pragati (13.16 %) were top hybrids for significant and positive economic heterosis for number of fruits/plant.

In E2 two crosses over better parent and twelve hybrids over standard check exhibits for significant and positive heterosis for number fruits/ plant. Heterobeltiosis ranges from -21.79% (IC058235 x EC169452) to 10.64% (Salkeerthi x Kashi Pragati), while heterosis over standard check ranges from -19.74% (IC058235 x EC169452) to 18.29% (Kashi Kranti x IC052321). Top significantly and positive heterobeltiosis was observed in the cross-combination Salkeerthi x Kashi Pragati (10.64%) and VRO-4 x EC169459 (7.71%). Cross combinations of Kashi Kranti x IC052321 (18.29%), Kashi Kranti x IC052310 (14.47 %) and Salkeerthi x Kashi Pragati (13.55%) were top cross for significant and positive economic heterosis for number of fruits/plant.

**Table 44. Magnitude of heterosis for diverse and pooled environments for number of fruits/plant**

| Crosses | Number of fruits/plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -4.66 | -5.79 | -5.26 | -5.26 | 15.94** | 5.26 | 12.29* | -7.86 |
| IC058710 x IC052310 | 0.4 | -0.79 | 0.26 | 0.26 | 21.74** | 10.53* | 16.25** | -4.62 |
| IC058710 x EC169459 | 9.19* | 7.89 | -8.42* | -8.42* | 5.87 | 1.97 | 5.48 | -2.09 |
| IC058710 x Kashi Pragati | -3.99 | -5.13 | 2.11 | 2.11 | 7.69 | 3.16 | 9.66 | -2.52 |
| IC058710 x IC052321 | 3.86 | 2.63 | 4.74 | 4.74 | 9.86 | -0.26 | 15.54** | -0.26 |
| IC045993 x EC169452 | -2.85 | -1.32 | 3.03 | 11.97** | 5.09 | 3.16 | 18.66** | 1.92 |
| IC045993 x IC052310 | 4.27 | 5.92 | -8.84* | -0.92 | 8.04 | 6.05 | 17.61** | 1.03 |
| IC045993 x EC169459 | 1.94 | 3.55 | 3.03 | 11.97** | 0 | -1.84 | 9.76 | 1.88 |
| IC045993 x Kashi Pragati | 10.75** | 12.5** | -2.42 | 6.05 | 3.75 | 1.84 | 17.07** | 4.06 |
| IC045993 x IC052321 | 7.9* | 9.61* | -2.42 | 6.05 | 0 | -1.84 | 18.07** | 1.92 |
| Pusa Sawani x EC169452 | -8.37* | -6.32 | -10.23** | -6.45 | -9.56* | -7.89 | -9.39 | -9.27 |
| Pusa Sawani x IC052310 | -0.64 | 1.58 | -0.63 | 3.55 | -7.75 | -6.05 | -2.99 | -2.86 |
| Pusa Sawani x EC169459 | -4.76 | -2.63 | 0.63 | 4.87 | 2.33 | 4.21 | -0.6 | -0.47 |
| Pusa Sawani x Kashi Pragati | -5.15 | -3.03 | -18.06** | -14.61** | 1.55 | 3.42 | -7.3 | -7.18 |
| Pusa Sawani x IC052321 | -16.34** | -14.47** | -5.93 | -1.97 | -9.82* | -8.16 | -10.67* | -10.56* |
| VRO-4 x EC169452 | 1.28 | 4.21 | -13.18** | -8.16* | -15.94** | -13.95** | -9.31 | -8.38 |
| VRO-4 x IC052310 | -9.72* | -7.11 | -9.08* | -3.82 | -3.86 | -1.58 | -7.57 | -6.62 |
| VRO-4 x EC169459 | 7.93* | 11.05** | 7.71* | 13.95** | -0.26 | 2.11 | 5.16 | 6.24 |
| VRO-4 x Kashi Pragati | -2.43 | 0.39 | 2.49 | 8.42* | -9.38* | -7.24 | -3.05 | -2.05 |
| VRO-4 x IC052321 | 6.52 | 9.61* | 0.5 | 6.32 | -5.91 | -3.68 | 0.38 | 1.41 |
| IC052299 x EC169452 | 0.24 | 9.47* | -10.51** | -2.5 | -10.04* | -4.47 | -6.73 | -1.75 |
| IC052299 x IC052310 | 2.65 | 12.11** | -6.52 | 1.84 | -13.51** | -8.16 | -5.72 | -0.68 |
| IC052299 x EC169459 | 2.65 | 12.11** | 0.72 | 9.74* | -3.1 | 2.89 | 0.12 | 5.47 |
| IC052299 x Kashi Pragati | -16.14** | -8.42* | -2.42 | 6.32 | -1.36 | 4.74 | -6.69 | -1.71 |
| IC052299 x IC052321 | -16.99** | -9.34* | -16.55** | -9.08* | -4.83 | 1.05 | -12.86** | -8.21 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | -8.77* | 1.32 | -0.12 | 10.53** | -5.85 | -0.53 | -7.07 | -1.2 |
| Kashi Kranti x IC052310 | -5.45 | 5 | 3.45 | 14.47** | -13.05** | -8.13 | -16.9** | -11.64* |
| Kashi Kranti x EC169459 | -0.24 | 10.79** | 2.02 | 12.89** | 5.11 | 11.05* | 2.25 | 8.72 |
| Kashi Kranti x Kashi Pragati | 1.9 | 13.16** | 1.55 | 12.37** | 11.33* | 17.63** | 10.12* | 11.45* |
| Kashi Kranti x IC052321 | -1.9 | 8.95* | 6.9 | 18.29** | 7.22 | 13.29** | 4.02 | 10.6* |
| Salkeerthi x EC169452 | -12.28** | -7.89 | -1.28 | 1.32 | 0.52 | 1.32 | 0.6 | 0.77 |
| Salkeerthi x IC052310 | -14.41** | -10.13* | -2.56 | 0 | -3.66 | -2.89 | -8.45 | -8.29 |
| Salkeerthi x EC169459 | 8.52* | 13.95** | 3.85 | 6.58 | 4.44 | 5.26 | 2.73 | 2.91 |
| Salkeerthi x Kashi Pragati | -7.64* | -3.03 | 10.64** | 13.55** | 6.53 | 7.37 | 3.46 | 3.63 |
| Salkeerthi x IC052321 | -2.76 | 2.11 | 4.74 | 7.5 | -4.57 | -3.82 | -0.64 | -0.47 |
| IC058235 x EC169452 | -15.89** | -19.21** | -21.79** | -19.74** | 4.72 | 2.24 | -4.84 | -8.42 |
| IC058235 x IC052310 | -7.95 | -11.58** | -17.95** | -15.79** | -1.89 | -4.21 | -4.71 | -8.29 |
| IC058235 x EC169459 | 20** | 15.26** | -14.1** | -11.84** | 6.2 | 3.68 | 9.33 | 5.21 |
| IC058235 x Kashi Pragati | 1.37 | -2.63 | 6.03 | 8.82* | 6.06 | 3.55 | 4.53 | 0.6 |
| IC058235 x IC052321 | 0.55 | -3.42 | 4.87 | 7.63 | 7.28 | 4.74 | 4.26 | 0.34 |
| Hisar Naveen x EC169452 | -9.62* | -6.05 | -4.88 | -2.63 | -3.71 | -1.05 | -6.09 | -5.73 |
| Hisar Naveen x IC052310 | -4.56 | -0.79 | -14.65** | -12.63** | -4.23 | -1.58 | -7.79 | -7.44 |
| Hisar Naveen x EC169459 | 4.68 | 8.82* | -3.47 | -1.18 | 0.38 | 3.16 | 0.55 | 0.94 |
| Hisar Naveen x Kashi Pragati | 1.39 | 5.39 | 2.83 | 5.26 | 1.66 | 4.47 | 1.96 | 2.35 |
| Hisar Naveen x IC052321 | -9.37* | -5.79 | -1.29 | 1.05 | -4.74 | -2.11 | -5.15 | -4.79 |
| IC052302 x EC169452 | -6.03 | -9.74* | 1.3 | 2.37 | 3.7 | 10.53* | -3.99 | -5.3 |
| IC052302 x IC052310 | -10.68* | -14.21** | -16.15** | -15.26** | -14.81** | -9.21* | -13.95** | -15.13** |
| IC052302 x EC169459 | 4.66 | 0.53 | -2.21 | -1.18 | -2.96 | 3.42 | -0.3 | -1.67 |
| IC052302 x Kashi Pragati | 4.66 | 0.53 | -0.78 | 0.26 | 1.23 | 7.89 | -0.17 | -1.54 |
| IC052302 x IC052321 | -1.64 | -5.53 | -1.04 | 0 | -6.79 | -0.66 | -3.25 | -4.57 |
| **Positive significance crosses** | 6 | 11 | 2 | 12 | 3 | 5 | 8 | 2 |
| **Negative significance crosses** | 10 | 9 | 13 | 9 | 8 | 2 | 3 | 3 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly. **HB:** Heterobeltiosis, **SH:** Standard Heterosis

In E3 three cross combinations over better parent and five hybrids over standard check exhibits for significant and positive heterosis for number fruits/ plant. Heterobeltiosis ranges from -15.94% (VRO-4 x EC169452) to 21.74% (IC058710 x IC052310), while heterosis over standard check ranges from -13.95% (VRO-4 x EC169452 to 17.63% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination IC058710 x IC052310 (21.74%), IC058710 x EC169452 (15.94%) and Kashi Kranti x Kashi Pragati (11.33%). Cross combinations of Kashi Kranti x Kashi Pragati (17.63%), Kashi Kranti x IC052321 (13.29 %) and Kashi Kranti x EC169459 (11.05) were top hybrids for significant and positive standard heterosis for number of fruits/plant.

In pooled analysis eight cross combinations over better parent and two hybrids over standard check exhibits for significant and positive heterosis for number fruits/ plant. Heterobeltiosis ranges from -16.9% (Kashi Kranti x IC052310) to 18.66% (IC045993 x EC169452), while heterosis over standard check ranges from -15.13% (IC052302 x IC052310) to 11.45% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination IC045993 x EC169452 (18.66%), IC045993 x IC052321 (18.07%) and IC045993 x IC052310 (17.61%). Cross combinations of Kashi Kranti x Kashi Pragati (11.45%) and Kashi Kranti x IC052321 (10.6%) were top hybrids for significant and positive economic heterosis for number of fruits/plant.

### 4.6.14 Number of marketable fruits per plant

In E1 seven cross combinations over better parent and eleven hybrids over economic heterosis exhibits for significant and positive heterosis for number of marketable fruits/ plant. Heterobeltiosis ranges -20.59 (IC058235 x EC169452) to 23.60 (IC058235 x EC169459), while heterosis over standard check ranges from -25.56 (IC058235 x EC169452) to 16.39 (IC058235 x EC169459). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC058235 x EC169459 (23.60) followed by IC045993 x Kashi Pragati (11.84%) and IC045993 x IC052321 (10.84%). Cross combinations of IC058235 x EC169459 (16.39), Kashi Kranti x Kashi Pragati (13.47 %) and Kashi Kranti x EC169459 (11.67%) were top hybrids for significant and positive standard heterosis for number of marketable fruits/plants.

In E2 four crosses over better parent and seven hybrids over standard check exhibits for significant and positive heterosis for number of marketable fruits/ plants. Heterobeltiosis ranges -14.14 % (IC052299 x IC052321) to 11.76% (Kashi Kranti x IC052321), while heterosis over standard check ranges from -11.51% (IC045993 x EC169459) to 19.73% (Kashi Kranti x IC052321). Top significantly and positive heterobeltiosis was observed in the cross-combination of Kashi Kranti x IC052321 (11.76%) followed by IC058235 x Kashi Pragati (11.11%) and IC045993 x IC052321 (9.99%). Cross combinations of Kashi Kranti x IC052321 (19.73), IC045993 x EC169452 (15.07 %) and IC045993 x EC169459 (13.7%) were top hybrids for significant and positive standard heterosis for number of marketable fruits/plant.

In E3 four cross combinations over better parent and three hybrids over standard check exhibits for significant and positive heterosis for number of marketable fruits/ plants. Heterobeltiosis ranges -14.74% (VRO-4 x EC169452 to 13.10 % (Kashi Kranti x Kashi Pragati), while heterosis over standard check ranges from -14.84 (VRO-4 x EC169452) to 18.75% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of Kashi Kranti x Kashi Pragati (13.10%) followed by Salkeerthi x Kashi Pragati (11.25%) and IC058235 x Kashi Pragati (10.58%). Cross combinations of Kashi Kranti x Kashi Pragati (18.75%) Kashi Kranti x EC169459 (13.19 %) and Salkeerthi x Kashi Pragati (9.86%) were top hybrids for significant and positive economic heterosis for number of marketable fruits/plant.

In pooled analysis four cross combinations over better parent and five hybrids over standard check exhibits for significant and positive heterosis for number of marketable fruits per plant. Heterobeltiosis ranges from -15.11% (VRO-4 x EC169452) to 18.81% (IC052302 x EC169452), while heterosis over standard check ranges from -13.38% (VRO-4 x EC169452) to 16.82% (IC052302 x EC169452). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC052302 x EC169452 (18.81%) followed by Hisar Naveen x IC052310 (13.72%) and IC058235 x EC169459 (12.57%). Cross combinations of IC052302 x EC169452 (16.82%), Hisar Naveen x IC052310 (16.67 %) and Kashi Kranti x Kashi Pragati (15.37%) were top hybrids for significant and positive standard heterosis for number of marketable fruits/plant.

**Table 45. Magnitude of heterosis for diverse and pooled environments for number of marketable fruits/plant**

| Crosses | Number of marketable fruits/plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -3.07 | -3.61 | -1.54 | -3.42 | -12.4** | -7.78 | -5.8 | -4.49 |
| IC058710 x IC052310 | -1.54 | -2.08 | 3.07 | 1.1 | -13.46** | -8.89 | -4.16 | -2.82 |
| IC058710 x EC169459 | 8.52 | 7.92 | -9.78* | -11.51* | -5.01 | 0 | -2.15 | -0.79 |
| IC058710 x Kashi Pragati | -7.96 | -8.47 | 0.84 | -1.1 | -2.11 | 3.06 | -3.06 | -1.71 |
| IC058710 x IC052321 | -0.98 | -1.53 | 5.73 | 3.7 | -5.41 | -0.42 | -0.32 | 1.06 |
| IC045993 x EC169452 | 4.85 | 2.08 | 9.09* | 15.07** | 7.59 | 2.36 | 3.39 | 3.19 |
| IC045993 x IC052310 | 9.84* | 6.94 | 6.49 | 12.33* | 8.91 | 3.61 | 3.8 | 3.61 |
| IC045993 x EC169459 | 6.28 | 3.47 | 7.79 | 13.7** | 4.23 | -0.83 | 4.82 | 4.63 |
| IC045993 x Kashi Pragati | 11.84* | 8.89 | 0.26 | 5.75 | 6.86 | 1.67 | 6.12 | 5.93 |
| IC045993 x IC052321 | 10.84* | 7.92 | -3.12 | 2.19 | 1.9 | -3.06 | 3.01 | 2.82 |
| Pusa Sawani x EC169452 | -5.64 | -7.08 | 6.27 | 6.85 | -9.42 | -9.17 | -7.67 | -7.45 |
| Pusa Sawani x IC052310 | 2.12 | 0.56 | 4.9 | 5.48 | -6.09 | -5.83 | 0.32 | 0.56 |
| Pusa Sawani x EC169459 | -3.95 | -5.42 | 4.9 | 5.48 | 3.6 | 3.89 | 1.57 | 1.81 |
| Pusa Sawani x Kashi Pragati | -2.96 | -4.44 | -10.49* | -10* | 1.66 | 1.94 | -3.97 | -3.75 |
| Pusa Sawani x IC052321 | -10.3* | -11.67* | -4.77 | -4.25 | -9.42 | -9.17 | -8.13 | -7.92 |
| VRO-4 x EC169452 | -19.61** | -19.17** | -11.17* | -7.4 | -14.74** | -14.86** | -15.11** | -13.38** |
| VRO-4 x IC052310 | 1.24 | 1.81 | -4.34 | -0.27 | -3.2 | -3.33 | -2.13 | -0.14 |
| VRO-4 x EC169459 | 4.01 | 4.58 | 5.12 | 9.59* | 3.06 | 2.92 | 4.08 | 6.2 |
| VRO-4 x Kashi Pragati | 0.41 | 0.97 | 0.92 | 5.21 | -6.54 | -6.67 | -1.68 | 0.32 |
| VRO-4 x IC052321 | 10.77* | 11.39* | 4.6 | 9.04 | -4.73 | -4.86 | 3.58 | 5.69 |
| IC052299 x EC169452 | -1.16 | 6.39 | -4.37 | 1.92 | -8.85 | -4.17 | -4.76 | 1.85 |
| IC052299 x IC052310 | -2.32 | 5.14 | -8.23 | -2.19 | -13.21** | -8.75 | -7.88 | -1.48 |
| IC052299 x EC169459 | -1.42 | 6.11 | 0.26 | 6.85 | -4.62 | 0.28 | -1.9 | 4.91 |
| IC052299 x Kashi Pragati | -14.97** | -8.47 | -0.9 | 5.62 | -0.66 | 4.44 | -5.54 | 1.02 |
| IC052299 x IC052321 | -18.45** | -12.22** | -14.14** | -8.49 | -5.68 | -0.83 | -12.81** | -6.76 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | -0.54 | 3.19 | -2.56 | 4.38 | -6.48 | -1.81 | -3.19 | 2.41 |
| Kashi Kranti x IC052310 | 1.87 | 5.69 | 0.9 | 8.08 | -10.03* | -5.53 | -12.45** | -7.38 |
| Kashi Kranti x EC169459 | 7.63 | 11.67* | 5.63 | 13.15** | 7.8 | 13.19** | 7 | 13.19** |
| Kashi Kranti x Kashi Pragati | 9.37* | 13.47** | 4.86 | 12.33* | 13.1** | 18.75** | 9.06* | 15.37** |
| Kashi Kranti x IC052321 | 6.96 | 10.97* | 11.76* | 19.73** | 4.5 | 9.72 | 7.79 | 14.03** |
| Salkeerthi x EC169452 | -16.82** | -12.78** | 4.96 | 4.38 | 1.55 | 0.28 | -1.73 | -0.28 |
| Salkeerthi x IC052310 | -17.88** | -13.89** | -8.26 | -8.77 | -2.81 | -4.03 | -10.99* | -9.68* |
| Salkeerthi x EC169459 | 7.15 | 12.36** | -1.65 | -2.19 | 4.64 | 3.33 | 2.37 | 3.89 |
| Salkeerthi x Kashi Pragati | -5.96 | -1.39 | 6.61 | 6.03 | 11.25* | 9.86* | 2.74 | 4.26 |
| Salkeerthi x IC052321 | -4.11 | 0.56 | 4.41 | 3.84 | -3.23 | -4.44 | 0.82 | 2.31 |
| IC058235 x EC169452 | -20.59** | -25.56** | 1.55 | -1.1 | 2.9 | -1.39 | -5.2 | -8.89 |
| IC058235 x IC052310 | -8.15 | -13.89** | -0.14 | -2.74 | -0.87 | -5 | -2.99 | -6.76 |
| IC058235 x EC169459 | 23.6** | 16.39** | 6.89 | 4.11 | 7.1 | 2.64 | 12.57* | 8.19 |
| IC058235 x Kashi Pragati | 5.19 | -1.39 | 11.11* | 8.22 | 10.36* | 5.97 | 9.01 | 4.77 |
| IC058235 x IC052321 | 2.96 | -3.47 | 9.99* | 7.12 | 10.58* | 5.97 | 7.9 | 3.7 |
| Hisar Naveen x EC169452 | -10.39* | -6.53 | -1.81 | -3.29 | -5.09 | -1.67 | -5.82 | -3.38 |
| Hisar Naveen x IC052310 | -3.46 | 0.69 | -3.06 | -4.52 | -4.02 | -0.56 | 13.72** | 16.67** |
| Hisar Naveen x EC169459 | 2.53 | 6.94 | 4.31 | 2.74 | 1.88 | 5.56 | 2.89 | 5.56 |
| Hisar Naveen x Kashi Pragati | -0.8 | 3.47 | 7.37 | 5.75 | -0.8 | 2.78 | 1.85 | 4.49 |
| Hisar Naveen x IC052321 | -12.92** | -9.17* | 3.76 | 2.19 | -4.56 | -1.11 | -4.69 | -2.22 |
| IC052302 x EC169452 | 0 | -10.14* | 5.42 | 3.84 | -5.7 | -1.11 | 18.81** | 16.82** |
| IC052302 x IC052310 | -5.26 | -14.86** | -5.98 | -7.4 | -14.7** | -10.56* | -8.86 | -10.51* |
| IC052302 x EC169459 | 3.54 | -2.5 | 1.53 | 0 | -2.25 | 2.5 | 2.31 | 0.46 |
| IC052302 x Kashi Pragati | 10.36* | -0.83 | 0.14 | -1.37 | -3.84 | 0.83 | 1.84 | 0 |
| IC052302 x IC052321 | 0 | -10.14* | 3.2 | 1.64 | -6.49 | -1.94 | -1.23 | -3.01 |
| Positive significance crosses | 7 | 11 | 4 | 7 | 4 | 3 | 4 | 5 |
| Negative significance crosses | 9 | 9 | 4 | 2 | 5 | 2 | 3 | 3 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly. **HB:** Heterobeltiosis, **SH:** Standard Heterosis

#### 4.6.15 Average fruit weight

In E1 four cross combinations over better parent and twenty-one hybrids over standard check exhibits for significant and positive heterosis for average fruit weight. Heterobeltiosis ranges -16.24% (IC058235 x EC169459) to 14.98% (IC052299 x IC052321), while heterosis over standard check ranges from -8.66% (IC052299 x IC052310) to 25.19% (IC052299 x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC052299 x IC052321 (14.98%) followed by Salkeerthi x IC052310 (13.71%), Pusa Sawani x IC052321 (11.3%). Cross combinations of IC052299 x Kashi Pragati (25.19%), IC052299 x IC052321 (19.24%) and Pusa Sawani x IC052321 (18.74%) were top hybrids for significant and positive economic heterosis for average fruit weight.

In E2 four cross combinations over better parent and twenty-nine hybrids over standard check exhibits for significant and positive heterosis for average fruit weight. Heterobeltiosis ranges from -10.78% (Salkeerthi x Kashi Pragati) to 14.21% (IC058710 x EC169459), while heterosis over standard check ranges from 4.49% (IC045993 x EC169452 to 33.20% (IC058710 x IC052310). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC052299 x IC052321 (14.98%), followed by IC052302 x IC052310 (13.95%), IC052299 x IC052321 (10.98%). Cross combinations of IC058710 x IC052310 (33.20%), IC052299 x IC052321 (29.34%), and IC052302 x IC052310 (28.53%) were top hybrids for significant and positive (desirable) economic heterosis for average fruit weight.

In E3 three crosses over better parent and fifteen hybrids over standard check exhibits for significant and positive heterosis for average fruit weight. Heterobeltiosis ranges from -11.6% (IC058235 x IC052310) to 10.26% (VRO-4 x Kashi Pragati), while heterosis over standard check ranges from -8.37% (IC052302 x EC169452) to 17.31% (VRO-4 x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of VRO-4 x Kashi Pragati (10.26%), followed by IC052302 x IC052321,Pusa Sawani x IC052321 (10.18%). Cross combinations of VRO-4 x Kashi Pragati (17.31), Pusa Sawani x IC052321 (17.02%), and Kashi Kranti x EC169452 (13.64%) were top hybrids for significant and positive standard heterosis for average fruit weight.

**Table 46. Magnitude of heterosis for diverse and pooled environments for average fruit weight**

| Crosses | Average fruit weight | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -4.35 | 3.48 | -6.69 | 8.82 | -8.27* | -2.11 | 10.31* | -1.26 |
| IC058710 x IC052310 | -8.41 | -0.91 | -3.05 | 13.07** | -7.96* | -1.78 | 1.87 | -1.32 |
| IC058710 x EC169459 | -4.26 | 3.57 | 14.21** | 33.2** | 2.99 | 9.9* | 13.02** | 10.03* |
| IC058710 x Kashi Pragati | 1.64 | 14.93** | -7.5 | 10.94 | 2.01 | 8.86* | 1.02 | 6.75 |
| IC058710 x IC052321 | -6.66 | 0.98 | -7.42 | 7.97 | -1.11 | 5.53 | 0.3 | 0.21 |
| IC045993 x EC169452 | -3.78 | 6.23 | -7.21 | 4.49 | -7.03 | -0.83 | -5.98 | -1.23 |
| IC045993 x IC052310 | -9.04* | 0.42 | 2.68 | 15.63** | -6.8 | -0.57 | -4.53 | 0.28 |
| IC045993 x EC169459 | -0.13 | 10.26* | -1.26 | 11.19* | 4.3 | 11.27** | 1.01 | 6.1 |
| IC045993 x Kashi Pragati | -11.3* | 0.29 | -7.38 | 11.08 | 1.06 | 7.81* | -3.79 | 1.67 |
| IC045993 x IC052321 | -14.94** | -6.1 | -9.11* | 5.92 | -10.89** | -4.94 | -10.7* | -6.19 |
| Pusa Sawani x EC169452 | -10* | -3.99 | -8 | 4.98 | -6.9 | -1.12 | -8.29 | -4.51 |
| Pusa Sawani x IC052310 | 1.37 | 8.14 | -4.31 | 9.19 | -1.53 | 4.58 | -1.47 | 2.59 |
| Pusa Sawani x EC169459 | 6.38 | 13.48** | -1.44 | 12.46* | -1.48 | 4.63 | 1.15 | 5.32 |
| Pusa Sawani x Kashi Pragati | 1.95 | 15.28** | 10.99** | 33.11** | 1.36 | 7.65 | 7 | 13.07** |
| Pusa Sawani x IC052321 | 11.3* | 18.74** | -2.99 | 13.05** | 10.18** | 17.02** | 6.92 | 11.33* |
| VRO-4 x EC169452 | -5.68 | 2.87 | -4.77 | 10.2 | 2.35 | 8.9* | -2.69 | 2.61 |
| VRO-4 x IC052310 | 1.01 | 10.17* | -0.78 | 14.82** | -1.06 | 5.27 | -0.27 | 5.16 |
| VRO-4 x EC169459 | -5.61 | 2.95 | -8.88* | 5.45 | 1.18 | 7.65 | -4.4 | 0.8 |
| VRO-4 x Kashi Pragati | -0.1 | 12.96* | 0.1 | 20.06** | 10.26** | 17.31** | 5.64 | 11.64** |
| VRO-4 x IC052321 | -4.91 | 3.72 | -1.43 | 14.88** | 2.3 | 8.84* | -1.12 | 4.27 |
| IC052299 x EC169452 | -10.9* | -7.6 | 0.67 | 6.66 | -6.73 | -6.36 | 10.28* | -6.93 |
| IC052299 x IC052310 | -11.93* | -8.66 | -1.6 | 9.78 | -1.95 | -1.56 | -1.67 | -4.75 |
| IC052299 x EC169459 | -0.79 | 2.88 | 3.18 | 12.41* | 7.44 | 7.87* | 5.73 | 2.93 |
| IC052299 x Kashi Pragati | 10.72* | 25.19** | -9.27* | 8.81 | 4.67 | 5.1 | 2.39 | 8.2 |
| IC052299 x IC052321 | 14.98** | 19.24** | 10.98* | 29.34** | 5.37 | 5.79 | 12.73** | 12.62** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | 9.22 | 17.5** | -1.58 | 13.35** | 6.28 | 13.64** | 4.69 | 9.89* |
| Kashi Kranti x IC052310 | -1.97 | 5.45 | -3.65 | 10.97* | 2.84 | 9.96* | 3.52 | 8.66* |
| Kashi Kranti x EC169459 | 2.6 | 10.38* | -0.3 | 14.83** | -2.79 | 3.94 | -0.18 | 4.79 |
| Kashi Kranti x Kashi Pragati | -2.53 | 10.21* | 2.98 | 23.51** | -6.83 | -0.38 | 0.2 | 5.88 |
| Kashi Kranti x IC052321 | -1.47 | 5.99 | -8.61* | 6.51 | -4.88 | 1.7 | -4.61 | 0.13 |
| Salkeerthi x EC169452 | 8.49 | 12.45* | -8.64* | 5.61 | -5.47 | -1.58 | 1.26 | 4.18 |
| Salkeerthi x IC052310 | 13.71** | 17.87** | 7.73 | 24.53** | -5.24 | -1.34 | 6.46 | 9.53* |
| Salkeerthi x EC169459 | -4.74 | -1.26 | 3.77 | 19.96** | 2.78 | 7.01 | 2.45 | 5.41 |
| Salkeerthi x Kashi Pragati | 3.13 | 16.61** | -10.78** | 7 | -0.13 | 3.98 | -2.43 | 3.11 |
| Salkeerthi x IC052321 | 4.2 | 8.01 | -4.15 | 11.71* | 6.96 | 11.36** | 2.93 | 5.9 |
| IC058235 x EC169452 | -0.67 | 14.62** | -1.89 | 3.95 | -2.16 | 8.6* | -4.75 | 4.47 |
| IC058235 x IC052310 | -6.38 | 8.03 | -5.29 | 5.67 | -11.6** | -1.88 | -9.42* | -0.65 |
| IC058235 x EC169459 | -16.24** | -3.35 | 6.71 | 16.25** | -4.12 | 6.43 | -7.39 | 1.57 |
| IC058235 x Kashi Pragati | -1.24 | 13.97** | -10.34* | 7.53 | -6.03 | 4.3 | -5.27 | 3.9 |
| IC058235 x IC052321 | -2.45 | 12.57* | -5.59 | 10.02 | -6.5 | 3.78 | -5.17 | 4.01 |
| Hisar Naveen x EC169452 | 1.81 | 9.37 | -4.18 | 14.09** | -7.19 | -1.39 | -3.21 | 2.47 |
| Hisar Naveen x IC052310 | -11.7* | -5.15 | -10.76* | 6.26 | -8.38* | -2.65 | -10.28* | -5.02 |
| Hisar Naveen x EC169459 | -3.11 | 4.08 | 2.34 | 21.86** | 5.2 | 11.77** | 1.49 | 7.44 |
| Hisar Naveen x Kashi Pragati | -4 | 8.55 | -0.81 | 18.96** | -1.49 | 4.67 | -0.18 | 5.67 |
| Hisar Naveen x IC052321 | 4.89 | 12.68* | -3.8 | 14.55** | -8.31* | -2.58 | -2.44 | 3.28 |
| IC052302 x EC169452 | 7.04 | 16.14** | -1.01 | 11.66 | -7.04 | -8.37* | -0.16 | 1.62 |
| IC052302 x IC052310 | 7.57 | 16.71** | 13.95** | 28.53** | -0.99 | -2.4 | 6.92 | 8.83* |
| IC052302 x EC169459 | -10.02* | -2.37 | -2.93 | 9.5 | 2.41 | 2.4 | -3.19 | -1.47 |
| IC052302 x Kashi Pragati | -5.18 | 7.21 | -1.27 | 18.41** | 5.73 | 5.1 | -0.44 | 5.21 |
| IC052302 x IC052321 | 2.24 | 10.93* | -1.75 | 14.5** | 10.18* | 8.61* | 4.56 | 6.42 |
| **Positive significance crosses** | 4 | 21 | 4 | 29 | 3 | 15 | 4 | 9 |
| **Negative significance crosses** | 8 | 0 | 8 | 0 | 5 | 0 | 2 | 0 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly**. HB**: Heterobeltiosis, **SH:** Standard Heterosis

In pooled analysis four cross combinations over better parent and nine hybrids over standard check exhibits for significant and positive (desirable) heterosis for average fruit weight. Heterobeltiosis ranges from -10.28% (Hisar Naveen x IC052310) to 13.02% (IC058710 x EC169459), while heterosis over standard check ranges from -6.93% (IC052299 x EC169452) to 13.07% (Pusa Sawani x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC058710 x EC169459 (13.02%), followed by IC052299 x IC052321 (12.73%), IC058710 x EC169452 (10.31%). Cross combinations of Pusa Sawani x Kashi Pragati (13.07%), IC052299 x IC052321 (12.62%), and VRO-4 x Kashi Pragati (11.64%) were top hybrids for significant and positive economic heterosis for average fruit weight.

**4.6.16. Number of pickings/plant**

In E1 three cross combinations over better parent and four hybrids over standard check exhibits for significant and positive heterosis for number of pickings/ plant. Heterobeltiosis ranges from -29.84% (Hisar Naveen x IC052321) to 18.79% (IC052299 x EC169459), while heterosis over standard check ranges from -23.04% (IC058235 x EC169452) to 23.91% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC052299 x EC169459 (18.79%) followed by IC052302 x IC052321 (15.57%), Kashi Kranti x Kashi Pragati (11.3%). Cross combinations of Kashi Kranti x Kashi Pragati (23.91%), Kashi Kranti x IC052321 (20.43%) and Kashi Kranti x EC169459 (16.96%) were top hybrids for significant and positive economic heterosis for number of pickings/plant.

In E2 three crosses over better parent and four hybrids over standard check exhibits for significant and positive heterosis for number of pickings/ plant. Heterobeltiosis ranges from -16.21% (Kashi Kranti x EC169452) to 34.71% (VRO-4 x EC169459), while heterosis over standard check ranges from -4.76% (IC052302 x IC052310) to 22.62% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of VRO-4 x EC169459 (34.71%) followed by VRO-4 x Kashi Pragati (25.26%), VRO-4 x EC169452 (24.12%). Cross combinations of Kashi Kranti x Kashi Pragati (22.62%), IC045993 x EC169459 (18.57%) and Kashi Kranti x EC169459 (15.71%) were top hybrids for significant and positive standard heterosis for number of pickings/plant.

In E3 three cross combinations over better parent and fifteen hybrids over standard check exhibits for significant and positive heterosis for number of pickings/ plant. Heterobeltiosis ranges from -18.88% (Hisar Naveen x IC052321) to 16.63% (IC058710 x EC169452), while heterosis over standard check ranges from -9.27% (IC052302 x IC052310) to 30.24% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC058710 x EC169452 (16.63%) followed by IC052302 x Kashi Pragati (14.83%), IC052299 x EC169459 (14.22%). Cross combinations of Kashi Kranti x Kashi Pragati (30.24%), Kashi Kranti x EC169452 (26.83%) and Kashi Kranti x IC052321 (24.39%) were top hybrids for significant and desirable economic heterosis for number of pickings/plant.

In pooled analysis four cross combinations over better parent and twenty-two hybrids over standard check exhibits for significant and positive heterosis for number of pickings/ plant. Heterobeltiosis ranges from -11.01% (IC058235 x IC052310) to 27.62% (IC052299 x IC052310), while heterosis over standard check ranges from - 4.17% (IC052302 x IC052310) to 34.92% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC052299 x IC052310 (27.62%) followed by IC052299 x EC169452 (26.19%) and IC052299 x Kashi Pragati (24.76%). Cross combinations of Kashi Kranti x Kashi Pragati (34.92%), IC052299 x EC169459 (24.5%) and Kashi Kranti x EC169459 (24.42%) were top hybrids for significant and desirable standard heterosis for number of pickings/plant.

**4.6.17 Fruit yield/plant**

In E1 three crosses over better parent and four hybrids over standard check exhibits for significant and positive heterosis for fruit yield/ plant. Heterobeltiosis ranges from -17.36% (Pusa Sawani x EC169459) to 10.87% (IC052299 x EC169459), while heterosis over standard check ranges from -14.52% (Pusa Sawani x EC169452) to 18.42% (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC052299 x EC169459 (10.87%) followed by IC052299 x Kashi Pragati (10.21%), Kashi Kranti x Kashi Pragati (8.81%). Cross combinations of Kashi Kranti x Kashi Pragati (18.42%), Kashi Kranti x EC169459 (16.09%) and Kashi Kranti x EC169452 (13.00%) were top hybrids for significant and positive standard heterosis for fruit yield/plant.

### Table 47. Magnitude of heterosis for diverse and pooled environments for number of pickings/plant

| Crosses | Number of pickings/plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -7.17 | -10 | -5.58 | -3.33 | 16.63* | 14.63 | -5.05 | 3.5 |
| IC058710 x IC052310 | 4.93 | 1.74 | -2.33 | 0 | 13.15 | 11.22 | 2.75 | 12* |
| IC058710 x EC169459 | 8.07 | 4.78 | 5.35 | 7.86 | 11.33 | 10.24 | 6.04 | 15.58** |
| IC058710 x Kashi Pragati | -4.93 | -7.83 | 4.65 | 7.14 | 6.7 | 4.88 | -0.31 | 8.67 |
| IC058710 x IC052321 | 2.24 | -0.87 | 5.58 | 8.1 | 14.81 | 15.37* | 5.73 | 15.25** |
| IC045993 x EC169452 | -10.66 | -5.22 | 1.44 | 0.95 | -8.09 | 5.37 | -6.1 | 7.67 |
| IC045993 x IC052310 | -6.35 | -0.65 | -5.26 | -5.71 | 0 | 14.63 | -3.85 | 10.25 |
| IC045993 x EC169459 | 5.53 | 11.96 | 19.14** | 18.57** | 0.43 | 15.12* | 7.92 | 23.75** |
| IC045993 x Kashi Pragati | 1.23 | 7.39 | 6.22 | 5.71 | 5.53 | 20.98** | 4.22 | 19.5** |
| IC045993 x IC052321 | -8.61 | -3.04 | 3.35 | 2.86 | -6.81 | 6.83 | -4.36 | 9.67 |
| Pusa Sawani x EC169452 | -0.65 | -0.22 | -9.63 | -6.19 | 1.4 | 6.34 | -2.94 | 7.42 |
| Pusa Sawani x IC052310 | 0.43 | 0.87 | 0.69 | 4.52 | 5.12 | 10.24 | 2.03 | 12.92* |
| Pusa Sawani x EC169459 | 5.63 | 6.09 | -8.72 | -5.24 | 10.23 | 15.61* | 2.41 | 13.33* |
| Pusa Sawani x Kashi Pragati | -20.35** | -20** | -4.13 | -0.48 | -0.47 | 4.39 | -8.58 | 1.17 |
| Pusa Sawani x IC052321 | -15.58* | -15.22* | -6.42 | -2.86 | -1.86 | 2.93 | -8.13 | 1.67 |
| VRO-4 x EC169452 | 2.45 | 8.91 | 24.12** | 0.48 | -15.38* | -3.41 | -5.04 | 9.92 |
| VRO-4 x IC052310 | -11.66 | -6.09 | 23.24** | -0.24 | 8.97 | 24.39** | -6.26 | 8.5 |
| VRO-4 x EC169459 | 4.09 | 10.65 | 34.71** | 9.05 | 5.56 | 20.49** | 5.18 | 21.75** |
| VRO-4 x Kashi Pragati | 2.25 | 8.7 | 25.26** | 13.33* | 3.21 | 17.8* | 5.04 | 21.58** |
| VRO-4 x IC052321 | -3.48 | 2.61 | 8.13 | 4.52 | 5.98 | 20.98** | 1.3 | 17.25** |
| IC052299 x EC169452 | -5.59 | -8.26 | 1.57 | 7.86 | 3.21 | 9.76 | 26.19** | 10.42 |
| IC052299 x IC052310 | 3.8 | 0.87 | -0.9 | 5.24 | -0.46 | 5.85 | 27.62** | 11.67* |
| IC052299 x EC169459 | 18.79** | 15.43* | 4.26 | 10.71 | 14.22* | 21.46** | 19.33** | 24.5** |
| IC052299 x Kashi Pragati | -3.36 | -6.09 | -1.79 | 4.29 | 0.92 | 7.32 | 24.76** | 9.17 |
| IC052299 x IC052321 | -10.96 | -13.48* | 1.57 | 7.86 | -8.26 | -2.44 | 1.38 | 4.25 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | -5.47 | 5.22 | -16.21** | 0.95 | 7.88 | 26.83** | -9.47* | 13.17* |
| Kashi Kranti x IC052310 | -8.2 | 2.17 | -7.91 | 10.95* | -9.09 | 6.88 | -9.03 | 13.72* |
| Kashi Kranti x EC169459 | 5.08 | 16.96** | -3.95 | 15.71** | -2.7 | 14.39 | -0.47 | 24.42** |
| Kashi Kranti x Kashi Pragati | 11.33* | 23.91** | 1.78 | 22.62** | 10.79 | 30.24** | 7.93 | 34.92** |
| Kashi Kranti x IC052321 | 8.2 | 20.43** | -4.94 | 14.52** | 5.81 | 24.39** | -1.27 | 23.42** |
| Salkeerthi x EC169452 | -13.87* | -9.57 | 12.09* | 14.76** | -2.7 | 5.37 | -4.72 | 7.75 |
| Salkeerthi x IC052310 | -8.07 | -3.48 | -6.05 | -3.81 | 0.23 | 8.54 | -4.5 | 8 |
| Salkeerthi x EC169459 | -8.9 | -4.35 | -1.4 | 0.95 | -0.45 | 7.8 | -1.25 | 11.67* |
| Salkeerthi x Kashi Pragati | -3.52 | 1.3 | 7.67 | 10.24 | -0.9 | 7.32 | 4.79 | 18.5** |
| Salkeerthi x IC052321 | -8.9 | -4.35 | -0.47 | 1.9 | -1.8 | 6.34 | -8.33 | 3.67 |
| IC058235 x EC169452 | -17.29* | -23.04** | 14.16** | 19.05** | -10.85 | -7.8 | -4.5 | 2.67 |
| IC058235 x IC052310 | -15.42* | -21.3** | -8.68 | -4.76 | -8.96 | -5.85 | -11.01* | -4.33 |
| IC058235 x EC169459 | 4.67 | -2.61 | -2.28 | 1.9 | 6.13 | 9.76 | 2.79 | 10.5 |
| IC058235 x Kashi Pragati | -5.14 | -11.74 | -6.39 | -2.38 | 3.07 | 6.59 | -2.87 | 4.42 |
| IC058235 x IC052321 | -4.67 | -11.3 | 3.2 | 7.62 | -4.72 | -1.46 | -2.02 | 5.33 |
| Hisar Naveen x EC169452 | -22.09** | -12.61* | -9.07 | 2.62 | -11.59 | 0.49 | -7.78 | 3.75 |
| Hisar Naveen x IC052310 | -13.95* | -3.48 | -15.61** | -4.76 | -8.15 | 4.39 | -5.78 | 6 |
| Hisar Naveen x EC169459 | -4.26 | 7.39 | -9.7* | 1.9 | 4.72 | 19.02* | 4.44 | 17.5** |
| Hisar Naveen x Kashi Pragati | -7.36 | 3.91 | -11.81* | -0.48 | 2.79 | 16.83* | 1.85 | 14.58* |
| Hisar Naveen x IC052321 | -29.84** | -21.3** | -13.08** | -1.9 | -18.88** | -7.8 | 3.56 | 16.5** |
| IC052302 x EC169452 | 6.13 | -2.17 | 0.96 | 0 | -4.31 | -2.44 | -4.93 | -0.33 |
| IC052302 x IC052310 | 1.42 | -6.52 | -3.85 | -4.76 | -11 | -9.27 | -8.59 | -4.17 |
| IC052302 x EC169459 | -2.83 | -10.43 | 1.44 | 0.48 | -4.78 | -2.93 | -2.07 | 2.67 |
| IC052302 x Kashi Pragati | 13.21 | 4.35 | 0 | -0.95 | 14.83* | 17.07* | 4.77 | 9.83 |
| IC052302 x IC052321 | 15.57* | 6.52 | -0.96 | -1.9 | -5.74 | -3.9 | -5.41 | -0.83 |
| **Positive significance crosses** | 3 | 4 | 3 | 4 | 3 | 15 | 4 | 22 |
| **Negative significance crosses** | 7 | 7 | 5 | 0 | 2 | 0 | 2 | 0 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly**. HB:** Heterobeltiosis, **SH:** Standard Heterosis

In E2 four crosses over better parent and six hybrids over standard check exhibits for significant and positive heterosis for fruit yield/ plant. Heterobeltiosis ranges from -16.65 (Pusa Sawani x EC169452) to 10.72 (IC052302 x EC169452), while heterosis over standard check ranges from -14.61 (Pusa Sawani x EC169452) to 20.55 (Kashi Kranti x Kashi Pragati). Top significantly and positive heterobeltiosis was observed in the cross-combination of IC052302 x EC169452 (10.72) followed by Kashi Kranti x Kashi Pragati (7.73%), IC052302 x Kashi Pragati (7.47%). Cross combinations of Kashi Kranti x Kashi Pragati (20.55%), Kashi Kranti x EC169459 (12.2%) and Kashi Kranti x IC052321 (9.47%) were top hybrids for significant and positive standard heterosis for fruit yield/plant.

In E3 three crosses over better parent and eight hybrids over standard check exhibits for significant and positive heterosis for fruit yield/ plant. Heterobeltiosis ranges from -30.99 Kashi Kranti x IC052310 to 20.24% (VRO-4 x IC052321), while heterosis over standard check ranges from -19.94% (Kashi Kranti x IC052310) to 34.37% (VRO-4 x IC052321). Top significantly and positive heterobeltiosis was observed in the cross-combination of VRO-4 x IC052321 (20.24%) followed by IC052302 x IC052321(18.4%) and Salkeerthi x EC169459 (15.53%). Cross combinations of VRO-4 x IC052321 (34.37%), Kashi Kranti x Kashi Pragati (20.26%) and Kashi Kranti x EC169459 (18.15%) were top hybrids for significant and positive standard heterosis for fruit yield/plant.

In pooled eight cross combinations over better parent and thirteen hybrids over standard check exhibits for significant and positive heterosis for fruit yield/ plant. Heterobeltiosis ranges from -16.58% (Pusa Sawani x EC169452) to 19.83% (IC058710 x EC169459), while heterosis over standard check ranges from -14.07 (Pusa Sawani x EC169452) to 16.89 (Kashi Kranti x Kashi Pragati. Top significantly and desirable heterobeltiosis was observed in the cross-combination of IC058710 x EC169459 (19.83%) followed by IC058710 x IC052321 (12.36%) and IC058710 x Kashi Pragati (10.49%). Cross combinations of Kashi Kranti x Kashi Pragati (16.89%), Kashi Kranti x EC169459 (12.69%) and Kashi Kranti x IC052321 (9.63%) were top hybrids for significant and positive economic heterosis for fruit yield/plant.

**Table 48. Magnitude of heterosis for diverse and pooled environments for fruit yield/plant**

| Crosses | Fruit yield/plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E1 | | E2 | | E3 | | Pooled | |
| | HB | SH | HB | SH | HB | SH | HB | SH |
| IC058710 x EC169452 | -8.81** | -13.66* | -9.39* | -10.42** | -16.53* | -4.76 | -10.77** | -15.30** |
| IC058710 x IC052310 | -7.89** | -12.79* | -0.55 | -1.68 | -16.58* | -4.82 | 6.01* | -6.6* |
| IC058710 x EC169459 | 4.6 | 6.14* | 7.26* | 6.04 | 0.76 | 14.96 | 19.83** | 6.35 |
| IC058710 x Kashi Pragati | 2 | -3.5 | -0.4 | -1.53 | 1.02 | 15.26 | 10.49** | 3.06 |
| IC058710 x IC052321 | -3.1 | -1.68 | -0.64 | -1.77 | -5.34 | 8.01 | 12.36** | -1.01 |
| IC045993 x EC169452 | -6.71* | -0.58 | -2.72 | 1.69 | -2.91 | 4.18 | -4.14 | -0.7 |
| IC045993 x IC052310 | -5.26 | 0.97 | -4.73 | -0.41 | 0.99 | 8.37 | -3.05 | 0.43 |
| IC045993 x EC169459 | 1.64 | 8.32** | 3.53 | 8.22* | 4.45 | 12.09 | 3.18 | 6.89 |
| IC045993 x Kashi Pragati | 0.4 | 7* | -2.39 | 2.03 | 5.02 | 12.7 | 0.96 | 4.6 |
| IC045993 x IC052321 | -8.34** | -2.32 | -6.64 | -2.41 | -10.72 | -4.2 | -8.54** | -5.26 |
| Pusa Sawani x EC169452 | -17.36** | -14.52** | -16.65** | -14.61** | -15.74* | -6.5 | -16.58** | -14.07** |
| Pusa Sawani x IC052310 | 0.62 | 4.07 | -4.15 | -1.8 | -9.12 | 0.84 | -4.24 | -1.36 |
| Pusa Sawani x EC169459 | 1.41 | 4.9 | 0.04 | 2.49 | 0.86 | 11.92 | 0.77 | 3.81 |
| Pusa Sawani x Kashi Pragati | 2.61 | 6.13* | -3.56 | -1.2 | 3.01 | 14.31 | 0.71 | 3.74 |
| Pusa Sawani x IC052321 | -6.89* | -3.69 | -8.14* | -5.89 | -0.84 | 10.03 | -5.26* | -2.41 |
| VRO-4 x EC169452 | -4.44 | 1.79 | -12.85** | -8.91* | -14.18* | -4.09 | -10.47** | -6.02* |
| VRO-4 x IC052310 | -8.88** | -2.94 | -8.47* | -4.33 | 4.53 | 16.82* | -7.39** | -2.79 |
| VRO-4 x EC169459 | 1.81 | 8.44** | -0.12 | 4.39 | 0.95 | 12.81 | 0.88 | 5.89 |
| VRO-4 x Kashi Pragati | 1 | 7.59* | 0.52 | 5.06 | -0.28 | 11.44 | 0.42 | 5.4 |
| VRO-4 x IC052321 | 1.21 | 7.8* | 1.4 | 5.98 | 20.24** | 34.37** | -0.34 | 4.61 |
| IC052299 x EC169452 | -2.62 | -3.87 | -15.9** | -9.64** | -16.06* | -8.14 | -14.17** | -9.4** |
| IC052299 x IC052310 | -1.57 | -2.83 | -9.65** | -2.92 | -15.28* | -7.29 | -11.48** | -6.56* |
| IC052299 x EC169459 | 10.87** | 9.46** | -0.24 | 7.2* | 4.08 | 13.89 | 1.84 | 7.5** |
| IC052299 x Kashi Pragati | 10.21** | 8.8** | -6.41 | 0.57 | 3.23 | 12.96 | -0.72 | 4.79 |
| IC052299 x IC052321 | 3.68 | 2.36 | -4.84 | 2.25 | 0.01 | 9.44 | -3.26 | 2.11 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kashi Kranti x EC169452 | 3.83 | 13** | -8.97** | 1.86 | -0.03 | 15.98* | -3.13 | 7.56** |
| Kashi Kranti x IC052310 | -3.93 | 4.55 | -6.66* | 4.45 | -30.99** | -19.94* | -4.66 | 5.87 |
| Kashi Kranti x EC169459 | 6.67* | 16.09** | 0.26 | 12.2** | 1.85 | 18.15* | 1.49 | 12.69** |
| Kashi Kranti x Kashi Pragati | 8.81** | 18.42** | 7.73* | 20.55** | 3.66 | 20.26** | 5.27* | 16.89** |
| Kashi Kranti x IC052321 | 0.72 | 9.62** | -2.17 | 9.47** | 1.81 | 18.11* | -1.27 | 9.63** |
| Salkeerthi x EC169452 | -4.72 | -1.71 | -1.64 | -0.92 | 2.47 | 2.58 | 2.39 | 3.73 |
| Salkeerthi x IC052310 | -3.32 | -0.26 | 3.02 | 3.76 | -1.35 | -1.25 | -1.82 | -0.54 |
| Salkeerthi x EC169459 | 3.5 | 6.77* | 5.48 | 6.25 | 15.53* | 15.65* | 6.1* | 7.49** |
| Salkeerthi x Kashi Pragati | 3.94 | 7.22* | 4.85 | 5.61 | 14.42 | 14.54 | 4.07 | 5.43 |
| Salkeerthi x IC052321 | 1.12 | 4.32 | 3.47 | 4.22 | 9.44 | 9.55 | 2.95 | 4.3 |
| IC058235 x EC169452 | -16.39** | -12.06** | -13.65** | -10.69** | 2.85 | 14 | -9.06** | -5.53 |
| IC058235 x IC052310 | -14.26** | -9.81** | -12.89** | -9.9** | -12.57 | -3.09 | -13.24** | -9.88** |
| IC058235 x EC169459 | 0.54 | 5.75 | 2.51 | 6.03 | 2.23 | 13.31 | 1.76 | 5.7 |
| IC058235 x Kashi Pragati | 0.07 | 5.26 | -1.64 | 1.74 | 0.04 | 10.88 | -0.5 | 3.35 |
| IC058235 x IC052321 | -2.18 | 2.89 | -0.63 | 2.78 | 0.68 | 11.6 | -0.71 | 3.14 |
| Hisar Naveen x EC169452 | -7.93** | -2.51 | -7.04* | -4 | -10.35 | 0.39 | -8.45** | -4.41 |
| Hisar Naveen x IC052310 | -15.65** | -10.69** | -12.88** | -10.04** | -12.13 | -1.6 | -13.56** | -9.75** |
| Hisar Naveen x EC169459 | 0.87 | 6.81* | 1.38 | 4.69 | 5.71 | 18.38* | 2.66 | 7.19** |
| Hisar Naveen x Kashi Pragati | 2.56 | 8.6** | 5.06 | 8.49* | 0.35 | 12.38 | 2.64 | 7.17 |
| Hisar Naveen x IC052321 | -4.89 | 0.71 | -2.57 | 0.61 | -12.41 | -1.91 | -6.66* | -2.54 |
| IC052302 x EC169452 | 3.81 | 2.65 | 10.72** | 5.98 | -0.51 | -6.92 | 8.85** | 7.02 |
| IC052302 x IC052310 | 5.3 | 4.12 | -1.37 | -5.6 | -2.62 | -8.89 | -7.29** | -8.84** |
| IC052302 x EC169459 | 4.9 | 3.73 | -1.82 | -6.03 | 9.96 | 8.72 | -2.4 | -4.04 |
| IC052302 x Kashi Pragati | 3.16 | 2 | 7.47* | 2.86 | 12.85 | 10.38 | 4.24 | -3.77 |
| IC052302 x IC052321 | 0.35 | -0.78 | 4 | -0.45 | 18.4* | 10.78 | 5.03 | -5.09 |
| Positive significance crosses | 3 | 4 | 4 | 6 | 3 | 8 | 8 | 13 |
| Negative significance crosses | 10 | 6 | 12 | 7 | 7 | 1 | 14 | 8 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly. **HB:** Heterobeltiosis, **SH:** Standard Heterosis

### 4.7 GENERAL AND SPECIFIC COMBINING ABILITY EFFECTS

The success of any breeding programme is heavily dependent on the parents chosen and the breeding process used. Combining ability is an effective technique for distinguishing between outstanding and terrible combiners and for selecting appropriate parental lines in a hybridization programme

Line x Tester study of 50 okra F1s obtained by crossing 10 lines with 5 testers was performed to determine fruit yield per plant and its contributing characters. The variance in the material investigated was classified as due to lines, testers, lines x testers and error causes. Furthermore, the components of variance attributable to parents were employed as measures of general combining ability variance using suitable expectations of the observed mean squares as specified in the material and methods (GCA), whereas the variations observed because of line x tester interactions were utilized to calculate the variance in particular combining ability (SCA).

#### 4.7.1 ANOVA for combining ability

The analysis of variance and variance components for combining ability for 17 traits under three environments as well as pooled over environments are presented in Table 49. In all the environments and pooled analysis all the crosses mean sum of square were significant among the seventeen traits. In Pooled analysis the mean square values attributable to line x tester were significant for all characters. The mean square values owing to lines were significant all traits except first fruiting node, days to first flowering, days to 50% flowering, days to first fruit harvest, fruit length and average fruit weight in Pooled analysis. In Pooled analysis the mean square values due to testers was significant for first flowering node, internodal length, number of nodes, average fruit weight and fruit yield/ plant. The SCA variance was considerably higher than their corresponding GCA variance for all the characters in the study which indicates the predominance of additive gene action.

#### 4.7.2 Combining ability (GCA and SCA) effects estimation

The following is a presentation of the key findings on the combining ability impacts for various characters. Table 50-58 given the estimations of the GCA impacts of the parents & SCA of the cross combinations for each of the seventeen traits

**Table 49. ANOVA of combining ability and variance components of seventeen characters in okra**

| Source of variation | d.f. | First flowering node | | | | First fruiting node | | | | Days to first flowering | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 0.101 | 0.16 | 0.020 | 0.11 | 0.042 | 0.13 | 0.096 | 0.21 | 0.56 | 0.5 | 1.13 | 1.38 |
| Crosses | 49 | 0.431** | 0.31** | 0.50** | 0.53** | 0.28** | 0.33* | 0.33** | 0.43** | 3.49** | 3.11** | 2.03** | 4.72** |
| Line Effect | 9 | 1.021** | 0.60** | 0.61 | 1.03** | 0.56* | 0.18 | 0.68* | 0.81** | 5.92 | 3.03 | 1.82 | 3.74 |
| Tester Effect | 4 | 0.245 | 1.20** | 2.13** | 1.91** | 0.29 | 0.96* | 0.30 | 0.10* | 1.48 | 8.4* | 5.34* | 12.50* |
| L x T Effect | 36 | 0.304** | 0.13 | 0.230** | 0.29** | 0.20 | 0.29** | 0.25** | 0.27** | 3.10** | 2.55** | 1.72** | 4.11** |
| Error | 98 | 0.090 | 0.09 | 0.13 | 0.10 | 0.14 | 0.11 | 0.10 | 0.102 | 0.62 | 0.83 | 0.74 | 0.72 |

| Source of variation | d.f. | Days to 50 % flowering | | | | Days to first picking | | | | Plant height | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 0.060 | 1.41 | 2.41 | 0.75 | 4.59 | 0.54 | 3.66* | 7.20** | 33.94 | 30.39 | 31.25 | 11.83 |
| Crosses | 49 | 3.47** | 6.20** | 3.53** | 7.63** | 5.44** | 5.43** | 3.61** | 6.50** | 82.36** | 76.76** | 76.60** | 128.27** |
| Line Effect | 9 | 5.26 | 4.78 | 4.26 | 8.36 | 6.51 | 9.88* | 5.36 | 5.96 | 162.10* | 107.43 | 86.12 | 271.79** |
| Tester Effect | 4 | 8.09* | 8.32 | 5.36 | 12.06 | 7.72 | 13.38** | 5.91 | 16.55* | 142.18 | 113.58 | 133.62 | 275.16* |
| L x T Effect | 36 | 2.51** | 6.32** | 3.14* | 6.96** | 4.93** | 3.43** | 2.91** | 5.51** | 55.78** | 65.00** | 67.89** | 76.07** |
| Error | 98 | 0.904 | 1.29 | 1.15 | 1.11 | 1.77 | 1.04 | 0.82 | 1.2 | 12.43 | 18.96 | 18.16 | 16.51 |

| Source of variation | d.f. | Internodal length | | | | Number of branches/plants | | | | Number of nodes/plant | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **E1** | **E2** | **E3** | **Pooled** | **E1** | **E2** | **E3** | **Pooled** | **E1** | **E2** | **E3** | **Pooled** |
| Replicates | 2 | 0.020 | 0.049 | 0.78** | 0.36 | 0.056 | 0.040 | 0.066 | 0.005 | 0.743 | 0.69 | 0.74 | 9.51** |
| Crosses | 49 | 0.77** | 0.63** | 0.44** | 0.69 ** | 0.68** | 0.48** | 0.39** | 0.85** | 5.36** | 1.60** | 5.36** | 3.58** |
| Line Effect | 9 | 1.30* | 0.69 | 0.38 | 1.12* | 1.95** | 0.79 | 0.65 | 1.97** | 7.37** | 4.84** | 7.38** | 10.82** |
| Tester Effect | 4 | 1.97** | 2.56** | 0.211 | 1.44* | 0.99* | 0.39 | 0.279 | 0.51 | 28.32** | 1.75 | 28.32** | 9.43** |
| L x T Effect | 36 | 0.50* | 0.40** | 0.48** | 0.500** | 0.33** | 0.42** | 0.34** | 0.60** | 2.30 | 0.77 | 2.30 | 1.12 |
| Error | 98 | 0.28 | 0.196 | 0.130 | 0.20 | 0.110 | 0.166 | 0.135 | 0.14 | 1.692 | 0.61 | 1.70 | 1.08 |

| Source of variation | d.f. | Fruit length | | | | Fruit diameter | | | | Number of ridges | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **E1** | **E2** | **E3** | **Pooled** | **E1** | **E2** | **E3** | **Pooled** | **E1** | **E2** | **E3** | **Pooled** |
| Replicates | 2 | 0.076 | 0.35 | 0.15 | 0.24 | 0.87 | 2.75* | 0.44 | 0.002 | 0.024 | 0.14* | 0.013 | 0.015 |
| Crosses | 49 | 2.03** | 1.82** | 1.16** | 2.69** | 2.79** | 3.22** | 2.91** | 4.75** | 0.28** | 0.15** | 0.07** | 0.23** |
| Line Effect | 9 | 2.87 | 1.52 | 2.90** | 5.06* | 7.19** | 1.19 | 4.67 | 6.47 | 0.56** | 0.082 | 0.072 | 0.37* |
| Tester Effect | 4 | 3.19 | 1.54 | 0.092 | 2.61 | 3.38 | 2.21 | 2.93 | 5.72 | 0.519* | 0.17 | 0.057 | 0.49* |
| L x T Effect | 36 | 1.68** | 1.93** | 0.84** | 2.10 ** | 1.62** | 3.85** | 2.47** | 4.22** | 0.19** | 0.16** | 0.07** | 0.17** |
| Error | 98 | 0.60 | 0.76 | 0.380 | 0.57 | 0.63 | 0.63 | 0.900 | 0.72 | 0.068 | 0.04 | 0.034 | 0.046 |

| Source of variation | d.f. | Number of fruit/plant | | | | Number of marketable fruits/plant | | | | Average fruit weight | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 3.73 | 4.60 | 12.75** | 0.73 | 2.24 | 5.98 | 5.92* | 0.480 | 0.90 | 0.101 | 0.019 | 0.608 |
| Crosses | 49 | 13.15** | 11.47** | 7.15** | 19.60** | 13.80** | 7.56** | 7.35** | 19.49** | 2.87** | 2.39** | 1.93** | 3.64** |
| Line Effect | 9 | 20.78* | 21.07* | 14.44** | 42.50** | 22.79* | 14.67* | 15.04** | 43.11** | 2.10 | 1.39 | 1.68 | 2.08 |
| Tester Effect | 4 | 37.75** | 21.57* | 24.74** | 70.80** | 35.06* | 11.57 | 28.16** | 61.69** | 4.89 | 3.81 | 6.12** | 8.59 |
| L x T Effect | 36 | 8.51** | 7.95** | 3.37** | 8.19** | 9.18** | 5.33** | 3.12** | 8.90** | 2.85** | 2.48** | 1.52** | 3.48** |
| Error | 98 | 1.65 | 1.76 | 1.40 | 1.6 | 1.70 | 2.17 | 1.50 | 1.78 | 0.70 | 0.48 | 0.380 | 0.52 |

| Source of variation | d.f. | Number of pickings/plant | | | | Fruit yield/plant | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| Replicates | 2 | 5.34* | 4.42** | 2.44 | 1.74 | 1012.05** | 1468.80** | 1868.45** | 286.3 |
| Crosses | 49 | 8.94** | 3.05** | 4.17** | 10.10** | 1707.14** | 1575.08** | 2456.51** | 4592.3** |
| Line Effect | 9 | 23.62** | 6.03* | 7.66** | 29.12** | 3339.17** | 3006.59** | 2715.24* | 7689.9** |
| Tester Effect | 4 | 20.50** | 4.55 | 13.85** | 30.92** | 8227.63** | 7095.82** | 15421.15** | 29363.3** |
| L x T Effect | 36 | 3.99** | 2.14** | 2.22 | 4.25** | 574.64** | 603.79** | 951.31** | 1065.6** |
| Error | 98 | 1.24 | 0.83 | 1.63 | 1.23 | 180.59 | 231.47** | 332.96 | 248.34 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly

### 4.7.1 First flowering node

In E1 GCA ranges from -0.456 (Kashi Kranti) to 0.331 (IC045993) in lines and while in testers - 0.089 (EC169452) to 0.137 (IC052310). Among the lines Kashi Kranti (-0.456), IC052302 (-0.403) and in testers EC169452 (-0.089) observed negative and significant desirable *gca* effect. Whereas, SCA ranges from -0.751 (IC058235 x IC052310) to 0.649 (Pusa Sawani x IC052310). Out of 50 crosses, 6 crosses recorded negative and significant desirable *sca* effect. Top desirable significant crosses were IC058235 x IC052310 (-0.751), Pusa Sawani x EC169459 (-0.604) and IC045993 x EC169452 (-0.471).

In E2 GCA ranges from -0.358 (VRO-4, Salkeerthi) to 0.135 (Hisar Naveen) in lines and while in testers -0.258 (IC052321) to 0.249 (IC052310). Among the lines VRO-4, Salkeerthi (-0.358) and in testers IC052321 (-0.258), Kashi Pragati (-0.138), showed negative and desirable significant *gca* effect. Whereas, SCA ranges varied from -0.422 (Pusa Sawani x EC169459) to 0.505 (Pusa Sawani x IC052310). Among the 50 crosses, 2 crosses recorded negative significant *sca* effect. Top desirable significant crosses were Pusa Sawani x EC169459 (-0.422) and IC058710 x EC169452 (0.385).

In E3, GCA ranges from -0.373 (VRO-4) to 0.267 (IC058235) in lines and Kashi Pragati (-0.460) to while in testers EC169459 (0.207). Among the lines VRO-4 (-0.373), IC052302 (-0.280) and in testers Kashi Pragati (-0.460) recorded negative and significant desirable *gca* effect. In SCA ranges from -0.560 (Salekerthi x IC052321) to 0.560 (Salkeerthi x EC169452). Three crosses showed negative (desirable) and significant *sca* effect. Top desirable crosses were Saleekerthi x IC052321 (-0.560), IC045993 x EC169459 (-0.500) and Pusa Sawani x IC052310 (-0.467).

While in pooled analysis GCA ranges from -0.285 (VRO-4) to 0.158 (Pusa Sawani) in lines and while in testers -0.189 (Kashi Pragati) to 0.182 (IC052310). Among the lines VRO-4 (-0.285), IC052302 (-0.200), Kashi Kranti (-0.107) and in testers Kashi Pragati (-0.189), IC052321 (-0.096) recorded negative and significant desirable *gca* effect. Whereas, SCA ranges varied from -0.365 (IC058710 x EC169452) to 0.287 (IC045993 x Kashi Pragati). Among 50 crosses, 2 crosses recorded were negative and significant *sca* effect. Top desirable crosses were IC058710 x EC169452 (-0.365) and IC045993 x EC169452 (-0.303).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.34), E2 (0.58), E3 (0.73), and the combined analysis (0.51) indicated the dominance of non-additive genetic effects for first flowering node.

#### 4.7.4.2 First fruiting node

In E1 first flowering node GCA ranges from -0.913 (Pusa Sawani) to 0.820 (IC058710) in lines and while in testers -0.258 (IC052321) to 0.249 (IC052310). Among the lines Pusa Sawani (-0.913), IC052299, Kashi Kranti (-0.713) and in testers Kashi Pragati (-0.280) recorded negative and significant *gca* effect. Whereas, SCA ranges from -0.513 (Pusa Sawani x EC169459) to 0.773 (Pusa Sawani x IC052310). Two crosses recorded negative (desirable) and significant *sca* effect. Top desirable significant crosses were Pusa Sawani x EC169459 (-0.513) and IC058235 x IC052310 (-0.373).

In E2 GCA ranges from -0.203 (VRO-4) to 0.131 (IC058235) in lines and in testers Kashi Pragati (-0.256) to EC169459 (0.164). Among the lines VRO-4 (-0.203) and in testers Kashi Pragati (-0.256), EC169452 (-0.103) recorded negative significant *gca* effect. Whereas, SCA ranges varied from -0.577 (Pusa Sawani x IC052310) to 0.809 (IC058710 x EC169459). Three crosses combinations recorded significant and desirable (negative) *sca* effect. Top desirable crosses were, Pusa Sawani x IC052310 (-0.577), IC045993 x EC169459 (-0.471) and IC058710 x EC169452 (-0.457).

In E3 GCA ranges from -0.373 (VRO-4) to 0.267 (IC058235) in lines and while in testers -0.460 (Kashi Pragati) to 0.207 (EC169459). Among the lines VRO-4 (-0.373), IC052302 (-0.280) and in testers Kashi Pragati (-0.460) observed negative and significant *gca* effect. Whereas, SCA ranges from -0.671 (Salkeerthi x IC052321) to 0.483 (Salekerthi x EC169452). Among 50 crosses 5 crosses expressed significant and negative *sca* effect. Top desirable crosses were Salkeerthi x IC052321 (-0.671), Kashi Kranti x Kashi Pragati (-0.557) and Hisar Naveen x IC052310 (-0.431).

**Table 50. Estimates combining ability of parents and hybrids across diverse and pooled environments for first flowering and first fruiting node**

| S. No. | Genotype | First flowering node | | | | First fruiting node | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| **Parents** | | | | | | | | | |
| **Lines** | | | | | | | | | |
| **1** | IC058710 | 0.224 ** | 0.069 | 0.04 | 0.111 * | 0.820 ** | 0.037 | 0.04 | 0.014 |
| **2** | IC045993 | 0.331 ** | 0.109 | -0.093 | 0.115 * | 0.553 ** | 0.051 | -0.093 | 0.049 |
| **3** | Pusa Sawani | 0.184 * | 0.235 ** | 0.053 | 0.158 ** | -0.913 ** | 0.144 | 0.053 | 0.129 * |
| **4** | VRO-4 | -0.123 | -0.358 ** | -0.373 ** | -0.285 ** | -0.313 | -0.203 * | -0.373 ** | -0.248 ** |
| **5** | IC052299 | 0.064 | 0.002 | 0.133 | 0.066 | -0.713 ** | -0.056 | 0.133 | 0.063 |
| **6** | Kashi Kranti | -0.456 ** | 0.069 | 0.067 | -0.107 * | -0.713 ** | -0.016 | 0.067 | -0.146 * |
| **7** | Salkeerthi | 0.024 | -0.358** | 0.200 * | -0.045 | 0.353 | 0.037 | 0.200 * | 0.116 * |
| **8** | IC058235 | -0.016 | 0.015 | 0.267 ** | 0.089 | 0.153 | 0.131 | 0.267 ** | 0.152 * |
| **9** | Hisar Naveen | 0.171 * | 0.135 | -0.013 | 0.098 | 0.087 | 0.024 | -0.013 | 0.009 |
| **10** | IC052302 | -0.403 ** | 0.082 | -0.280 ** | -0.200 ** | 0.687 ** | -0.149 | -0.280 ** | -0.137 * |
| **Testers** | | | | | | | | | |
| **11** | EC169452 | -0.089 * | 0.105 * | 0.053 | 0.023 | 0.02 | -0.103* | 0.053 | -0.044 |
| **12** | IC052310 | 0.137 ** | 0.249 ** | 0.160 ** | 0.182 ** | 0.287 * | 0.044 | 0.160 ** | 0.083 * |
| **13** | EC169459 | -0.009 | 0.042 | 0.207 ** | 0.080 * | 0.12 | 0.164 ** | 0.207 ** | 0.114 ** |
| **14** | Kashi Pragati | 0.031 | -0.138 ** | -0.460 ** | -0.189 ** | -0.280 * | -0.256 ** | -0.460 ** | -0.151 ** |
| **15** | IC052321 | -0.069 | -0.258 ** | 0.04 | -0.096 ** | -0.147 | 0.151 ** | 0.04 | -0.002 |
| **HYBRIDS** | | | | | | | | | |
| **16** | IC058710 x EC169452 | -0.364 * | -0.385 * | -0.347 | -0.365 ** | -0.227 | -0.457 * | -0.264 | -0.316 * |
| **17** | IC058710 x IC052310 | 0.209 | 0.271 | 0.08 | 0.187 | 0.173 | 0.263 | 0.169 | 0.202 |
| **18** | IC058710 x EC169459 | 0.289 | 0.011 | 0.3 | 0.2 | 0.153 | 0.809 ** | 0.283 | 0.415 ** |
| **19** | IC058710 x Kashi Pragati | 0.183 | 0.125 | 0.233 | 0.18 | 0.047 | -0.304 | -0.037 | -0.098 |
| **20** | IC058710 x IC052321 | -0.317 | -0.022 | -0.267 | -0.202 | -0.147 | -0.311 | -0.151 | -0.203 |
| **21** | IC045993 x EC169452 | -0.471 ** | -0.225 | -0.213 | -0.303 * | -0.227 | 0.129 | -0.091 | -0.063 |

| *Table continues…* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **22** | IC045993 x IC052310 | 0.169 | -0.102 | -0.053 | 0.005 | 0.173 | -0.084 | -0.057 | 0.011 |
| **23** | IC045993 x EC169459 | 0.316 | 0.305 | -0.500 * | 0.04 | 0.153 | -0.471 * | -0.411 * | -0.243 |
| **24** | IC045993 x Kashi Pragati | 0.343 | 0.085 | 0.433 * | 0.287 * | 0.113 | 0.216 | 0.203 | 0.177 |
| **25** | IC045993 x IC052321 | -0.357 * | -0.062 | 0.333 | -0.029 | -0.213 | 0.209 | 0.356 | 0.117 |
| **26** | Pusa Sawani x EC169452 | 0.076 | -0.052 | -0.093 | -0.023 | -0.227 | 0.369 | -0.171 | -0.009 |
| **27** | Pusa Sawani x IC052310 | 0.649 ** | 0.505 ** | -0.467 * | 0.229 | 0.773 ** | -0.577 ** | -0.404 * | -0.069 |
| **28** | Pusa Sawani x EC169459 | -0.604 ** | -0.422 * | 0.487 * | -0.18 | -0.513 * | -0.231 | 0.243 | -0.167 |
| **29** | Pusa Sawani x Kashi Pragati | -0.044 | 0.091 | 0.02 | 0.022 | -0.22 | 0.523 ** | 0.323 | 0.208 |
| **30** | Pusa Sawani x IC052321 | -0.077 | -0.122 | 0.053 | -0.049 | 0.187 | -0.084 | 0.009 | 0.037 |
| **31** | VRO-4 x EC169452 | 0.116 | 0.108 | -0.2 | 0.008 | -0.12 | -0.351 | -0.157 | -0.209 |
| **32** | VRO-4 x IC052310 | 0.156 | -0.235 | 0.027 | -0.018 | 0.08 | 0.103 | 0.143 | 0.108 |
| **33** | VRO-4 x EC169459 | 0.103 | 0.038 | 0.113 | 0.085 | 0.06 | 0.583 ** | 0.123 | 0.255 * |
| **34** | VRO-4 x Kashi Pragati | -0.204 | -0.049 | 0.18 | -0.024 | -0.047 | -0.131 | -0.064 | -0.08 |
| **35** | VRO-4 x IC052321 | -0.171 | 0.138 | -0.12 | -0.051 | 0.027 | -0.204 | -0.044 | -0.074 |
| **36** | IC052299 x EC169452 | -0.004 | -0.052 | 0.36 | 0.101 | 0.093 | 0.236 | 0.243 | 0.191 |
| **37** | IC052299 x IC052310 | 0.036 | 0.005 | 0.187 | 0.076 | -0.04 | -0.177 | 0.076 | -0.047 |
| **38** | IC052299 x EC169459 | -0.017 | 0.011 | -0.26 | -0.089 | -0.193 | -0.031 | -0.211 | -0.145 |
| **39** | IC052299 x Kashi Pragati | -0.124 | -0.142 | -0.26 | -0.175 | 0.1 | -0.211 | -0.131 | -0.08 |
| **40** | IC052299 x IC052321 | 0.109 | 0.178 | -0.027 | 0.087 | 0.04 | 0.183 | 0.023 | 0.082 |
| **41** | Kashi Kranti x EC169452 | -0.151 | 0.481 ** | 0.293 | 0.208 | -0.013 | 0.196 | 0.349 | 0.177 |
| **42** | Kashi Kranti x IC052310 | -0.377 * | -0.195 | 0.187 | -0.129 | -0.413 | 0.249 | 0.183 | 0.006 |
| **43** | Kashi Kranti x EC169459 | 0.036 | -0.055 | -0.193 | -0.071 | 0.3 | -0.137 | 0.029 | 0.064 |
| **44** | Kashi Kranti x Kashi Pragati | 0.129 | -0.209 | -0.327 | -0.135 | -0.007 | -0.317 | -0.557 ** | -0.294 * |
| **45** | Kashi Kranti x IC052321 | 0.363 * | -0.022 | 0.04 | 0.127 | 0.133 | 0.009 | -0.004 | 0.046 |
| **46** | Salkeerthi x EC169452 | -0.031 | -0.159 | 0.560 ** | 0.124 | -0.08 | 0.076 | 0.483 * | 0.16 |
| **47** | Salkeerthi x IC052310 | -0.124 | -0.035 | 0.053 | -0.035 | -0.213 | 0.196 | 0.116 | 0.033 |
| **48** | Salkeerthi x EC169459 | 0.023 | 0.171 | 0.073 | 0.089 | 0.033 | -0.124 | 0.029 | -0.02 |
| **49** | Salkeerthi x Kashi Pragati | -0.084 | 0.151 | -0.127 | -0.02 | 0.193 | -0.037 | 0.043 | 0.066 |
| **50** | Salkeerthi x IC052321 | 0.216 | -0.129 | -0.560 ** | -0.158 | 0.067 | -0.111 | -0.671 ** | -0.238 |

| *Table continues…* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **51** | IC058235 x EC169452 | 0.276 | 0.068 | 0.027 | 0.124 | 0.293 | -0.217 | -0.037 | 0.013 |
| **52** | IC058235 x IC052310 | -0.751 ** | -0.142 | 0.32 | -0.191 | -0.373* | -0.031 | 0.263 | -0.047 |
| **53** | IC058235 x EC169459 | -0.004 | 0.065 | -0.26 | -0.066 | -0.06 | -0.017 | -0.157 | -0.078 |
| **54** | IC058235 x Kashi Pragati | -0.111 | 0.045 | -0.327 | -0.131 | -0.1 | 0.003 | -0.211 | -0.103 |
| **55** | IC058235 x IC052321 | 0.589 ** | -0.035 | 0.24 | 0.265 * | 0.24 | 0.263 | 0.143 | 0.215 |
| **56** | Hisar Naveen x EC169452 | 0.423 * | 0.281 | -0.093 | 0.204 | 0.373 | 0.089 | -0.264 | 0.066 |
| **57** | Hisar Naveen x IC052310 | 0.063 | 0.005 | -0.4 | -0.111 | 0.107 | -0.057 | -0.431 * | -0.127 |
| **58** | Hisar Naveen x EC169459 | -0.124 | -0.122 | 0.353 | 0.036 | -0.18 | -0.111 | 0.283 | -0.003 |
| **59** | Hisar Naveen x Kashi Pragati | -0.031 | -0.209 | 0.087 | -0.051 | -0.087 | 0.109 | 0.296 | 0.106 |
| **60** | Hisar Naveen x IC052321 | -0.331 | 0.045 | 0.053 | -0.078 | -0.213 | -0.031 | 0.116 | -0.043 |
| **61** | IC052302 x EC169452 | 0.129 | -0.065 | -0.293 | -0.076 | 0.133 | -0.071 | -0.091 | -0.009 |
| **62** | IC052302 x IC052310 | -0.031 | -0.075 | 0.067 | -0.013 | -0.267 | 0.116 | -0.057 | -0.069 |
| **63** | IC052302 x EC169459 | -0.017 | -0.002 | -0.113 | -0.044 | 0.247 | -0.271 | -0.211 | -0.078 |
| **64** | IC052302 x Kashi Pragati | -0.057 | 0.111 | 0.087 | 0.047 | 0.007 | 0.149 | 0.136 | 0.097 |
| **65** | IC052302 x IC052321 | -0.024 | 0.031 | 0.253 | 0.087 | -0.12 | 0.076 | 0.223 | 0.06 |
| **GCA (line)** | | 0.077 | 0.077 | 0.093 | 0.048 | 0.245 | 0.088 | 0.093 | 0.052 |
| **GCA (Tester)** | | 0.055 | 0.055 | 0.066 | 0.034 | 0.174 | 0.062 | 0.066 | 0.037 |
| **SCA** | | 0.173 | 0.172 | 0.208 | 0.107 | 0.549 | 0.196 | 0.208 | 0.116 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly

In pooled analysis GCA ranges from -0.248 (VRO-4) to 0.152 (IC058235) in lines and while in testers -0.151 (Kashi Pragati) to 0.114 (EC169459). Among the lines VRO-4 (-0.248), Kashi Kranti (-0.146), IC052302 (-0137) and in testers Kashi Pragati (-0.151) recorded negative and significant *gca* effect. Whereas, SCA, ranges varied from -0.316 (IC058710 x EC169452) to 0.415 (IC058710 x EC169459). Among 50 crosses, 2 crosses recorded were negative and significant *sca effect*. Top desirable crosses were IC058710 x EC169452 (-0.316) and Kashi Kranti x Kashi Pragati (-0.294).

The research revealed varying ratios of $\sigma^2$gca to $\sigma^2$sca across experiments 0.78 for E1, 0.34 for E2, 0.36 for E3, and 0.45 for the combined analysis. These findings indicate the predominance of non-additive genetic effects on first fruiting node.

**4.7.4.3 Days to first flowering**

In E1 days to first flowering GCA ranges from -0.487 (Kashi Kranti) to 0.193 (IC045993) in lines and while in testers -0.107 (IC052321) to 0.107 (IC052310). Among the lines Kashi Kranti (-0.487) and in testers IC052321 (-0.107) observed negative and significant *gca* effect. Whereas, SCA ranges from -2.620 (IC052302 x IC052310) to 1.547 (IC052302 x EC169459). Among the 50 crosses, 7 crosses revealed negative significant desirable *sca* effect. Top desirable significant crosses were IC052302 x IC052310 (-2.620), Salkeerthi x IC052321 (-1.520) and IC045993 x IC052321 (-1.387).

In E2 GCA ranges from -0.700 (IC052299) to 0.900 (IC045993) in lines and while in testers -0.900 (Kashi Pragati) to 0.433 (IC052310). Among the lines IC052299 (-0.700), Kashi Kranti (-0.500) and in testers Kashi Pragati (-0.900) recorded negative and significant *gca* effect. Whereas, SCA ranges from -1.500 (Salkeerthi x IC052321) to 1.700 (IC052302 x IC052321). Out of 50 crosses, 7 crosses revealed negative significant *sca* effect. Top desirable crosses were, Salkeerthi x IC052321 (-1.500), IC052302 x IC052310 (-1.300) and IC052299 x EC169459 (-1.233).

In E3 GCA ranges from -0.613 (IC045993) to 0.587 (Hisar Naveen) in lines and while in testers -0.547 (Kashi Pragati) to 0.453 (IC052310). Among lines IC045993 (-0.613) and in testers Kashi Pragati (-0.547), IC052321 (-0.313) observed negative and significant *gca* effect. Whereas, SCA ranges from -1.320 (IC058710 x EC169452) to 2.213 (IC058710 x Kashi Pragati). Out of 50 crosses, 4 crosses revealed negative significant *sca* effect. Top desirable crosses were IC058710 x EC169452 (-1.320), IC052299 x IC052310, Kashi Kranti x Kashi Pragati (-1.120) and Pusa Sawani x Kashi Pragati (-1.053).

While in pooled analysis GCA ranges from -0.431 (Kashi Kranti) to 0.347 (IC052302) in lines and in testers -0.576 (Kashi Pragati) to 0.391 (IC052310). Among the lines Kashi Kranti (-0.431), IC052299 (-0.387), Pusa Sawani (-0.320), and in testers Kashi Pragati (-0.576) recorded negative and significant *gca* effect. Whereas, SCA, ranges varied from -1.280 (IC052302 x IC052310) to 1.231 (IC052302 x IC052321). Among 50 crosses, 7 crosses recorded were negative and significant *sca effect*. Top desirable crosses were IC052302 x IC052310 (-1.280), Salekerthi x Kashi Pragati (-1.013) and IC052302 x EC169452 (-1.002).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.17), E2 (0.37), E3 (0.39), and the combined analysis (0.17) indicated the dominance of non-additive genetic effects for this trait.

**4.7.4.4 Days to 50 % flowering**

In E1 GCA ranges from -0.987 (Pusa Sawani) to 0.813 (IC052302) in lines and while in testers -0.553 (Kashi Pragati) to 0.847 (IC052310). Among lines Pusa Sawani (-0.987), VRO-4 (-0.587), Kashi Kranti (-0.520) and in testers Kashi Pragati (-0.553) recorded negative and significant *gca* effect. Whereas, SCA ranges from -2.313 (IC052302 x IC052310) to 1.620 (IC052302 x IC052321). Two crosses had negative significant *sca* effect. Top desirable significant crosses were IC052302 x IC052310 (-2.313) and IC045993 x IC052321 (-1.380).

In E2 in this character GCA ranges from -0.940 (Kashi Kranti) to 1.060 (IC058235) in lines and while in testers -0.507 (EC169459) to IC052321 (0.827). Among the lines Kashi Kranti (-0.940) and in testers EC169459 (-0.507) recorded negative and significant *gca* effect. Whereas, SCA ranges from -2.267 (IC052302 x IC052310) to 2.873 (IC052302 x Kashi Pragati). Out of 50 crosses, 6 crosses recorded negative significant *sca* effect. Top desirable crosses were IC052302 x IC052310 (-2.267), Kashi Kranti x Kashi Pragati (-2.260) and VRO-4 x Kashi Pragati (-1.927).

In E3 GCA ranges from -0.727 (IC045993, Kashi Kranti) to 0.940 (IC052302) in lines and while in testers Kashi Pragati (-0.627) to EC169452 (0.440). Among the lines

IC045993, Kashi Kranti (-0.727) and in testers Kashi Pragati (-0.627) recorded negative and significant *gca* effect. Whereas, SCA ranges from -2.140 (IC058710 x IC052321) to 1.693 (Kashi Kranti x EC169452). Out of 50 crosses, 5 crosses revealed negative significant *sca* effect. Top desirable crosses were IC058710 x IC052321 (-2.410), VRO-4 x Kashi Pragati (-1.707) and IC052302 x EC169452 (-1.640).

While in pooled analysis GCA ranges from -0.729 (Kashi Kranti) to 0.671 (IC052302) in lines and -0.484 (Kashi Pragati) to 0.460 (IC052310) in testers. Among the lines Kashi Kranti (-0.729), IC052299 (-0.396) and in testers Kashi Pragati (-0.484), EC169459 (-0.196) recorded negative and significant *gca* effect. For SCA, ranges varied from -1.493 (VRO-4 x Kashi Pragati) to 1.351 (IC052302 x Kashi Pragati). Among 50 crosses, 6 crosses recorded were negative and significant *sca* effect. Top desirable crosses Top desirable crosses were VRO-4 x Kashi Pragati (-1.493), Kashi Kranti x Kashi Pragati (-1.471) and IC052302 x EC169452 (-1.460).

Throughout the investigation E1 (0.48), E2 (0.13), E3 (0.24), and the combined analysis (0.06), revealing a prevalent influence of non-additive genetics on days to 50% flowering.

**4.7.4.5 Days to first fruit harvest**

In E1 GCA ranges from -1.373 (Kashi Kranti) to 0.827 Hisar Naveen in lines and in testers -0.807 (EC169459) to IC052321 (0.460). Among lines and testers Kashi Kranti (-1.373) and EC169459 (-0.807) were observed negative and significant *gca* effect. Whereas, SCA ranges from -2.427 (Pusa Sawani x EC169459) to 2.040 (Salkeerthi x IC052310). Among 50 crosses, 8 crosses revealed negative significant *sca* effect. Top desirable significant crosses were Pusa Sawani x EC169459 (-2.427), Kashi Kranti x Kashi Pragati (-2.027) and Salkeerthi x Kashi Pragati (-1.893).

In E2 GCA ranges from -1.547 (VRO-4) to 0.853 (Kashi Kranti) in lines and while in testers -1.013 (EC169459) to 0.553 (EC169452). Among the lines VRO-4 (-1.547), Hisar Naveen (-1.280) and in testers Kashi Pragati (-1.013) revealed negative and significant *gca* effect. Whereas, SCA ranges from -1.987 (IC052302 x IC052310) to 2.147 (IC052302 x Kashi Pragati). Out of 50 crosses, 7 crosses revealed negative significant *sca* effect. Top desirable crosses were IC052302 x IC052310 (-1.987), IC045993 x EC169459 and Kashi Kranti x Kashi Pragati (-1.520).

**Table 51. Estimates combining ability of parents and hybrids across diverse and pooled environments for days to first flowering and days to 50% flowering**

| S.No. | Genotype | Days to first flowering | | | | Days to 50% flowering | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| **Parents** | | | | | | | | | |
| **Lines** | | | | | | | | | |
| 1 | IC058710 | 0.06 | 0.233 | -0.413 | 0.213 | 0.08 | 0.327 | -0.06 | 0.116 |
| 2 | IC045993 | 0.193 * | 0.900 ** | -0.613 ** | 0.280 * | 0.48 | -0.207 | -0.727 * | -0.151 |
| 3 | Pusa Sawani | 0.127 | 0.1 | -0.147 | -0.320 * | -0.987 ** | -0.473 | 0.607 * | -0.284 |
| 4 | VRO-4 | -0.113 | -0.167 | 0.187 | -0.098 | -0.587 * | 0.06 | 0.073 | -0.151 |
| 5 | IC052299 | 0.14 | -0.700 ** | 0.253 | -0.387 * | -0.453 | -0.54 | -0.193 | -0.396 * |
| 6 | Kashi Kranti | -0.487 ** | -0.500 * | -0.08 | -0.431 ** | -0.520 * | -0.940 ** | -0.727 * | -0.729 ** |
| 7 | Salkeerthi | 0.047 | 0.167 | -0.08 | 0.147 | 0.413 | 0.127 | -0.327 | 0.071 |
| 8 | IC058235 | 0.073 | -0.167 | 0.253 | 0.08 | 0.413 | 1.060 ** | 0.14 | 0.538 ** |
| 9 | Hisar Naveen | -0.007 | -0.167 | 0.587 ** | 0.169 | 0.347 | 0.327 | 0.273 | 0.316 |
| 10 | IC052302 | -0.033 | 0.3 | 0.053 | 0.347 * | 0.813 ** | 0.26 | 0.940 ** | 0.671 ** |
| **Testers** | | | | | | | | | |
| 11 | EC169452 | 0.04 | 0.333 * | 0.320 ** | 0.224 ** | -0.22 | -0.24 | 0.440 ** | -0.007 |
| 12 | IC052310 | 0.107 * | 0.433 ** | 0.453 ** | 0.391 ** | 0.847 ** | 0.193 | 0.340 * | 0.460 ** |
| 13 | EC169459 | 0.06 | 0.033 | 0.087 | 0.08 | 0.013 | -0.507 ** | -0.093 | -0.196 * |
| 14 | Kashi Pragati | -0.1 | -0.900 ** | -0.547 ** | -0.576 ** | -0.553 ** | -0.273 | -0.627 ** | -0.484 ** |
| 15 | IC052321 | -0.107 * | 0.1 | -0.313 * | -0.12 | -0.087 | 0.827 ** | -0.06 | 0.227 * |
| **HYBRIDS** | | | | | | | | | |
| 16 | IC058710 x EC169452 | 0.18 | 0.867 | -1.320 ** | -0.091 | 0.82 | 0.107 | -0.64 | 0.096 |
| 17 | IC058710 x IC052310 | 0.247 | -0.9 | 0.547 | -0.036 | 0.42 | 0.673 | 0.793 | 0.629 |
| 18 | IC058710 x EC169459 | -0.253 | 0.167 | -0.753 | -0.28 | -0.413 | 1.04 | 0.56 | 0.396 |
| 19 | IC058710 x Kashi Pragati | -0.853 | -0.567 | 2.213 ** | 0.264 | -0.513 | -1.193 | 1.427 * | -0.093 |
| 20 | IC058710 x IC052321 | 0.68 | 0.433 | -0.687 | 0.142 | -0.313 | -0.627 | -2.140 ** | -1.027 * |
| 21 | IC045993 x EC169452 | 0.113 | -0.8 | -0.453 | -0.38 | 0.087 | -0.693 | -0.307 | -0.304 |

*Table continues…*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **22** | IC045993 x IC052310 | 0.513 | 0.767 | 1.080 * | 0.787 * | 0.687 | -1.127 | 0.793 | 0.118 |
| **23** | IC045993 x EC169459 | 1.013 * | 0.833 | -0.22 | 0.542 | 1.187 * | -0.093 | -0.107 | 0.329 |
| **24** | IC045993 x Kashi Pragati | -0.253 | -0.9 | -0.587 | -0.58 | -0.58 | 1.007 | -0.24 | 0.062 |
| **25** | IC045993 x IC052321 | -1.387 ** | 0.1 | 0.18 | -0.369 | -1.380 * | 0.907 | -0.14 | -0.204 |
| **26** | Pusa Sawani x EC169452 | -0.42 | 1.667 ** | 0.413 | 0.553 | -0.447 | -0.427 | -0.307 | -0.393 |
| **27** | Pusa Sawani x IC052310 | -0.687 | -1.100 * | -0.053 | -0.613 | -0.513 | -0.86 | -0.54 | -0.638 |
| **28** | Pusa Sawani x EC169459 | 0.48 | 0.3 | 0.98 | 0.587 | 0.32 | 2.507 ** | 0.893 | 1.240 ** |
| **29** | Pusa Sawani x Kashi Pragati | 0.547 | 0.233 | -1.053 * | -0.091 | 0.22 | -0.727 | -0.24 | -0.249 |
| **30** | Pusa Sawani x IC052321 | 0.08 | -1.100 * | -0.287 | -0.436 | 0.42 | -0.493 | 0.193 | 0.04 |
| **31** | VRO-4 x EC169452 | -0.353 | -1.067 * | 0.08 | -0.447 | -0.18 | 2.040 ** | 0.56 | 0.807 * |
| **32** | VRO-4 x IC052310 | 1.047 * | 0.833 | -0.387 | 0.498 | 1.420 * | -0.393 | -1.007 | 0.007 |
| **33** | VRO-4 x EC169459 | -0.787 | -0.1 | 0.647 | -0.08 | -0.747 | -0.693 | 1.427 * | -0.004 |
| **34** | VRO-4 x Kashi Pragati | -0.387 | 0.167 | -0.72 | -0.313 | -0.847 | -1.927 ** | -1.707 ** | -1.493 ** |
| **35** | VRO-4 x IC052321 | 0.48 | 0.167 | 0.38 | 0.342 | 0.353 | 0.973 | 0.727 | 0.684 |
| **36** | IC052299 x EC169452 | 0.38 | 0.133 | 0.013 | 0.176 | 0.02 | -0.027 | -0.84 | -0.282 |
| **37** | IC052299 x IC052310 | -0.553 | -0.633 | -1.120 * | -0.769 * | -1.047 | 0.873 | -1.407 * | -0.527 |
| **38** | IC052299 x EC169459 | -1.380** | -1.233 * | 0.58 | -0.680 * | -0.547 | -1.427 * | 0.027 | -0.649 |
| **39** | IC052299 x Kashi Pragati | 0.68 | 1.033 * | 0.213 | 0.642 * | 0.687 | -0.327 | 0.56 | 0.307 |
| **40** | IC052299 x IC052321 | 0.88 | 0.7 | 0.313 | 0.631 * | 0.887 | 0.907 | 1.660 ** | 1.151 ** |
| **41** | Kashi Kranti x EC169452 | 1.380 ** | 0.933 | 1.347 ** | 1.220 ** | 1.087 | -0.293 | 1.693 ** | 0.829 * |
| **42** | Kashi Kranti x IC052310 | 0.78 | 0.5 | 0.213 | 0.498 | 0.687 | 2.607 ** | 0.127 | 1.140 ** |
| **43** | Kashi Kranti x EC169459 | -1.053 * | -0.433 | -0.42 | -0.636 * | -0.813 | -0.027 | -0.44 | -0.427 |
| **44** | Kashi Kranti x Kashi Pragati | -0.653 | -0.833 | -1.120 * | -0.869 * | -0.913 | -2.260 ** | -1.240 * | -1.471 ** |
| **45** | Kashi Kranti x IC052321 | -0.453 | -0.167 | -0.02 | -0.213 | -0.047 | -0.027 | -0.14 | -0.071 |
| **46** | Salkeerthi x EC169452 | 0.980 * | 0.6 | 0.347 | 0.642 * | 0.487 | 1.973 ** | 0.627 | 1.029 * |
| **47** | Salkeerthi x IC052310 | 1.380 ** | 1.500 ** | -0.12 | 0.920 ** | 0.42 | 0.207 | 1.06 | 0.562 |
| **48** | Salkeerthi x EC169459 | 0.213 | -0.433 | -0.087 | -0.102 | 0.253 | -0.427 | -0.507 | -0.227 |
| **49** | Salkeerthi x Kashi Pragati | -1.053 * | -0.167 | -0.12 | -0.447 | -0.18 | -0.327 | -0.307 | -0.271 |
| **50** | Salkeerthi x IC052321 | -1.520 ** | -1.500 ** | -0.02 | -1.013 ** | -0.98 | -1.427 * | -0.873 | -1.093 ** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **51** | IC058235 x EC169452 | -0.487 | -0.4 | 0.013 | -0.291 | -0.847 | -1.293 | 0.493 | -0.549 |
| **52** | IC058235 x IC052310 | -0.42 | -0.167 | -0.12 | -0.236 | 0.087 | 0.607 | 0.26 | 0.318 |
| **53** | IC058235 x EC169459 | 0.08 | 0.567 | -0.087 | 0.187 | -0.413 | 0.307 | -0.64 | -0.249 |
| **54** | IC058235 x Kashi Pragati | 0.813 | 0.167 | 0.213 | 0.398 | 0.82 | 1.073 | 0.56 | 0.818 * |
| **55** | IC058235 x IC052321 | 0.013 | -0.167 | -0.02 | -0.058 | 0.353 | -0.693 | -0.673 | -0.338 |
| **56** | Hisar Naveen x EC169452 | -0.753 | -0.733 | 0.347 | -0.38 | -0.113 | 0.44 | 0.36 | 0.229 |
| **57** | Hisar Naveen x IC052310 | 0.313 | 0.5 | -0.12 | 0.231 | 0.153 | -0.327 | -0.54 | -0.238 |
| **58** | Hisar Naveen x EC169459 | 0.147 | -0.1 | -0.087 | -0.013 | 0.32 | -0.627 | -0.773 | -0.36 |
| **59** | Hisar Naveen x Kashi Pragati | 0.547 | 0.5 | 0.213 | 0.42 | 0.553 | 1.807 ** | 0.76 | 1.040 * |
| **60** | Hisar Naveen x IC052321 | -0.253 | -0.167 | -0.353 | -0.258 | -0.913 | -1.293 | 0.193 | -0.671 |
| **61** | IC052302 x EC169452 | -1.020 * | -1.200 * | -0.787 | -1.002 ** | -0.913 | -1.827 ** | -1.640 ** | -1.460 ** |
| **62** | IC052302 x IC052310 | -2.620 ** | -1.300 * | 0.08 | -1.280 ** | -2.313 ** | -2.267 ** | 0.46 | -1.371 ** |
| **63** | IC052302 x EC169459 | 1.547 ** | 0.433 | -0.553 | 0.476 | 0.853 | -0.56 | -0.44 | -0.049 |
| **64** | IC052302 x Kashi Pragati | 0.613 | 0.367 | 0.747 | 0.576 | 0.753 | 2.873 ** | 0.427 | 1.351 ** |
| **65** | IC052302 x IC052321 | 1.480 ** | 1.700 ** | 0.513 | 1.231 ** | 1.620 ** | 1.773 ** | 1.193 | 1.529 ** |
| **GCA (line)** | | 0.097 | 0.233 | 0.222 | 0.127 | 0.245 | 0.293 | 0.277 | 0.157 |
| **GCA (Tester)** | | 0.069 | 0.165 | 0.157 | 0.090 | 0.174 | 0.207 | 0.196 | 0.111 |
| **SCA** | | 0.217 | 0.521 | 0.496 | 0.284 | 0.549 | 0.656 | 0.619 | 0.352 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly.

In E3 GCA ranges from -0.873 (Kashi Kranti) to 0.660 (Hisar Naveen) in lines and while in testers -0.607 (EC169459) to 0.593 (EC169452). In lines Kashi Kranti (-0.873), IC045993 (-0.673), VRO-4 (-0.607) and in testers EC169459 (-0.607) recorded negative and significant *gca* effect. Whereas, SCA range revealed from -1.793 (VRO-4 x EC169452) to 1.673 (Pusa Sawani x EC169452). Among 50 crosses, 6 crosses revealed negative significant *sca* effect. Top desirable crosses were VRO-4 x EC169452 (-1.793), IC045993 x Kashi Pragati (-1.593) and IC052302 x EC169452 (-1.527).

While in pooled analysis GCA ranges from -0.753 (VRO-4) to 0.402 (IC058235) in lines and in testers -0.587 (EC169459) to 0.324 (EC169452). Among the lines VRO-4 (-0.753), Kashi Kranti (-0.464) and in testers EC169459 (-0.587), Kashi Pragati (-0.331) recorded negative and significant *gca* effect. Whereas, SCA range varied from -1.536 (Kashi Kranti x Kashi Pragati) to 1.576 (IC052302 x Kashi Pragati). Among 50 crosses, 7 crosses recorded were negative and significant *sca effect*. Top desirable crosses were Kashi Kranti x Kashi Pragati (-1.536), IC052302 x EC169452 (-1.191) and IC045993 x Kashi Pragati (-1.136).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.23), E2 (0.58), E3 (0.31), and the combined analysis (0.10) indicated the dominance of non-additive genetic effects for days to first fruit harvest.

**4.7.6 Plant height (cm)**

In E1 plant height GCA ranges from -5.494 (Hisar Naveen) to 5.101(VRO-4) in lines and in testers -2.217 (IC052310) to 2.669 (Kashi Pragati) recorded. Among the lines VRO-4 (5.101), IC045993 (2.702), IC058710 (2.206), Kashi Kranti (2.159) and in testers EC169459 (1.663), Kashi Pragati (2.669) observed significant positive *gca* effect. Whereas, SCA ranges from -9.917 (Kashi Kranti x IC052310) to 5.917 (Kashi Kranti x Kashi Pragati). Out of 50 crosses, 7 crosses revealed positive significant *sca* effect. Top desirable significant crosses were Kashi Kranti x Kashi Pragati (5.917), Hisar Naveen x IC052310 (5.876) and IC052302 x IC052321 (5.751).

In E2 GCA for ranges from -5.781 (Hisar Naveen) to 3.598 (VRO-4) in lines and while in testers IC052310 (-3.211) to Kashi Pragati (1.905). Among the lines VRO-4 (3.598) and in testers Kashi Pragati (1.905) observed in significant positive *gca* effect. Whereas, SCA ranges from -8.980 (IC052302 x EC169459) to 11.800 (IC052302 x IC052321). Four crosses recorded positive significant *sca* effect. Top desirable crosses were IC052302 x IC052321 (11.800), VRO-4 x IC052310 (8.378) and IC058235 x IC052310 (6.952).

In E3 GCA range from -4.786 (Salekerthi) to 3.168 (VRO-4) in lines and in testers -2.239 (IC052321) to 2.568 (Kashi Pragati). Among the lines VRO-4 (3.168) and in testers Kashi Pragati (2.568), EC169452 (1.570) showed positive and significant *gca* effect. Whereas, SCA ranges from -8.658 (Pusa Sawani x EC169459) to 10.497 (IC052302 x EC169452). Out of 50 crosses 7 crosses revealed positive significant *sca* effect. Top desirable crosses were IC052302 x EC169452 (10.497), Salekerthi x EC169459 (8.802) and Pusa Sawani x EC169452 (6.376).

In pooled analysis GCA ranges from -4.542 (Hisar Naveen) to 3.956 (VRO-4) in lines and while in testers -2.454 (IC052310) to 2.380 (Kashi Pragati). Among the lines Hisar Naveen (3.956), IC045993 (2.055), Kashi Kranti (1.729) and in testers Kashi Pragati (2.380) recorded positive and significant *gca* effect. Whereas, SCA, ranges varied from -4.670 (IC058710 x IC052321) to 4.761 (IC058235 x IC052310). Among 50 crosses, 7 crosses recorded were positive and significant *sca effect*. Top desirable crosses were IC058235 x IC052310 (4.761), IC052302 x IC052321 (4.386) and Pusa Sawani x IC052321 (4.111).

The research revealed varying ratios of $\sigma^2$gca to $\sigma^2$sca across experiments 0. 43 for E1, 0.26 for E2, 0.25 for E3 and 0.73 for the combined analysis. These findings indicate the predominance of non-additive genetic effects on plant height.

**Table 52. Estimates combining ability of parents and hybrids across diverse and pooled environments for days to first fruit harvest and Plant height**

| S.No. | Genotype | Days to first fruit harvest | | | | Plant height | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| **PARENTS** | | | | | | | | | |
| **Lines** | | | | | | | | | |
| **1** | IC058710 | 0.760 * | 0.52 | -0.407 | 0.291 | 2.026 * | -1.474 | 1.188 | 0.58 |
| **2** | IC045993 | 0.227 | -0.147 | -0.673 ** | -0.198 | 2.702 ** | 1.61 | 1.854 | 2.055** |
| **3** | Pusa Sawani | -0.373 | 0.187 | 0.593 * | 0.136 | 0.858 | -0.4 | 1.636 | 0.698 |
| **4** | VRO-4 | -0.107 | -1.547 ** | -0.607 * | -0.753 ** | 5.101 ** | 3.598 ** | 3.168 ** | 3.956** |
| **5** | IC052299 | -0.173 | 0.52 | -0.073 | 0.091 | 0.713 | 0.31 | 0.628 | 0.55 |
| **6** | Kashi Kranti | -1.373 ** | 0.853 ** | -0.873 ** | -0.464 * | 2.159 * | 1.714 | 1.314 | 1.729* |
| **7** | Salkeerthi | -0.507 | 0.587 * | 0.593 * | 0.224 | -3.295 ** | 2.171 | -1.178 | -0.767 |
| **8** | IC058235 | 0.427 | 0.453 | 0.327 | 0.402 * | -1.521 | 0.523 | -4.786 ** | -1.928** |
| **9** | Hisar Naveen | 0.827 * | -1.280 ** | 0.660 ** | 0.069 | -5.494 ** | -5.781 ** | -2.352 * | -4.542** |
| **10** | IC052302 | 0.293 | -0.147 | 0.46 | 0.202 | -3.251 ** | -2.269 * | -1.472 | -2.331** |
| **Testers** | | | | | | | | | |
| **11** | EC169452 | -0.173 | 0.553 ** | 0.593 ** | 0.324 ** | -2.036 ** | 0.126 | 1.570 * | -0.113 |
| **12** | IC052310 | 0.293 | 0.453 ** | 0.093 | 0.280 ** | -2.217 ** | -3.211 ** | -1.935 ** | -2.454 ** |
| **13** | EC169459 | -0.807 ** | -0.347 * | -0.607 ** | -0.587 ** | 1.663 ** | 0.094 | 0.036 | 0.598 |
| **14** | Kashi Pragati | 0.227 | -1.013 ** | -0.207 | -0.331 ** | 2.669 ** | 1.905 ** | 2.568 ** | 2.380 ** |
| **15** | IC052321 | 0.460 * | 0.353 * | 0.127 | 0.313 ** | -0.079 | 1.086 | -2.239 ** | -0.41 |
| **HYBRIDS** | | | | | | | | | |
| **16** | IC058710 x EC169452 | 0.573 | -0.087 | -0.993 | -0.169 | 2.875 | 4.046 | 1.937 | 2.953 |
| **17** | IC058710 x IC052310 | -0.56 | 0.013 | 0.507 | -0.013 | 4.456 * | -3.644 | 6.008 * | 2.274 |
| **18** | IC058710 x EC169459 | 0.207 | 1.147 | -0.46 | 0.298 | 0.602 | 2.718 | 0.27 | 1.197 |
| **19** | IC058710 x Kashi Pragati | -0.827 | -1.187 * | 1.140 * | -0.291 | -4.290 * | 1.16 | -2.128 | -1.752 |
| **20** | IC058710 x IC052321 | 0.607 | 0.113 | -0.193 | 0.176 | -3.643 | -4.281 | -6.088 * | -4.670 ** |
| **21** | IC045993 x EC169452 | 1.107 | -0.087 | 1.607 ** | 0.876 * | 0.119 | 0.415 | -3.596 | -1.021 |
| **22** | IC045993 x IC052310 | 1.640 * | 0.013 | 0.107 | 0.587 | 2.587 | -5.888 * | -1.825 | -1.709 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **23** | IC045993 x EC169459 | 0.407 | -1.520 * | -0.527 | -0.547 | 3.62 | 0.421 | 2.97 | 2.337 |
| **24** | IC045993 x Kashi Pragati | -1.627 * | -0.187 | -1.593 ** | -1.136 * | -1.319 | 0.99 | 0.272 | -0.019 |
| **25** | IC045993 x IC052321 | -1.527 * | 1.780 ** | 0.407 | 0.22 | -5.005 * | 4.062 | 2.179 | 0.412 |
| **26** | Pusa Sawani x EC169452 | -0.293 | -0.087 | 1.673 ** | 0.431 | 2.95 | 0.211 | 6.376 * | 3.179 * |
| **27** | Pusa Sawani x IC052310 | -2.427 ** | 0.013 | -0.16 | -0.858 * | -2.476 | -3.925 | -4.333 | -3.578 * |
| **28** | Pusa Sawani x EC169459 | 0.34 | -0.853 | -0.127 | -0.213 | 0.497 | 3.324 | -8.658 ** | -1.612 |
| **29** | Pusa Sawani x Kashi Pragati | 1.640 * | 0.48 | -0.193 | 0.642 | -4.049 * | -3.001 | 0.751 | -2.1 |
| **30** | Pusa Sawani x IC052321 | 0.74 | 0.447 | -1.193 * | -0.002 | 3.079 | 3.391 | 5.864 * | 4.111 * |
| **31** | VRO-4 x EC169452 | -0.56 | -0.687 | -1.793 ** | -1.013 * | 3.453 | 0.58 | 1.524 | 1.852 |
| **32** | VRO-4 x IC052310 | -0.027 | -0.92 | -0.627 | -0.524 | -1.373 | 8.378 ** | 2.495 | 3.167 * |
| **33** | VRO-4 x EC169459 | 0.073 | -0.12 | 1.073 * | 0.342 | -2.94 | -3.22 | -5.176 * | -3.779 * |
| **34** | VRO-4 x Kashi Pragati | 0.373 | 0.547 | 0.673 | 0.531 | 3.721 | -5.285 * | 1.992 | 0.143 |
| **35** | VRO-4 x IC052321 | 0.14 | 1.180 * | 0.673 | 0.664 | -2.861 | -0.453 | -0.834 | -1.383 |
| **36** | IC052299 x EC169452 | 0.84 | 1.247 * | -0.66 | 0.476 | -1.252 | -0.245 | -1.403 | -0.967 |
| **37** | IC052299 x IC052310 | 0.373 | 0.013 | -1.160 * | -0.258 | 0.723 | -0.568 | 3.868 | 1.341 |
| **38** | IC052299 x EC169459 | -1.527 * | 0.147 | 0.207 | -0.391 | 5.436 ** | 1.288 | -0.703 | 2.007 |
| **39** | IC052299 x Kashi Pragati | -0.227 | -1.187 * | 0.473 | -0.313 | -5.703 ** | 1.65 | -3.101 | -2.385 |
| **40** | IC052299 x IC052321 | 0.54 | -0.22 | 1.140 * | 0.487 | 0.797 | -2.125 | 1.339 | 0.004 |
| **41** | Kashi Kranti x EC169452 | 1.04 | 0.913 | 0.807 | 0.920 * | -4.758 * | 2.531 | -4.023 | -2.083 |
| **42** | Kashi Kranti x IC052310 | -0.427 | 0.68 | 0.64 | 0.298 | -9.917 ** | 0.835 | 1.115 | -2.656 |
| **43** | Kashi Kranti x EC169459 | 0.007 | 0.48 | -0.993 | -0.169 | 3.936 | -3.323 | 1.01 | 0.541 |
| **44** | Kashi Kranti x Kashi Pragati | -2.027 ** | -1.520 * | -1.060 * | -1.536 ** | 5.917 ** | 2.006 | 4.179 | 4.034 * |
| **45** | Kashi Kranti x IC052321 | 1.407 | -0.553 | 0.607 | 0.487 | 4.824 * | -2.049 | -2.281 | 0.165 |
| **46** | Salkeerthi x EC169452 | 0.173 | 0.847 | 0.673 | 0.564 | 0.266 | -0.56 | -3.798 | -1.364 |
| **47** | Salkeerthi x IC052310 | 2.040 ** | 0.28 | -0.827 | 0.498 | -0.916 | 1.284 | -6.660 ** | -2.097 |
| **48** | Salkeerthi x EC169459 | 0.473 | 0.413 | 0.54 | 0.476 | -5.080 * | 1.766 | 8.802 ** | 1.83 |
| **49** | Salkeerthi x Kashi Pragati | -1.893 * | -0.587 | -0.193 | -0.891 * | 4.298 * | -3.505 | -3.756 | -0.988 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **50** | Salkeerthi x IC052321 | -0.793 | -0.953 | -0.193 | -0.647 | 1.432 | 1.014 | 5.411 * | 2.619 |
| **51** | IC058235 x EC169452 | -1.760 * | 0.313 | -0.727 | -0.724 | 1.902 | -3.085 | -1.856 | -1.013 |
| **52** | IC058235 x IC052310 | -0.227 | 0.747 | 0.44 | 0.32 | 3.683 | 6.952 ** | 3.648 | 4.761 ** |
| **53** | IC058235 x EC169459 | 0.873 | -0.12 | 0.473 | 0.409 | -0.064 | 4.521 | -0.29 | 1.389 |
| **54** | IC058235 x Kashi Pragati | 1.173 | 0.213 | 0.407 | 0.598 | -3.41 | -2.29 | 0.246 | -1.818 |
| **55** | IC058235 x IC052321 | -0.06 | -1.153 | -0.593 | -0.602 | -2.109 | -6.098 * | -1.748 | -3.318 * |
| **56** | Hisar Naveen x EC169452 | -0.493 | -0.953 | 0.94 | -0.169 | -4.238 * | 1.119 | -5.656 * | -2.925 |
| **57** | Hisar Naveen x IC052310 | 1.04 | 1.147 | 0.44 | 0.876 * | 5.876 ** | 0.836 | -1.818 | 1.631 |
| **58** | Hisar Naveen x EC169459 | -0.527 | -0.053 | -0.86 | -0.48 | -1.118 | 1.485 | 1.144 | 0.504 |
| **59** | Hisar Naveen x Kashi Pragati | 1.773 * | 1.280 * | -0.593 | 0.820 * | 1.743 | 1.82 | 5.779 * | 3.114 * |
| **60** | Hisar Naveen x IC052321 | -1.793 * | -1.420 * | 0.073 | -1.047 * | -2.263 | -5.261 * | 0.552 | -2.324 |
| **61** | IC052302 x EC169452 | -0.627 | -1.420 * | -1.527 ** | -1.191 ** | -1.315 | -5.013 * | 10.497 ** | 1.39 |
| **62** | IC052302 x IC052310 | -1.427 | -1.987 ** | 0.64 | -0.924 * | -2.641 | -4.262 | -2.498 | -3.134 * |
| **63** | IC052302 x EC169459 | -0.327 | 0.48 | 0.673 | 0.276 | -4.888 * | -8.980 ** | 0.63 | -4.413 ** |
| **64** | IC052302 x Kashi Pragati | 1.640 * | 2.147 ** | 0.94 | 1.576 ** | 3.093 | 6.455 * | -4.234 | 1.771 |
| **65** | IC052302 x IC052321 | 0.74 | 0.78 | -0.727 | 0.264 | 5.751 ** | 11.800 ** | -4.394 | 4.386 ** |
| **GCA (line)** | | 0.344 | 0.263 | 0.233 | 0.164 | 0.910 | 1.124 | 1.100 | 0.606 |
| **GCA (Tester)** | | 0.243 | 0.186 | 0.165 | 0.116 | 0.644 | 0.795 | 0.778 | 0.428 |
| **SCA** | | 0.768 | 0.588 | 0.522 | 0.366 | 2.036 | 2.514 | 2.460 | 1.355 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly.

### 4.7.7 Internodal length (cm)

In E1 GCA ranges from -0.435 (IC052302) to 0.497 (Kashi Kranti) in lines and while in testers -0.156 (IC052321) to 0.456 (EC169459). Among the lines VRO-4 (0.349), Kashi Kranti (0.497) and in testers EC169459 (0.456) negative and significant *gca* effect. Whereas, SCA ranges from -0.654 (IC052302 x IC052321) to 0.804 (Pusa Sawani x IC052321). Among total crosses, 3 crosses revealed positive significant *sca* effect. Top desirable significant crosses were Pusa Sawani x IC052321 (0.804), IC045993 x EC169459 (0.677) and Hisar Naveen x EC169452 (0.622).

In E2 GCA ranges from -0.154 (IC058235) to 0.478 (IC045993) in lines and in testers -0.213 (EC169459) to 0.507 (Kashi Pragati). Among the lines IC045993 (0.478) and in testers Kashi Pragati (0.507) recorded positive and significant *gca* effect. Whereas, SCA ranges varied from -0.586 (IC058710 x EC169459) to 0.873 (IC058235 x EC169459). Among the 50 crosses 4 crosses revealed positive significant *sca* effect. Top desirable crosses were IC058235 x EC169459 (0.873), Pusa Sawani x IC052321 (0.649) and VRO-4 x EC169452 (0.582).

In E3 GCA ranges from -0.288 (IC058235) to 0.264 Kashi Kranti in lines and while in testers -0.089 (IC052321) to 0.109 (Kashi Pragati). Among the lines Kashi Kranti (0.264) and in testers Kashi Pragati (0.109) recorded positive and significant *gca* effect. Whereas, SCA ranges from -0.579 (IC052299 x EC169452) to 0.814 (Salekerthi x EC169452). Among 50 crosses, 8 crosses revealed positive significant *sca* effect. Top desirable crosses were Salekerthi x EC169452 (0.814), IC052299 x IC052310 (0.732) and IC058235 x EC169452 (0.671).

In pooled analysis GCA ranges from -0.232 (IC058710) to 0.263 (Kashi Kranti) in lines and while in testers -0.128 (IC052321) to 0.175 (Kashi Pragati). Among the lines Kashi Kranti (0.263), IC045993 (0.184) and in testers Kashi Pragati (0.175) recorded positive and significant *gca* effect. Whereas, SCA ranges varied from -0.395 (IC058235 x IC052321) to 0.543 (Pusa Sawani x IC052321). Three crosses recorded positive and significant *sca* effect. Top desirable crosses were Pusa Sawani x IC052321 (0.543), IC045993 x EC169459 (4.98), Kashi Kranti x Kashi Pragati (0.386).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.94), E2 (0.95), E3 (0.06), and the combined analysis (0.18) indicated the dominance of non-additive genetic effects for internodal length.

**4.7.8 Number of branches per plant**

In E1 GCA ranges from -0.405 (Hisar Naveen) to 0.648 (Kashi Kranti) in lines and in testers -0.179 (EC169452) to 0.288 (EC169459). Among lines Pusa Sawani (0.595), Kashi Kranti (0.648) and in testers EC169459 (0.288) recorded positive and significant *gca* effect. Whereas, SCA ranges from -0.675 (IC045993 x EC169452) to 0.705 (IC058235 x IC052321). Out of 50 crosses, 4 crosses had positive significant *sca* effect. Top desirable significant crosses were IC058235 x IC052321 (0.705), IC045993 x Kashi Pragati (0.539) and Salkeerthi x EC169459 (0.525).

In E2 GCA ranges from -0.339 (IC052302) to 0.301 (IC058235) in lines and while in testers -0.105 (EC169459) to 0.175 Kashi Pragati. Among the lines IC045993 (0.275), Salkeerthi (0.221), IC058235 (0.301) and in testers Kashi Pragati (0.175) recorded positive and significant *gca* effect. Whereas, SCA ranges from -0.708 (IC058710 x EC169459) to 0.732 (IC058235 x EC169459). Among the 50 crosses 4 crosses observed positive significant *sca* effect. Top desirable crosses were IC058235 x EC169459 (0.732), IC058235 x IC052310 (0.572) and Salkeerthi x EC169452 (0.545)

In E3 GCA ranges from -0.324 (IC052302) to 0.329 (Salekerthi) in lines and while in testers -0.084 (EC169459) to 0.149 (Kashi Pragati). Among the lines Salkeerthi (0.329), IC045993 (0.236) and in testers Kashi Pragati (0.149) recorded positive *gca* effect. Whereas, SCA ranges from -0.709 (IC058710 x IC052310) to 0.697 (VRO-4 x IC052321). Three crosse were observed positive significant sca effect. Top desirable crosses were VRO-4 x IC052321 (0.697), Salekerthi x EC169452 (0.581) and IC058235 x IC052310 (0.531).

While in pooled analysis GCA ranges from -0.276 (VRO-4) to 0.222 (IC058710) in lines and in testers -0.103 (EC052302) to 0.066 (Kashi Pragati). Among the lines IC058710 (0.222), Pusa Sawani (0.217), Kashi Kranti (0.200), IC058235 (0.177) and in testers none of tester recorded positive and significant gca effect. Whereas, SCA, ranges varied from -0.460 (IC058710 x IC052310) to 0.400 (Salkeerthi x EC169452). Four crosses recorded were positive and significant sca effect. Top desirable crosses were Salkeerthi x EC169452 (0.400), VRO-4 x IC052321 (0.378) and IC058235 x IC052310 (0.372).

**Table 53. Estimates combining ability of parents and hybrids in individual and pooled environments for internodal length and number of branches/plant**

| S.No. | Genotype | Internodal length | | | | Number of branches/plant | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| **PARENTS** | | | | | | | | | |
| **Lines** | | | | | | | | | |
| 1 | IC058710 | -0.415 ** | -0.145 | -0.135 | -0.232 ** | -0.325 ** | -0.085 | -0.097 | -0.169 * |
| 2 | IC045993 | -0.061 | 0.478 ** | 0.133 | 0.184 * | 0.155 | 0.275 * | 0.236 * | 0.222 ** |
| 3 | Pusa Sawani | -0.039 | 0.262 * | -0.041 | 0.061 | 0.595 ** | 0.075 | -0.017 | 0.217 ** |
| 4 | VRO-4 | 0.349 * | -0.17 | -0.12 | 0.02 | -0.232 ** | -0.312 ** | -0.284 ** | -0.276 ** |
| 5 | IC052299 | -0.095 | -0.13 | 0.056 | -0.056 | -0.072 | 0.075 | 0.063 | 0.022 |
| 6 | Kashi Kranti | 0.497 ** | 0.027 | 0.264 ** | 0.263 ** | 0.648 ** | -0.059 | 0.009 | 0.200 ** |
| 7 | Salkeerthi | -0.024 | 0.047 | 0.136 | 0.053 | -0.112 | 0.221 * | 0.143 | 0.084 |
| 8 | IC058235 | 0.04 | -0.154 | -0.288 ** | -0.134 | -0.099 | 0.301 ** | 0.329 ** | 0.177 ** |
| 9 | Hisar Naveen | 0.181 | -0.106 | 0.028 | 0.035 | -0.405 ** | -0.152 | -0.057 | -0.205 ** |
| 10 | IC052302 | -0.435 ** | -0.11 | -0.035 | -0.193 * | -0.152 | -0.339 ** | -0.324 ** | -0.272 ** |
| **Testers** | | | | | | | | | |
| 11 | EC169452 | -0.107 | -0.136 * | -0.067 | -0.104 * | -0.179 ** | -0.105 | -0.024 | -0.103 ** |
| 12 | IC052310 | -0.102 | -0.017 | 0.061 | -0.019 | -0.012 | -0.079 | -0.077 | -0.056 |
| 13 | EC169459 | 0.456 ** | -0.213 ** | -0.015 | 0.076 | 0.288 ** | -0.032 | -0.084 | 0.057 |
| 14 | Kashi Pragati | -0.091 | 0.507 ** | 0.109 * | 0.175 ** | -0.125 ** | 0.175 ** | 0.149 ** | 0.066 |
| 15 | IC052321 | -0.156 * | -0.141 * | -0.089 | -0.128 ** | 0.028 | 0.041 | 0.036 | 0.035 |
| **HYBRIDS** | | | | | | | | | |
| 16 | IC058710 x EC169452 | -0.288 | 0.191 | 0.078 | -0.006 | 0.139 | 0.319 | 0.237 | 0.232 |
| 17 | IC058710 x IC052310 | -0.12 | -0.102 | 0.123 | -0.033 | 0.039 | -0.708 ** | -0.709 ** | -0.460 ** |
| 18 | IC058710 x EC169459 | 0.409 | -0.586 * | 0.092 | -0.028 | -0.061 | 0.312 | 0.364 | 0.205 |
| 19 | IC058710 x Kashi Pragati | 0.292 | 0.015 | -0.225 | 0.027 | -0.115 | 0.105 | 0.131 | 0.04 |
| 20 | IC058710 x IC052321 | -0.293 | 0.482 | -0.067 | 0.041 | -0.001 | -0.028 | -0.023 | -0.017 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| 21 | IC045993 x EC169452 | -0.296 | 0.115 | -0.163 | -0.115 | -0.675 ** | -0.108 | -0.163 | -0.315 * |
| 22 | IC045993 x IC052310 | -0.428 | 0.182 | 0.048 | -0.066 | -0.308 | 0.465 | 0.357 | 0.172 |
| 23 | IC045993 x EC169459 | 0.677 * | 0.152 | 0.664 ** | 0.498 ** | -0.075 | -0.515 * | -0.436 * | -0.342 * |
| 24 | IC045993 x Kashi Pragati | -0.466 | -0.461 | -0.193 | -0.373 * | 0.539 ** | 0.079 | 0.131 | 0.249 |
| 25 | IC045993 x IC052321 | 0.512 | 0.013 | -0.355 | 0.057 | 0.519 ** | 0.079 | 0.111 | 0.236 |
| 26 | Pusa Sawani x EC169452 | -0.178 | -0.369 | 0.217 | -0.11 | 0.085 | 0.025 | 0.024 | 0.045 |
| 27 | Pusa Sawani x IC052310 | 0.084 | -0.385 | -0.245 | -0.182 | 0.052 | -0.001 | 0.077 | 0.043 |
| 28 | Pusa Sawani x EC169459 | -0.068 | 0.558 * | -0.242 | 0.082 | -0.315 | 0.485 * | 0.217 | 0.129 |
| 29 | Pusa Sawani x Kashi Pragati | -0.641 * | -0.452 | 0.095 | -0.333 * | 0.232 | -0.255 | -0.149 | -0.057 |
| 30 | Pusa Sawani x IC052321 | 0.804 ** | 0.649 * | 0.175 | 0.543 ** | -0.055 | -0.255 | -0.169 | -0.16 |
| 31 | VRO-4 x EC169452 | -0.373 | 0.582 * | -0.537 * | -0.109 | 0.179 | -0.655 ** | -0.576 ** | -0.351 * |
| 32 | VRO-4 x IC052310 | 0.462 | -0.364 | -0.245 | -0.049 | 0.145 | -0.015 | -0.056 | 0.025 |
| 33 | VRO-4 x EC169459 | -0.489 | 0.102 | -0.303 | -0.23 | 0.312 | 0.139 | 0.151 | 0.2 |
| 34 | VRO-4 x Kashi Pragati | 0.257 | -0.294 | 0.554 ** | 0.172 | -0.341 | -0.201 | -0.216 | -0.253 |
| 35 | VRO-4 x IC052321 | 0.142 | -0.026 | 0.531 * | 0.216 | -0.295 | 0.732 ** | 0.697 ** | 0.378 * |
| 36 | IC052299 x EC169452 | -0.342 | -0.057 | -0.579 ** | -0.326 | 0.352 | 0.025 | -0.056 | 0.107 |
| 37 | IC052299 x IC052310 | -0.127 | -0.41 | 0.732 ** | 0.065 | -0.215 | -0.201 | -0.203 | -0.206 |
| 38 | IC052299 x EC169459 | 0.228 | -0.047 | 0.108 | 0.096 | -0.181 | 0.019 | 0.071 | -0.031 |
| 39 | IC052299 x Kashi Pragati | 0.008 | 0.447 | -0.382 | 0.024 | 0.032 | 0.212 | 0.237 | 0.16 |
| 40 | IC052299 x IC052321 | 0.233 | 0.068 | 0.122 | 0.141 | 0.012 | -0.055 | -0.049 | -0.031 |
| 41 | Kashi Kranti x EC169452 | 0.299 | -0.074 | -0.254 | -0.01 | 0.099 | -0.108 | 0.397 | 0.129 |
| 42 | Kashi Kranti x IC052310 | -0.292 | 0.053 | -0.189 | -0.143 | -0.068 | -0.135 | -0.149 | -0.117 |
| 43 | Kashi Kranti x EC169459 | -0.324 | 0.029 | -0.107 | -0.134 | -0.368 | 0.019 | -0.143 | -0.164 |
| 44 | Kashi Kranti x Kashi Pragati | 0.399 | 0.103 | 0.657 ** | 0.386 * | 0.312 | 0.212 | -0.043 | 0.16 |
| 45 | Kashi Kranti x IC052321 | -0.082 | -0.11 | -0.106 | -0.099 | 0.025 | 0.012 | -0.063 | -0.008 |
| 46 | Salkeerthi x EC169452 | 0.134 | -0.128 | 0.814 ** | 0.273 | 0.125 | 0.545 * | 0.581 * | 0.400 ** |
| 47 | Salkeerthi x IC052310 | 0.369 | -0.001 | 0.125 | 0.164 | 0.225 | -0.481 * | -0.349 | -0.202 |
| 48 | Salkeerthi x EC169459 | -0.489 | 0.042 | -0.245 | -0.231 | 0.525 ** | -0.195 | -0.076 | 0.085 |

| Table continues… | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 49 | Salkeerthi x Kashi Pragati | -0.049 | 0.163 | -0.415 * | -0.101 | -0.461 * | -0.335 | -0.243 | -0.346 * |
| 50 | Salkeerthi x IC052321 | 0.036 | -0.076 | -0.278 | -0.106 | -0.415 * | 0.465 | 0.137 | 0.063 |
| 51 | IC058235 x EC169452 | -0.11 | -0.1 | 0.671 ** | 0.154 | -0.221 | 0.199 | 0.077 | 0.018 |
| 52 | IC058235 x IC052310 | 0.168 | 0.873 ** | -0.124 | 0.306 | 0.012 | 0.572 * | 0.531 * | 0.372 * |
| 53 | IC058235 x EC169459 | 0.017 | -0.217 | 0.192 | -0.003 | -0.021 | -0.141 | -0.129 | -0.097 |
| 54 | IC058235 x Kashi Pragati | 0.287 | -0.073 | -0.398 | -0.062 | -0.475 * | -0.415 | -0.429 * | -0.440 ** |
| 55 | IC058235 x IC052321 | -0.362 | -0.482 | -0.341 | -0.395 * | 0.705 ** | -0.215 | -0.049 | 0.147 |
| 56 | Hisar Naveen x EC169452 | 0.622 * | -0.088 | -0.225 | 0.103 | -0.248 | -0.148 | -0.269 | -0.222 |
| 57 | Hisar Naveen x IC052310 | -0.083 | 0.132 | 0.027 | 0.025 | 0.185 | 0.092 | 0.117 | 0.132 |
| 58 | Hisar Naveen x EC169459 | -0.081 | -0.258 | -0.011 | -0.117 | 0.019 | -0.088 | -0.009 | -0.026 |
| 59 | Hisar Naveen x Kashi Pragati | -0.121 | 0.505 | -0.141 | 0.081 | 0.165 | 0.439 | 0.357 | 0.320 * |
| 60 | Hisar Naveen x IC052321 | -0.336 | -0.29 | 0.35 | -0.092 | -0.121 | -0.295 | -0.196 | -0.204 |
| 61 | IC052302 x EC169452 | 0.531 | -0.071 | -0.021 | 0.146 | 0.165 | -0.095 | -0.203 | -0.044 |
| 62 | IC052302 x IC052310 | -0.034 | 0.023 | -0.25 | -0.087 | -0.068 | 0.412 | 0.384 | 0.243 |
| 63 | IC052302 x EC169459 | 0.121 | 0.226 | -0.147 | 0.066 | 0.165 | -0.035 | -0.009 | 0.04 |
| 64 | IC052302 x Kashi Pragati | 0.035 | 0.049 | 0.449 * | 0.178 | 0.112 | 0.159 | 0.224 | 0.165 |
| 65 | IC052302 x IC052321 | -0.654 * | -0.226 | -0.03 | -0.303 | -0.375 | -0.441 | -0.396 | -0.404 ** |
| **GCA (line)** | | 0.137 | 0.114 | 0.093 | 0.067 | 0.086 | 0.105 | 0.095 | 0.055 |
| **GCA (Tester)** | | 0.097 | 0.081 | 0.066 | 0.047 | 0.060 | 0.074 | 0.067 | 0.039 |
| **SCA** | | 0.305 | 0.256 | 0.209 | 0.150 | 0.191 | 0.235 | 0.212 | 0.123 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly

During this study, E1 (0.82), E2 (0.22), E3 (0.22), and the combined analysis (0.09) indicated the dominance of non-additive genetic effects for no. of branches/plant.

**4.7.9 Number of nodes per plant**

In E1 GCA ranges from -0.713 (Hisar Naveen) to 1.147 (VRO-4) in lines and in testers -1.152 (IC052310) to 1.190 (EC169459). Among lines VRO-4 (1.147), Kashi Kranti (0.909) and in testers EC169452 (0.731), EC169459 (1.190) revealed positive and significant *gca* effect. Whereas, SCA ranges reveal from -1.947 (Pusa Sawani x Kashi Pragati) to 1.820 (VRO-4 x Kashi Pragati). Among the 50 crosses, 3 crosses were recorded positive significant *sca* effect. Top desirable significant crosses were VRO-4 x Kashi Pragati (1.820), IC058235 x EC169459 (1.743) and Kashi Kranti x IC052321 (1.593).

In E2 GCA ranges from -0.628 (Salkeerthi) to 0.851 (Kashi Kranti) in lines and while in testers -0.220 (EC169452) to 0.369 (Kashi Pragati). Among the lines Kashi Kranti (0.851), IC058235 (0.583), Pusa Sawani (0.561), VRO-4 (0.560) and in testers Kashi Pragati (0.369) recorded positive and significant gca effect. Whereas, SCA ranges from -1.277 (Pusa Sawani x IC052310) to 1.524 (VRO-4 x IC052310). Two crosses recorded positive significant *sca* effect. Top desirable crosses were VRO-4 x IC052310 (1.524) and Pusa Sawani x EC169452 (0.896).

In E3 GCA ranges from -0.394 (IC058235) to 0.980 (Kashi Kranti) in lines and in testers -0.154 (EC169459) to 0.224 (EC169452) recorded. Among the lines Kashi Kranti (0.980) and in testers none of the tester recorded positive and significant *gca* effect. In SCA ranges exhibit from -1.767 (VRO-4 x IC052310) to 2.258 (VRO-4 x EC169459). Total crosses two crosses were recorded positive significant *sca* effect. Top desirable crosses were VRO-4 x EC169459 (2.258) and Hisar Naveen x IC052310 (1.590).

While in pooled analysis GCA ranges from -0.545 (Hisar Naveen) to 0.914 (Kashi Kranti) in lines and while in testers -0.391 (IC052310) to 0.361 (EC169459). Among the lines Kashi Kranti (0.914), VRO-4 (0.647), Pusa Sawani (0.378) and in testers EC169459 (0.361), EC169452 (0.245) recorded positive and significant *gca* effect. Whereas, SCA ranges varied from -0.577 (IC045993 x IC052310) to 0.813 (Hisar Naveen x IC052310). Two crosses recorded were positive and significant *sca* effect. Top desirable crosses were Hisar Naveen x IC052310 (0.813) and Pusa Sawani x EC169452 (0.662).

During this study, E1 (0.8), E2 (0.22), E3 (0.22), and the combined analysis (0.09) indicated the dominance of non-additive genetic effects for no. nodes/plant.

**4.7.10 Fruit length (cm)**

In E1 GCA ranges from -0.656 (IC058710) to 0.605 (IC052299) in lines and while in testers -0.505 (EC169452) to 0.281 (Kashi Pragati) in testers. Among the lines VRO-4 (0.445), IC052299 (0.605), Kashi Kranti (0.536) and in testers Kashi Pragati (0.281), EC169459 (0.250) recorded positive and significant *gca* effect. Whereas, SCA ranges from -1.324 (IC058235 x IC052310) to 1.717 (IC058235 x EC169452). Among 50 crosses 4 crosses resulted positive significant *sca* effect. Top desirable significant crosses were IC058235 x EC169452 (1.717), Pusa Sawani x EC169452 (1.012) and Salkeerthi x IC052310 (0.996).

In E2 GCA ranges from -0.452 (IC058235) to 0.652 (Kashi Kranti) in lines and in testers EC169452 (-0.279) to Kashi Pragati (0.264). Among the lines Kashi Kranti (0.652) and in testers Kashi Pragati (0.264) recorded positive and significant *gca* effect. Whereas, SCA ranges from -1.626 (Pusa Sawani x IC052321) to 1.369 (IC052302 x IC052310). Out of 50 crosses, 4 crosses observed positive and significant sca effect. Top desirable crosses were IC052302 x IC052310 (1.369), Hisar Naveen x EC169452 (1.086), Kashi Kranti x EC169459 (1.074).

In E3 GCA ranges from -0.553 (IC058710) to 0.796 (VRO-4) in lines and -0.079 (EC169459) to 0.059 (IC052310) in testers. Among the lines VRO-4 (0.796), Kashi Kranti (0.715) and no testers recorded positive and significant *gca* effect. Whereas, SCA exhibit ranges from -1.116 (IC058710) x Kashi Pragati to 0.804 (Kashi Kranti x Kashi Pragati). Among 50 crosses, 3 crosses observed positive significant *sca* effect. Top desirable crosses were Kashi Kranti x Kashi Pragati (0.804), VRO-4 x IC052310 (0.802) and VRO-4 x Kashi Pragati (0.769).

While in pooled analysis GCA ranges from -0.470 (IC058710) to 0.634 (Kashi Kranti) in lines and in testers -0.269 (EC169452) to 0.197 (Kashi Pragati recorded. Among the lines Kashi Kranti (0.634), VRO-4 (0.481) and in testers Kashi Pragati (0.197) recorded positive and significant *gca* effect. Whereas, SCA ranges varied from -0.722 (IC058235 x IC052310) to 0.930 (IC058235 x EC169452).

**Table 54. Estimates combining ability of parents and hybrids across diverse and pooled environments for number of nodes/plant and fruit length**

| S.No. | Genotype | Number of nodes/plant | | | | Fruit length | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| **PARENTS** | | | | | | | | | |
| **Lines** | | | | | | | | | |
| **1** | IC058710 | -0.659 | -0.234 | -0.2 | -0.364 * | -0.656 ** | -0.201 | -0.553 ** | -0.470 ** |
| **2** | IC045993 | -0.125 | -0.413 * | -0.032 | -0.19 | -0.011 | 0.118 | -0.306 | -0.067 |
| **3** | Pusa Sawani | 0.365 | 0.561 ** | 0.21 | 0.378 * | 0.063 | -0.066 | -0.191 | -0.064 |
| **4** | VRO-4 | 1.147 * | 0.560 ** | 0.235 | 0.647 ** | 0.445 * | 0.202 | 0.796 ** | 0.481 ** |
| **5** | IC052299 | 0.582 | -0.369 | -0.032 | 0.06 | 0.605 ** | -0.125 | -0.208 | 0.091 |
| **6** | Kashi Kranti | 0.909 ** | 0.851 ** | 0.980 ** | 0.914 ** | 0.536 ** | 0.652 ** | 0.715 ** | 0.634 ** |
| **7** | Salkeerthi | -0.527 | -0.628 ** | -0.07 | -0.408 * | -0.272 | 0.17 | 0.043 | -0.02 |
| **8** | IC058235 | -0.710 * | 0.583 ** | -0.394 | -0.174 | -0.195 | -0.452 * | -0.077 | -0.242 |
| **9** | Hisar Naveen | -0.713 * | -0.600 ** | -0.322 | -0.545 ** | 0.055 | 0.072 | -0.313 | -0.062 |
| **10** | IC052302 | -0.27 | -0.309 | -0.374 | -0.318 | -0.569 ** | -0.368 | 0.094 | -0.281 * |
| **Testers** | | | | | | | | | |
| **11** | EC169452 | 0.731 ** | -0.220 * | 0.224 | 0.245 * | -0.505 ** | -0.279 * | -0.022 | -0.269 ** |
| **12** | IC052310 | -1.152 ** | 0.02 | -0.042 | -0.391 ** | -0.134 | 0.178 | 0.059 | 0.035 |
| **13** | EC169459 | 1.190 ** | 0.047 | -0.154 | 0.361 ** | 0.250 * | 0.11 | -0.079 | 0.057 |
| **14** | Kashi Pragati | -0.067 | 0.369 ** | -0.138 | 0.054 | 0.281 * | 0.264 * | 0.046 | 0.197 ** |
| **15** | IC052321 | -0.702 ** | -0.216 | 0.111 | -0.269 ** | 0.108 | -0.163 | -0.004 | -0.02 |
| **HYBRIDS** | | | | | | | | | |
| **16** | IC058710 x EC169452 | 0.254 | 0.034 | -0.165 | 0.041 | -0.389 | -0.131 | 0.515 | -0.001 |
| **17** | IC058710 x IC052310 | -0.33 | -0.082 | -0.586 | -0.332 | 0.62 | 0.115 | -0.156 | 0.193 |
| **18** | IC058710 x EC169459 | -0.105 | -0.476 | 0.086 | -0.165 | 0.05 | -0.89 | 0.136 | -0.235 |
| **19** | IC058710 x Kashi Pragati | 0.126 | 0.236 | 0.363 | 0.242 | -0.349 | 0.609 | -1.116 ** | -0.285 |
| **20** | IC058710 x IC052321 | 0.054 | 0.287 | 0.301 | 0.214 | 0.068 | 0.296 | 0.621 | 0.328 |
| **21** | IC045993 x EC169452 | -0.513 | 0.15 | 0.434 | 0.024 | -0.737 | -0.72 | 0.565 | -0.297 |

| *Table continues…* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **22** | IC045993 x IC052310 | -0.63 | -0.169 | -0.933 | -0.577 | 0.315 | -0.083 | -0.749 * | -0.173 |
| **23** | IC045993 x EC169459 | 1.061 | 0.243 | -0.621 | 0.228 | 0.312 | 1.035 * | 0.022 | 0.456 |
| **24** | IC045993 x Kashi Pragati | 0.222 | 0.149 | 0.173 | 0.181 | 0.133 | 0.064 | -0.349 | -0.051 |
| **25** | IC045993 x IC052321 | -0.14 | -0.374 | 0.947 | 0.145 | -0.023 | -0.296 | 0.511 | 0.064 |
| **26** | Pusa Sawani x EC169452 | 1.231 | 0.896 * | -0.141 | 0.662* | 1.012 * | 0.957 | -0.01 | 0.653 * |
| **27** | Pusa Sawani x IC052310 | 0.014 | -1.277 ** | -0.355 | -0.539 | 0.24 | 0.803 | 0.535 | 0.526 |
| **28** | Pusa Sawani x EC169459 | 0.172 | 0.366 | -0.33 | 0.069 | -0.68 | -0.175 | -0.366 | -0.407 |
| **29** | Pusa Sawani x Kashi Pragati | -1.947 * | 0.391 | 0.987 | -0.189 | 0.399 | 0.041 | -0.624 | -0.062 |
| **30** | Pusa Sawani x IC052321 | 0.531 | -0.378 | -0.162 | -0.003 | -0.971 * | -1.626 ** | 0.466 | -0.711 * |
| **31** | VRO-4 x EC169452 | 0.381 | -0.53 | 0.734 | 0.195 | 0.277 | 0.336 | -0.750 * | -0.045 |
| **32** | VRO-4 x IC052310 | -0.569 | 1.524 ** | -1.767 ** | -0.271 | -0.134 | -0.891 | 0.802 * | -0.074 |
| **33** | VRO-4 x EC169459 | -1.214 | -0.7 | 2.258 ** | 0.115 | -0.171 | 0.364 | -0.7 | -0.169 |
| **34** | VRO-4 x Kashi Pragati | 1.820 * | -0.091 | -1.291 * | 0.146 | 0.204 | -0.19 | 0.769 * | 0.261 |
| **35** | VRO-4 x IC052321 | -0.418 | -0.204 | 0.066 | -0.185 | -0.176 | 0.38 | -0.121 | 0.028 |
| **36** | IC052299 x EC169452 | 0.197 | -0.24 | -0.62 | -0.221 | -0.273 | -0.51 | -0.286 | -0.357 |
| **37** | IC052299 x IC052310 | -0.464 | 0.13 | 0.4 | 0.022 | -0.042 | 0.849 | 0.473 | 0.427 |
| **38** | IC052299 x EC169459 | -0.189 | 0.246 | 0.545 | 0.201 | 0.515 | 0.187 | -0.069 | 0.211 |
| **39** | IC052299 x Kashi Pragati | 0.192 | -0.425 | 0.095 | -0.046 | -0.48 | -0.873 | -0.254 | -0.536 |
| **40** | IC052299 x IC052321 | 0.264 | 0.289 | -0.42 | 0.044 | 0.28 | 0.347 | 0.136 | 0.254 |
| **41** | Kashi Kranti x EC169452 | -1.237 | 0.196 | -0.445 | -0.495 | -0.817 | -0.98 | 0.175 | -0.541 |
| **42** | Kashi Kranti x IC052310 | 0.269 | 0.126 | 0.828 | 0.408 | -1.109 * | -0.891 | -0.157 | -0.719 * |
| **43** | Kashi Kranti x EC169459 | -0.743 | -0.015 | -0.367 | -0.375 | 0.898 * | 1.074 * | -0.062 | 0.637 * |
| **44** | Kashi Kranti x Kashi Pragati | 0.118 | 0.157 | 0.283 | 0.186 | 0.306 | 0.6 | 0.804 * | 0.570 * |
| **45** | Kashi Kranti x IC052321 | 1.593 * | -0.465 | -0.299 | 0.276 | 0.723 | 0.197 | -0.760 * | 0.053 |
| **46** | Salkeerthi x EC169452 | 0.609 | -0.295 | 0.259 | 0.191 | -0.756 | -0.178 | -0.363 | -0.433 |
| **47** | Salkeerthi x IC052310 | -0.155 | -0.058 | 0.005 | -0.069 | 0.996 * | -0.542 | -0.351 | 0.034 |
| **48** | Salkeerthi x EC169459 | -0.604 | 0.165 | 0.01 | -0.143 | -0.134 | 0.429 | 0.607 | 0.301 |
| **49** | Salkeerthi x Kashi Pragati | -0.113 | 0.297 | -0.759 | -0.192 | 0.794 | 0.412 | 0.256 | 0.487 |
| **50** | Salkeerthi x IC052321 | 0.262 | -0.109 | 0.485 | 0.213 | -0.899 * | -0.121 | -0.148 | -0.389 |

| *Table continues…* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **51** | IC058235 x EC169452 | -1.278 | 0.421 | -0.137 | -0.331 | 1.717 ** | 0.67 | 0.403 | 0.930 ** |
| **52** | IC058235 x IC052310 | 0.218 | -0.605 | 0.596 | 0.07 | -1.324 ** | -0.737 | -0.105 | -0.722 * |
| **53** | IC058235 x EC169459 | 1.743 * | 0.341 | -0.472 | 0.537 | -0.381 | 0.165 | 0.194 | -0.008 |
| **54** | IC058235 x Kashi Pragati | -0.463 | -0.561 | 0.258 | -0.255 | -0.759 | -0.696 | -0.384 | -0.613 * |
| **55** | IC058235 x IC052321 | -0.221 | 0.404 | -0.244 | -0.02 | 0.747 | 0.597 | -0.108 | 0.412 |
| **56** | Hisar Naveen x EC169452 | -0.059 | -0.403 | -0.629 | -0.363 | 0.714 | 1.086 * | -0.194 | 0.535 |
| **57** | Hisar Naveen x IC052310 | 0.764 | 0.084 | 1.590 ** | 0.813 * | 0.292 | 0.006 | -0.322 | -0.008 |
| **58** | Hisar Naveen x EC169459 | 0.139 | -0.07 | -0.844 | -0.258 | -0.808 | -0.799 | 0.17 | -0.479 |
| **59** | Hisar Naveen x Kashi Pragati | -0.053 | -0.065 | 0.246 | 0.043 | -0.693 | -0.65 | 0.585 | -0.253 |
| **60** | Hisar Naveen x IC052321 | -0.792 | 0.453 | -0.363 | -0.234 | 0.494 | 0.357 | -0.238 | 0.204 |
| **61** | IC052302 x EC169452 | 0.415 | -0.231 | 0.71 | 0.298 | -0.749 | -0.531 | -0.055 | -0.445 |
| **62** | IC052302 x IC052310 | 0.882 | 0.326 | 0.222 | 0.477 | 0.146 | 1.369 ** | 0.031 | 0.515 |
| **63** | IC052302 x EC169459 | -0.26 | -0.101 | -0.266 | -0.209 | 0.4 | -1.390 ** | 0.069 | -0.307 |
| **64** | IC052302 x Kashi Pragati | 0.097 | -0.089 | -0.355 | -0.116 | 0.445 | 0.683 | 0.314 | 0.481 |
| **65** | IC052302 x IC052321 | -1.134 | 0.095 | -0.311 | -0.45 | -0.242 | -0.131 | -0.359 | -0.244 |
| **GCA (line)** | | 0.336 | 0.201 | 0.253 | 0.156 | 0.199 | 0.225 | 0.159 | 0.113 |
| **GCA (Tester)** | | 0.238 | 0.142 | 0.179 | 0.110 | 0.141 | 0.159 | 0.113 | 0.080 |
| **SCA** | | 0.751 | 0.450 | 0.567 | 0.348 | 0.446 | 0.504 | 0.356 | 0.254 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly.

Among 50 crosses, 4 crosses were positive and significant *sca effect*. Top desirable crosses were IC058235 x EC169452 (0.930), Pusa Sawani x EC169452 (0.653) and Kashi Kranti x EC169459 (0.637).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.30), E2 (0.08), E3 (0.22), and the combined analysis (0.09) indicated the dominance of non-additive genetic effects for fruit length.

### 4.7.11 Fruit diameter (nm)

In E1 GCA ranges from -0.841(Pusa Sawani) to 1.248 (Salkeerthi) in lines and while in testers IC052310 (-0.294) to EC169459 (0.549). Among the lines Salkeerthi (1.248) and in testers EC169459 (0.549) recorded positive and significant *gca* effect. Whereas, SCA express ranges from -1.249 (IC058235 x IC052310) to 1.224 (Pusa Sawani x IC052321). Out of 50 crosses, 6 crosses recorded positive significant *sca* effect. Top desirable significant crosses were Pusa Sawani x IC052321 (1.224), IC052299 x EC169459 (1.183) and IC045993 x Kashi Pragati (1.104).

In E2 GCA ranges from -0.400 (IC058235) to 0.610 (Kashi Kranti) in lines and in testers -0.206 (EC169452) to 0.404 (Kashi Pragati). Among the lines Kashi Kranti (0.610) and in testers Kashi Pragati (0.404) recorded positive and significant *gca* effect. Whereas, SCA exabit ranges from -1.370 (Salkeerthi x Kashi Pragati) to 3.029 (Salkeerthi x EC169459). Among 50 crosses 7 crosses observed positive significant *sca* effect. Top desirable significant crosses were Salkeerthi x EC169459 (3.029), IC052299 x EC169452 (2.623) and Kashi Kranti x IC052310 (2.402).

In E3 GCA ranges from -0.585 (IC052302) to 1.234 (VRO-4), in lines and while in testers -0.515 (IC052321) to 0.291 (Kashi Pragati). Among the lines VRO-4 (1.234) and in testers Kashi Pragati (0.291) recorded positive and significant *gca* effect. Whereas, SCA ranges from -1.587 (IC058710 x Kashi Pragati) to 2.763 (Salekerthi x EC169459). Out of 50 crosses 7 crosses observed positive significant *sca* effect. Top desirable crosses were Salekerthi x EC169459 (2.763), IC045993 x Kashi Pragati (1.434) and Hisar Naveen x IC052321 (1.355).

While in pooled analysis GCA ranges from -0.537 (Hisar Naveen) to 0.560 (VRO-4) in lines and in testers -0.247 (IC052321) to 0.302 (EC169459). Among the lines VRO-4 (0.560), Kashi Kranti (0.449), Salkeerthi (0.316) and in testers EC169459 (0.302), Kashi

Pragati (0.241) recorded positive and significant *gca* effect. In SCA, ranges varied from -0.758 (IC052299 x Kashi Pragati) to 1.846 (Salekerthi x EC169459). Among 50 crosses, 6 crosses recorded were positive and significant *sca* effect. Top desirable crosses were Salekerthi x EC169459 (1.846), IC045993 x Kashi Pragati (1.245) and IC052299 x EC169452 (1.196).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.63), E2 (0.04), E3 (0.25), and the combined analysis (0.08) indicated the dominance of non-additive genetic effects for fruit diameter.

**4.7.12 Number of ridges per fruit**

In E1 GCA ranges from -0.300 (IC058710) to 0.327 (VRO-4) in lines and while in testers -0.153 (EC169459) to 0.200 (Kashi Pragati). Among the lines IC045993 (0.140), VRO-4 (0.327), Kashi Kranti (0.260) and in testers Kashi Pragati (0.200) recorded positive and significant *gca* effect. Whereas, SCA ranges from -0.320 (IC045993 x IC052321) to 0.573 (Pusa Sawani x IC052310). Out of 50 crosses, 7 were observed positive significant *sca* effect. Top desirable significant crosses were Pusa Sawani x IC052310 (0.573), IC045993 x EC169452 (0.433) and Salkeerthi x IC052321 (0.400).

In E2 GCA ranges from -0.099 (Salkeerthi) to 0.115 (Hisar Naveen) in lines and while in testers -0.092 (EC169452) to 0.101 (Kashi Pragati). Among the lines Hisar Naveen (0.115) and in testers Kashi Pragati (0.101) recorded positive and significant *gca* effect. Whereas, SCA ranges from -0.268 (Pusa Sawani x EC169452) to 0.632 (IC058235 x IC052321). Out of 50 crosses 5 crosses observed positive significant *sca* effect. Top desirable crosses were IC058235 x IC052321 (0.632), IC052302 x EC169459 (0.472) and Hisar Naveen x IC052310 (0.452).

In E3 GCA ranges from -0.112 (Salekerthi) to 0.115 (VRO-4) in lines and -0.052 (IC052310) to in testers 0.061 (Kashi Pragati). Among the lines VRO-4 (0.115) and in testers Kashi Pragati (0.061) recorded positive and significant *gca* effect. Whereas, SCA ranges from -0.261 (IC058235 x Kashi Pragati) to 0.252 (IC058235 x IC052310). Out of 50 crosses 6 crosses observed positive significant *sca* effect. Top desirable crosses were IC058235 x IC052310 (0.252), IC052299 x EC169459 (0.241) and IC045993 x EC169452 (0.232).

**Table 55. Estimates combining ability of parents and hybrids across diverse and pooled environments for fruit diameter and number of ridges/fruit**

| S.No. | Genotype | Fruit diameter | | | | Number of ridges/fruit | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| **PARENTS** | | | | | | | | | |
| **Lines** | | | | | | | | | |
| **1** | IC058710 | 0.083 | -0.214 | -0.073 | -0.068 | -0.300 ** | -0.045 | 0.008 | -0.112 ** |
| **2** | IC045993 | -0.045 | 0.189 | 0.353 | 0.166 | 0.140 * | 0.075 | 0.021 | 0.079 * |
| **3** | Pusa Sawani | -0.841 ** | 0.128 | -0.573 * | -0.429 ** | -0.153 * | -0.032 | -0.059 | -0.081 * |
| **4** | VRO-4 | 0.848 ** | -0.4 | 1.234 ** | 0.560 ** | 0.327 ** | -0.005 | 0.115 * | 0.145 ** |
| **5** | IC052299 | -0.172 | 0.029 | 0.22 | 0.026 | 0.033 | -0.099 * | -0.019 | -0.028 |
| **6** | Kashi Kranti | 0.422 * | 0.610 ** | 0.313 | 0.449 ** | 0.260 ** | -0.005 | 0.048 | 0.101 ** |
| **7** | Salkeerthi | 1.248 ** | -0.135 | -0.166 | 0.316 * | -0.113 | -0.099 * | -0.112 * | -0.108 ** |
| **8** | IC058235 | -0.096 | 0.092 | -0.212 | -0.072 | -0.033 | 0.088 | 0.048 | 0.034 |
| **9** | Hisar Naveen | -0.887 ** | -0.216 | -0.509 * | -0.537 ** | -0.087 | 0.115 * | 0.035 | 0.021 |
| **10** | IC052302 | -0.562 ** | -0.084 | -0.585 * | -0.410 ** | -0.073 | 0.008 | -0.085 | -0.05 |
| **Testers** | | | | | | | | | |
| **11** | EC169452 | -0.247 * | -0.169 | -0.021 | -0.146 | -0.073 | -0.092 ** | -0.005 | -0.057 ** |
| **12** | IC052310 | -0.294 * | -0.206 | 0.047 | -0.151 | 0.013 | 0.041 | -0.052 * | 0.001 |
| **13** | EC169459 | 0.549 ** | 0.159 | 0.198 | 0.302 ** | -0.153 ** | -0.005 | -0.025 | -0.061 ** |
| **14** | Kashi Pragati | 0.028 | 0.404 ** | 0.291 * | 0.241 ** | 0.200 ** | 0.101 ** | 0.061 * | 0.121 ** |
| **15** | IC052321 | -0.036 | -0.189 | -0.515 ** | -0.247 ** | 0.013 | -0.045 | 0.021 | -0.004 |
| **HYBRIDS** | | | | | | | | | |
| **16** | IC058710 x EC169452 | 0.561 | 0.597 | 0.205 | 0.454 | 0.007 | 0.145 | -0.155 | -0.001 |
| **17** | IC058710 x IC052310 | -0.348 | 0.02 | 0.063 | -0.088 | 0.053 | -0.055 | 0.092 | 0.03 |
| **18** | IC058710 x EC169459 | -0.355 | 1.015 * | 1.240 * | 0.633 * | 0.02 | 0.125 | -0.135 | 0.004 |
| **19** | IC058710 x Kashi Pragati | 0.083 | -0.607 | -1.587 ** | -0.704 * | -0.2 | -0.248 * | -0.021 | -0.156 |
| **20** | IC058710 x IC052321 | 0.06 | -1.024 * | 0.079 | -0.295 | 0.12 | 0.032 | 0.219 * | 0.124 |
| **21** | IC045993 x EC169452 | 0.466 | -0.397 | -0.308 | -0.08 | 0.433 ** | -0.108 | 0.232 * | 0.186 * |
| **22** | IC045993 x IC052310 | -0.214 | -0.44 | -0.443 | -0.366 | 0.347 * | 0.092 | -0.188 | 0.084 |

| *Table continues…* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **23** | IC045993 x EC169459 | -0.72 | -0.422 | -0.546 | -0.563 | -0.153 | 0.072 | -0.015 | -0.032 |
| **24** | IC045993 x Kashi Pragati | 1.104 * | 1.196 * | 1.434 * | 1.245 ** | -0.307 * | -0.035 | 0.165 | -0.059 |
| **25** | IC045993 x IC052321 | -0.635 | 0.063 | -0.137 | -0.237 | -0.320 * | -0.021 | -0.195 | -0.179 * |
| **26** | Pusa Sawani x EC169452 | -0.285 | -0.365 | 0.798 | 0.049 | -0.14 | -0.268 * | -0.155 | -0.188 * |
| **27** | Pusa Sawani x IC052310 | -0.058 | 0.238 | 0.25 | 0.143 | 0.573 ** | 0.132 | 0.092 | 0.266 ** |
| **28** | Pusa Sawani x EC169459 | -0.044 | -0.761 | -0.214 | -0.34 | 0.007 | -0.088 | 0.065 | -0.005 |
| **29** | Pusa Sawani x Kashi Pragati | -0.836 | -0.592 | -0.403 | -0.611 | -0.28 | 0.405 ** | -0.021 | 0.035 |
| **30** | Pusa Sawani x IC052321 | 1.224 ** | 1.481 ** | -0.431 | 0.758 * | -0.16 | -0.181 | 0.019 | -0.108 |
| **31** | VRO-4 x EC169452 | -0.737 | 0.036 | 0.251 | -0.15 | 0.047 | -0.028 | 0.005 | 0.008 |
| **32** | VRO-4 x IC052310 | 0.950 * | 0.079 | 0.24 | 0.423 | -0.173 | -0.161 | -0.148 | -0.161 * |
| **33** | VRO-4 x EC169459 | -0.58 | -0.493 | -0.43 | -0.501 | 0.327 * | -0.181 | 0.225 * | 0.124 |
| **34** | VRO-4 x Kashi Pragati | 0.275 | -0.111 | -0.093 | 0.024 | 0.107 | 0.445 ** | 0.005 | 0.186 * |
| **35** | VRO-4 x IC052321 | 0.092 | 0.489 | 0.032 | 0.204 | -0.307 * | -0.075 | -0.088 | -0.156 |
| **36** | IC052299 x EC169452 | -0.004 | 2.623 ** | 0.969 | 1.196 ** | -0.193 | 0.132 | 0.072 | 0.004 |
| **37** | IC052299 x IC052310 | 0.323 | -0.75 | -0.076 | -0.168 | -0.147 | -0.001 | -0.148 | -0.099 |
| **38** | IC052299 x EC169459 | 1.183 * | -0.245 | -0.553 | 0.128 | 0.22 | -0.155 | 0.241 * | 0.097 |
| **39** | IC052299 x Kashi Pragati | -1.146 * | -0.87 | -0.246 | -0.754 * | 0.067 | 0.072 | -0.128 | 0.004 |
| **40** | IC052299 x IC052321 | -0.355 | -0.757 | -0.094 | -0.402 | 0.053 | -0.048 | -0.021 | -0.005 |
| **41** | Kashi Kranti x EC169452 | -0.418 | -0.815 | -0.651 | -0.628 * | 0.047 | 0.105 | -0.061 | 0.03 |
| **42** | Kashi Kranti x IC052310 | -1.091 * | 2.402 ** | 1.117 * | 0.809 * | -0.107 | -0.028 | -0.148 | -0.094 |
| **43** | Kashi Kranti x EC169459 | 0.269 | -1.260 ** | -1.126 * | -0.706 * | -0.14 | 0.019 | 0.225 * | 0.035 |
| **44** | Kashi Kranti x Kashi Pragati | 1.100 * | 0.618 | 1.251 * | 0.990 ** | 0.04 | -0.088 | 0.072 | 0.008 |
| **45** | Kashi Kranti x IC052321 | 0.141 | -0.945 * | -0.591 | -0.465 | 0.16 | -0.008 | -0.088 | 0.021 |
| **46** | Salkeerthi x EC169452 | -0.288 | -0.833 | -0.825 | -0.649 * | -0.247 | 0.065 | -0.101 | -0.094 |
| **47** | Salkeerthi x IC052310 | 0.26 | -1.256 ** | -0.427 | -0.474 | -0.267 | 0.065 | 0.012 | -0.063 |
| **48** | Salkeerthi x EC169459 | -0.254 | 3.029 ** | 2.763 ** | 1.846 ** | -0.167 | 0.045 | -0.015 | -0.045 |
| **49** | Salkeerthi x Kashi Pragati | 0.678 | -1.370 ** | -0.907 | -0.533 | 0.28 | -0.195 | 0.165 | 0.084 |
| **50** | Salkeerthi x IC052321 | -0.395 | 0.43 | -0.605 | -0.19 | 0.400 ** | 0.019 | -0.061 | 0.119 |
| **51** | IC058235 x EC169452 | 0.747 | -0.633 | -0.453 | -0.113 | 0.207 | -0.055 | 0.072 | 0.075 |

| *Table continues…* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **52** | IC058235 x IC052310 | -1.249 ** | -0.227 | -0.767 | -0.748 * | -0.013 | -0.255 * | 0.252 * | -0.005 |
| **53** | IC058235 x EC169459 | 0.844 | -0.155 | -0.331 | 0.119 | -0.113 | -0.141 | -0.241 * | -0.165 * |
| **54** | IC058235 x Kashi Pragati | -0.308 | 1.916 ** | 1.366 * | 0.992 ** | 0 | -0.181 | -0.261 * | -0.148 |
| **55** | IC058235 x IC052321 | -0.034 | -0.9 | 0.185 | -0.25 | -0.08 | 0.632 ** | 0.179 | 0.244 ** |
| **56** | Hisar Naveen x EC169452 | -0.632 | -0.062 | -0.066 | -0.253 | -0.073 | -0.015 | 0.019 | -0.023 |
| **57** | Hisar Naveen x IC052310 | 0.998 * | -0.029 | -0.231 | 0.246 | -0.027 | 0.452 ** | 0.132 | 0.186 * |
| **58** | Hisar Naveen x EC169459 | -0.262 | -0.417 | -0.481 | -0.387 | 0.007 | -0.168 | -0.228 * | -0.13 |
| **59** | Hisar Naveen x Kashi Pragati | 0.036 | -0.042 | -0.577 | -0.194 | 0.320 * | -0.008 | 0.085 | 0.132 |
| **60** | Hisar Naveen x IC052321 | -0.14 | 0.551 | 1.355 * | 0.589 | -0.227 | -0.261 * | -0.008 | -0.165 * |
| **61** | IC052302 x EC169452 | 0.592 | -0.151 | 0.08 | 0.174 | -0.087 | 0.025 | 0.072 | 0.004 |
| **62** | IC052302 x IC052310 | 0.43 | -0.034 | 0.272 | 0.222 | -0.24 | -0.241 * | 0.052 | -0.143 |
| **63** | IC052302 x EC169459 | -0.08 | -0.289 | -0.322 | -0.23 | -0.007 | 0.472 ** | -0.108 | 0.119 |
| **64** | IC052302 x Kashi Pragati | -0.986 * | -0.138 | -0.238 | -0.454 | -0.027 | -0.168 | -0.061 | -0.085 |
| **65** | IC052302 x IC052321 | 0.045 | 0.612 | 0.207 | 0.288 | 0.360 * | -0.088 | 0.045 | 0.106 |
| **GCA (line)** | | 0.205 | 0.206 | 0.245 | 0.127 | 0.068 | 0.049 | 0.047 | 0.032 |
| **GCA (Tester)** | | 0.145 | 0.146 | 0.173 | 0.090 | 0.048 | 0.035 | 0.034 | 0.023 |
| **SCA** | | 0.459 | 0.461 | 0.548 | 0.284 | 0.151 | 0.111 | 0.106 | 0.072 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly

While in pooled analysis GCA ranges from -0.112 (IC058710) to 0.145 (VRO-4) in lines and in testers -0.061 (EC169459) to 0.121 (Kashi Pragati). Among the lines VRO-4 (0.145), Kashi Kranti (0.101) and in testers Kashi Pragati (0.121) recorded positive and significant *gca* effect. For SCA, range varied from -0.188 (Pusa Sawani x EC169452) to 0.266 (Pusa Sawani x IC052310). Among 50 crosses, 4 crosses recorded were positive and significant *sca* effect. Top desirable crosses were Pusa Sawani x IC052310 (0.266), IC058235 x Kashi Pragati (0.244), IC045993 x IC052310 and VRO-4 x Kashi Pragati (0.186)

During this study of experiment E1 (0.52), E2 (0.08), E3 (0.10), and the combined analysis (0.88) indicated the dominance of non-additive genetic effects for no. of ridges/fruit.

**4.7.13 Number of fruits per plant**

In E1 GCA ranges from -1.581 (IC052302) to 1.846 (Kashi Kranti) and while in testers -1.081 (EC169452) to 1.839 (EC169459). Among the lines, Kashi Kranti (1.846), IC045993 (1.393), VRO-4 (0.779), IC052299 (0.666) and in testers EC169459 (1.839) recorded positive and significant *gca* effect. Whereas, SCA ranges from -3.106 (IC052299 x Kashi Pragati) to 3.121 (IC058235 x EC169459). Among 50 crosses, 4 crosses observed positive significant *sca* effect. Top desirable significant crosses were IC058235 x EC169459 (3.121), IC052299 x IC052310 (2.841) and IC052299 x EC169452 (2.674).

In E2 GCA ranges from -1.314 (Pusa Sawani) to 2.233 (Kashi Kranti) in lines and while in testers -1.241 (IC052310) to 0.723 (Kashi Pragati). Among the lines Kashi Kranti (2.233), IC045993 (1.206), Salkeerthi (0.759) and in testers Kashi Pragati (0.723), EC169459 (0.693) recorded positive and significant *gca* effect. Whereas, SCA ranges from -3.683 (Pusa Sawani x Kashi Pragati) to 2.881 (Pusa Sawani x IC052310). Among 50 crosses 7 crosses, observed positive significant *sca* effect. Top desirable significant crosses were Pusa Sawani x IC052310 (2.881), Salkeerthi x EC169452 (2.121) and Salkeerthi x Kashi Pragati (2.044).

In E3 GCA range from -1.299 (VRO-4) to 2.388 (Kashi Kranti) in lines and while in testers -0.869 (IC052310) to 1.021 (Kashi Pragati). Among the lines Kashi Kranti (2.388) and in testers Kashi Pragati (1.021), EC169459 (0.871) recorded positive and significant *gca* effect. Whereas, SCA ranges from -1.745 (Kashi Kranti x EC169452) to 2.029 (IC045993 x

IC052310). Out of 50 crosses, 2 crosses observed positive significant sca effect. Top desirable crosses were IC045993 x IC052310 (2.209) and VRO-4 x IC052310 (1.702).

While in pooled analysis GCA ranges from -1.171 (Pusa Sawani) to 2.156 (Kashi Kranti) in lines and -0.897 (IC052310) to 1.134 (EC169459) in testers. Among the lines Kashi Kranti (2.156), IC045993 (0.969) and in testers EC169459 (1.134), Kashi Pragati (0.637) recorded positive and significant *gca* effect. Whereas, SCA ranges varied from -1.704 (IC052299 x IC052321) to 1.730 (Pusa Sawani x IC052310). Among 50 crosses, 5 crosses recorded were positive and significant *sca effect*. Top desirable crosses were Pusa Sawani x IC052310 (1.730), Kashi Kranti x IC052321 (1.078) and Kashi Kranti x IC052321 (1.078).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.54), E2 (0.42), E3 (0.81), and the combined analysis (0.4) indicated the dominance of non-additive genetic effects for no. of fruits/ plant.

**4.7.14 Number of marketable fruits per plant**

In E1 GCA ranges from -1.617 (IC052302) to 2.390 (Kashi Kranti) in lines and while in testers -1.360 (EC169452) to 1.607 (EC169459) in testers. Among lines Kashi Kranti (2.390), IC045993 (1.637), and in testers EC169459 (1.607) observed in significant positive *gca* effect. Whereas, SCA ranges from -3.433 (IC058235 x EC169452) to 3.667 (IC058235 x EC169459). Among the 50 crosses, 5 crosses revealed positive significant *sca* effect. Top desirable significant crosses were IC058235 x EC169459 (3.667), IC052299 x EC169452 (3.040) and VRO-4 x IC052321 (2.963).

In E2 GCA ranges from -0.982 (IC058710) to 2.371 (Kashi Kranti) in lines and IC052310 (-0.809) to in testers EC169459 (0.528). Among the lines Kashi Kranti (2.371) and in testers EC169459 (0.528), Kashi Pragati (0.445) observed significant positive *gca* effect. In SCA exhibit ranges from -2.781 (IC058710 x EC169459) to 2.662 (Pusa Sawani x IC052310). Two crosses observed positive significant *sca* effect. Top desirable significant crosses were Pusa Sawani x IC052310 (2.660) and Salkeerthi x EC169452 (1.809).

In E3 GCA ranges from -1.191 (VRO-4) to 2.429 (Kashi Kranti)) in lines and while in testers -0.921 (EC169452) to Kashi Pragati (1.129). Among the lines Kashi Kranti (2.429) and in testers Kashi Pragati (1.129), EC169459 (0.912) recorded significant positive *gca* effect.

**Table 56. Estimates combining ability of parents and hybrids across diverse and pooled environments for number of fruits/plant and marketable fruits/plant**

| S.No. | Genotype | Number of fruits/plant | | | | Marketable fruits/plant | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| **PARENTS** | | | | | | | | | |
| **Lines** | | | | | | | | | |
| **1** | IC058710 | -0.201 | -0.907 ** | -0.379 | -0.496 * | -0.143 | -0.982 * | -0.578 | -0.568 * |
| **2** | IC045993 | 1.393 ** | 1.206 ** | 0.308 | 0.969 ** | 1.637 ** | 0.551 | 0.275 | 0.821 ** |
| **3** | Pusa Sawani | -1.401 ** | -1.314 ** | -0.799 * | -1.171 ** | -1.117 ** | -0.955 * | -0.785 * | -0.952 ** |
| **4** | VRO-4 | 0.779 * | 0.273 | -1.299 ** | -0.082 | 0.21 | 0.351 | -1.191 ** | -0.21 |
| **5** | IC052299 | 0.666 * | -0.254 | -0.265 | 0.049 | 0.083 | -0.255 | -0.338 | -0.17 |
| **6** | Kashi Kranti | 1.846 ** | 2.233 ** | 2.388 ** | 2.156 ** | 2.390 ** | 2.371 ** | 2.429 ** | 2.397 ** |
| **7** | Salkeerthi | -0.207 | 0.759 * | -0.152 | 0.133 | -0.343 | -0.515 | -0.238 | -0.366 |
| **8** | IC058235 | -1.234 ** | 0.366 | 0.441 | -0.142 | -1.110 ** | 0.325 | 0.489 | -0.099 |
| **9** | Hisar Naveen | -0.061 | -1.087 ** | 0.081 | -0.356 | 0.01 | -0.295 | 0.335 | 0.017 |
| **10** | IC052302 | -1.581 ** | -1.274 ** | -0.325 | -1.060 ** | -1.617 ** | -0.595 | -0.398 | -0.870 ** |
| **Testers** | | | | | | | | | |
| **11** | EC169452 | -1.081 ** | -0.487 * | -0.842 ** | -0.803 ** | -1.360 ** | -0.529 * | -0.921 ** | -0.937 ** |
| **12** | IC052310 | -0.581 ** | -1.241 ** | -0.869 ** | -0.897 ** | -0.333 | -0.809 ** | -0.855 ** | -0.666 ** |
| **13** | EC169459 | 1.839 ** | 0.693 ** | 0.871 ** | 1.134 ** | 1.607 ** | 0.528 * | 0.912 ** | 1.016 ** |
| **14** | Kashi Pragati | 0.166 | 0.723 ** | 1.021 ** | 0.637 ** | 0.297 | 0.445 * | 1.129 ** | 0.623 ** |
| **15** | IC052321 | -0.344 | 0.313 | -0.182 | -0.071 | -0.21 | 0.365 | -0.265 | -0.037 |
| **HYBRIDS** | | | | | | | | | |
| **16** | IC058710 x EC169452 | -0.326 | -0.513 | -0.178 | -0.339 | 0.867 | 0.242 | -0.272 | 0.279 |
| **17** | IC058710 x IC052310 | 0.441 | 1.641 * | -0.285 | 0.599 | 0.207 | 1.622 | -0.605 | 0.408 |
| **18** | IC058710 x EC169459 | 0.221 | -2.493 ** | -0.058 | -0.777 | 0.667 | -2.781 ** | -0.239 | -0.784 |
| **19** | IC058710 x Kashi Pragati | -1.406 | 0.144 | 0.092 | -0.39 | -1.957 * | -0.165 | 0.278 | -0.614 |
| **20** | IC058710 x IC052321 | 1.071 | 1.221 | 0.429 | 0.907 | 0.217 | 1.082 | 0.838 | 0.712 |
| **21** | IC045993 x EC169452 | -0.786 | 1.741 * | 1.269 | 0.741 | 0.453 | 0.442 | 1.308 | 0.734 |
| **22** | IC045993 x IC052310 | 0.547 | -0.773 | 2.029 ** | 0.601 | 0.593 | -0.445 | 1.541 * | 0.563 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **23** | IC045993 x EC169459 | -2.473 ** | 0.561 | -1.711 * | -1.208 * | -2.180 ** | 0.852 | -1.292 | -0.873 |
| **24** | IC045993 x Kashi Pragati | 1.467 | -0.969 | -0.928 | -0.143 | 0.43 | -0.031 | -0.909 | -0.17 |
| **25** | IC045993 x IC052321 | 1.244 | -0.559 | -0.658 | 0.009 | 0.703 | -0.818 | -0.649 | -0.254 |
| **26** | Pusa Sawani x EC169452 | 0.741 | -0.406 | -0.425 | -0.03 | 1.007 | -0.751 | -0.399 | -0.048 |
| **27** | Pusa Sawani x IC052310 | 2.241 ** | 2.881 ** | 0.069 | 1.730 ** | 1.813 * | 2.662 ** | 0.335 | 1.603 ** |
| **28** | Pusa Sawani x EC169459 | -1.246 | 1.281 | 0.929 | 0.321 | -1.560 * | 1.325 | 0.901 | 0.222 |
| **29** | Pusa Sawani x Kashi Pragati | 0.327 | -3.683 ** | 0.579 | -0.926 | -0.017 | -2.358 ** | 0.218 | -0.719 |
| **30** | Pusa Sawani x IC052321 | -2.063 ** | -0.073 | -1.151 | -1.096 * | -1.243 | -0.878 | -1.055 | -1.059 * |
| **31** | VRO-4 x EC169452 | 1.227 | -2.426 ** | -1.458 * | -0.886 | -3.220 ** | -2.058 * | -1.359 | -2.212 ** |
| **32** | VRO-4 x IC052310 | -2.139 ** | -0.573 | 1.702 * | -0.337 | 0.787 | -0.045 | 1.341 | 0.694 |
| **33** | VRO-4 x EC169459 | 0.041 | 1.994 * | 0.895 | 0.977 * | -0.487 | 1.019 | 1.075 | 0.536 |
| **34** | VRO-4 x Kashi Pragati | -0.986 | 0.564 | -1.621 * | -0.681 | -0.043 | 0.035 | -1.442 * | -0.483 |
| **35** | VRO-4 x IC052321 | 1.857 * | 0.441 | 0.482 | 0.927 | 2.963 ** | 1.049 | 0.385 | 1.466 ** |
| **36** | IC052299 x EC169452 | 2.674 ** | -0.466 | -0.091 | 0.706 | 3.040 ** | 0.815 | 0.355 | 1.403 ** |
| **37** | IC052299 x IC052310 | 2.841 ** | 1.387 | -0.998 | 1.077 * | 1.713 * | 0.095 | -0.812 | 0.332 |
| **38** | IC052299 x EC169459 | 0.421 | 1.454 | 0.062 | 0.646 | 0.007 | 0.959 | -0.412 | 0.184 |
| **39** | IC052299 x Kashi Pragati | -3.106 ** | 0.557 | 0.379 | -0.723 | -2.183 ** | 0.742 | 0.371 | -0.357 |
| **40** | IC052299 x IC052321 | -2.829 ** | -2.933 ** | 0.649 | -1.704 ** | -2.577 ** | -2.611 ** | 0.498 | -1.563 ** |
| **41** | Kashi Kranti x EC169452 | -0.573 | -1.453 | -1.745 * | -1.257 * | -0.033 | -1.211 | -1.845 * | -1.030 * |
| **42** | Kashi Kranti x IC052310 | -0.139 | 0.567 | 0.182 | 0.203 | -0.46 | -0.031 | 0.621 | 0.043 |
| **43** | Kashi Kranti x EC169459 | -1.093 | -0.233 | -0.525 | -0.617 | -0.967 | -0.135 | -0.079 | -0.393 |
| **44** | Kashi Kranti x Kashi Pragati | 1.181 | -0.396 | 0.992 | 0.592 | 0.777 | -0.251 | 1.038 | 0.521 |
| **45** | Kashi Kranti x IC052321 | 0.624 | 1.514 | 1.095 | 1.078 * | 0.683 | 1.629 | 0.265 | 0.859 |
| **46** | Salkeerthi x EC169452 | 0.214 | 2.121 ** | 0.462 | 0.932 * | 0.533 | 1.809 * | 0.588 | 0.977 |
| **47** | Salkeerthi x IC052310 | -1.253 | -1.593 * | -1.111 | -1.319 ** | -2.327 ** | -1.978 * | -0.979 | -1.761 ** |
| **48** | Salkeerthi x EC169459 | 0.961 | -1.426 | 0.815 | 0.117 | 0.933 | -0.581 | 0.355 | 0.236 |
| **49** | Salkeerthi x Kashi Pragati | -0.266 | 2.044 ** | 1.332 | 1.037 * | 0.177 | 1.035 | 1.671 * | 0.961 |
| **50** | Salkeerthi x IC052321 | 0.344 | -1.146 | -1.498 * | -0.767 | 0.683 | -0.285 | -1.635 * | -0.412 |
| **51** | IC058235 x EC169452 | -2.693 ** | -0.719 | 0.902 | -0.837 | -3.433 ** | -0.498 | 0.195 | -1.246 * |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **52** | IC058235 x IC052310 | -1.259 | -0.166 | -0.705 | -0.71 | -1.660 * | -0.618 | -0.739 | -1.006 * |
| **53** | IC058235 x EC169459 | 3.121 ** | -0.366 | -0.445 | 0.77 | 3.667 ** | -0.288 | -0.672 | 0.902 |
| **54** | IC058235 x Kashi Pragati | 0.261 | 0.571 | -0.628 | 0.068 | 0.71 | 0.795 | -0.089 | 0.472 |
| **55** | IC058235 x IC052321 | 0.571 | 0.681 | 0.875 | 0.709 | 0.717 | 0.609 | 1.305 | 0.877 |
| **56** | Hisar Naveen x EC169452 | -0.533 | 0.334 | 0.429 | 0.077 | 0.013 | -0.411 | 0.281 | -0.039 |
| **57** | Hisar Naveen x IC052310 | 0.301 | -1.446 | 0.322 | -0.274 | 0.72 | -0.431 | 0.481 | 0.257 |
| **58** | Hisar Naveen x EC169459 | 0.314 | -0.479 | -0.218 | -0.128 | 0.28 | -0.001 | 0.181 | 0.153 |
| **59** | Hisar Naveen x Kashi Pragati | 1.121 | 1.124 | -0.035 | 0.737 | 0.757 | 0.815 | -0.702 | 0.29 |
| **60** | Hisar Naveen x IC052321 | -1.203 | 0.467 | -0.498 | -0.411 | -1.770 * | 0.029 | -0.242 | -0.661 |
| **61** | IC052302 x EC169452 | 0.054 | 1.787 * | 0.835 | 0.892 | 0.773 | 1.622 | 1.148 | 1.181 * |
| **62** | IC052302 x IC052310 | -1.579 * | -1.926 * | -1.205 | -1.570 ** | -1.387 | -0.831 | -1.185 | -1.134 * |
| **63** | IC052302 x EC169459 | -0.266 | -0.293 | 0.255 | -0.101 | -0.36 | -0.368 | 0.181 | -0.182 |
| **64** | IC052302 x Kashi Pragati | 1.407 | 0.044 | -0.161 | 0.43 | 1.35 | -0.618 | -0.435 | 0.099 |
| **65** | IC052302 x IC052321 | 0.384 | 0.387 | 0.275 | 0.349 | -0.377 | 0.195 | 0.291 | 0.037 |
| **GCA (line)** | | 0.332 | 0.342 | 0.305 | 0.189 | 0.336 | 0.380 | 0.316 | 0.199 |
| **GCA (Tester)** | | 0.234 | 0.242 | 0.216 | 0.133 | 0.238 | 0.269 | 0.224 | 0.141 |
| **SCA** | | 0.741 | 0.765 | 0.682 | 0.422 | 0.752 | 0.851 | 0.708 | 0.446 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly.

Whereas, SCA ranges from -1.845 (Kashi Kranti x EC169452) to 1.671 (Salekerthi x Kashi Pragati). The out of 50 crosses 2 crosses, revealed positive significant sca effect. Top desirable crosses were Salekerthi x Kashi Pragati (1.671) and IC045993 x IC052310 (1.541).

While in pooled analysis GCA ranges from -0.952 (Pusa Sawani) to 2.397 (Kashi Kranti) in lines and in testers -0.937 (EC169452) to 1.016 (EC169459). Among the lines Kashi Kranti (2.397), IC045993 (0.821) and in testers EC169459 (1.134), Kashi Pragati (0.637) recorded positive and significant *gca* effect. Whereas, SCA, ranges varied from -2.212 (VRO-4 x EC169452) to 1.603 (Pusa Sawani x IC052310). Among 50 crosses, 4 crosses recorded positive and significant *sca* effect. Top desirable crosses were Pusa Sawani x IC052310 (1.60.), VRO-4 x IC052321 (1.466) and IC052299 x EC169452 (1.403).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.45), E2 (0.46), E3 (0.60), and the combined analysis (0.80) indicated the dominance of non-additive genetic effects for no. of marketable fruits/ plant.

**4.7.4.15 Average fruit weight**

In E1 GCA ranges from -0.680 (IC045993) to 0.463 (Salkeerthi) and while in testers -0.387 (EC169459) to 0.599 (Kashi Pragati). Among lines Salkeerthi (0.463) and in testers Kashi Pragati (0.599) resulted significant positive *gca* effect. Whereas, SCA ranges from -1.758 (Pusa Sawani x EC169452) to 1.819 (IC052299 x Kashi Pragati). Among the 50 crosses, 5 crosses revealed positive significant *sca* effect. Top desirable significant crosses were IC052299 x Kashi Pragati (1.819), IC052299 x IC052321 (1.481) and IC045993 x EC169459 (1.411).

In E2 GCA ranges varied from -0.575 (IC058235) to 0.326 (Salkeerthi) in lines and in testers -0.604 (EC169452) to 0.267 (EC169459) in testers. Among the lines Salkeerthi (0.326) and in testers EC169459 (0.267), Kashi Pragati (0.245) observed significant positive *gca* effect. Whereas, SCA ranges revealed -1.606 (Salkeerthi x Kashi Pragati) to 1.920 (Pusa Sawani x Kashi Pragati). Among 50 crosses, 5 crosses observed positive significant *sca* effect. Top desirable crosses were Pusa Sawani x Kashi Pragati (1.920), IC052299 x IC052321 (1.872) and IC058710 x EC169459 (1.880).

In E3 GCA ranges from IC052302 (-0.379) to VRO-4 (0.730) in lines and in testers IC052310 (-0.499) to EC169459 (0.419) recorded. Among the lines Pusa Sawani (0.336), VRO-4 (0.730) and in testers EC169459 (0.419), Kashi Pragati (0.309), IC052321 (0.253) resulted significant positive *gca* effect. Whereas, SCA ranges from -1.226 (IC045993 x IC052321) to 1.599 (Kashi Kranti x EC169452). Out of 50 crosses, 7 crosses revealed positive significant *sca* effect. Top desirable crosses were Kashi Kranti x EC169452 (1.599), Salkerthi x IC052321 (1.432) and Pusa Sawani x IC052321 (1.107).

While in pooled analysis GCA ranges from -0.442 (IC045993) to 0.266 (Pusa Sawani) in lines and in testers -0.384 (EC169452) to 0.384 (Kashi Pragati). Among the lines Pusa Sawani (0.266) and in testers Kashi Pragati (0.384), IC052321 (0.139) recorded positive and significant *gca* effect. Whereas SCA ranges from -0.929 (Pusa Sawani x EC169452) to 1.190 (IC052299 x IC052321). Among 50 crosses, 8 crosses recorded were positive and significant *sca* effect. Top desirable crosses were IC052299 x IC052321 (1.190), IC052302 x IC052310 (0.853) and Salkerthi x IC052310 (0.736).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.17), E2 (0.14), E3 (0.41), and the combined analysis (0.1) indicated the dominance of non-additive genetic effects for average fruit weight.

**4.7.4.16 Number of pickings per plant**

In E1 GCA ranges from -1.820 (IC058235) to 2.433 (Kashi Kranti) in lines and in testers -0.720 (IC052321) to 1.243 (EC169459). Among the lines IC045993 (0.647), VRO-4 (1.087), Kashi Kranti (2.433) and in tester EC169459 (1.243), Kashi Pragati (0.380) in observed significant positive *gca* effect. Whereas, SCA ranges from -2.573 (Pusa Sawani x Kashi Pragati) to 1.747 (Kashi Kranti x Kashi Pragati). Among the 50 crosses, 6 crosses observed positive significant s*ca* effect. Top desirable significant crosses were Kashi Kranti x Kashi Pragati (1.747), Pusa Sawani x EC169452 (1.533) and Salkeerthi x IC052310 (1.490).

In E2 GCA ranges from -0.855 (Pusa Sawani) to 1.245 (Kashi Kranti) in lines and in testers -0.595 (IC052310) to 0.372 (Kashi Pragati). Among the lines Kashi Kranti (1.245) and in testers Kashi Pragati (0.372), EC169459 (0.325) observed significant positive *gca* effect. Whereas, SCA exhibit ranges from -1.589 (Kashi Kranti x EC169452) to 2.158 (IC058235 x EC169452). Among the 50 crosses 4 crosses observed positive significant *sca* effect. Top desirable crosses were IC058235 x EC169452 (2.158), IC045993 x EC169459 (1.648) and Pusa Sawani x IC052310 (1.515).

In E3 GCA ranges from -1.317 (IC052302) to 0.863 (Kashi Kranti) in lines and while in testers -0.730 (EC169452) to 0.793 (EC169459). Among the lines IC045993 (0.670), VRO-4 (0.750), Kashi Kranti (0.863) and in testers EC169459 (0.793), Kashi Pragati (0.650) recorded positive and significant. Whereas, SCA ranges from -1.550 (Hisar Naveen x IC052321) to 1.570 (Kashi Kranti x Kashi Pragati). Out of 50 crosses, 2 crosses observed positive significant *sca* effect. Top desirable crosses were Kashi Kranti x Kashi Pragati (1.570), VRO-4 x IC052321 (1.483).

While in pooled analysis GCA ranges from -1.239 (IC052302) to 1.514 (Kashi Kranti) in lines and in testers -0.505 (EC169452) to 0.787 (EC169459). Among the lines Kashi Kranti (1.514), IC045993 (0.458) and in testers EC169459 (0.787), Kashi Pragati (0.467) recorded positive and significant *gca* effect. Whereas, SCA, ranges varied from -1.285 (Pusa Sawani x Kashi Pragati) to 1.244 (Kashi Kranti x Kashi Pragati). Among 50 crosses, 4 crosses recorded were positive and significant *sca* effect. Top desirable crosses were Kashi Kranti x Kashi Pragati (1.244), Pusa Sawani x IC052310 (1.116) and IC058710 x IC052321 (0.949).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.69), E2 (0.45), E3 (0.8), and the combined analysis (0.7) indicated the dominance of non-additive genetic effects for number of pickings/ plant.

### 4.7. 17 Fruit yield per plant (g)

In E1 GCA ranges from -15.685 (IC052302) to 34.475 (Kashi Kranti) lines and testers -16.851 (IC052310) to 17.982 (Kashi Pragati). Among the lines VRO-4 (7.969), Kashi Kranti (34.475), Salkeerthi (8.922) and in testers Kashi Pragati (17.982), EC169459 (15.469) recorded positive and significant *gca* effect. Whereas, SCA ranges from -31.749 (IC052302 x EC169459) to 32.798 (Pusa Sawani x IC052310). Among 50 crosses, 4 crosses observed positive significant *sca* effect. Top desirable significant crosses were Pusa Sawani x IC052310 (32.798), IC052302 x EC169452 (21.858) and Kashi Kranti x EC169452 (18.065).

**Table 57. Estimates combining ability of parents and hybrids across diverse and pooled environments for average fruit weight and number of pickings/plant**

| S.No | Genotype | Average fruit weight | | | | Number of pickings/plant | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled | E1 | E2 | E3 | Pooled |
| **PARENTS** | | | | | | | | | |
| **Lines** | | | | | | | | | |
| **1** | IC058710 | -0.401 | 0.139 | 0.016 | -0.082 | -0.047 | -0.015 | 0.17 | 0.036 |
| **2** | IC045993 | -0.680 ** | -0.461 * | -0.184 | -0.442 ** | 0.647 * | 0.059 | 0.670 * | 0.458 * |
| **3** | Pusa Sawani | 0.352 | 0.111 | 0.336 * | 0.266 * | -0.547 | -0.855 ** | 0.03 | -0.457 * |
| **4** | VRO-4 | -0.132 | -0.061 | 0.730 ** | 0.179 | 1.087 ** | 0.192 | 0.750 * | 0.676 ** |
| **5** | IC052299 | -0.17 | -0.024 | -0.235 | -0.143 | -0.027 | 0.439 | 0.097 | 0.17 |
| **6** | Kashi Kranti | 0.297 | 0.026 | 0.142 | 0.155 | 2.433 ** | 1.245 ** | 0.863 * | 1.514 ** |
| **7** | Salkeerthi | 0.463 * | 0.326* | -0.199 | 0.197 | 0.38 | 0.312 | -0.097 | 0.198 |
| **8** | IC058235 | 0.206 | -0.575 ** | 0.036 | -0.111 | -1.820 ** | 0.032 | -1.017 ** | -0.935 ** |
| **9** | Hisar Naveen | -0.211 | 0.18 | -0.261 | -0.098 | -0.473 | -0.641 ** | -0.15 | -0.422 * |
| **10** | IC052302 | 0.276 | 0.34 | -0.379 * | 0.079 | -1.633 ** | -0.768 ** | -1.317 ** | -1.239 ** |
| **Testers** | | | | | | | | | |
| 11 | EC169452 | -0.066 | -0.604 ** | -0.481 ** | -0.384 ** | -0.693 ** | -0.091 | -0.730 ** | -0.505 ** |
| 12 | IC052310 | -0.326 ** | 0.107 | -0.499 ** | -0.239 ** | -0.21 | -0.595 ** | -0.297 | -0.367 ** |
| 13 | EC169459 | -0.387 ** | 0.267 ** | 0.419 ** | 0.1 | 1.243 ** | 0.325 * | 0.793 ** | 0.787 ** |
| 14 | Kashi Pragati | 0.599 ** | 0.245 * | 0.309 ** | 0.384 ** | 0.380 * | 0.372 ** | 0.650 ** | 0.467 ** |
| 15 | IC052321 | 0.181 | -0.016 | 0.253 ** | 0.139 * | -0.720 ** | -0.011 | -0.417 * | -0.383 ** |
| **HYBRIDS** | | | | | | | | | |
| 16 | IC058710 x EC169452 | -0.052 | -0.093 | -0.322 | -0.155 | -0.467 | -0.929 | -0.09 | -0.495 |
| 17 | IC058710 x IC052310 | -0.352 | -0.307 | -0.264 | -0.308 | 0.85 | 0.041 | 0.61 | 0.5 |
| 18 | IC058710 x EC169459 | 0.279 | 1.880 ** | 0.338 | 0.832 ** | -0.137 | 0.221 | -0.613 | -0.176 |
| 19 | IC058710 x Kashi Pragati | 0.743 | -0.698 | 0.311 | 0.118 | -1.207 | 0.075 | -1.203 | -0.778 |
| 20 | IC058710 x IC052321 | -0.619 | -0.781 | -0.063 | -0.487 | 0.96 | 0.591 | 1.297 | 0.949 * |
| 21 | IC045993 x EC169452 | 0.577 | 0.102 | 0.045 | 0.207 | -0.427 | -0.402 | -0.257 | -0.362 |
| 22 | IC045993 x IC052310 | 0.097 | 0.586 | 0.092 | 0.259 | -0.21 | -0.832 | 0.577 | -0.155 |

***Table continues…***

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **23** | IC045993 x EC169459 | 1.411 ** | -0.087 | 0.715 * | 0.680 * | 0.27 | 1.648 ** | -0.447 | 0.49 |
| **24** | IC045993 x Kashi Pragati | -0.845 | -0.078 | 0.374 | -0.183 | 0.433 | -0.199 | 0.497 | 0.244 |
| **25** | IC045993 x IC052321 | -1.240 * | -0.421 | -1.226 ** | -0.962 ** | -0.067 | -0.215 | -0.37 | -0.217 |
| **26** | Pusa Sawani x EC169452 | -1.758 ** | -0.512 | -0.516 | -0.929 ** | 1.533 * | -0.489 | 0.517 | 0.52 |
| **27** | Pusa Sawani x IC052310 | 0.048 | -0.733 | 0.242 | -0.147 | 1.217 | 1.515 ** | 0.617 | 1.116 * |
| **28** | Pusa Sawani x EC169459 | 0.789 | -0.512 | -0.666 | -0.13 | 0.563 | -0.772 | 0.26 | 0.017 |
| **29** | Pusa Sawani x Kashi Pragati | 0.029 | 1.920 ** | -0.167 | 0.594 * | -2.573 ** | -0.152 | -1.13 | -1.285 ** |
| **30** | Pusa Sawani x IC052321 | 0.891 | -0.163 | 1.107 ** | 0.612 * | -0.74 | -0.102 | -0.263 | -0.368 |
| **31** | VRO-4 x EC169452 | -0.401 | 0.27 | 0.394 | 0.088 | 1.300 * | -0.602 | -1.537 * | -0.28 |
| **32** | VRO-4 x IC052310 | 0.789 | 0.096 | -0.065 | 0.273 | -1.483 * | -0.199 | -0.137 | -0.606 |
| **33** | VRO-4 x EC169459 | -0.071 | -1.160 ** | -0.673 | -0.634 * | -0.37 | 0.181 | 0.207 | 0.006 |
| **34** | VRO-4 x Kashi Pragati | 0.22 | 0.568 | 0.693 | 0.494 | 0.193 | 0.735 | -0.017 | 0.304 |
| **35** | VRO-4 x IC052321 | -0.538 | 0.226 | -0.35 | -0.221 | 0.36 | -0.115 | 1.483 * | 0.576 |
| **36** | IC052299 x EC169452 | -1.692 ** | -0.18 | -0.628 | -0.833 ** | -0.22 | 0.185 | 0.917 | 0.294 |
| **37** | IC052299 x IC052310 | -1.569 ** | -0.531 | 0.013 | -0.695 * | 0.697 | 0.321 | -0.05 | 0.323 |
| **38** | IC052299 x EC169459 | -0.039 | -0.38 | 0.325 | -0.031 | 1.477 * | 0.168 | 0.993 | 0.879 * |
| **39** | IC052299 x Kashi Pragati | 1.819 ** | -0.782 | 0.071 | 0.37 | -0.96 | -0.779 | -0.797 | -0.845 * |
| **40** | IC052299 x IC052321 | 1.481 ** | 1.872 ** | 0.218 | 1.190 ** | -0.993 | 0.105 | -1.063 | -0.651 |
| **41** | Kashi Kranti x EC169452 | 1.034 * | 0.547 | 1.599 ** | 1.060 ** | -0.613 | -1.589 ** | 0.15 | -0.684 |
| **42** | Kashi Kranti x IC052310 | -0.24 | -0.441 | 0.673 | -0.002 | -1.563 * | 0.315 | -0.683 | -0.644 |
| **43** | Kashi Kranti x EC169459 | 0.447 | -0.15 | -0.565 | -0.089 | -0.75 | 0.061 | -0.74 | -0.476 |
| **44** | Kashi Kranti x Kashi Pragati | -0.562 | 0.882 * | -1.019 ** | -0.233 | 1.18 | 0.981 | 1.570 * | 1.244 ** |
| **45** | Kashi Kranti x IC052321 | -0.68 | -0.838 * | -0.689 | -0.735 * | 1.747 ** | 0.231 | -0.297 | 0.56 |
| **46** | Salkeerthi x EC169452 | 0.138 | -0.6 | -0.914 * | -0.459 | 0.173 | 0.845 | 0.11 | 0.376 |
| **47** | Salkeerthi x IC052310 | 0.908 | 1.639 ** | -0.34 | 0.736 * | 1.490 * | -0.619 | 0.31 | 0.394 |
| **48** | Salkeerthi x EC169459 | -0.609 | 0.359 | 0.046 | -0.068 | -1.363 * | -0.805 | -0.147 | -0.772 |
| **49** | Salkeerthi x Kashi Pragati | -0.231 | -1.606 ** | -0.225 | -0.687 * | 0.5 | 1.315 * | -0.703 | 0.37 |
| **50** | Salkeerthi x IC052321 | -0.206 | 0.208 | 1.432 ** | 0.478 | -0.8 | -0.735 | 0.43 | -0.368 |
| **51** | IC058235 x EC169452 | 0.761 | 0.051 | 1.045 ** | 0.619 * | -0.693 | 2.158 ** | -0.37 | 0.365 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | | | |
| **52** | IC058235 x IC052310 | 0.181 | -0.46 | -0.298 | -0.192 | -0.91 | -0.672 | -0.537 | -0.706 |
| **53** | IC058235 x EC169459 | -1.209 * | 0.617 | -0.135 | -0.242 | 0.503 | -0.659 | 0.507 | 0.117 |
| **54** | IC058235 x Kashi Pragati | 0.012 | -0.381 | -0.299 | -0.223 | -0.033 | -1.305 * | 0.217 | -0.374 |
| **55** | IC058235 x IC052321 | 0.254 | 0.173 | -0.313 | 0.038 | 1.133 | 0.478 | 0.183 | 0.598 |
| **56** | Hisar Naveen x EC169452 | 0.508 | 0.48 | 0.045 | 0.344 | -0.44 | 0.531 | -0.103 | -0.004 |
| **57** | Hisar Naveen x IC052310 | -1.082 * | -1.145 ** | -0.101 | -0.776 ** | 0.477 | 0.001 | -0.003 | 0.158 |
| **58** | Hisar Naveen x EC169459 | 0.155 | 0.519 | 0.858 * | 0.511 | 0.69 | 0.015 | 0.907 | 0.537 |
| **59** | Hisar Naveen x Kashi Pragati | -0.264 | 0.201 | 0.044 | -0.006 | 1.02 | -0.365 | 0.75 | 0.468 |
| **60** | Hisar Naveen x IC052321 | 0.681 | -0.055 | -0.846 * | -0.073 | -1.747 ** | -0.182 | -1.550 * | -1.160 ** |
| **61** | IC052302 x EC169452 | 0.884 | 0.036 | -0.747 * | 0.058 | -0.147 | 0.291 | 0.663 | 0.269 |
| **62** | IC052302 x IC052310 | 1.218 * | 1.295 ** | 0.047 | 0.853 ** | -0.563 | 0.128 | -0.703 | -0.38 |
| **63** | IC052302 x EC169459 | -1.155 * | -1.084 ** | -0.244 | -0.828 ** | -0.883 | -0.059 | -0.927 | -0.623 |
| **64** | IC052302 x Kashi Pragati | -0.921 | -0.026 | 0.215 | -0.244 | 1.447 * | -0.305 | 0.817 | 0.653 |
| **65** | IC052302 x IC052321 | -0.026 | -0.222 | 0.729 * | 0.16 | 0.147 | -0.055 | 0.15 | 0.08 |
| **GCA (line)** | | 0.217 | 0.178 | 0.159 | 0.108 | 0.288 | 0.236 | 0.329 | 0.166 |
| **GCA (Tester)** | | 0.153 | 0.126 | 0.113 | 0.076 | 0.203 | 0.167 | 0.233 | 0.117 |
| **SCA** | | 0.485 | 0.398 | 0.356 | 0.240 | 0.643 | 0.527 | 0.737 | 0.370 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly

In E2 GCA ranges from -16.723 (Pusa Sawani) to 30.563 (Kashi Kranti) in lines and in testers -20.283 (EC169452) to EC169459 (15.810). Among the lines Kashi Kranti (30.563), Salkeerthi (17.40) and in tester EC169459 (15.810), Kashi Pragati (12.633) observed significant positive *gca* effect. Whereas, SCA ranges from -29.537 (IC052302 x EC169459) to 24.523 (IC052302 x EC169452). Among 50 crosses 4 crosses recoded significant positive *sca* effect. Top desirable crosses were IC052302 x EC169452 (24.52), Kashi Kranti x Kashi Pragati (24.233) and IC045993 x EC169452 (19.823).

In E3 GCA ranges from -13.418 (IC052302) to 34.89 (Kashi Kranti) in lines and in testers -23.551 (EC169452) to 22.479 (EC169459). Among the lines Kashi Kranti (34.89), EC169459 (15.81) and in testers EC169459 (22.47), Kashi Pragati (21.16) recorded positive and significant *gca* effect. Whereas, SCA ranges from -37.865 (IC045993 x IC052321) to 38.505 (IC058235 x EC169452). Out of 50 crosses 5 crosses observed positive significant *sca* effect. Top desirable crosses were IC058235 x EC169452 (38.505), IC045993 x IC052310 (28.795) and IC052302 x IC052321 (22.441).

While in pooled analysis GCA ranges from -12.771 (IC052302) to 33.310 (Kashi Kranti) in lines and in testers -19.880 (EC169452) to 17.259 (Kashi Pragati). Among the lines Kashi Kranti (33.310), Salkeerthi (6.542) and in testers Kashi Pragati (17.259), EC169459 (17.919) recorded positive and significant *gca* effect. Whereas, SCA, ranges varied from -23.709 (IC045993 x IC052321) to 19.356 (Pusa Sawani x IC052310). Among 50 crosses, 4 crosses recorded were positive and significant *sca* effect. Top desirable crosses were Pusa Sawani x IC052310 (19.356), IC045993 x IC052310 (14.370) and IC045993 x EC169452 (13.422).

During this study, the proportion of $\sigma^2$gca to $\sigma^2$sca across experiments E1 (0.95), E2 (0.96), E3 (0.9), and the combined analysis (0.9) indicated the dominance of non-additive genetic effects for fruit yield/ plant.

**Table 58. Estimates combining ability of parents and hybrids across diverse and pooled environments for fruit yield/plant**

| S.No. | Genotype | Fruit yield/plant | | | |
|---|---|---|---|---|---|
| | | E1 | E2 | E3 | Pooled |
| **PARENTS** | | | | | |
| **Lines** | | | | | |
| **1** | IC058710 | -11.531 ** | -8.803 * | -4.058 | -8.131** |
| **2** | IC045993 | 1.669 | 3.757 | -1.178 | 1.416 |
| **3** | Pusa Sawani | -9.545 ** | -16.723 ** | -2.811 | -9.693** |
| **4** | VRO-4 | 7.969 * | -0.95 | -0.471 | 2.182 |
| **5** | IC052299 | 2.029 | -4.163 | -9.065 | -3.733 |
| **6** | Kashi Kranti | 34.475 ** | 30.563 ** | 34.890 ** | 33.31** |
| **7** | Salkeerthi | 8.922 * | 17.403 ** | -6.698 | 6.542* |
| **8** | IC058235 | -12.851 ** | -9.263 * | 7.522 | -4.864 |
| **9** | Hisar Naveen | -5.451 | -2.61 | -4.711 | -4.258 |
| **10** | IC052302 | -15.685 ** | -9.210 * | -13.418 ** | -12.771** |
| **Testers** | | | | | |
| **11** | EC169452 | -15.805 ** | -20.283 ** | -23.551 ** | -19.880 |
| **12** | IC052310 | -16.851 ** | -10.857 ** | -23.208 ** | -16.972** |
| **13** | EC169459 | 15.469 ** | 15.810 ** | 22.479 ** | 17.919** |
| **14** | Kashi Pragati | 17.982 ** | 12.633 ** | 21.162 ** | 17.259** |
| **15** | IC052321 | -0.795 | 2.697 | 3.119 | 1.694 |
| **HYBRIDS** | | | | | |
| **16** | IC058710 x EC169452 | -5.462 | -8.783 | -10.115 | -8.12 |
| **17** | IC058710 x IC052310 | -1.249 | 11.523 | -10.659 | -0.128 |
| **18** | IC058710 x EC169459 | 9.498 | 11.09 | 7.154 | 9.247 |
| **19** | IC058710 x Kashi Pragati | -1.982 | -11.467 | 9.438 | -1.337 |
| **20** | IC058710 x IC052321 | -0.805 | -2.363 | 4.181 | 0.338 |
| **21** | IC045993 x EC169452 | 4.738 | 19.823 * | 15.705 | 13.422 * |
| **22** | IC045993 x IC052310 | 11.051 | 3.263 | 28.795** | 14.370 * |
| **23** | IC045993 x EC169459 | 3.698 | 5.93 | -4.959 | 1.556 |
| **24** | IC045993 x Kashi Pragati | -3.315 | -11.927 | -1.675 | -5.639 |
| **25** | IC045993 x IC052321 | -16.172 * | -17.09 | -37.865 ** | -23.709 |
| **26** | Pusa Sawani x EC169452 | -31.415 ** | -15.097 | -16.962 | -21.158 ** |
| **27** | Pusa Sawani x IC052310 | 32.798 ** | 19.010 * | 6.261 | 19.356 ** |
| **28** | Pusa Sawani x EC169459 | 3.278 | 6.943 | -3.859 | 2.121 |
| **29** | Pusa Sawani x Kashi Pragati | 4.965 | -2.413 | 5.125 | 2.559 |
| **30** | Pusa Sawani x IC052321 | -9.625 | -8.443 | 9.435 | -2.878 |
| **31** | VRO-4 x EC169452 | 6.471 | -11.503 | -11.569 | -5.534 |
| **32** | VRO-4 x IC052310 | -8.549 | -5.363 | 21.688 * | 2.592 |
| **33** | VRO-4 x EC169459 | -2.202 | -2.363 | -3.333 | -2.633 |
| **34** | VRO-4 x Kashi Pragati | -7.615 | 3.08 | -6.415 | -3.65 |
| **35** | VRO-4 x IC052321 | 11.895 | 16.15 | -0.372 | 9.224 |
| **36** | IC052299 x EC169452 | -6.789 | -10.757 | -15.975 | -11.174 |
| **37** | IC052299 x IC052310 | -2.209 | 2.65 | -13.585 | -4.381 |
| **38** | IC052299 x EC169459 | 7.205 | 10.383 | 8.727 | 8.772 |

| *Table continues…* | | | | | |
|---|---|---|---|---|---|
| **39** | IC052299 x Kashi Pragati | 2.458 | -8.973 | 7.045 | 0.176 |
| **40** | IC052299 x IC052321 | -0.665 | 6.697 | 13.788 | 6.606 |
| **41** | Kashi Kranti x EC169452 | 18.065 * | -6.383 | 17.503 | 9.728 |
| **42** | Kashi Kranti x IC052310 | -9.589 | -7.01 | 19.86 | 1.087 |
| **43** | Kashi Kranti x EC169459 | -2.709 | -7.343 | -21.554 * | -10.535 |
| **44** | Kashi Kranti x Kashi Pragati | 2.678 | 24.233 ** | -13.477 | 4.478 |
| **45** | Kashi Kranti x IC052321 | -8.445 | -3.497 | -2.333 | -4.758 |
| **46** | Salkeerthi x EC169452 | 6.985 | 10.543 | -16.475 | 0.351 |
| **47** | Salkeerthi x IC052310 | 3.831 | 16.417 | -21.619 * | -0.457 |
| **48** | Salkeerthi x EC169459 | -2.189 | -6.917 | 12.294 | 1.063 |
| **49** | Salkeerthi x Kashi Pragati | -8.802 | -12.907 | 12.211 | -3.166 |
| **50** | Salkeerthi x IC052321 | 0.175 | -7.137 | 13.588 | 2.209 |
| **51** | IC058235 x EC169452 | -19.742 * | -9.223 | 38.505 ** | 3.18 |
| **52** | IC058235 x IC052310 | -11.062 | -15.983 | -16.705 | -14.584 * |
| **53** | IC058235 x EC169459 | 9.485 | 11.517 | -9.726 | 3.758 |
| **54** | IC058235 x Kashi Pragati | 5.305 | 0.093 | -16.209 | -3.604 |
| **55** | IC058235 x IC052321 | 16.015 * | 13.597 | 4.135 | 11.249 |
| **56** | Hisar Naveen x EC169452 | 5.291 | 6.857 | 7.071 | 6.406 |
| **57** | Hisar Naveen x IC052310 | -21.429 ** | -23.103 ** | 0.328 | -14.735 * |
| **58** | Hisar Naveen x EC169459 | 5.685 | 0.297 | 18.774* | 8.252 |
| **59** | Hisar Naveen x Kashi Pragati | 9.238 | 16.407 | 0.825 | 8.823 |
| **60** | Hisar Naveen x IC052321 | 1.215 | -0.457 | -26.999 * | -8.747 |
| **61** | IC052302 x EC169452 | 21.858 ** | 24.523 ** | -7.689 | 12.898 * |
| **62** | IC052302 x IC052310 | 6.405 | -1.403 | -14.365 | -3.121 |
| **63** | IC052302 x EC169459 | -31.749 ** | -29.537 ** | -3.519 | -21.602 ** |
| **64** | IC052302 x Kashi Pragati | -2.929 | 3.873 | 3.131 | 1.359 |
| **65** | IC052302 x IC052321 | 6.415 | 2.543 | 22.441 * | 10.466 |
| **GCA (line)** | | 3.470 | 3.928 | 4.711 | 2.349 |
| **GCA (Tester)** | | 2.454 | 2.778 | 3.332 | 1.661 |
| **SCA** | | 7.759 | 8.784 | 10.535 | 5.253 |

The signs *, ** represent significance levels of 5% and 1%, correspondingly.

**4.8 Proportional contribution of Lines, Testers, and Lines x Testers for different characters in okra.**

In E1, E2, E3 and pooled analysis contribution of lines, testers and their interactions for each of the seventeen characters are mentioned in Table 59. In E1 the contribution of lines was higher in magnitude as compared to testers and line x testers *viz*., number of branches per plant (52.56%), fruit diameter (47.31%) and number of pickings/ plant (48.51%). The contribution of testers was higher in magnitude as compared to lines and line x testers *viz*., number of nodes/ plant and fruit yield/ plant. The contribution of line x testers was higher in traits first flowering node (51.86%), fruit yield/ plant (54.34%), days to first flowering (53.12%), days to 1$^{st}$ fruit harvest (66.47%), plant height (49.79%), internodal length (47.97%), fruit length (61.05%), no. of ridges/ fruit (48.96%), no. of fruits/ plant (47.54%) and marketable fruits/ plant (48.90) and average fruit weight (72.72).

In E2 contribution of lines was higher in magnitude as compared to testers and line x testers *viz*., first flowering node (35.76%), number of nodes/ plant (55.58%), number of pickings/ plant (36.30%). The contribution of testers was higher in magnitude as compared to lines and line x testers *viz*., fruit yield/ plant (36.77%). The contribution of line x testers was higher in traits first fruiting node (65.84%), days to first flowering (60.19%), days to 1$^{st}$ fruit harvest (46.45%), plant height (62.21%), internodal length (46.48%), no. of branches/ plant (63.51%), fruit length (77.73%), fruit diameter (87.63%), no. of ridges/ fruit (80.49%), number of fruits/ plant (50.91%), marketable fruits/ plant (51.83%), average fruit weight (76.28%) and number of pickings/ plant (51.51%).

In E3 contribution of lines was higher in magnitude as compared to testers and line x testers *viz*., number of fruits/ plant (37.10%) and marketable fruits/ plant (37.57%). The contribution of testers was higher in magnitude as compared to lines and line x testers *viz*., fruit yield/ plant (51.24%). The contribution of line x testers was higher in traits like first flowering node (43.13%), first fruiting node (54.91%), days to first flowering (62.14%), days to 50% flowering (65.43%), days to 1$^{st}$ fruit harvest (59.36%), plant height (65.11%), internodal length (80.28%), no. of branches/ plant (63.51%), fruit length (53.38%), no,f nodes/ plant (72.90%), fruit diameter (62.28%), no. of ridges/ fruit (76.08%), average fruit weight (58.08%) and number of pickings/ plant (28.45%).

In pooled contribution of lines was higher in magnitude as compared to testers and line x testers *viz*., first flowering node (35.93%), number of nodes/ plant (55.47%), no. of fruits/ plant (39.81%), no. of marketable fruits/ plant (40.62%) and no. of pickings/ plant (48.64%). The contribution of testers was higher in magnitude as compared to lines and line x testers *viz*., fruit yield/ plant (51.19%). The contribution of line x testers was higher in traits like first fruiting node (46.51%), days to first flowering (63.86%), days to 50% flowering (66.97%), days to 1st fruit harvest (62.35%), plant height (43.56%), internodal length (53.28%), no. of branches/ plant (52.28%), fruit length (57.49%), fruit diameter (65.19%), no. of ridges/ fruit (57.49%) and average fruit weight (70.25%).

**Table 59. Contributions of lines, testers and their interactions**

| Characters | Environment 1 | | | Environment 2 | | | Environment 3 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Line % | Tester % | Line x Tester % | Line % | Tester % | Line x Tester % | Line % | Tester % | Line x Tester % | Line % | Tester % | Line x Tester % |
| **FFN** | 43.49 | 4.64 | 51.86 | 35.76 | 32.00 | 32.22 | 22.21 | 34.65 | 43.13 | 35.93 | 29.53 | 34.52 |
| **FFRN** | 37.22 | 8.43 | 54.34 | 10.31 | 23.83 | 65.84 | 37.77 | 7.30 | 54.91 | 34.52 | 18.95 | 46.51 |
| **DFF** | 31.20 | 3.45 | 65.34 | 17.81 | 21.98 | 60.19 | 16.42 | 21.43 | 62.14 | 14.53 | 21.59 | 63.86 |
| **D50F** | 27.83 | 19.04 | 53.12 | 14.13 | 10.94 | 74.91 | 22.17 | 12.39 | 65.43 | 20.12 | 12.90 | 66.97 |
| **DFFRH** | 21.94 | 11.57 | 66.47 | 33.42 | 20.11 | 46.45 | 27.27 | 13.36 | 59.36 | 16.84 | 20.79 | 62.35 |
| **PH** | 39.14 | 14.09 | 49.79 | 25.70 | 12.07 | 62.21 | 20.64 | 14.23 | 65.11 | 38.91 | 17.51 | 43.56 |
| **INL** | 31.10 | 20.92 | 47.97 | 20.19 | 33.31 | 46.48 | 15.80 | 3.90 | 80.28 | 26.67 | 17.03 | 53.28 |
| **NB** | 52.56 | 11.79 | 35.64 | 30.05 | 6.43 | 63.51 | 30.59 | 5.88 | 63.51 | 42.82 | 4.8 | 52.28 |
| **NND** | 25.30 | 43.16 | 31.53 | 55.58 | 8.93 | 35.48 | 23.72 | 3.36 | 72.90 | 55.47 | 21.47 | 23.04 |
| **FL** | 26.06 | 12.88 | 61.05 | 15.34 | 6.91 | 77.73 | 45.95 | 0.65 | 53.38 | 34.58 | 7.91 | 57.49 |
| **FD** | 47.31 | 9.89 | 42.78 | 6.75 | 5.61 | 87.63 | 29.48 | 8.23 | 62.28 | 24.98 | 9.8 | 65.19 |
| **NRG** | 36.12 | 14.91 | 48.96 | 10.17 | 9.32 | 80.49 | 17.68 | 6.23 | 76.08 | 29.30 | 17.28 | 53.40 |
| **NFR** | 29.02 | 23.43 | 47.54 | 33.73 | 15.34 | 50.91 | 37.10 | 28.25 | 34.64 | 39.81 | 29.48 | 30.69 |
| **MFP** | 30.34 | 20.74 | 48.90 | 35.66 | 12.49 | 51.83 | 37.57 | 31.27 | 31.15 | 40.62 | 25.83 | 33.53 |
| **AFW** | 13.98 | 13.87 | 72.72 | 10.69 | 13.01 | 76.28 | 16.00 | 25.90 | 58.08 | 10.49 | 19.24 | 70.25 |
| **NPS** | 48.51 | 18.71 | 32.76 | 36.30 | 12.18 | 51.51 | 33.77 | 27.14 | 39.08 | 48.64 | 22.95 | 28.39 |
| **FYP** | 35.92 | 39.34 | 24.73 | 35.06 | 36.77 | 28.16 | 23.30 | 51.24 | 28.45 | 30.75 | 52.19 | 17.04 |

### 4.9 Stability analysis

One of the primary goals of all breeding programs is the development of a stable genotype. For commercial agricultural plant production, phenotypically stable genotypes are sought. Any breeding program must screen for and select phenotypically stable genotypes that can performs evenly in varying conditions of environment. For stability analysis, multiple models have been given. One of them Eberhart & Russell (1966), one that yields greater than mean, with regression coefficient (b=1) and deviation from regression equals zero, *i.e.,* ($s^2di=0$). A coefficient of regression (bi>1) indicates genotype suits rich environment, whilst coefficient of regression (bi<1) shows it may be adapted to poor environments. Stability analysis might be more informative if study material is evaluated in a variety of environments that influence genotype growth and development. In the present study, 50 hybrids and 15 parents were evaluated under three different environments *viz.*, during March to October 2023.

#### 4.9.1 Stability analysis of variance

Stability ANOVA illustrated that variations owning to genotypes among all traits were significant (Table.60). According to the pooled analysis of variance, except number of nodes, fruit length, number of nodes, number of fruit/plant and fruit yield/plant in the individual environment significant and Environments + (Genotype x Environment) demonstrated significant difference among all parameters. Genotype x Environment (linear) all traits were significant except fruit yield per plant. The pooled deviation significant all traits except number of nodes and number of pickings. When examined environment (linear) revealed a significant difference in all characteristics.

**Table 60. Analysis of variance for stability with three environments in okra (Eberhart and Russell, 1966)**

| Source of variation | df | DFN | DFFRH | DFF | D50F | DFFRH | PH | INL | NB | NND |
|---|---|---|---|---|---|---|---|---|---|---|
| Genotypes | 64 | 0.203** | 0.154** | 1.769** | 2.987** | 2.565** | 47.03** | 0.313** | 0.3** | 1.321* |
| Genotype x Environment | 128 | 0.106 | 0.084 | 0.724 | 0.966 | 1.425* | 20.551 | 0.182 | 0.116 | 0.842 |
| Environments + (Genotype x Environment) | 130 | 0.148** | 0.089** | 2.84** | 2.798** | 2.08** | 28.265** | 0.235** | 0.307** | 0.858** |
| Environments | 2 | 2.851** | 0.434** | 138.28** | 120.018** | 44.052** | 521.984** | 3.633** | 12.574** | 1.868 |
| Environments (linear) | 1 | 5.702** | 0.868** | 276.56** | 240.035** | 88.104** | 1043.97** | 7.266** | 25.149** | 3.736** |
| Genotype x Environment (linear) | 64 | 0.138** | 0.082** | 1.053** | 0.825** | 1.455** | 25.648** | 0.215** | 0.222** | 1.055** |
| Pooled deviation | 65 | 0.073** | 0.084** | 0.388** | 1.091** | 1.372** | 15.215** | 0.148** | 0.009 | 0.62** |
| Pooled error | 384 | 0.1023 | 0.1175 | 0.7675 | 1.1129 | 1.0844 | 17.4583 | 0.1934 | 0.1413 | 1.0092 |

| Source of variation | df | FL | FD | NRG | NFP | MFP | AFW | NPS | FYP |
|---|---|---|---|---|---|---|---|---|---|
| Genotypes | 64 | 1.686** | 1.689** | 0.08** | 15.985** | 15.832** | 1.146** | 4.618** | 3770.816** |
| Genotype x Environment | 128 | 0.472 | 0.756 | 0.045 | 1.7 | 1.367 | 0.502 | 0.729 | 159.514 |
| Environments + (Genotype x Environment) | 130 | 0.471** | 0.962** | 0.053** | 1.729** | 1.551** | 0.525** | 0.782** | 163.277** |
| Environments | 2 | 0.453 | 14.164** | 0.542** | 3.639 | 13.29** | 2.018* | 4.163** | 404.119 |
| Environments (linear) | 1 | 0.905* | 28.329** | 1.084** | 7.279** | 26.58** | 4.037** | 8.326** | 808.238** |
| Genotype x Environment (linear) | 64 | 0.541** | 0.873** | 0.062** | 1.396** | 1.196** | 0.525** | 0.944** | 51.905 |
| Pooled deviation | 65 | 0.396** | 0.629** | 0.028** | 1.973** | 1.515** | 0.472** | 0.507 | 263.013** |
| Pooled error | 384 | 0.57 | 0.73 | 0.042 | 1.51 | 1.69 | 0.47 | 1.30 | 229.04 |

### 4.9.2 Stability for individual traits

The phenotypic stability of genotypes was estimated by mean performance over the environments, regression coefficient (bi) and deviation from regression ($S^2di$) (Table 61 to 70). For all the traits, except first flowering node, first fruiting node, days to 1$^{st}$ flowering, days to 50%flowering, days to 1$^{st}$ fruit harvest mean value was found greater than grand mean which is desirable. Mean performance across environments, regression coefficient (R.C) denoted as (bi) & deviation from regression (D.F.R) denoted ($S^2di$) were used to determine genotype's phenotypic stability.

#### 4.9.2.1 First flowering node

Among parents and hybrids, none of the parent recorded ideal stable, however in hybrids VRO-4 x IC052310, IC052302 x IC052310 and IC052302 x EC169459 carried low mean compared to grand mean, have regression coefficient values close to unity (bi=1) with small deviation from regression ($S^2di$~0) suggesting that they were stable and ideal.

Whereas, parents and hybrids, none of the parent recorded below average stability and in hybrids IC058710 x EC169452, VRO-4 x EC169459, VRO-4 x IC052321, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x IC052321, Salkeerthi x IC052321, Hisar Naveen x IC052321 and IC052302 x IC052321 exhibited low mean compared to grand mean paired with greater value of regression coefficient (bi>1) above the unity with small deviation from regression ($S^2di$~0), indicates below average stability.

In Parents and hybrids IC058710, IC045993, IC052299, Pusa Sawani Salkeerthi, IC058235, Hisar Naveen, IC052302, Kashi Pragati, IC052321 in parents and IC045993 x EC169452, VRO-4 x EC169452, VRO-4 x Kashi Pragati, IC052299 x Kashi Pragati, Kashi Kranti x Kashi Pragati, Salkeerthi x Kashi Pragati, IC058235 x Kashi Pragati, IC052302 x EC169452 and IC052302 x Kashi Pragati in hybrids exhibited low mean value with regression coefficient less than unity and minimum deviation from regression ($S^2di$~0) indicate above average stability.

#### 4.9.2.2 First fruiting node

In this study none of the parent recorded ideal stable however in hybrids IC058235 x Kashi Pragati and Hisar Naveen x Kashi Pragati, carried low mean compared to grand mean, unit regression coefficient (bi=1) and minimum deviation from regressions, it indicates they were stable, perfect.

Among parents and hybrids VRO-4 and IC052302 in parents, and however in cross combinations IC058710 x IC052321, VRO-4 x IC052321, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x IC052321, Hisar Naveen x Kashi Pragati, Hisar Naveen x IC052321and IC052302 x IC052321 exhibits low mean compared to grand mean with regression coefficient above unity (bi>1) with minimum deviation from regression, demonstrating below average stability.

Whereas, parents and hybrids IC058710, Pusa Sawani, Hisar Naveen, IC045993, IC052299, Salkeerthi, IC058235, IC052321 in parents and IC058710 x EC169452, IC058710 x Kashi Pragati, IC045993 x EC69459, VRO-4 x EC169452, VRO-4 x IC052310, VRO-4 x Kashi Pragati, IC052299 x Kashi Pragati, Hisar Naveen x IC052310, IC052302 x EC169452, IC052302 x EC69459 and IC052302 x Kashi Pragati in crosses exhibited low mean compared to grand mean paired with regression below the unity, with minimal deviation from regression, demonstrating above average stability.

**4.8.2.3 Days to first flowering**

Whereas, Pusa Sawani in parents and VRO-4 x Kashi Pragati, in crosses carried low mean compared to grand mean, with regression coefficient close to unity, and minimal deviation from regression suggesting that they were stable and ideal. In the hybrids Salekeerthi x EC169459, IC058235 x EC169459 and IC052302 x Kashi Pragati carried greater mean compared to grand mean, regression close to unity, and minimal degree from regression indicate that they were stable but not ideal.

In this study IC052299, Hisar Naveen in parents and IC058710 x Kashi Pragati, Pusa Sawani x IC052310, Pusa Sawani x IC052321, VRO-4 x EC169452, VRO-4 x EC169459, IC052299 x IC052310, IC052299 x EC169459, IC052299 x Kashi Pragati, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x Kashi Pragati, Salkeerthi x IC052321, IC058235 x EC169452, IC058235 x Kashi Pragati, Hisar Naveen x IC052321, IC052302 x EC169452, IC052302 x IC052310 in cross combinations carried low mean compared to grand mean paired with regression coefficient above the unity (bi>1) with minimal deviation from regression demonstrating below average stability.

**Table 61. Assessing parental and hybrid stability for first flowering node and first fruiting node**

| Sr.No. | Genotypes | First flowering node | | | First fruiting node | | |
|---|---|---|---|---|---|---|---|
| | | Mean | $b_i$ | $S^2d_i$ | Mean | $b_i$ | $S^2d_i$ |
| **PARENTS** | | | | | | | |
| **1** | IC058710 | 4.58 | 0.39 | -0.03 | 4.98 | -1.79 | -0.03 |
| **2** | IC045993 | 4.60 | 0.82 | -0.03 | 5.09 | -0.09 | 0.00 |
| **3** | Pusa Swani | 4.47 | -0.50 | 0.01 | 5.11 | -2.60 | 0.00 |
| **4** | VRO-4 | 4.69 | 0.24 | 0.00 | 5.07 | 2.95 | -0.04 |
| **5** | IC052299 | 4.62 | 0.21 | -0.03 | 4.78 | -1.52 | -0.03 |
| **6** | Kashi Kranti | 4.67 | 0.53 | -0.02 | 5.33 | 5.11 | 0.00 |
| **7** | SALEKERTHI | 4.60 | -0.82 | -0.03 | 5.07 | -0.01 | 0.21 |
| **8** | IC058235 | 4.49 | -0.85 | 0.06 | 5.00 | -0.55 | 0.14 |
| **9** | Hisar Naveen | 4.56 | 0.21 | -0.03 | 5.07 | -0.82 | 0.23 |
| **10** | IC052302 | 4.51 | 0.39 | -0.03 | 5.09 | 1.52 | -0.01 |
| **11** | EC169452 | 4.82 | 1.22 | 0.06 | 5.38 | 1.97 | -0.01 |
| **12** | IC052310 | 4.96 | 2.37 | -0.01 | 5.47 | 4.57 | 0.03 |
| **13** | EC169459 | 4.64 | 0.39 | -0.03 | 5.16 | 2.06 | 0.02 |
| **14** | Kashi Pragati | 4.58 | 0.66 | -0.03 | 5.13 | -1.08 | 0.09 |
| **15** | IC052321 | 4.60 | 0.10 | 0.11 | 5.11 | -1.53 | 0.08 |
| **Parent Mean** | | 4.63 | - | - | 5.12 | - | - |
| **HYBRIDS** | | | | | | | |
| **16** | IC058710 x EC169452 | 4.07 | 1.11 | -0.03 | 4.56 | -1.17 | -0.04 |
| **17** | IC058710 x IC052310 | 4.78 | 0.37 | -0.03 | 5.20 | 1.34 | -0.04 |
| **18** | IC058710 x EC169459 | 4.69 | 1.92 | 0.02 | 5.44 | 6.00 | -0.03 |
| **19** | IC058710 x Kashi Pragati | 4.40 | 0.08 | 0.05 | 4.67 | -2.15 | -0.04 |
| **20** | IC058710 x IC052321 | 4.11 | 1.21 | -0.03 | 4.71 | 1.70 | -0.04 |
| **21** | IC045993 x EC169452 | 4.13 | 0.79 | -0.01 | 4.84 | 1.97 | -0.01 |
| **22** | IC045993 x IC052310 | 4.60 | 0.08 | 0.05 | 5.04 | -1.26 | 0.02 |
| **23** | IC045993 x EC169459 | 4.53 | -1.35 | 0.00 | 4.82 | -2.25 | 0.13 |
| **24** | IC045993 x Kashi Pragati | 4.51 | -0.06 | 0.19 | 4.98 | 0.09 | -0.04 |
| **25** | IC045993 x IC052321 | 4.29 | 2.43 | -0.03 | 5.07 | 4.30 | -0.01 |
| **26** | Pusa Sawani x EC169452 | 4.46 | 0.58 | -0.03 | 4.98 | 4.39 | -0.02 |
| **27** | Pusa Sawani x IC052310 | 4.87 | -2.22 | -0.03 | 5.04 | -6.64 | 0.25 |
| **28** | Pusa Sawani x EC169459 | 4.36 | 4.01 | 0.05 | 4.98 | 2.79 | 0.31 |
| **29** | Pusa Sawani x Kashi Pragati | 4.29 | -0.37 | -0.03 | 5.09 | 4.48 | 0.06 |
| **30** | Pusa Sawani x IC052321 | 4.31 | 1.79 | -0.02 | 5.07 | 1.34 | -0.04 |
| **31** | VRO-4 x EC169452 | 4.04 | 0.11 | -0.03 | 4.40 | -1.35 | 0.00 |
| **32** | VRO-4 x IC052310 | 4.18 | 1.02 | 0.09 | 4.84 | 0.62 | -0.02 |
| **33** | VRO-4 x EC169459 | 4.18 | 1.53 | -0.01 | 5.02 | 5.01 | 0.02 |
| **34** | VRO-4 x Kashi Pragati | 3.80 | 0.60 | 0.00 | 4.42 | -0.63 | -0.02 |
| **35** | VRO-4 x IC052321 | 3.87 | 1.13 | -0.03 | 4.58 | 1.16 | 0.00 |
| **36** | IC052299 x EC169452 | 4.49 | 2.66 | -0.02 | 5.11 | -0.18 | -0.03 |
| **37** | IC052299 x IC052310 | 4.62 | 1.85 | -0.03 | 5.00 | -1.61 | 0.01 |
| **38** | IC052299 x EC169459 | 4.36 | 1.29 | -0.03 | 4.93 | 1.61 | -0.04 |
| **39** | IC052299 x Kashi Pragati | 4.00 | 0.05 | 0.00 | 4.73 | -2.95 | -0.04 |
| ***Table continues…*** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | |
| **40** | IC052299 x IC052321 | 4.36 | 1.61 | -0.02 | 5.04 | 2.51 | -0.04 |
| **41** | Kashi Kranti x EC169452 | 4.42 | 2.15 | 0.96 | 4.89 | 3.68 | 0.27 |
| **42** | Kashi Kranti x IC052310 | 4.24 | 2.99 | 0.37 | 4.84 | 6.82 | 0.42 |
| **43** | Kashi Kranti x EC169459 | 4.20 | 1.85 | 0.11 | 4.93 | 1.62 | 0.04 |
| **44** | Kashi Kranti x Kashi Pragati | 3.69 | -0.13 | -0.01 | 4.31 | 1.17 | -0.04 |
| **45** | Kashi Kranti x IC052321 | 4.22 | 2.14 | -0.03 | 4.80 | 4.57 | 0.03 |
| **46** | Salkeerthi x EC169452 | 4.40 | 4.22 | -0.01 | 5.13 | 0.28 | 0.31 |
| **47** | Salkeerthi x IC052310 | 4.40 | 2.53 | -0.03 | 5.13 | 2.69 | 0.11 |
| **48** | Salkeerthi x EC169459 | 4.42 | 2.72 | -0.03 | 5.11 | 0.36 | 0.04 |
| **49** | Salkeerthi x Kashi Pragati | 4.04 | 0.71 | 0.01 | 4.93 | -1.61 | 0.01 |
| **50** | Salkeerthi x IC052321 | 4.00 | 1.29 | 0.37 | 4.78 | 2.23 | 0.08 |
| **51** | IC058235 x EC169452 | 4.53 | 1.66 | -0.03 | 5.02 | -2.51 | -0.04 |
| **52** | IC058235 x IC052310 | 4.38 | 3.83 | 0.34 | 5.09 | 2.34 | 0.33 |
| **53** | IC058235 x EC169459 | 4.40 | 1.64 | -0.02 | 5.09 | 2.33 | -0.03 |
| **54** | IC058235 x Kashi Pragati | 4.07 | 0.00 | -0.03 | 4.80 | 1.08 | -0.03 |
| **55** | IC058235 x IC052321 | 4.56 | 2.55 | 0.22 | 5.27 | 3.23 | -0.03 |
| **56** | Hisar Naveen x EC169452 | 4.62 | -0.37 | -0.03 | 4.93 | -0.55 | 0.14 |
| **57** | Hisar Naveen x IC052310 | 4.47 | -0.55 | -0.03 | 4.87 | 0.53 | 0.06 |
| **58** | Hisar Naveen x EC169459 | 4.51 | 2.58 | -0.03 | 5.02 | 1.80 | 0.14 |
| **59** | Hisar Naveen x Kashi Pragati | 4.16 | 0.26 | 0.04 | 4.87 | 1.08 | 0.09 |
| **60** | Hisar Naveen x IC052321 | 4.22 | 1.82 | -0.02 | 4.87 | 3.77 | 0.02 |
| **61** | IC052302 x EC169452 | 4.04 | 0.00 | 0.08 | 4.71 | -1.26 | 0.02 |
| **62** | IC052302 x IC052310 | 4.27 | 1.01 | 0.13 | 4.78 | 2.51 | -0.04 |
| **63** | IC052302 x EC169459 | 4.13 | 1.01 | 0.13 | 4.80 | -1.62 | 0.04 |
| **64** | IC052302 x Kashi Pragati | 3.96 | -0.18 | 0.07 | 4.71 | 0.36 | -0.04 |
| **65** | IC052302 x IC052321 | 4.09 | 2.06 | 0.05 | 4.82 | 3.14 | -0.02 |
| **Hybrid Mean** | | 4.29 | - | - | 4.90 | - | - |

Among the parents and crosses VRO-4, Kashi Kranthi, IC058235, IC052302, Kashi Pragathi in parents and IC045993, and in crosses IC045993 x Kashi Pragathi, IC045993 x IC052321, Pusa Swami x Kashi Pragathi in crosses recorded low mean compared to grand mean paired with regression coefficient less than unity (bi<1) with minimal deviation demonstrating above average stability.

**4.9.2.4 Days to 50% first flowering**

In this study among the parents and hybrids none of the parent recorded ideal stable however in crosses IC045993 x Kashi Pragati, IC052299 x EC169452, IC052299 x IC052310, Kashi Kranti x EC169459 and Kashi Kranti x IC052321 had regression coefficient (bi) values close to unity with small deviation from regression suggesting that they were ideal and stable.

While parents and crosses Kashi Kranti in parents and IC058235 x IC052310, IC058235 x EC169459, IC052299 x EC169452, IC058235 x Kashi Pragati, IC052302 x IC052321 in crosses recorded higher mean compared parent grand mean value, regression, and minimal deviation from regression revealed stable but not ideal stability.

Among parents and hybrids IC052299, Hisar Naveen, IC052302 in parents and IC058710 x Kashi Pragati, Pusa Sawani x EC169452, Pusa Sawani x IC052310, Pusa Sawani x Kashi Pragati, Pusa Sawani x IC052321, VRO-4 x EC169459, IC058235 x EC169452 in crosses exhibited low mean compared to grand mean paired with regression coefficient above the unity with minimal deviation ($S^2di \sim 0$), demonstrating below average stability.

Among the parents and crosses IC045993, Pusa Swani, VRO-4, EC169459, Kashi Pragati in parents and, IC058710 x IC052321, IC045993 x EC169452, IC045993 x EC169459, VRO-4 x Kashi Pragati, IC052299 x EC169459, IC052299 x Kashi Pragati, Salkeerthi x EC169459, Salkeerthi x Kashi Pragati, Hisar Naveen x EC169459, IC052302 x EC169452 in crosses recorded low mean compared to grand mean paired with regression coefficient (bi<1) with minimal deviation from regression ($S^2di \sim 0$), demonstrating above average stability.

**Table 62. Assessing parental and hybrid stability for days to first flowering and days to 50% flowering**

| Sr.No. | Genotypes | Days to first flowering | | | Days to 50% flowering | | |
|---|---|---|---|---|---|---|---|
| | | Mean | $b_i$ | $S^2d_i$ | Mean | $b_i$ | $S^2d_i$ |
| **PARENTS** | | | | | | | |
| **1** | IC058710 | 39.67 | 0.60 | -0.22 | 43.11 | 1.26 | 3.02 |
| **2** | IC045993 | 38.89 | 0.87 | 0.17 | 41.22 | 0.52 | 0.68 |
| **3** | Pusa Swani | 38.89 | 1.08 | 1.55 | 41.11 | 0.72 | -0.23 |
| **4** | VRO-4 | 39.00 | 0.81 | 0.54 | 41.44 | 0.90 | -0.23 |
| **5** | IC052299 | 39.11 | 1.13 | -0.23 | 42.22 | 1.60 | -0.15 |
| **6** | Kashi Kranti | 38.78 | 0.93 | -0.09 | 43.33 | 1.02 | 0.37 |
| **7** | Salekerthi | 38.89 | 0.47 | 0.20 | 43.00 | 1.62 | 2.38 |
| **8** | IC058235 | 38.67 | 0.79 | -0.25 | 43.22 | 1.36 | 0.94 |
| **9** | Hisar Naveen | 38.22 | 1.26 | -0.23 | 41.56 | 1.42 | -0.30 |
| **10** | IC052302 | 38.00 | 0.02 | 1.74 | 42.00 | 1.17 | 6.06 |
| **11** | EC169452 | 40.67 | 0.59 | -0.18 | 44.56 | 0.76 | -0.25 |
| **12** | IC052310 | 41.00 | 0.19 | -0.19 | 44.11 | 0.50 | -0.34 |
| **13** | EC169459 | 39.44 | 0.32 | 0.28 | 42.00 | -0.22 | -0.33 |
| **14** | Kashi Pragati | 38.78 | 0.54 | 0.57 | 42.00 | 0.86 | -0.25 |
| **15** | IC052321 | 40.44 | -0.07 | -0.20 | 43.89 | 0.32 | 0.20 |
| **Parent Mean** | | 39.23 | - | - | 42.59 | - | - |
| **HYBRIDS** | | | | | | | |
| **16** | IC058710 x EC169452 | 39.22 | 0.07 | -0.20 | 42.11 | 0.70 | -0.36 |
| **17** | IC058710 x IC052310 | 39.44 | 1.10 | 1.32 | 43.11 | 0.92 | -0.36 |
| **18** | IC058710 x EC169459 | 38.89 | 0.46 | -0.18 | 42.22 | 1.40 | -0.33 |
| **19** | IC058710 x Kashi Pragati | 38.78 | 1.90 | 0.45 | 41.44 | 1.39 | 1.73 |
| **20** | IC058710 x IC052321 | 39.11 | 0.12 | -0.02 | 41.22 | 0.70 | 2.72 |
| **21** | IC045993 x EC169452 | 39.00 | 0.59 | -0.18 | 41.44 | 0.52 | 0.03 |
| **22** | IC045993 x IC052310 | 40.33 | 0.80 | -0.08 | 42.33 | 0.05 | 1.62 |
| **23** | IC045993 x EC169459 | 39.78 | 0.13 | -0.25 | 41.89 | -0.06 | -0.31 |
| **24** | IC045993 x Kashi Pragati | 38.00 | 0.58 | 0.30 | 41.33 | 1.00 | 1.40 |
| **25** | IC045993 x IC052321 | 38.67 | 0.81 | 1.59 | 41.78 | 1.48 | 2.31 |
| **26** | Pusa Sawani x EC169452 | 39.33 | 1.23 | 4.92 | 41.22 | 1.67 | 1.62 |
| **27** | Pusa Sawani x IC052310 | 38.33 | 1.59 | -0.12 | 41.44 | 1.17 | 1.18 |
| **28** | Pusa Sawani x EC169459 | 39.22 | 1.46 | -0.12 | 42.67 | 1.90 | -0.37 |
| **29** | Pusa Sawani x Kashi Pragati | 37.89 | 0.66 | -0.25 | 40.89 | 1.23 | 0.63 |
| **30** | Pusa Sawani x IC052321 | 38.00 | 1.19 | -0.25 | 41.89 | 1.43 | 0.17 |
| **31** | VRO-4 x EC169452 | 38.56 | 1.65 | -0.13 | 42.56 | 2.02 | -0.08 |
| **32** | VRO-4 x IC052310 | 39.67 | 0.79 | -0.25 | 42.22 | 0.14 | -0.37 |
| **33** | VRO-4 x EC169459 | 38.78 | 1.72 | -0.13 | 41.56 | 1.69 | 3.16 |
| **34** | VRO-4 x Kashi Pragati | 37.89 | 1.06 | -0.25 | 39.78 | 0.92 | -0.36 |
| **35** | VRO-4 x IC052321 | 39.00 | 1.19 | -0.25 | 42.67 | 1.66 | 0.14 |
| **36** | IC052299 x EC169452 | 38.89 | 1.45 | -0.24 | 41.22 | 1.00 | -0.26 |
| **37** | IC052299 x IC052310 | 38.11 | 1.32 | -0.25 | 41.44 | 1.08 | 0.85 |
| **38** | IC052299 x EC169459 | 37.89 | 2.24 | -0.23 | 40.67 | 0.91 | 2.72 |
| ***Table continues…*** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | |
| **39** | IC052299 x Kashi Pragati | 38.56 | 1.25 | -0.15 | 41.33 | 0.88 | 0.30 |
| **40** | IC052299 x IC052321 | 39.00 | 1.19 | -0.25 | 42.89 | 1.42 | -0.30 |
| **41** | Kashi Kranti x EC169452 | 39.89 | 1.45 | -0.24 | 42.00 | 0.93 | 4.59 |
| **42** | Kashi Kranti x IC052310 | 39.33 | 1.19 | -0.25 | 42.78 | 0.86 | 1.34 |
| **43** | Kashi Kranti x EC169459 | 37.78 | 1.53 | 0.11 | 40.56 | 1.00 | -0.26 |
| **44** | Kashi Kranti x Kashi Pragati | 37.00 | 1.18 | 0.05 | 39.22 | 0.60 | 0.37 |
| **45** | Kashi Kranti x IC052321 | 38.11 | 1.33 | -0.11 | 41.33 | 1.04 | -0.22 |
| **46** | Salkeerthi x EC169452 | 39.89 | 0.85 | -0.17 | 43.00 | 1.24 | 0.06 |
| **47** | Salkeerthi x IC052310 | 40.33 | 0.40 | -0.25 | 43.00 | 0.66 | 0.01 |
| **48** | Salkeerthi x EC169459 | 39.00 | 0.98 | 0.35 | 41.56 | 0.36 | -0.33 |
| **49** | Salkeerthi x Kashi Pragati | 38.00 | 1.19 | -0.25 | 41.22 | 0.76 | -0.25 |
| **50** | Salkeerthi x IC052321 | 37.89 | 1.45 | -0.24 | 41.11 | 0.90 | -0.23 |
| **51** | IC058235 x EC169452 | 38.89 | 1.45 | -0.24 | 41.89 | 1.45 | 1.08 |
| **52** | IC058235 x IC052310 | 39.11 | 1.32 | -0.25 | 43.22 | 0.96 | 0.01 |
| **53** | IC058235 x EC169459 | 39.22 | 1.06 | -0.25 | 42.00 | 1.02 | 0.37 |
| **54** | IC058235 x Kashi Pragati | 38.78 | 1.10 | 1.32 | 42.78 | 1.08 | 0.85 |
| **55** | IC058235 x IC052321 | 38.78 | 1.12 | -0.16 | 42.33 | 0.80 | 0.76 |
| **56** | Hisar Naveen x EC169452 | 38.89 | 1.85 | -0.24 | 42.44 | 1.36 | -0.11 |
| **57** | Hisar Naveen x IC052310 | 39.67 | 1.19 | -0.25 | 42.44 | 0.50 | -0.34 |
| **58** | Hisar Naveen x EC169459 | 39.11 | 1.31 | 0.06 | 41.67 | 0.44 | -0.20 |
| **59** | Hisar Naveen x Kashi Pragati | 38.89 | 1.24 | 0.37 | 42.78 | 1.30 | 0.44 |
| **60** | Hisar Naveen x IC052321 | 38.67 | 1.19 | -0.25 | 41.78 | 1.36 | -0.11 |
| **61** | IC052302 x EC169452 | 38.44 | 1.12 | -0.16 | 41.11 | 0.75 | 1.34 |
| **62** | IC052302 x IC052310 | 38.33 | 1.79 | 0.09 | 41.67 | 1.37 | 6.58 |
| **63** | IC052302 x EC169459 | 39.78 | 0.31 | 1.19 | 42.33 | 0.26 | 0.94 |
| **64** | IC052302 x Kashi Pragati | 39.22 | 1.04 | 0.77 | 43.44 | 1.28 | 1.51 |
| **65** | IC052302 x IC052321 | 40.33 | 0.40 | -0.25 | 44.33 | 1.04 | -0.22 |
| **Hybrid mean** | | 38.87 | - | - | 41.91 | - | - |

#### 4.9.2.5 Days to first fruit harvest

Among parents and hybrids, none of the parent recorded ideal stable and in hybrids IC058710 x EC169459, IC052302 x EC169452 carried low mean compared to grand mean, regression coefficient near to unity and minimal deviation from regression suggests that they were fair and ideal stability.

In this study parents and hybrids none of the parent recorded stable but not ideal type however in the crosses IC045993 x EC169452, Kashi Kranti x IC052321 carried greater mean compared to grand mean, regression coefficient near to unity, and minimal deviation from regression, suggesting that they were stable but not perfect.

Among parents and hybrids VRO-4, IC052299 in parents and in crosses Pusa Sawani x IC052310, VRO-4 x EC169459, IC052299 x EC169459, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Salkeerthi x Kashi Pragati, Hisar Naveen x IC052321, IC052302 x IC052310, IC058235 x EC169452 exhibited low mean compared to grand mean paired with high regression coefficient unity with minimal deviation from regression, demonstrating below average stability.

While in parents and crosses, IC058710, Pusa Sawani, Hisar Naveen, EC169459 in parents and VRO-4 x EC169459, IC058710 x Kashi Pragati, IC045993 x EC169459, IC045993 x Kashi Pragati, VRO-4 x EC169452, VRO-4 x IC052310 and VRO-4 x Kashi Pragati in hybrids exhibited low mean compared to grand mean paired with regression coefficient less than unity with insignificant deviation from regression demonstrating above average stability.

#### 4.9.2.6 Plant height

Among parents and hybrids VRO-4 and Kashi Kranti x Kashi Pragati respectively, recorded high mean with regression coefficient (bi) values close to unity with minimal deviation to regression suggesting that they were ideal and stable. In parent Salkeerthi carried low mean compared to grand mean, regression coefficient close to unity (bi=1), and minimal deviation from regression suggesting that they were indicated stability but not ideal.

Among parents and hybrids IC052299 in parents and IC058710 x EC169459, IC058710 x Kashi Pragati, IC045993 x EC169452, IC045993 x Kashi Pragati, IC045993 x IC052321, VRO-4 x IC052310, VRO-4 x IC052321, IC052299 x EC169459, IC052299 x Kashi Pragati,

**Table 63. Assessing parental and hybrid stability for days to first fruit harvest and plant height**

| Sr.No. | Genotypes | Days to first fruit harvest | | | Plant height | | |
|---|---|---|---|---|---|---|---|
| | | Mean | $b_i$ | $S^2d_i$ | Mean | $b_i$ | $S^2d_i$ |
| **PARENTS** | | | | | | | |
| **1** | IC058710 | 48.22 | -0.14 | 0.14 | 89.55 | 2.23 | 9.35 |
| **2** | IC045993 | 48.44 | -0.59 | -0.31 | 92.09 | 0.45 | 8.74 |
| **3** | Pusa Swani | 48.11 | 0.14 | 0.14 | 94.40 | 0.87 | 1.11 |
| **4** | VRO-4 | 47.78 | 1.14 | 0.62 | 97.35 | 1.07 | -4.84 |
| **5** | IC052299 | 48.44 | 1.14 | 0.62 | 92.61 | 2.66 | -4.95 |
| **6** | Kashi Kranti | 48.00 | 0.66 | 1.72 | 91.56 | 0.75 | 38.17 |
| **7** | Salekerthi | 48.89 | -0.18 | 4.12 | 89.96 | 1.06 | -5.44 |
| **8** | IC058235 | 48.44 | 0.10 | 0.15 | 94.50 | 0.69 | 37.01 |
| **9** | Hisar Naveen | 48.00 | -0.01 | -0.14 | 87.89 | 0.74 | 27.96 |
| **10** | IC052302 | 49.44 | 0.77 | 2.47 | 92.74 | 0.79 | -2.25 |
| **11** | EC169452 | 49.89 | 1.58 | 3.44 | 83.81 | -4.10 | 23.28 |
| **12** | IC052310 | 48.67 | -0.01 | -0.14 | 81.54 | -0.91 | 7.99 |
| **13** | EC169459 | 48.11 | -0.96 | 0.46 | 86.68 | 0.10 | -5.34 |
| **14** | Kashi Pragati | 47.56 | 0.52 | 4.23 | 92.66 | -0.47 | 0.84 |
| **15** | IC052321 | 48.56 | -0.49 | 0.50 | 85.90 | 1.58 | 38.78 |
| | **Parent Mean** | 48.44 | - | - | 90.22 | - | - |
| **16** | IC058710 x EC169452 | 47.78 | 0.44 | 0.56 | 95.53 | 0.78 | -5.38 |
| **17** | IC058710 x IC052310 | 47.89 | 1.28 | -0.28 | 92.51 | -0.86 | 39.89 |
| **18** | IC058710 x EC169459 | 47.33 | 1.00 | 2.50 | 94.49 | 1.30 | -1.89 |
| **19** | IC058710 x Kashi Pragati | 47.00 | 0.75 | 3.09 | 93.32 | 1.10 | -4.14 |
| **20** | IC058710 x IC052321 | 48.11 | 0.10 | 0.15 | 87.61 | 1.82 | 0.65 |
| **21** | IC045993 x EC169452 | 48.33 | 1.08 | 0.93 | 93.04 | 1.56 | -4.91 |
| **22** | IC045993 x IC052310 | 48.00 | -0.36 | -0.31 | 90.01 | 0.62 | 40.85 |
| **23** | IC045993 x EC169459 | 46.00 | 0.01 | -0.14 | 97.10 | 0.94 | 8.06 |
| **24** | IC045993 x Kashi Pragati | 45.67 | 0.69 | -0.11 | 96.53 | 1.11 | -5.23 |
| **25** | IC045993 x IC052321 | 47.67 | 2.42 | 1.27 | 94.17 | 1.67 | 36.42 |
| **26** | Pusa Sawani x EC169452 | 48.22 | 3.09 | 2.76 | 95.88 | -0.66 | -4.95 |
| **27** | Pusa Sawani x IC052310 | 46.89 | 3.39 | -0.35 | 86.78 | 0.79 | -1.83 |
| **28** | Pusa Sawani x EC169459 | 46.67 | 1.43 | 0.43 | 91.80 | 3.17 | -2.65 |
| **29** | Pusa Sawani x Kashi Pragati | 47.78 | 0.14 | 0.14 | 93.09 | -0.07 | -4.93 |
| **30** | Pusa Sawani x IC052321 | 47.78 | 0.80 | 0.19 | 96.51 | 0.92 | -5.19 |
| **31** | VRO-4 x EC169452 | 45.89 | 0.59 | -0.31 | 97.81 | 0.90 | -4.74 |
| **32** | VRO-4 x IC052310 | 46.33 | 0.03 | 0.53 | 96.78 | 1.78 | 19.17 |
| **33** | VRO-4 x EC169459 | 46.33 | 1.10 | 2.23 | 92.89 | 1.84 | 2.22 |
| **34** | VRO-4 x Kashi Pragati | 46.78 | 0.16 | 2.35 | 98.59 | 0.28 | 43.05 |
| **35** | VRO-4 x IC052321 | 47.56 | 0.95 | -0.17 | 94.28 | 1.88 | -4.56 |
| **36** | IC052299 x EC169452 | 48.22 | 1.59 | 1.83 | 91.58 | 0.90 | 1.19 |
| **37** | IC052299 x IC052310 | 47.44 | 0.78 | 1.11 | 91.55 | 0.11 | -5.48 |
| **38** | IC052299 x EC169459 | 46.44 | 2.91 | -0.24 | 95.27 | 1.84 | 17.82 |
| **39** | IC052299 x Kashi Pragati | 46.78 | 0.86 | 2.26 | 92.66 | 1.59 | 13.75 |
| ***Table continues…*** | | | | | | | |

| *Table continues…* | | | | | | | |
|---|---|---|---|---|---|---|---|
| **40** | IC052299 x IC052321 | 48.22 | 1.30 | 0.07 | 92.26 | 1.19 | -4.12 |
| **41** | Kashi Kranti x EC169452 | 48.11 | 2.54 | 0.73 | 91.65 | 1.78 | 33.62 |
| **42** | Kashi Kranti x IC052310 | 47.44 | 2.88 | 1.31 | 88.73 | 0.43 | 56.80 |
| **43** | Kashi Kranti x EC169459 | 46.11 | 2.16 | 4.51 | 94.98 | 0.90 | 32.30 |
| **44** | Kashi Kranti x Kashi Pragati | 45.00 | 2.10 | -0.35 | 100.26 | 0.96 | 4.47 |
| **45** | Kashi Kranti x IC052321 | 47.67 | 1.04 | -0.28 | 93.60 | 2.29 | 22.84 |
| **46** | Salkeerthi x EC169452 | 48.44 | 2.92 | -0.34 | 89.87 | 1.83 | 15.54 |
| **47** | Salkeerthi x IC052310 | 48.33 | 0.33 | 0.16 | 86.80 | 2.81 | 6.46 |
| **48** | Salkeerthi x EC169459 | 47.44 | 2.22 | -0.34 | 93.77 | -0.14 | 85.51 |
| **49** | Salkeerthi x Kashi Pragati | 46.33 | 2.48 | 0.81 | 92.74 | 1.92 | 1.69 |
| **50** | Salkeerthi x IC052321 | 47.22 | 2.00 | 0.04 | 93.56 | 1.29 | 16.80 |
| **51** | IC058235 x EC169452 | 47.33 | 2.79 | -0.02 | 89.06 | 1.74 | -5.06 |
| **52** | IC058235 x IC052310 | 48.33 | 1.74 | -0.27 | 92.49 | 2.40 | -0.92 |
| **53** | IC058235 x EC169459 | 47.56 | 0.95 | -0.17 | 92.17 | 2.93 | -0.96 |
| **54** | IC058235 x Kashi Pragati | 48.00 | 0.03 | 0.53 | 90.75 | 1.46 | -2.59 |
| **55** | IC058235 x IC052321 | 47.44 | 0.48 | -0.15 | 86.46 | 2.07 | -4.36 |
| **56** | Hisar Naveen x EC169452 | 47.56 | 1.37 | 8.71 | 84.53 | 1.16 | 25.95 |
| **57** | Hisar Naveen x IC052310 | 48.56 | 0.26 | 0.51 | 86.75 | 1.10 | 12.08 |
| **58** | Hisar Naveen x EC169459 | 46.33 | 0.73 | 0.48 | 88.67 | 0.52 | -3.35 |
| **59** | Hisar Naveen x Kashi Pragati | 47.89 | -1.14 | 0.62 | 93.07 | -0.39 | -4.21 |
| **60** | Hisar Naveen x IC052321 | 46.67 | 1.13 | 6.14 | 84.84 | 0.10 | -5.74 |
| **61** | IC052302 x EC169452 | 46.67 | 1.07 | 0.09 | 91.06 | -2.35 | 7.21 |
| **62** | IC052302 x IC052310 | 46.89 | 1.70 | 4.89 | 84.20 | 0.49 | -5.73 |
| **63** | IC052302 x EC169459 | 47.22 | 2.00 | 0.04 | 85.97 | -0.65 | -4.32 |
| **64** | IC052302 x Kashi Pragati | 48.78 | 0.48 | -0.15 | 93.94 | 2.82 | -4.26 |
| **65** | IC052302 x IC052321 | 48.11 | 0.45 | -0.12 | 93.76 | 4.46 | 2.51 |
| **Hybrid Mean** | | 47.33 | - | - | 92.11 | - | - |

IC052299 x EC169459, Salkeerthi x Kashi Pragati, Salkeerthi x IC052321, IC052299 x Kashi Pragati, IC058235 x IC052310, IC058235 x EC169459, IC052302 x Kashi Pragati and IC052302 x IC052321 in crosses recorded higher mean coupled with regression coefficient higher unity and minute deviation from regression recorded below average stability.

In contrast, parents and cross combinations IC045993, Pusa Swani, Kashi Kranti, IC058235, Kashi Pragati and IC058710 x EC169452, IC058710 x IC052310, IC045993 x EC169459, Pusa Sawani x EC169452, Pusa Sawani x Kashi Pragati, Pusa Sawani x IC052321, VRO-4 x EC169452, Salkeerthi x EC169459 and Hisar Naveen x Kashi Pragati in cross combinations recorded higher mean value along regression coefficient lower than unity (bi<1) and a small deviation from regression suggesting above average stability.

#### 4.9.2.7 Internodal length

In this study none of the parent and cross combinations were recorded ideal stable. However, among the parents, Kashi Kranti and IC052299 x IC052310 in crosses carried low mean compared to grand mean, R.C *i.e.*, (bi=1), and minimal deviation from regression suggesting that they were indicated stable but not ideal.

Among parents none of the parent recorded above average stability and in cross combinations IC045993 x EC169459, IC045993 x IC052321, Pusa Sawani x EC169459, Pusa Sawani x IC052321, IC052299 x EC169459, IC052299 x IC0169459, Kashi Kranti x EC169452, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x EC169452, Salkeerthi x IC052310, Hisar Naveen x EC169452 and Hisar Naveen x IC052310 recorded higher mean coupled with high regression coefficient higher then unity and small deviation from regression *i.e.*, ($S^2di\sim0$) recorded below average stability.

While in parents and crosses IC045993, Pusa Sawani, VRO-4, IC052299, IC058235, Hisar Naveen, EC169459, IC052302 and IC052321 in parents and IC045993 x IC052310, IC052299 x Kashi Pragati, Salkeerthi x Kashi Pragati, IC058235 x IC052310, IC052302 x Kashi Pragati and Hisar Naveen x Kashi Pragati in crosses recorded higher mean value along regression coefficient lower than unity and a small deviation from regression ($S^2di\sim0$) suggesting above average stability.

#### 4.9.2.8 Number of branches/plants

Whereas, none of the parent recorded ideal stable, however in crosses IC052299 x IC052321 had minimal deviation from regression ($S^2di$~0), regression close to unity (bi=1) with a higher mean compared general mean, suggesting ideal and stable.

While in parents and crosses Pusa Sawani in parents and IC052299 x IC052310, Hisar Naveen x IC052321and IC052302 x Kashi Pragati in crosses carried low mean compared to grand mean, regression close to unity, *i.e*., (bi=1) along minimal deviation from regression *i.e*., ($S^2di$~0), suggesting that they were indicated stable but not ideal.

Among parents and hybrids IC058710, IC045993, Kashi Kranti, IC058235, Hisar Naveen, IC052302, EC169452 in parents and IC058710 x EC169459, IC045993 x IC052310, VRO-4 x IC052321, IC052299 x Kashi Pragati, Salkeerthi x EC169452, IC058235 x IC052310, Salkeerthi x IC052321, IC058235 x EC169452, Hisar Naveen x Kashi Pragati in crosses recorded higher mean coupled with high regression coefficient then unity *i.e*., (bi>1) and minimal deviation from regression recorded below average stability.

In contrast, parents and crosses, none of the parent recorded above average stability and in crosses IC045993 x Kashi Pragati, IC045993 x IC052321, Pusa Sawani x EC169452, Pusa Sawani x IC052310, Pusa Sawani x EC169459, Pusa Sawani x Kashi Pragati, Pusa Sawani x IC052321, IC052299 x EC169452, IC052299 x EC169459, Kashi Kranti x EC169452, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x EC169459, IC058235 x EC169459, IC058235 x IC052321 recorded higher mean value alongside regression coefficient lower than unity and a small deviation from regression ($S^2di$~0) suggesting above average stability.

**Table 64. Assessing parental and hybrid stability for internodal length and number of branches/plant**

| Sr.No. | Genotypes | Internodal length | | | Number of branches/plant | | |
|---|---|---|---|---|---|---|---|
| | | Mean | $b_i$ | $S^2d_i$ | Mean | $b_i$ | $S^2d_i$ |
| **PARENTS** | | | | | | | |
| **1** | IC058710 | 5.30 | -0.12 | -0.06 | 4.76 | 1.22 | -0.05 |
| **2** | IC045993 | 5.37 | 0.22 | -0.03 | 4.67 | 1.44 | -0.05 |
| **3** | Pusa Swani | 5.42 | 0.75 | 0.00 | 4.31 | 1.01 | -0.03 |
| **4** | VRO-4 | 5.65 | 0.03 | 0.40 | 4.40 | 1.31 | -0.04 |
| **5** | IC052299 | 5.57 | 0.15 | -0.04 | 4.58 | 2.06 | -0.03 |
| **6** | Kashi Kranti | 5.32 | 0.97 | 0.01 | 5.18 | 2.71 | -0.04 |
| **7** | SALEKERTHI | 5.21 | 0.64 | 0.01 | 4.44 | 0.74 | -0.05 |
| **8** | IC058235 | 5.57 | -0.45 | -0.01 | 4.71 | 1.66 | -0.05 |
| **9** | Hisar Naveen | 5.45 | -0.12 | 0.06 | 4.62 | 1.22 | -0.05 |
| **10** | IC052302 | 5.52 | -0.74 | -0.05 | 4.82 | 1.48 | -0.05 |
| **11** | EC169452 | 4.84 | 1.63 | 0.74 | 4.87 | 1.57 | -0.05 |
| **12** | IC052310 | 5.28 | 0.04 | -0.06 | 4.60 | 1.44 | -0.05 |
| **13** | EC169459 | 5.42 | -0.19 | -0.06 | 4.47 | 0.92 | -0.05 |
| **14** | Kashi Pragti | 5.30 | -0.94 | 0.22 | 4.44 | 2.05 | -0.05 |
| **15** | IC052321 | 5.41 | 0.18 | -0.02 | 4.47 | 1.70 | -0.05 |
| **Parent Mean** | | 5.37 | - | - | 4.62 | - | - |
| **HYBRIDS** | | | | | | | |
| **16** | IC058710 x EC169452 | 5.49 | -0.42 | -0.06 | 4.89 | 1.48 | -0.05 |
| **17** | IC058710 x IC052310 | 5.55 | 0.20 | 0.00 | 4.24 | 0.09 | -0.05 |
| **18** | IC058710 x EC169459 | 5.65 | 4.11 | 0.04 | 5.02 | 1.22 | -0.05 |
| **19** | IC058710 x Kashi Pragati | 5.80 | 0.25 | 0.13 | 4.87 | 1.83 | -0.05 |
| **20** | IC058710 x IC052321 | 5.51 | -0.97 | -0.02 | 4.78 | 1.14 | -0.05 |
| **21** | IC045993 x EC169452 | 5.80 | -0.59 | 0.03 | 4.73 | 1.83 | -0.05 |
| **22** | IC045993 x IC052310 | 5.93 | -1.44 | -0.05 | 5.27 | 1.83 | -0.03 |
| **23** | IC045993 x EC169459 | 6.59 | 2.65 | -0.06 | 4.87 | 0.00 | -0.05 |
| **24** | IC045993 x Kashi Pragati | 5.82 | -1.17 | -0.03 | 5.47 | 0.79 | -0.05 |
| **25** | IC045993 x IC052321 | 5.94 | 1.56 | 0.28 | 5.42 | 0.44 | -0.05 |
| **26** | Pusa Sawani x EC169452 | 5.68 | 0.89 | -0.01 | 5.09 | 0.17 | -0.05 |
| **27** | Pusa Sawani x IC052310 | 5.69 | 1.54 | -0.04 | 5.13 | 0.00 | -0.05 |
| **28** | Pusa Sawani x EC169459 | 6.05 | 1.22 | 0.47 | 5.33 | 0.51 | 0.04 |
| **29** | Pusa Sawani x Kashi Pragati | 5.73 | -1.23 | -0.06 | 5.16 | -0.09 | -0.05 |
| **30** | Pusa Sawani x IC052321 | 6.31 | 1.34 | 0.31 | 5.02 | -0.09 | -0.05 |
| **31** | VRO-4 x EC169452 | 5.64 | 0.92 | 0.53 | 4.20 | -0.13 | -0.03 |
| **32** | VRO-4 x IC052310 | 5.78 | 4.18 | -0.04 | 4.62 | 0.44 | -0.05 |
| **33** | VRO-4 x EC169459 | 5.78 | 2.40 | 0.15 | 4.91 | 0.09 | -0.05 |
| **34** | VRO-4 x Kashi Pragati | 6.42 | 0.95 | -0.04 | 4.47 | 1.31 | -0.05 |
| **35** | VRO-4 x IC052321 | 5.94 | 2.52 | 0.02 | 5.07 | 2.10 | -0.05 |
| **36** | IC052299 x EC169452 | 5.34 | 0.92 | -0.01 | 4.96 | 0.70 | -0.05 |
| **37** | IC052299 x IC052310 | 5.82 | 1.01 | 0.92 | 4.69 | 0.96 | -0.05 |
| **38** | IC052299 x EC169459 | 5.95 | 3.33 | -0.05 | 4.98 | 0.87 | -0.05 |
| ***Table continues…*** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | |
| **39** | IC052299 x Kashi Pragati | 5.97 | -0.49 | 0.38 | 5.18 | 1.66 | -0.05 |
| **40** | IC052299 x IC052321 | 5.79 | 1.57 | -0.05 | 4.96 | 0.96 | -0.05 |
| **41** | Kashi Kranti x EC169452 | 5.98 | 3.32 | -0.04 | 5.16 | 0.19 | 0.17 |
| **42** | Kashi Kranti x IC052310 | 5.93 | 1.34 | -0.06 | 4.96 | -0.22 | -0.04 |
| **43** | Kashi Kranti x EC169459 | 6.04 | 3.01 | -0.06 | 5.02 | -0.09 | -0.04 |
| **44** | Kashi Kranti x Kashi Pragati | 6.65 | 1.46 | -0.02 | 5.36 | 0.04 | -0.03 |
| **45** | Kashi Kranti x IC052321 | 5.87 | 2.28 | -0.06 | 5.16 | -0.09 | -0.05 |
| **46** | Salkeerthi x EC169452 | 6.05 | 1.16 | 0.50 | 5.31 | 1.92 | -0.05 |
| **47** | Salkeerthi x IC052310 | 6.03 | 1.63 | -0.05 | 4.76 | 0.31 | -0.04 |
| **48** | Salkeerthi x EC169459 | 5.73 | 1.45 | -0.06 | 5.16 | -0.09 | -0.05 |
| **49** | Salkeerthi x Kashi Pragati | 5.96 | -0.29 | 0.27 | 4.73 | 1.83 | -0.05 |
| **50** | Salkeerthi x IC052321 | 5.65 | 1.39 | -0.05 | 5.11 | 2.17 | 0.05 |
| **51** | IC058235 x EC169452 | 5.75 | 1.38 | 0.13 | 5.02 | 2.01 | -0.05 |
| **52** | IC058235 x IC052310 | 5.98 | 0.49 | 0.53 | 5.42 | 2.01 | -0.05 |
| **53** | IC058235 x EC169459 | 5.77 | 3.65 | -0.06 | 5.07 | 0.79 | -0.05 |
| **54** | IC058235 x Kashi Pragati | 5.81 | 1.71 | 0.48 | 4.73 | 1.83 | -0.05 |
| **55** | IC058235 x IC052321 | 5.17 | 1.98 | -0.06 | 5.29 | 0.31 | -0.03 |
| **56** | Hisar Naveen x EC169452 | 5.86 | 3.73 | 0.00 | 4.40 | 1.44 | -0.05 |
| **57** | Hisar Naveen x IC052310 | 5.87 | 1.20 | -0.06 | 4.80 | 1.05 | -0.04 |
| **58** | Hisar Naveen x EC169459 | 5.82 | 3.67 | -0.05 | 4.76 | 0.70 | -0.04 |
| **59** | Hisar Naveen x Kashi Pragati | 6.12 | -0.41 | 0.27 | 5.11 | 1.92 | -0.05 |
| **60** | Hisar Naveen x IC052321 | 5.64 | 1.34 | 0.22 | 4.56 | 1.10 | -0.03 |
| **61** | IC052302 x EC169452 | 5.68 | 1.91 | -0.06 | 4.51 | 0.35 | -0.05 |
| **62** | IC052302 x IC052310 | 5.53 | 0.24 | -0.06 | 4.84 | 1.14 | -0.05 |
| **63** | IC052302 x EC169459 | 5.78 | 1.93 | -0.02 | 4.76 | -0.09 | -0.05 |
| **64** | IC052302 x Kashi Pragati | 5.99 | -1.01 | -0.02 | 4.89 | 1.09 | -0.05 |
| **65** | IC052302 x IC052321 | 5.21 | -0.75 | 0.06 | 4.29 | 0.57 | -0.05 |
| **Hybrid Mean** | | 5.84 | - | - | 4.93 | - | - |

#### 4.9.2.9 Number of nodes per plant

Whereas, none of the parent and crosses recorded ideal stable. While in crosses IC052302 x IC052310 carried low mean compared to grand mean regression coefficient close to unity, and minimal deviation from regression *i.e*., ($S^2di$~0), suggesting they were indicated stable but not ideal.

In parents and hybrids IC045993, IC052299, Kashi Kranti, IC058235, Hisar Naveen, IC052302 in parents and IC045993 x EC169452, Pusa Sawani x Kashi Pragati, VRO-4 x EC169459, VRO-4 x IC052321 and Kashi Kranti x IC052310 in crosses recorded higher mean coupled with high regression coefficient above the unity and minimum deviation from regression recorded below average stability.

While in, parents and hybrids Pusa Sawani, VRO-4 in parents and IC045993 x EC169459, Pusa Sawani x EC169452, Pusa Sawani x EC169459, VRO-4 x EC169452, IC052299 x EC169452, IC052299 x EC169459, IC052299 x Kashi Pragati, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x EC169452, IC052302 x EC169452 cross combinations recorded higher mean value along with regression coefficient over than unity (bi<1) and a small deviation from regression suggesting above average stability.

#### 4.9.2.10 Fruit length

In this study none of the cross were recorded ideal stability and whereas among the parents EC169459 had high mean, unity regression coefficient (bi=1) and small deviation from regression ($S^2di$~0) indicate ideal and stable.

Whereas, parents and hybrids IC058710, IC045993, Pusa Sawani, VRO-4, IC052299, Kashi Kranti, IC058235, Hisar Naveen, IC052321 in parents and Pusa Sawani x IC052310, VRO-4 x IC052310, Kashi Kranti x Kashi Pragati, Salkeerthi x EC169459, IC052302 x IC052310, IC052302 x Kashi Pragati in cross combinations recorded higher mean coupled with high regression coefficient then unity small deviation from regression indicated below average stability.

**Table 65. Assessing parental and hybrid stability for number of nodes per plant and fruit length**

| Sr.No. | Genotypes | Number of nodes/plant | | | Fruit length | | |
|---|---|---|---|---|---|---|---|
| | | Mean | $b_i$ | $S^2d_i$ | Mean | $b_i$ | $S^2d_i$ |
| **PARENTS** | | | | | | | |
| **1** | IC058710 | 15.28 | 1.30 | 0.20 | 13.57 | 10.24 | 0.15 |
| **2** | IC045993 | 16.12 | 1.37 | -0.32 | 13.85 | 4.46 | -0.17 |
| **3** | Pusa Swani | 16.37 | -2.56 | -0.33 | 13.87 | 12.09 | -0.17 |
| **4** | VRO-4 | 16.16 | -0.46 | -0.24 | 14.18 | 1.83 | -0.19 |
| **5** | IC052299 | 16.41 | 4.21 | -0.23 | 13.91 | 4.96 | -0.14 |
| **6** | Kashi Kranti | 16.17 | 7.99 | -0.11 | 13.40 | 5.33 | -0.18 |
| **7** | Salkeerthi | 15.54 | 6.01 | 0.06 | 13.82 | -1.93 | -0.11 |
| **8** | IC058235 | 16.35 | 6.78 | -0.25 | 13.58 | 19.39 | -0.05 |
| **9** | Hisar Naveen | 16.10 | 8.09 | 0.18 | 13.32 | 2.02 | -0.11 |
| **10** | IC052302 | 16.44 | 1.76 | 0.22 | 13.23 | 10.99 | 0.52 |
| **11** | EC169452 | 14.58 | 6.68 | -0.15 | 10.09 | 13.23 | 3.46 |
| **12** | IC052310 | 15.00 | 5.98 | -0.12 | 12.54 | 3.04 | -0.04 |
| **13** | EC169459 | 15.63 | 3.74 | 0.16 | 13.37 | 0.99 | -0.18 |
| **14** | Kashi Pragti | 15.76 | 4.08 | 0.08 | 13.14 | 2.06 | -0.15 |
| **15** | IC052321 | 15.43 | 6.48 | -0.30 | 13.80 | 10.79 | -0.19 |
| | **Parent Mean** | 15.82 | - | - | 13.31 | - | - |
| **16** | IC058710 x EC169452 | 16.35 | -1.11 | -0.06 | 13.40 | 7.69 | -0.17 |
| **17** | IC058710 x IC052310 | 15.34 | 3.76 | 0.64 | 13.90 | -2.24 | 0.13 |
| **18** | IC058710 x EC169459 | 16.26 | -1.73 | 0.19 | 13.50 | -2.95 | -0.02 |
| **19** | IC058710 x Kashi Pragati | 16.36 | 1.83 | -0.08 | 13.59 | -1.57 | 2.68 |
| **20** | IC058710 x IC052321 | 16.01 | 4.70 | -0.22 | 13.98 | 2.48 | -0.19 |
| **21** | IC045993 x EC169452 | 16.50 | 2.10 | 0.18 | 13.51 | 6.45 | 0.14 |
| **22** | IC045993 x IC052310 | 15.27 | 2.59 | 0.18 | 13.94 | -5.66 | 0.48 |
| **23** | IC045993 x EC169459 | 16.82 | -8.64 | 0.52 | 14.59 | -3.35 | 1.00 |
| **24** | IC045993 x Kashi Pragati | 16.47 | 0.02 | -0.34 | 14.22 | -5.01 | 0.33 |
| **25** | IC045993 x IC052321 | 16.11 | 6.69 | 0.25 | 14.12 | -1.11 | -0.08 |
| **26** | Pusa Sawani x EC169452 | 17.71 | -6.12 | -0.26 | 14.46 | -4.06 | 0.15 |
| **27** | Pusa Sawani x IC052310 | 15.87 | 2.03 | -0.30 | 14.64 | 1.88 | 0.05 |
| **28** | Pusa Sawani x EC169459 | 17.23 | -6.14 | -0.34 | 13.73 | -1.63 | -0.08 |
| **29** | Pusa Sawani x Kashi Pragati | 16.67 | 7.92 | 1.73 | 14.22 | -8.34 | 0.18 |
| **30** | Pusa Sawani x IC052321 | 16.53 | 0.11 | -0.28 | 13.35 | 1.54 | 1.81 |
| **31** | VRO-4 x EC169452 | 17.51 | -2.45 | 2.58 | 14.31 | -1.49 | -0.14 |
| **32** | VRO-4 x IC052310 | 16.41 | -4.14 | 5.58 | 14.59 | 4.10 | 1.73 |
| **33** | VRO-4 x EC169459 | 17.55 | 4.58 | 1.81 | 14.51 | -2.83 | -0.02 |
| **34** | VRO-4 x Kashi Pragati | 17.27 | -12.51 | -0.19 | 15.08 | 0.74 | 0.55 |
| **35** | VRO-4 x IC052321 | 16.62 | 1.36 | -0.33 | 14.63 | 0.60 | -0.18 |
| **36** | IC052299 x EC169452 | 16.51 | -5.34 | 1.43 | 13.61 | -3.84 | -0.10 |
| **37** | IC052299 x IC052310 | 16.12 | 4.29 | -0.32 | 14.70 | -0.18 | 0.05 |
| **38** | IC052299 x EC169459 | 17.05 | -3.25 | 0.69 | 14.50 | -11.01 | -0.17 |
| **39** | IC052299 x Kashi Pragati | 16.49 | -2.00 | 0.20 | 13.90 | -6.77 | -0.10 |
| ***Table continues…*** | | | | | | | |

| *Table continues…* | | | | | | | |
|---|---|---|---|---|---|---|---|
| **40** | IC052299 x IC052321 | 16.26 | -1.28 | -0.27 | 14.47 | -7.38 | -0.19 |
| **41** | Kashi Kranti x EC169452 | 17.09 | 1.15 | -0.31 | 13.97 | 6.73 | 0.49 |
| **42** | Kashi Kranti x IC052310 | 17.36 | 5.48 | -0.32 | 14.09 | 6.34 | -0.12 |
| **43** | Kashi Kranti x EC169459 | 17.33 | -2.63 | -0.31 | 15.47 | -5.42 | 0.42 |
| **44** | Kashi Kranti x Kashi Pragati | 18.12 | -2.23 | -0.16 | 15.43 | 4.15 | -0.17 |
| **45** | Kashi Kranti x IC052321 | 17.35 | -2.56 | 0.79 | 14.81 | -8.31 | -0.02 |
| **46** | Salkeerthi x EC169452 | 16.45 | -0.45 | 2.00 | 13.42 | 7.07 | -0.11 |
| **47** | Salkeerthi x IC052310 | 15.56 | 5.36 | -0.25 | 14.19 | -6.06 | -0.19 |
| **48** | Salkeerthi x EC169459 | 16.24 | -0.58 | -0.20 | 14.48 | 4.02 | -0.15 |
| **49** | Salkeerthi x Kashi Pragati | 15.88 | -0.99 | 0.04 | 14.81 | -2.63 | -0.05 |
| **50** | Salkeerthi x IC052321 | 15.96 | 5.03 | -0.02 | 13.72 | 5.41 | -0.15 |
| **51** | IC058235 x EC169452 | 16.17 | 2.49 | 1.27 | 14.56 | -6.16 | -0.08 |
| **52** | IC058235 x IC052310 | 15.93 | 5.44 | 0.10 | 13.22 | 7.21 | -0.04 |
| **53** | IC058235 x EC169459 | 17.15 | -10.03 | -0.34 | 13.95 | 0.89 | -0.17 |
| **54** | IC058235 x Kashi Pragati | 16.05 | 2.70 | 0.52 | 13.49 | -0.11 | -0.12 |
| **55** | IC058235 x IC052321 | 15.96 | 2.87 | 1.94 | 14.30 | -5.88 | -0.19 |
| **56** | Hisar Naveen x EC169452 | 15.76 | -1.67 | 0.31 | 14.35 | -2.81 | 0.87 |
| **57** | Hisar Naveen x IC052310 | 16.30 | 7.54 | -0.21 | 14.11 | -4.05 | 0.15 |
| **58** | Hisar Naveen x EC169459 | 15.98 | -5.75 | -0.15 | 13.66 | -0.04 | -0.11 |
| **59** | Hisar Naveen x Kashi Pragati | 15.98 | 1.97 | -0.31 | 14.03 | 2.23 | -0.09 |
| **60** | Hisar Naveen x IC052321 | 15.38 | 4.81 | 0.44 | 14.27 | -6.81 | 0.07 |
| **61** | IC052302 x EC169452 | 16.65 | -0.29 | 1.34 | 13.15 | 8.55 | 0.15 |
| **62** | IC052302 x IC052310 | 16.19 | 1.06 | -0.26 | 14.41 | 6.21 | 0.70 |
| **63** | IC052302 x EC169459 | 16.26 | -4.25 | -0.16 | 13.61 | -4.74 | 1.65 |
| **64** | IC052302 x Kashi Pragati | 16.05 | -1.99 | -0.24 | 14.54 | 1.44 | -0.15 |
| **65** | IC052302 x IC052321 | 15.39 | 4.54 | 0.27 | 13.60 | 1.20 | -0.16 |
| **Hybrid Mean** | | 16.44 | - | - | 14.14 | - | - |

Among the Parents and crosses Salkeerthi in parents and IC045993 x EC169459, IC045993 x Kashi Pragati, Pusa Sawani x EC169452, Pusa Sawani x Kashi Pragati, VRO-4 x EC169452, VRO-4 x EC169459, VRO-4 x Kashi Pragati, VRO-4 x IC052321, IC052299 x IC052310, IC052299 x EC169459, IC052299 x IC052321, Kashi Kranti x EC169459,Kashi Kranti x IC052321, Salkeerthi x IC052310, Salkeerthi x Kashi Pragati, IC058235 x EC169452, IC058235 x IC052321, Hisar Naveen x EC169452, and Hisar Naveen x IC052321 in cross combinations recorded higher mean value along regression coefficient lower than unity (bi<1) and a small deviation from regression ($S^2$di~0) suggesting above average stability.

#### 4.9.2.11 Fruit diameter

In this study none of the parent and crosses were recorded ideal stabile. While in hybrids IC045993 x IC052321 carried low mean comparison to grand mean, regression coefficient close to unity, and minimal deviation from regression suggesting that they were indicate stable but not ideal.

In contrast parents and hybrids none of the parent recorded below average stability and in crosses IC058710 x EC169452, Pusa Sawani x IC052321, VRO-4 x IC052310, VRO-4 x EC169459, VRO-4 x Kashi Pragati, VRO-4 x IC052321, IC052299 x IC052310, IC052299 x EC169459, Salkeerthi x Kashi Pragati, IC058235 x EC169459, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Salkeerthi x Kashi Pragati, IC058235 x EC169459 had higher mean coupled with higher regression coefficient higher than the unity *i.e*., (bi>1) and minimum deviation from regression *i.e*., ($S^2$di~0) indicated below average stability.

Whereas, parents IC045993, VRO-4, IC052299, Hisar Naveen, IC052310, IC052321 in parents and while in crosses IC058710 x EC169459, IC045993 x Kashi Pragati, VRO-4 x EC169452, Kashi Kranti x IC052310, Salkeerthi x EC169459, IC058235 x Kashi Pragati combinations recorded higher mean value alongside regression coefficient less than unity (bi<1) and a small deviation from regression ($S^2$di~0) indicate above average stability.

#### 4.9.2.12 Number of ridges

Among parents and hybrids none of the parent and crosses recorded ideal stable. However, among both parents and hybrids, VRO-4 in parents and IC058710 x IC052321, IC045993 x EC169452, IC045993 x EC169459, VRO-4 x EC169459, VRO-4 x Kashi Pragati, Pusa Sawani x EC169459, VRO-4 x IC052321, IC052299 x IC052310,IC045993 x

IC052321, Kashi Kranti x IC052310, IC052299 x EC169459, IC052299 x Kashi Pragati, IC052299 x IC052321, Kashi Kranti x EC169452, Kashi Kranti x IC052321, Salkeerthi x Kashi Pragati, IC058235 x Kashi Pragati in crosses recorded higher mean coupled with higher regression coefficient i.e., (bi>1) and small deviation from regression *i.e.*, ($S^2$di~0) indicated below average stability.

In parents and crosses IC058710, Salkeerthi, Hisar Naveen, IC052302, EC169459 in parents and in crosses IC045993 x Kashi Pragati, IC045993 x Kashi Pragati, Salkeerthi x EC169459, IC058235 x EC169459, Kashi Kranti x Kashi Pragati, Hisar Naveen x EC169459, Hisar Naveen x Kashi Pragati recorded higher mean value along regreesion lower than unity (bi<1) and a small deviation from regression suggesting above average stability.

#### 4.8.2.13 Number of fruits per plant

Whereas, parents and hybrids, IC052299 in parents and Kashi Kranti x EC169459 in crosses recorded minimal deviation from regression ($S^2$di~0), regression coefficient close to unity (bi=1) with a higher mean compared general mean, suggesting ideal and stable. While IC058710 x Kashi Pragati cross carried low mean compared to grand mean, regression coefficient close to unity *i.e.*, (bi=1), and minimal deviation from regression *i.e.*, ($S^2$di~0), suggesting that they were indicated fair and stabile but not ideal.

While parents and hybrids IC045993, Pusa Sawani, VRO-4, Kashi Kranti, IC058235 in parents and IC058710 x IC052321, IC045993 x EC169452, IC045993 x EC169459, IC045993 x IC052321, Pusa Sawani x EC169459, VRO-4 x EC169459, VRO-4 x IC052321,IC052299 x IC052310, IC052299 x EC169459, Kashi Kranti x EC169452, Kashi Kranti x IC052310, Kashi Kranti x IC052321, Salkeerthi x EC169452, Salkeerthi x Kashi Pragati, IC058235 x Kashi Pragati, IC058235 x Kashi Pragati and IC058235 x IC052321 in crosses had higher mean coupled with higher regression coefficient above the unity and minute deviation from regression indicated below average stability.

Among the Parents IC058710, Salkeerthi, Hisar Naveen, IC052302 and in crosses IC045993 x EC169452, IC045993 x IC052310, IC045993 x Kashi Pragati, IC052299 x EC169452, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Salkeerthi x EC169459, IC058235 x EC169459 in hybrids recorded higher mean value along with regression lower than unity (bi<1) and a small deviation from regression suggesting above average stability.

**Table 66. Assessing parental and hybrid stability for fruit diameter and number of ridges/fruit**

| Sr.No. | Genotypes | Fruit diameter | | | Number of ridges/fruit | | |
|---|---|---|---|---|---|---|---|
| | | Mean | $b_i$ | $S^2d_i$ | Mean | $b_i$ | $S^2d_i$ |
| **PARENTS** | | | | | | | |
| **1** | IC058710 | 15.08 | -0.20 | -0.25 | 5.20 | -0.38 | 0.01 |
| **2** | IC045993 | 15.72 | 0.47 | -0.15 | 5.00 | -0.71 | -0.01 |
| **3** | Pusa Swani | 14.59 | 0.11 | -0.08 | 5.22 | -0.17 | 0.14 |
| **4** | VRO-4 | 15.69 | 0.71 | -0.15 | 5.29 | 1.29 | 0.00 |
| **5** | IC052299 | 15.20 | 0.00 | -0.03 | 5.04 | -0.58 | -0.01 |
| **6** | Kashi Kranti | 14.65 | -0.02 | -0.19 | 5.07 | -0.71 | -0.01 |
| **7** | Salkeerthi | 15.09 | 1.28 | -0.15 | 5.20 | -0.17 | -0.01 |
| **8** | IC058235 | 14.79 | -2.31 | -0.10 | 5.07 | -0.17 | -0.01 |
| **9** | Hisar Naveen | 15.33 | 0.27 | -0.25 | 5.07 | -0.54 | -0.01 |
| **10** | IC052302 | 14.86 | -0.34 | -0.23 | 5.18 | -0.75 | 0.02 |
| **11** | EC169452 | 14.16 | -0.86 | 1.81 | 5.18 | -0.42 | -0.01 |
| **12** | IC052310 | 17.08 | -1.67 | 1.57 | 4.89 | -2.45 | 0.03 |
| **13** | EC169459 | 14.92 | 0.45 | -0.01 | 5.11 | -0.79 | 0.01 |
| **14** | Kashi Pragati | 14.81 | -2.14 | 0.52 | 5.09 | -0.34 | 0.08 |
| **15** | IC052321 | 15.15 | -1.35 | 0.36 | 5.16 | -0.13 | -0.01 |
| | **Parent Mean** | 15.14 | - | - | 5.12 | - | - |
| **HYBRIDS** | | | | | | | |
| **16** | IC058710 x EC169452 | 15.96 | 1.78 | -0.24 | 5.11 | -0.58 | -0.01 |
| **17** | IC058710 x IC052310 | 15.41 | 0.81 | -0.21 | 5.20 | 0.17 | -0.01 |
| **18** | IC058710 x EC169459 | 16.58 | 0.24 | -0.25 | 5.11 | -1.29 | 0.00 |
| **19** | IC058710 x Kashi Pragati | 15.19 | 3.18 | -0.23 | 5.13 | 0.33 | 0.02 |
| **20** | IC058710 x IC052321 | 15.11 | 2.25 | 0.82 | 5.29 | 0.20 | 0.04 |
| **21** | IC045993 x EC169452 | 15.66 | 1.67 | -0.05 | 5.49 | 4.65 | 0.01 |
| **22** | IC045993 x IC052310 | 15.37 | 0.91 | -0.20 | 5.44 | 4.07 | 0.15 |
| **23** | IC045993 x EC169459 | 15.62 | 1.21 | -0.25 | 5.27 | -0.17 | -0.01 |
| **24** | IC045993 x Kashi Pragati | 17.37 | 0.34 | -0.24 | 5.42 | 0.58 | -0.01 |
| **25** | IC045993 x IC052321 | 15.40 | 0.95 | -0.10 | 5.18 | 0.67 | 0.00 |
| **26** | Pusa Sawani x EC169452 | 15.19 | -0.31 | -0.25 | 4.96 | 1.29 | 0.00 |
| **27** | Pusa Sawani x IC052310 | 15.28 | 0.37 | 0.14 | 5.47 | 3.57 | 0.03 |
| **28** | Pusa Sawani x EC169459 | 15.25 | 1.74 | -0.24 | 5.13 | 0.17 | -0.01 |
| **29** | Pusa Sawani x Kashi Pragati | 14.92 | 0.30 | 0.38 | 5.36 | -2.03 | 0.06 |
| **30** | Pusa Sawani x IC052321 | 15.80 | 3.37 | 2.49 | 5.09 | 0.75 | 0.02 |
| **31** | VRO-4 x EC169452 | 15.98 | -0.22 | 0.99 | 5.38 | 3.65 | -0.01 |
| **32** | VRO-4 x IC052310 | 16.54 | 1.57 | 2.69 | 5.27 | 3.20 | -0.01 |
| **33** | VRO-4 x EC169459 | 16.08 | 1.39 | 1.74 | 5.49 | 4.81 | 0.05 |
| **34** | VRO-4 x Kashi Pragati | 16.54 | 1.26 | 1.23 | 5.73 | 2.70 | 0.09 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **35** | VRO-4 x IC052321 | 16.24 | 1.71 | 0.41 | 5.27 | 2.12 | -0.01 |
| **36** | IC052299 x EC169452 | 16.79 | -0.48 | 2.26 | 5.20 | 0.17 | -0.01 |
| **37** | IC052299 x IC052310 | 15.42 | 1.17 | 0.48 | 5.16 | 1.50 | 0.01 |
| ***Table continues…*** | | | | | | | |
| ***Table continues…*** | | | | | | | |
| **38** | IC052299 x EC169459 | 16.17 | 3.41 | 0.13 | 5.29 | 2.86 | 0.05 |
| **39** | IC052299 x Kashi Pragati | 15.23 | -0.27 | -0.24 | 5.38 | 3.16 | 0.02 |
| **40** | IC052299 x IC052321 | 15.09 | 1.30 | -0.06 | 5.24 | 2.95 | -0.01 |
| **41** | Kashi Kranti x EC169452 | 15.39 | 1.60 | -0.23 | 5.36 | 2.91 | -0.01 |
| **42** | Kashi Kranti x IC052310 | 16.82 | -1.46 | 3.37 | 5.29 | 2.74 | 0.02 |
| **43** | Kashi Kranti x EC169459 | 15.76 | 3.59 | 0.16 | 5.36 | 0.75 | 0.02 |
| **44** | Kashi Kranti x Kashi Pragati | 17.40 | 1.12 | -0.23 | 5.51 | 4.19 | -0.01 |
| **45** | Kashi Kranti x IC052321 | 15.45 | 2.96 | -0.14 | 5.40 | 4.44 | -0.01 |
| **46** | Salkeerthi x EC169452 | 15.24 | 3.46 | 0.38 | 5.02 | -0.29 | -0.01 |
| **47** | Salkeerthi x IC052310 | 15.41 | 3.57 | 2.18 | 5.11 | -0.58 | -0.01 |
| **48** | Salkeerthi x EC169459 | 18.18 | 0.00 | 0.11 | 5.07 | -0.71 | -0.01 |
| **49** | Salkeerthi x Kashi Pragati | 15.74 | 4.64 | 1.48 | 5.38 | 4.36 | 0.00 |
| **50** | Salkeerthi x IC052321 | 15.60 | 3.77 | -0.15 | 5.29 | 4.15 | 0.00 |
| **51** | IC058235 x EC169452 | 15.39 | 2.72 | -0.02 | 5.33 | 2.12 | -0.01 |
| **52** | IC058235 x IC052310 | 14.75 | 0.60 | 0.21 | 5.31 | 1.33 | 0.05 |
| **53** | IC058235 x EC169459 | 16.07 | 3.32 | -0.16 | 5.09 | 0.25 | 0.00 |
| **54** | IC058235 x Kashi Pragati | 16.88 | -0.71 | 1.67 | 5.29 | 2.74 | 0.02 |
| **55** | IC058235 x IC052321 | 15.15 | 1.93 | 0.08 | 5.56 | -2.57 | 0.03 |
| **56** | Hisar Naveen x EC169452 | 14.78 | 0.10 | -0.02 | 5.22 | -0.13 | -0.01 |
| **57** | Hisar Naveen x IC052310 | 15.28 | 2.03 | -0.25 | 5.49 | -2.03 | 0.06 |
| **58** | Hisar Naveen x EC169459 | 15.10 | 1.66 | -0.23 | 5.11 | 0.67 | 0.00 |
| **59** | Hisar Naveen x Kashi Pragati | 15.23 | 1.35 | 0.26 | 5.56 | 2.91 | -0.01 |
| **60** | Hisar Naveen x IC052321 | 15.52 | -0.13 | -0.16 | 5.13 | 0.33 | 0.02 |
| **61** | IC052302 x EC169452 | 15.34 | 1.81 | -0.24 | 5.18 | 0.29 | -0.01 |
| **62** | IC052302 x IC052310 | 15.38 | 1.28 | -0.25 | 5.09 | 0.58 | -0.01 |
| **63** | IC052302 x EC169459 | 15.38 | 2.13 | -0.24 | 5.29 | -1.66 | 0.18 |
| **64** | IC052302 x Kashi Pragati | 15.09 | 0.27 | 0.52 | 5.27 | 2.49 | -0.01 |
| **65** | IC052302 x IC052321 | 15.35 | 1.75 | 0.42 | 5.33 | 3.90 | -0.01 |
| **Hybrid Mean** | | 15.72 | - | - | 5.28 | - | - |

**Table 67. Assessing parental and hybrid stability for number of fruits/plant and number of marketable fruits/plant**

| Sr.No. | Genotypes | Number of fruits/plant | | | Number of marketable fruits/plant | | |
|---|---|---|---|---|---|---|---|
| | | Mean | $b_i$ | $S^2d_i$ | Mean | $b_i$ | $S^2d_i$ |
| **PARENTS** | | | | | | | |
| **1** | IC058710 | 25.59 | -1.47 | 0.30 | 24.33 | -0.70 | 0.56 |
| **2** | IC045993 | 26.04 | 5.77 | -0.43 | 23.96 | 3.29 | -0.13 |
| **3** | Pusa Swani | 26.03 | 1.38 | -0.50 | 24.06 | 0.88 | -0.50 |
| **4** | VRO-4 | 26.27 | 2.00 | -0.50 | 24.49 | 1.70 | -0.49 |
| **5** | IC052299 | 27.39 | 1.07 | -0.26 | 25.67 | 0.43 | -0.34 |
| **6** | Kashi Kranti | 27.64 | 1.96 | 0.25 | 25.39 | 1.38 | -0.55 |
| **7** | Salkeerthi | 26.04 | 0.26 | 0.07 | 24.36 | -0.53 | 0.45 |
| **8** | IC058235 | 25.02 | 3.41 | -0.25 | 23.07 | 1.33 | -0.50 |
| **9** | Hisar Naveen | 26.10 | -0.49 | -0.44 | 24.62 | -1.32 | -0.56 |
| **10** | IC052302 | 25.64 | -1.22 | 2.90 | 23.57 | 1.34 | 5.48 |
| **11** | EC169452 | 15.58 | -0.39 | 1.37 | 14.04 | 0.64 | 0.36 |
| **12** | IC052310 | 14.91 | 0.15 | 0.50 | 13.59 | 0.01 | 0.35 |
| **13** | EC169459 | 24.13 | -1.73 | -0.49 | 22.08 | -1.09 | -0.47 |
| **14** | Kashi Pragati | 23.11 | -1.71 | 1.41 | 21.50 | -0.95 | 0.19 |
| **15** | IC052321 | 22.44 | -1.84 | -0.47 | 20.68 | -1.14 | -0.51 |
| | **Parent Mean** | 24.13 | - | - | 22.36 | - | - |
| **HYBRIDS** | | | | | | | |
| **16** | IC058710 x EC169452 | 23.96 | 0.11 | -0.49 | 22.92 | 0.98 | 0.08 |
| **17** | IC058710 x IC052310 | 24.80 | 2.69 | 0.06 | 23.32 | 2.27 | 1.28 |
| **18** | IC058710 x EC169459 | 25.46 | -7.63 | 1.92 | 23.81 | -4.78 | 0.36 |
| **19** | IC058710 x Kashi Pragati | 25.34 | 1.07 | 1.99 | 23.59 | 1.37 | 2.90 |
| **20** | IC058710 x IC052321 | 25.93 | 2.48 | -0.36 | 24.26 | 1.97 | -0.56 |
| **21** | IC045993 x EC169452 | 26.50 | 6.36 | 0.97 | 24.77 | 0.93 | -0.56 |
| **22** | IC045993 x IC052310 | 26.27 | -4.27 | -0.44 | 24.87 | -1.70 | -0.37 |
| **23** | IC045993 x EC169459 | 26.49 | 7.39 | -0.22 | 25.11 | 2.97 | 0.41 |
| **24** | IC045993 x Kashi Pragati | 27.06 | 0.38 | 3.19 | 25.42 | 0.35 | 1.04 |
| **25** | IC045993 x IC052321 | 26.50 | 2.49 | 3.24 | 24.68 | -0.03 | 2.96 |
| **26** | Pusa Sawani x EC169452 | 23.59 | 0.56 | -0.43 | 22.21 | 0.56 | -0.40 |
| **27** | Pusa Sawani x IC052310 | 25.26 | 4.33 | 0.76 | 24.13 | 2.79 | 1.20 |
| **28** | Pusa Sawani x EC169459 | 25.88 | 1.83 | 1.35 | 24.43 | 2.78 | 1.30 |
| **29** | Pusa Sawani x Kashi Pragati | 24.13 | -9.76 | -0.17 | 23.10 | -2.13 | 1.06 |
| **30** | Pusa Sawani x IC052321 | 23.26 | 5.12 | 1.66 | 22.10 | 2.46 | -0.51 |
| **31** | VRO-4 x EC169452 | 23.82 | -0.20 | 10.54 | 20.79 | 3.60 | -0.37 |
| **32** | VRO-4 x IC052310 | 24.28 | -0.23 | 0.49 | 23.97 | 0.40 | 0.28 |
| **33** | VRO-4 x EC169459 | 27.62 | 5.44 | 1.18 | 25.49 | 2.26 | -0.33 |
| **34** | VRO-4 x Kashi Pragati | 25.47 | 8.06 | 0.30 | 24.08 | 2.72 | 1.80 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **35** | VRO-4 x IC052321 | 26.37 | 3.40 | 4.39 | 25.37 | 1.70 | 8.00 |
| **36** | IC052299 x EC169452 | 25.54 | -1.68 | 6.51 | 24.44 | 0.31 | 2.80 |
| **37** | IC052299 x IC052310 | 25.82 | 1.95 | 12.26 | 23.64 | -0.21 | 5.02 |
| ***Table continues…*** | | | | | | | |
| ***Table continues…*** | | | | | | | |
| **38** | IC052299 x EC169459 | 27.42 | 2.30 | 1.86 | 25.18 | 1.40 | 0.69 |
| **39** | IC052299 x Kashi Pragati | 25.56 | 3.70 | 6.41 | 24.24 | 3.35 | 3.18 |
| **40** | IC052299 x IC052321 | 23.87 | -4.08 | 2.20 | 22.38 | 0.20 | 3.18 |
| **41** | Kashi Kranti x EC169452 | 25.69 | 2.05 | -0.45 | 24.58 | 1.44 | 0.40 |
| **42** | Kashi Kranti x IC052310 | 27.06 | 1.30 | -0.30 | 25.92 | 0.86 | -0.35 |
| **43** | Kashi Kranti x EC169459 | 28.27 | 1.09 | -0.48 | 27.17 | 0.78 | -0.52 |
| **44** | Kashi Kranti x Kashi Pragati | 28.98 | -2.31 | -0.05 | 27.69 | -0.51 | 0.34 |
| **45** | Kashi Kranti x IC052321 | 28.76 | 3.98 | 0.58 | 27.37 | 3.44 | -0.31 |
| **46** | Salkeerthi x EC169452 | 25.86 | 8.73 | 0.27 | 23.82 | 3.49 | -0.50 |
| **47** | Salkeerthi x IC052310 | 23.51 | 1.24 | -0.50 | 21.36 | 0.38 | -0.03 |
| **48** | Salkeerthi x EC169459 | 26.98 | -3.36 | 0.55 | 25.03 | -1.80 | -0.21 |
| **49** | Salkeerthi x Kashi Pragati | 27.40 | 6.45 | 4.13 | 25.37 | 1.12 | 2.46 |
| **50** | Salkeerthi x IC052321 | 24.89 | 4.12 | 0.44 | 23.33 | 1.64 | 2.20 |
| **51** | IC058235 x EC169452 | 23.81 | 2.42 | 15.99 | 21.87 | 5.23 | 13.15 |
| **52** | IC058235 x IC052310 | 23.84 | 2.99 | 1.84 | 22.38 | 2.87 | 1.09 |
| **53** | IC058235 x EC169459 | 27.36 | -1.59 | 4.39 | 25.97 | -1.76 | 4.32 |
| **54** | IC058235 x Kashi Pragati | 26.16 | 4.53 | 1.49 | 25.14 | 2.62 | 0.53 |
| **55** | IC058235 x IC052321 | 26.09 | 3.48 | 2.40 | 24.89 | 2.67 | 1.39 |
| **56** | Hisar Naveen x EC169452 | 24.51 | 0.07 | 0.34 | 23.19 | 0.86 | 0.02 |
| **57** | Hisar Naveen x IC052310 | 24.07 | -6.97 | -0.16 | 23.76 | -1.08 | -0.54 |
| **58** | Hisar Naveen x EC169459 | 26.24 | -3.85 | 1.12 | 25.33 | -0.71 | -0.53 |
| **59** | Hisar Naveen x Kashi Pragati | 26.61 | 0.30 | -0.47 | 25.08 | 1.27 | -0.51 |
| **60** | Hisar Naveen x IC052321 | 24.76 | 2.71 | 0.21 | 23.47 | 3.06 | 0.71 |
| **61** | IC052302 x EC169452 | 24.62 | 3.91 | 2.84 | 23.52 | 3.77 | 0.96 |
| **62** | IC052302 x IC052310 | 22.07 | -2.69 | 0.06 | 21.48 | 2.24 | -0.25 |
| **63** | IC052302 x EC169459 | 25.57 | -2.24 | -0.35 | 24.11 | 0.62 | 0.09 |
| **64** | IC052302 x Kashi Pragati | 25.60 | -0.91 | -0.42 | 24.00 | 0.06 | -0.48 |
| **65** | IC052302 x IC052321 | 24.81 | 1.42 | 0.45 | 23.28 | 3.17 | 0.74 |
| | **Hybrid Mean** | 25.59 | - | - | 24.15 | - | - |

#### 4.9.2.14 Number of marketable fruits

Among parents and hybrids none of the parent and crosses recorded ideal stable. While IC058710 x EC169452 cross carried low mean compared to grand mean, regression coefficient close to unity, and minimal deviation from regression, suggesting that they were indicated stable but not ideal.

Whereas, parents and hybrids IC045993, VRO-4, Kashi Kranti, IC058235, IC052302 in parents and IC058710 x IC052321, IC045993 x EC169459, Pusa Sawani x EC169459, VRO-4 x EC169459, VRO-4 x IC052321, IC052299 x EC169459, IC052299 X Kashi Pragati, Kashi Kranti x EC169452, Kashi Kranti x IC052321, IC058235 x Kashi Pragati, IC058235 x IC052321 and Hisar Naveen x Kashi Pragati in crosses recorded higher mean coupled with higher R.C *i.e.*, (bi>1) and small deviation from regression *i.e.*, ($S^2$di~0) recorded below average stability.

In this study in parents IC058710, Pusa Sawani, IC052299, Salkeerthi, Hisar Naveen and IC045993 x Kashi Pragati, IC045993 x Kashi Pragati, IC045993 x IC052321, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Salkeerthi x EC169459, IC058235 x EC169459 and Hisar Naveen x EC169459 in crosses recorded higher mean value with regression coefficient lower than unity (bi<1) and a small deviation from regression suggesting above average stability.

#### 4.9.2.15 Average fruit weight

Among parents and hybrids none of the parent and crosses recorded ideal stable. In parents and hybrids, IC045993, VRO-4, IC058235 in parents and in crosses IC058710 x Kashi Pragati, IC045993 x EC169459, Pusa Sawani X EC169459, Pusa Sawani x IC052321, VRO-4 x EC16945, VRO-4 x Kashi Pragati, IC052299 X Kashi Pragati, Kashi Kranti x EC169452, Kashi Kranti x EC169459, Salkeerthi x IC052321, IC058235 x EC169452, IC058235 x Kashi Pragati, IC052302 x Kashi Pragati, IC058235 x IC052321 and IC052302 x IC052321 had higher mean coupled with higher R.C *i.e.*, (bi>1) and minute deviation from regression indicated below average stability.

While in Parents and crosses, IC058710, Pusa Swani, Salkeerthi, Kashi Kranti, Kashi Pragati in parents and IC058710 x EC169459, Pusa Sawani x Kashi Pragati, VRO-4 x IC052321, Kashi Kranti x Kashi Pragati, Salkeerthi x IC025310, Salkeerthi x EC169459, Hisar Naveen x EC169459 IC052299 x IC052321, IC052302 x IC052310, and Hisar Naveen x Kashi Pragati in crosses recorded higher mean value alongside R.C lower than unity (bi<1) and a small deviation from regression ($S^2$di~0) suggesting above average stability.

### 4.9.2.16 Number of pickings per plant

In parents IC058710 had minimal deviation from regression, regression coefficient close to unity with a higher mean compared general mean, suggesting ideal and fair stable.

In this study IC045993, Pusa Sawani, VRO-4, Salkeerthi, Hisar Naveen in parents, and whereas crosses IC058710 x IC052310, IC045993 x EC169459, IC058710 x EC169459, IC045993 x IC052310, IC045993 x EC169459, IC045993 x Kashi Pragati, Pusa Sawani x IC052310, Pusa Sawani x EC169459, VRO-4 x EC169459, VRO-4 x Kashi Pragati, VRO-4 x IC052321, Kashi Kranti x ICEC169459, IC058235 x EC169459, IC052299 x IC052310, IC052299 x EC169459, Kashi Kranti x EC169452, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x IC052310, Salkeerthi x EC169459, Hisar Naveen x EC169459 and Hisar Naveen x Kashi Pragati had higher mean coupled with higher value of regression coefficient and small deviation from regression indicated below average stability.

The parents IC052299, Kashi Kranti, IC058235 and the crosses IC058710 x IC052321, Kashi Kranti x IC052310, Salkeerthi x EC169452 and Salkeerthi x Kashi Pragati recorded higher mean value along with regression coefficient lower than unity and a small deviation from regression suggesting above average stability.

**Table 68. Assessing parental and hybrid stability for average fruit weight and number of pickings/plant**

| Sr.No. | Genotypes | Average fruit weight | | | Number of pickings/plant | | |
|---|---|---|---|---|---|---|---|
| | | Mean | $b_i$ | $S^2d_i$ | Mean | $b_i$ | $S^2d_i$ |
| **PARENTS** | | | | | | | |
| 1 | IC058710 | 13.75 | 0.58 | -0.14 | 14.53 | 1.03 | -0.42 |
| 2 | IC045993 | 13.69 | 2.82 | -0.13 | 15.29 | 4.40 | 0.14 |
| 3 | Pusa Swani | 13.57 | 0.94 | -0.08 | 14.76 | 1.99 | -0.27 |
| 4 | VRO-4 | 13.74 | 1.21 | -0.15 | 15.43 | 3.67 | -0.23 |
| 5 | IC052299 | 13.25 | -0.93 | -0.11 | 14.77 | 0.22 | -0.36 |
| 6 | Kashi Kranti | 13.68 | 0.92 | -0.09 | 16.67 | 0.78 | 0.05 |
| 7 | Salkeerthi | 13.41 | -0.77 | -0.12 | 15.08 | 3.69 | -0.42 |
| 8 | IC058235 | 14.30 | 2.84 | -0.15 | 14.33 | -0.53 | -0.35 |
| 9 | Hisar Naveen | 13.80 | -0.60 | -0.15 | 16.18 | 3.20 | -0.08 |
| 10 | IC052302 | 13.27 | 1.65 | 0.20 | 13.98 | 0.56 | -0.43 |
| 11 | EC169452 | 12.12 | -2.72 | 0.43 | 11.02 | 0.69 | 0.15 |
| 12 | IC052310 | 12.63 | -2.05 | -0.15 | 11.02 | -0.72 | 0.75 |
| 13 | EC169459 | 12.69 | -0.86 | 0.02 | 13.91 | -0.42 | -0.18 |
| 14 | Kashi Pragati | 13.77 | 0.68 | 0.96 | 13.22 | 2.09 | -0.40 |
| 15 | IC052321 | 13.02 | -1.79 | 0.47 | 13.71 | 0.65 | -0.43 |
| **Parent Mean** | | 13.38 | - | - | 14.26 | - | - |
| **HYBRIDS** | | | | | | | |
| 16 | IC058710 x EC169452 | 12.87 | 1.33 | -0.12 | 13.80 | 0.36 | -0.31 |
| 17 | IC058710 x IC052310 | 12.86 | -1.74 | -0.15 | 14.93 | 3.01 | -0.15 |
| 18 | IC058710 x EC169459 | 14.34 | -6.92 | -0.13 | 15.41 | 2.14 | -0.35 |
| 19 | IC058710 x Kashi Pragati | 13.91 | 5.13 | -0.13 | 14.49 | -1.62 | -0.34 |
| 20 | IC058710 x IC052321 | 13.06 | 1.17 | 0.47 | 15.37 | -0.12 | -0.19 |
| 21 | IC045993 x EC169452 | 12.87 | 3.94 | -0.15 | 14.36 | 0.77 | -0.42 |
| 22 | IC045993 x IC052310 | 13.07 | -2.13 | -0.15 | 14.70 | 3.43 | 1.60 |
| 23 | IC045993 x EC169459 | 13.83 | 3.52 | 0.33 | 16.50 | 1.62 | 0.29 |
| 24 | IC045993 x Kashi Pragati | 13.25 | -0.08 | 0.76 | 15.93 | 2.93 | 0.45 |
| 25 | IC045993 x IC052321 | 12.23 | -1.08 | -0.11 | 14.62 | 0.94 | -0.43 |
| 26 | Pusa Sawani x EC169452 | 12.45 | 0.18 | 0.11 | 14.32 | 4.17 | -0.15 |
| 27 | Pusa Sawani x IC052310 | 13.37 | 3.16 | -0.12 | 15.06 | 1.65 | -0.42 |
| 28 | Pusa Sawani x EC169459 | 13.73 | 3.83 | -0.09 | 15.11 | 5.53 | 1.05 |
| 29 | Pusa Sawani x Kashi Pragati | 14.74 | -2.95 | 0.51 | 13.49 | -3.81 | 0.09 |
| 30 | Pusa Sawani x IC052321 | 14.51 | 6.10 | 0.34 | 13.56 | -1.52 | -0.14 |
| 31 | VRO-4 x EC169452 | 13.38 | 1.18 | 0.74 | 14.66 | 6.17 | 1.56 |
| 32 | VRO-4 x IC052310 | 13.71 | 1.84 | -0.15 | 14.47 | 0.50 | 0.11 |
| 33 | VRO-4 x EC169459 | 13.14 | 2.90 | 0.81 | 16.23 | 3.23 | -0.18 |
| 34 | VRO-4 x Kashi Pragati | 14.55 | 1.54 | 0.54 | 16.21 | 1.66 | -0.43 |
| 35 | VRO-4 x IC052321 | 13.59 | -0.23 | 0.35 | 15.63 | 1.61 | 1.07 |
| 36 | IC052299 x EC169452 | 12.13 | -1.96 | -0.14 | 14.72 | -2.23 | -0.39 |
| 37 | IC052299 x IC052310 | 12.41 | -3.21 | 0.18 | 14.89 | 1.73 | -0.26 |
| 38 | IC052299 x EC169459 | 13.42 | 0.33 | 0.41 | 16.60 | 4.38 | -0.35 |
| ***Table continues…*** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Table continues…*** | | | | | | | |
| 39 | IC052299 x Kashi Pragati | 14.10 | 9.26 | 0.48 | 14.56 | -0.47 | -0.42 |
| 40 | IC052299 x IC052321 | 14.68 | -0.27 | 1.10 | 13.90 | -3.28 | 0.41 |
| 41 | Kashi Kranti x EC169452 | 14.32 | 5.37 | 0.02 | 15.09 | 4.04 | -0.41 |
| 42 | Kashi Kranti x IC052310 | 13.41 | 1.68 | 0.09 | 15.27 | 0.69 | 0.19 |
| 43 | Kashi Kranti x EC169459 | 13.66 | 1.84 | -0.11 | 16.59 | 4.06 | 0.43 |
| 44 | Kashi Kranti x Kashi Pragati | 13.80 | -1.62 | 0.82 | 17.99 | 3.77 | -0.43 |
| 45 | Kashi Kranti x IC052321 | 13.05 | 3.24 | -0.14 | 16.46 | 5.86 | 2.12 |
| 46 | Salkeerthi x EC169452 | 12.85 | 4.87 | 1.45 | 14.83 | -0.99 | 0.78 |
| 47 | Salkeerthi x IC052310 | 14.19 | -2.76 | 3.89 | 14.99 | 6.20 | -0.43 |
| 48 | Salkeerthi x EC169459 | 13.72 | -3.01 | -0.12 | 14.98 | 1.54 | -0.22 |
| 49 | Salkeerthi x Kashi Pragati | 13.39 | 6.78 | -0.13 | 15.80 | 0.19 | 1.89 |
| 50 | Salkeerthi x IC052321 | 14.31 | 1.49 | 0.53 | 14.21 | -0.80 | -0.21 |
| 51 | IC058235 x EC169452 | 13.62 | 7.55 | 0.01 | 13.69 | -8.98 | 3.33 |
| 52 | IC058235 x IC052310 | 12.95 | 4.08 | -0.04 | 12.76 | -2.59 | -0.43 |
| 53 | IC058235 x EC169459 | 13.24 | -3.31 | 0.56 | 14.73 | 1.16 | -0.27 |
| 54 | IC058235 x Kashi Pragati | 13.54 | 5.79 | -0.14 | 13.92 | -0.68 | 0.14 |
| 55 | IC058235 x IC052321 | 13.56 | 4.36 | -0.12 | 14.04 | -2.55 | 0.35 |
| 56 | Hisar Naveen x EC169452 | 13.36 | 1.48 | 0.32 | 13.83 | -1.86 | -0.37 |
| 57 | Hisar Naveen x IC052310 | 12.38 | -0.76 | -0.01 | 14.13 | 2.83 | -0.31 |
| 58 | Hisar Naveen x EC169459 | 14.01 | -2.50 | 0.39 | 15.67 | 3.99 | 0.58 |
| 59 | Hisar Naveen x Kashi Pragati | 13.77 | -0.27 | -0.12 | 15.28 | 3.54 | 0.75 |
| 60 | Hisar Naveen x IC052321 | 13.46 | 2.40 | 0.93 | 12.80 | -3.19 | -0.22 |
| 61 | IC052302 x EC169452 | 13.25 | 4.35 | 2.95 | 13.29 | -2.95 | -0.41 |
| 62 | IC052302 x IC052310 | 14.19 | -1.31 | 3.08 | 12.78 | -1.22 | -0.13 |
| 63 | IC052302 x EC169459 | 12.84 | -0.72 | 0.22 | 13.69 | -0.39 | -0.13 |
| 64 | IC052302 x Kashi Pragati | 13.71 | -0.50 | -0.15 | 14.64 | 2.51 | -0.24 |
| 65 | IC052302 x IC052321 | 13.87 | 2.42 | -0.09 | 13.22 | -1.80 | -0.38 |
| **Hybrid Mean** | | 13.49 | - | - | 14.76 | - | - |

#### 4.9.2.17 Fruit yield per plant

Whereas, parents and hybrids IC058235 and Pusa Sawani x EC169459 respectively had higher mean compared to general mean, unit regression coefficient close to unity (bi=1) and minimum deviation from regression indicate suggesting ideal and fair stable.

In contrast, parents and hybrids IC045993, VRO-4, Kashi Kranti, Hisar Naveen in parents and IC058710 x Kashi Pragati, Pusa Sawani x Kashi Pragati, IC045993 x Kashi Pragati, VRO-4 x EC169459, VRO-4 x Kashi Pragati, VRO-4 x IC052321, IC052299 x EC169459, IC052299 x EC169459, IC052299 x Kashi Pragati, IC058235 x Kashi Pragati, Kashi Kranti x EC169452 and Kashi Kranti x EC169459 in crosses recorded higher mean coupled with higher than unity regression coefficient above the unity and small deviation from regression indicated below average stability.

Among the Parents and crosses IC058710, Pusa Sawani, IC052299 in parents IC058710 x EC169459, IC052299 x IC052321, Kashi Kranti x IC052310, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, IC045993 x EC169459, IC058235 x EC169459, IC058235 x EC169459, Hisar Naveen x Kashi Pragati, IC058235 x IC052321, IC052302 x Kashi Pragati, Salekerthi x EC169459, Salekerthi x Kashi Pragati, Salekerthi x IC05232, Hisar Naveen x Kashi Pragati, IC052302 x Kashi Pragati and Hisar Naveen x EC169459 in hybrids recorded higher mean value with regression coefficient lower than unity (bi<1) and a small deviation from regression suggesting above average stability,

**Table 69. Assessing parental and hybrid stability for fruit yield per plant**

| Sr.No. | Genotypes | Fruits yield per plant | | |
|---|---|---|---|---|
| | | Mean | $b_i$ | $S^2d_i$ |
| **PARENTS** | | | | |
| **1** | IC058710 | 349.02 | 0.12 | 406.93 |
| **2** | IC045993 | 353.96 | 2.23 | 25.40 |
| **3** | Pusa Swani | 351.96 | 0.21 | -44.35 |
| **4** | VRO-4 | 358.63 | 1.30 | -73.71 |
| **5** | IC052299 | 360.64 | 0.87 | 47.90 |
| **6** | Kashi Kranti | 379.38 | 1.63 | -20.73 |
| **7** | Salkeerthi | 346.13 | 1.67 | -74.83 |
| **8** | IC058235 | 354.91 | 1.05 | -71.08 |
| **9** | Hisar Naveen | 356.74 | 1.49 | -52.55 |
| **10** | IC052302 | 335.94 | 1.13 | 132.76 |
| **11** | EC169452 | 186.68 | 0.85 | -72.82 |
| **12** | IC052310 | 187.21 | 1.24 | 20.72 |
| **13** | EC169459 | 303.24 | 0.45 | 261.02 |
| **14** | Kashi Pragati | 318.68 | -0.14 | -38.71 |
| **15** | IC052321 | 289.14 | 2.56 | 24.19 |
| Parent Mean | | 322.15 | - | - |
| **HYBRID** | | | | |
| **16** | IC058710 x EC169452 | 308.20 | 2.21 | -74.02 |
| **17** | IC058710 x IC052310 | 319.10 | -2.15 | 289.88 |
| **18** | IC058710 x EC169459 | 363.37 | -0.53 | -30.35 |
| **19** | IC058710 x Kashi Pragati | 352.12 | 1.74 | 510.42 |
| **20** | IC058710 x IC052321 | 338.21 | -0.79 | 25.64 |
| **21** | IC045993 x EC169452 | 339.29 | -1.18 | -23.46 |
| **22** | IC045993 x IC052310 | 343.14 | 0.45 | -34.63 |
| **23** | IC045993 x EC169459 | 365.22 | 0.51 | -34.15 |
| **24** | IC045993 x Kashi Pragati | 357.37 | 2.95 | -8.03 |
| **25** | IC045993 x IC052321 | 323.71 | 1.51 | 291.45 |
| **26** | Pusa Sawani x EC169452 | 293.60 | -0.61 | -15.53 |
| **27** | Pusa Sawani x IC052310 | 337.02 | 5.23 | 73.82 |
| **28** | Pusa Sawani x EC169459 | 354.68 | 1.06 | -28.40 |
| **29** | Pusa Sawani x Kashi Pragati | 354.46 | 3.83 | 294.18 |
| **30** | Pusa Sawani x IC052321 | 333.43 | -0.39 | 534.70 |
| **31** | VRO-4 x EC169452 | 321.10 | 8.55 | 8.13 |
| **32** | VRO-4 x IC052310 | 332.13 | 0.02 | 64.99 |
| **33** | VRO-4 x EC169459 | 361.80 | 2.69 | -67.39 |
| **34** | VRO-4 x Kashi Pragati | 360.12 | 1.89 | -73.57 |
| **35** | VRO-4 x IC052321 | 357.41 | 2.27 | 87.66 |
| **36** | IC052299 x EC169452 | 309.54 | 5.29 | 117.27 |
| **37** | IC052299 x IC052310 | 319.24 | 2.02 | 581.22 |
| **38** | IC052299 x EC169459 | 367.29 | 1.65 | -74.90 |
| **39** | IC052299 x Kashi Pragati | 358.03 | 5.19 | 33.09 |
| ***Table continues…*** | | | | |

| | | | | |
|---|---|---|---|---|
| ***Table continues…*** | | | | |
| **40** | IC052299 x IC052321 | 348.88 | -0.23 | -67.13 |
| **41** | Kashi Kranti x EC169452 | 367.49 | 7.17 | 80.66 |
| **42** | Kashi Kranti x IC052310 | 361.76 | -1.24 | 170.49 |
| **43** | Kashi Kranti x EC169459 | 385.02 | 3.15 | -55.31 |
| **44** | Kashi Kranti x Kashi Pragati | 399.38 | -0.31 | 219.83 |
| **45** | Kashi Kranti x IC052321 | 374.56 | -0.40 | -45.72 |
| **46** | Salkeerthi x EC169452 | 331.34 | 2.64 | 1646.88 |
| **47** | Salkeerthi x IC052310 | 333.44 | -0.68 | 2755.08 |
| **48** | Salkeerthi x EC169459 | 369.86 | -0.04 | -70.99 |
| **49** | Salkeerthi x Kashi Pragati | 364.97 | 0.66 | -24.41 |
| **50** | Salkeerthi x IC052321 | 354.76 | 0.12 | -73.03 |
| **51** | IC058235 x EC169452 | 322.77 | -5.03 | 2444.97 |
| **52** | IC058235 x IC052310 | 307.91 | -0.29 | -61.40 |
| **53** | IC058235 x EC169459 | 361.14 | -0.51 | -67.35 |
| **54** | IC058235 x Kashi Pragati | 353.12 | 2.10 | -45.80 |
| **55** | IC058235 x IC052321 | 352.39 | -0.55 | -27.48 |
| **56** | Hisar Naveen x EC169452 | 326.60 | 1.37 | -57.10 |
| **57** | Hisar Naveen x IC052310 | 308.37 | -1.21 | -4.36 |
| **58** | Hisar Naveen x EC169459 | 366.24 | 0.11 | 231.90 |
| **59** | Hisar Naveen x Kashi Pragati | 366.16 | 0.51 | -34.15 |
| **60** | Hisar Naveen x IC052321 | 333.00 | 1.69 | 385.48 |
| **61** | IC052302 x EC169452 | 324.58 | 2.40 | 855.93 |
| **62** | IC052302 x IC052310 | 311.47 | 1.77 | 430.59 |
| **63** | IC052302 x EC169459 | 327.88 | -2.86 | 510.98 |
| **64** | IC052302 x Kashi Pragati | 350.18 | -1.05 | -56.63 |
| **65** | IC052302 x IC052321 | 343.70 | -1.40 | 115.86 |
| **Hybrid Mean** | | 344.33 | - | - |

## IV. CHARACTERIZATION OF PARENTS AND THEIR TESTERS ON MORPHOLOGICAL DESCRIPTOR

### 4.10 Characterization of okra parents and hybrids based on morphology

The characterization of germplasm provides information on the characteristics possessed by each genotype, ensuring maximal use of the germplasm collection by end users. Morphological characters are the oldest and most used genetic markers and they may still be appropriate for certain germplasm management applications. Morphological characterization is the initial stage in the description, classification and arrangement of germplasm collections. Plant characterization identifies unique accessions required by gene bank curators and plant breeders. Landraces, germplasms, genotypes and local cultivars must be morphologically characterized by vegetable breeders seeking novel trait genes. The characterization of genetic resources is the means of selecting, differentiating, or distinguishing accessions depending on their character or quality (traits). Qualitative trait characterization of newly collected germplasm is necessary for crop improvement. It also gives information on genetic diversity for agricultural development, use of plant genetic resources and conservation. The 15 parents and their 50 hybrids of okra characterized upon 10 qualitative characters in this study and showed broad variation for most qualitative traits (Table 70).

#### 4.10.1 Leaf characters:

In the study, the depth of leaf lobing was found to be 20.00 % with shallow, 46.66% medium and 33.33% deep in 15 parents of okra. In 50 hybrids depth of leaf lobe was 30.00 % shallow, 50.00% medium and 20.00%.in deep.

#### 4.10.2 Colouring of various plant parts:

The pigmentation of the stems, flowers and fruits of the plants in the research was studied. The stem colour of 15 parents was recorded as 40.00% green and 60.00 % green with a purple tinge, while for the 50 hybrids it was observed as 42.00% green and 58.00 % green with a purple ting respectively. The Petal colour of 15 parents was observed, as 60% cream and 40% yellow petals, while for the 50 hybrids it was observed as 78% cream and 22% yellow petals respectively. Whereas in mature fruit colour of 15 parents was recorded 13.33 % of yellowish-green, 42.00 % of green and 46.66% of dark-green fruits, while for 50 crosses was recorded as 18.00 % of yellowish-green, 42.00 % of green and 40.00% of dark-green fruits were recorded.

### 4.10.3 Pubescence (hairiness/spininess) fruit:

In this study, pubescence traits fruit (hairiness). In fruit pubescence of 15 parents, 26.66% of genotypes were downy, 46.66 % slightly rough and 26.66 % prickly, while for 50 hybrids 40.00% of hybrids were downy, 40.00 % slightly rough and 20.00 % prickly.

### 4.10.4 Plant habit and seed shape:

In the study, plant habit and seed shape expressed large diversity in parents and hybrids. Plant habit of 15 parents recorded erect with 60.00%, medium with 33.33% and procumbent with 6.66%, while for 50 hybrids 64% erect,20.00% medium and 16.00 % procumbent.

The seed shape varied greatly in the research with 58.18% straight and 23.63 % curved. In this study, genotypes displayed variation in round with 46.66 %, spherical with 20.00% and 33.33 % kidney type, while for 50 hybrids 54.00% round, 16.00% spherical and 30.00% were kidney shape.

### 4.10.5 Fruit characters:

In the study, fruit characteristics like surface between ridges, fruit axis, shape of apex and constriction of basal part expressed large diversity in parents and crosses. The fruit surface between the ridges of the15 parents varied concave with 53.33% and flat with 46.66%, while for 50 hybrids varied concave with 48.00% and flat with 52.00%. The fruit axis of the15 parents varied with 80.00% straight and 20.00 % curved, while for 50 hybrids 84.00 straight and 16.00% curved. In this study, fruit shape of apex of the15 parents was recorded as 40.0% with narrow acute, 33.33 % with acute and with 26.66 % broad acute types of fruit apex, while for 50 hybrids varied 46% with narrow acute, 42% with acute and 12% with broad acute.

**Table 70. Qualitative morphological characteristics of 15 parents and 50 hybrids of okra**

| **Characteristics** | **Plant habit** | **Depth of leaf lobing** | **Mature fruit colour** | **Fruit surface** | **Fruit axis** | **Fruit pubescence** | **Petal colour** | **Stem colour** | **Fruit shape** | **Seed shape** |
|---|---|---|---|---|---|---|---|---|---|---|
| **PARENTS** | | | | | | | | | | |
| IC058710 | E | M | DG | CC | C | P | C | GPT | BA | K |
| IC045993 | E | M | G | F | S | D | C | GPT | BA | R |
| Pusa Sawani | E | M | YG | CC | S | SR | Y | G | A | R |
| VRO-4 | m | D | DG | F | S | SR | Y | G | NA | S |
| IC052299 | M | D | DG | F | S | SR | Y | GPT | BA | R |
| Kashi Kranti | E | S | DG | CC | S | D | C | GPT | BA | K |
| Salkeerthi | M | M | G | CC | S | SR | Y | G | A | K |
| IC058235 | E | D | G | F | S | P | C | GPT | NA | K |
| Hisar Naveen | E | D | DG | CC | C | P | Y | GPT | NA | R |
| IC052302 | M | M | DG | CC | S | SR | Y | G | NA | S |
| EC169452 | PC | M | YG | F | S | SR | C | GPT | A | R |
| IC052310 | M | D | G | F | S | D | C | GPT | NA | R |
| EC169459 | E | M | G | F | S | SR | C | G | A | R |
| Kashi Pragati | E | S | G | CC | S | P | C | GPT | A | S |
| IC052321 | E | S | DG | CC | C | D | C | G | NA | K |
| **Descriptor** | **E** | **S** | **DG** | **CC** | **S** | **D** | **C** | **GPT** | **NA** | **K** |
| Number of cultivars | 9 | 3 | 7 | 8 | 12 | 4 | 9 | 9 | 6 | 5 |
| Percentage of cultivars | 60 | 20 | 46.66 | 53.33 | 80 | 26.66 | 60 | 60 | 40 | 33.33 |
| **Descriptor** | **M** | **M** | **G** | **F** | **C** | **P** | **Y** | **G** | **A** | **S** |
| Number of cultivars | 5 | 7 | 6 | 7 | 3 | 4 | 6 | 6 | 5 | 3 |
| Percentage of cultivars | 33.33 | 46.66 | 40 | 46.66 | 20 | 26.66 | 40 | 40 | 33.33 | 20 |
| **Descriptor** | **PC** | **D** | **YG** | **-** | **-** | **SR** | **-** | **-** | **BA** | **R** |
| Number of cultivars | 1 | 5 | 2 | - | | 7 | | - | 4 | 7 |
| **Percentage** of cultivars | 6.66 | 33.33 | 13.33 | - | - | 46.66 | | - | 26.66 | 46.66 |
| **HYBRIDS** | | | | | | | | | | |
| IC058710 x EC169452 | E | M | DG | CC | S | SR | C | GPT | A | R |
| IC058710 x IC052310 | M | D | G | F | S | D | C | GPT | NA | K |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| IC058710 x EC169459 | E | M | DG | F | S | SR | C | G | NA | R |
| IC058710 x Kashi Pragati | E | M | DG | CC | S | P | C | GPT | A | S |
| IC058710 x IC052321 | E | S | DG | CC | C | D | C | G | BA | K |
| IC045993 x EC169452 | PC | M | YG | F | S | SR | C | G | A | R |
| IC045993 x IC052310 | E | D | G | F | S | D | Y | GPT | NA | R |
| IC045993 x EC169459 | E | M | G | F | S | D | C | G | BA | R |
| IC045993 x Kashi Pragati | E | S | G | CC | S | P | C | GPT | A | R |
| IC045993 x IC052321 | E | S | DG | CC | C | D | C | G | NA | K |
| Pusa Sawani x EC169452 | PC | M | DG | CC | S | SR | Y | G | NA | R |
| Pusa Sawani x IC052310 | M | M | YG | CC | S | SR | C | GPT | A | R |
| Pusa Sawani x EC169459 | E | D | DG | F | S | D | C | G | NA | R |
| Pusa Sawani x Kashi Pragati | E | M | G | F | S | SR | Y | G | A | S |
| Pusa Sawani x IC052321 | E | M | YG | CC | S | P | C | GPT | A | R |
| VRO-4 x EC169452 | PC | M | YG | F | S | SR | C | G | A | R |
| VRO-4 x IC052310 | M | D | G | F | S | D | C | GPT | NA | R |
| VRO-4 x EC169459 | E | M | DG | F | S | SR | Y | G | A | R |
| VRO-4 x Kashi Pragati | E | D | DG | CC | S | SR | C | GPT | NA | S |
| VRO-4 x IC052321 | E | S | DG | CC | C | D | Y | G | NA | K |
| IC052299 x EC169452 | PC | M | YG | F | S | SR | C | GPT | BA | R |
| IC052299 x IC052310 | M | D | G | F | S | D | Y | GPT | NA | R |
| IC052299 x EC169459 | E | M | DG | F | S | SR | C | G | BA | R |
| IC052299 x Kashi Pragati | E | D | G | CC | S | P | C | GPT | A | S |
| IC052299 x IC052321 | E | S | DG | F | S | D | Y | GPT | NA | K |
| Kashi Kranti x EC169452 | E | M | YG | F | S | SR | C | GPT | BA | R |
| Kashi Kranti x IC052310 | M | S | G | CC | S | D | C | GPT | NA | R |
| Kashi Kranti x EC169459 | E | M | DG | F | S | SR | C | G | A | K |
| Kashi Kranti x Kashi Pragati | E | S | G | CC | S | D | C | GPT | BA | K |
| Kashi Kranti x IC052321 | E | S | DG | CC | C | D | C | G | NA | K |
| Salekerthi x EC169452 | PC | M | YG | F | S | SR | C | GPT | A | K |
| Salekerthi x IC052310 | M | D | G | CC | S | D | Y | GPT | NA | R |
| Salekerthi x EC169459 | E | M | G | F | S | SR | C | G | NA | R |
| Salekerthi x Kashi Pragati | M | S | G | CC | S | P | C | GPT | A | S |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Salekerthi x IC052321 | E | M | DG | CC | C | D | C | G | NA | K |
| IC058235 x EC169452 | PC | M | YG | F | S | SR | C | GPT | A | R |
| IC058235 x IC052310 | M | D | G | F | S | D | C | GPT | NA | K |
| IC058235 x EC169459 | E | M | G | F | S | P | C | G | NA | K |
| IC058235 x Kashi Pragati | E | S | G | CC | S | P | C | GPT | A | S |
| IC058235 x IC052321 | E | S | DG | CC | C | D | C | GPT | NA | K |
| Hisar Naveen x EC169452 | PC | M | YG | F | S | SR | C | GPT | A | R |
| Hisar Naveen x IC052310 | E | S | G | F | S | P | C | GPT | NA | R |
| Hisar Naveen x EC169459 | E | M | G | F | S | SR | C | G | A | R |
| Hisar Naveen x Kashi Pragati | E | S | G | CC | S | P | C | GPT | A | R |
| Hisar Naveen x IC052321 | E | S | DG | CC | C | D | C | G | NA | K |
| IC052302 x EC169452 | PC | M | DG | CC | S | SR | Y | GPT | A | R |
| IC052302 x IC052310 | M | D | DG | F | S | D | Y | GPT | NA | R |
| IC052302 x EC169459 | M | M | G | F | S | SR | C | G | A | S |
| IC052302 x Kashi Pragati | E | S | G | CC | S | P | C | GPT | A | S |
| IC052302 x IC052321 | E | M | DG | CC | C | D | Y | G | NA | K |
| **Descriptor** | **E** | **M** | **DG** | **CC** | **C** | **SR** | **C** | **GPT** | **NA** | **R** |
| Number of cultivars | 32 | 25 | 20 | 24 | 8 | 20 | 39 | 29 | 23 | 27 |
| Percentage of cultivars | 64 | 50 | 40 | 48 | 16 | 40 | 78 | 58 | 46 | 54 |
| **Descriptor** | **M** | **S** | **G** | **F** | **S** | **D** | **Y** | **G** | **A** | **S** |
| Number of cultivars | 10 | 15 | 21 | 26 | 42 | 20 | 11 | 21 | 21 | 8 |
| Percentage of cultivars | 20 | 30 | 42 | 52 | 84 | 40 | 22 | 42 | 42 | 16 |
| **Descriptor** | **PC** | **D** | **YG** | **-** | **-** | **P** | **-** | **-** | **BA** | **K** |
| Number of cultivars | 8 | 10 | 9 | - | - | 10 | - | - | 6 | 15 |
| Percentage of cultivars | 16 | 20 | 18 | - | - | 20 | - | - | 12 | 30 |

**E:** Erect, **M**; Medium, **PC**: Procumbent, **D**: Deep, **M**: Medium, **S**: Shallow, **DG**: Dark Green, **YG**; Yellow Green, **G**: Green, **CC**: Concave, **F**: Flat, **S**: Stright, **C**: Curve, **D**: Downy, **SR:** Slightly rough, **P:** Prickly **Y:** Yellow, **C**: cream, **GPT:** Green with Purple Tinge, **BA**: Broad Acute, **NA**: Narrow Acute, **A:** Acute, **K:** Kidney**, R:** Round, **S**: Spherical.

*CHAPTER - 5*

# DISCUSSIONS

Okra is one of the most significant vegetables cultivated in the India. Its rapid growth, short lifespan and photo-insensitivity allow biologists and plant breeders to produce more than one generation each year, allowing for faster genetic improvement. The ultimate outcome in substantially all agricultural plants is an increase in yield or other economically useful features. Identifying optimal and genetically diverse parent plants poses a considerable challenge for plant breeders, requiring a profound understanding of the genetic variability present in the accessible germplasm.

The current study was thus undertaken to obtain first-hand information of fifty-five okra genotypes based on genetic variability and genetic diversity analysis to select potential parents. A line x tester mating system comprising ten lines and five testers was used to grow the chosen parents in order to determine the degree of heterosis, combining ability and stability. To find out the stable parents and hybrids among the selected ones across three different dates of sowing ($4^{th}$ March, $4^{th}$ April and $4^{th}$ May)

This chapter discusses the most significant findings of the present inquiry considering what past researchers have discovered.

**I. Genetic variability and diversity of okra genotypes**

5.1 Genetic variability studies

5.2 Morphological diversity (Mahalanobis $D^2$)

**II. Studies on heterosis and combining ability**

5.3 Analysis of variance and Mean performance

5.4 Magnitude and extent of heterosis

5.7 Estimation of general and specific combining ability effects

**III. Validation of selected parents and hybrids for stability (G x E) analysis**

5.8 Regression model (Eberhart and Russell, 1966)

**IV. Characterization of genotypes based on morphological descriptor**

5.9 Characterization of okra parents and hybrids based on morphology

**EXPERIMENT-I: GENETIC VARIABILITY AND DIVERSITY OF OKRA GENOTYPES**

Characterization stands out as a pivotal and foundational stage in the evaluation and categorization of genotypes. Typically, germplasm accessions undergo scrutiny for morphological, physiological, biochemical, plant pathological, entomological, and other traits. The detailed characterisation of many agro-morphological variables aids in the identification of connections and links between diverse features. For optimal application in breeding programmes, the traits evaluated must be relevant to the requirements of the breeders.

## 5.1 GENETIC VARIABILITY STUDIES

### 5.1.1 Analysis of variance

The ANOVA revealed highly significant mean squares for all seventeen traits in terms of genotypes, pointing to considerable genetic diversity within the studied material. The absence of statistically significant variance in replication suggests a lesser influence of environmental error. This may give breeders with a decent probability of identifying high-performing accessions for desirable traits to improve crop breeding efforts. Likewise, Rambabu *et al*., ((2019)) and Tudu *et al*., (2021) discovered considerable diversity in the evaluated quantitative attributes across okra genotypes.

### 5.1.2 Mean performance

Mean is the first order statistic which is given prime importance in selecting the genotypes. The first criteria in choosing a desirable genotype are to select the one with superior mean performance for desirable traits (Gilbert, 1958). The mean performances for 17 characters across 55 genotypes are detailed in Table.15. Notably, a broad range of variation was observed in all the studied characters. In Table 71 the superior genotype for each character is listed, determined by the mean performance across the 55 genotypes. Kashi Kranti excelled in yield, number of fruits per plant, and number of marketable fruits per plant. Pusa Sawani stood out for its early days to first fruit harvest and higher average fruit weight. VRO-4 achieved the best results in the number of nodes per plant and plant height. Likewise, results of mean fruiting behaviour were reported earlier by Temam *et al*., (2020), Ranga *et al*., (2021), Mohammed *et al*., (2022) and Kenaw *et al*., ((2023)) in okra crop.

**Table 71. Selection of better genotype based on mean values for seventeen traits of okra**

| Characters | Best performing genotype |
|---|---|
| First flowering node | Pusa Makhmali |
| Frist fruiting node | IC052320 and Hari Kranti |
| Days to first flower | Hisar Naveen |
| Days to 50% flowering | IC045993 |
| Days to first fruit harvest | Pusa Sawani |
| Plant height (cm) | VRO-4 |
| Internodal length (cm) | VRO-4 |
| Number of branches per plant | IC052320 |
| Number of nodes per plant | Pusa Sawani |
| Fruit length (cm) | Salekeerthi |
| Fruit diameter (mm) | IC058710 |
| No. of ridges per fruit | GFS Gold |
| Number of fruits per plant | Kashi Kranti |
| Number of marketable fruits per plant | Kashi Kranti |
| Average fruit weight (g) | Pusa Swami |
| Number of pickings per plant | IC058235 |
| Fruit yield per plant (g) | Kashi Kranti |

### 5.1.3 Genetic variability parameters

Crop improvement efforts are influenced by the extent of genetic variation in different traits and the heritability of the targeted features. Evaluating variability in yield and yield-contributing traits, as well as their heritable features in plant material, is crucial in crop breeding efforts. Fifty-five okra genotypes were evaluated for diversity in seventeen unique aspects in the current study. The findings in these areas are described under the following headings

#### 5.1.3.1 Genotypic and phenotypic coefficients of variation

The presence of higher magnitudes of variation in genotypes promotes crop improvement. In this study, PCV higher GCV across all traits, indicating minimal environmental influence on the traits under examination, similar results in okra crop studies by Sundaram *et al*., (2020), Temam *et al*., (2020), and Mohammed *et al*., (2022).

Higher estimates of GCV and PCV were observed in fruit yield per plant, number of marketable fruits/ plant and number of fruits per plant. This suggests that phenotypic selection can be more effective in breeding programs because there is a substantial genetic component driving the variation in the trait. Moderate PCV and GCV were observed for the number of pickings per plant, this indicate more influenced by hereditary variables because environmental influences on phenotypic expression are minimal. Moderate PCV and low GCV were observed for the following traits the first flowering node and internodal length. Lower values of GCV and PCV were recorded for plant height, average fruit weight, fruit length, first fruiting node, number of nodes per plant, and number of branches per plant, fruit diameter, days to 50% flowering, days to first flower, days to first fruit harvest and number of ridges per fruit. While low PCV and GCV values indicate that the environment has a significant impact on these traits, this implies that phenotypic selection would not be effective for breeding programs. Table 72 provides further evidence that confirms the existing conclusions.

**Table 72. Characteristics summary exhibiting phenotypic and genotypic coefficients of variation**

| Characters | PCV | GCV | Similar kind of results found by |
|---|---|---|---|
| FFN | Low | Low | Kharat *et al*., (2022) |
| FFRN | Moderate | Low | Syad *et al*., (2023) |
| DFF | Low | Low | Prakash *et al*., (2022) and Kumar *et al*., (2023) |
| D50F | Low | Low | Pattnaik *et al*., (2023) |
| DFFH | Low | Low | Raval *et al*., (2018) and Reddy *et al*., (2022) |
| PH | Low | Low | Kharat *et al*., (2022) and Kumar *et al*., (2023) |
| INL | Moderate | Low | Reddy *et al*., (2022) |
| NB | Low | Low | Sravanthi *et al*., (2021) |
| NON | Low | Low | Syad *et al*., (2023) |
| FL | Low | Low | Pattnaik *et al*., (2023) and Syad *et al*., (2023) |
| FD | Low | Low | Baghel *et al*., (2022) and Reddy *et al*., (2022) |
| NRG | Low | Low | Kharat *et al*., (2022) and Prakash *et al*., (2022) |
| NFP | High | High | Gurve *et al*., (2022) |
| NMF | High | High | Mohammad *et al*., (2015) and Priyanka *et al*., (2018) |
| AFW | Low | Low | Rathava *et al*., (2019) and Pattnaik *et al*., (2023) |
| NPS | Moderate | Moderate | Komal *et al*., (2022) |
| FYP | High | High | Prakash *et al*., (2022) |

#### 5.1.3.2 Heritability and Genetic advance

According to Robinson (1966), heritability is defined as the potential and extent of improvement achievable through selection, applicable in broad and specific contexts. It serves as a valuable indicator of the efficiency with which traits are transmitted from parents to offspring (Temam *et al*., (2020)). Genetic advance (GA) refers to the improvement in the standard genetic value of a group that has been chosen in comparison to the general population over a period of time. High heritability estimates suggest that future okra development programs should focus on traits such as fruit yield and number of fruits. This insight aids in assessing the potential gains through selection when implementing genetic modifications.

High heritability (>60%) was observed for the traits fruit yield per plant followed number of fruits per plant, number of marketable fruits per plant, plant height, number of pickings per plant, days to first flowering, days to 50% flowering, average fruit weight, number of nodes per plant, first flowering node, fruit length, and Moderate heritability (30-60%) was observed for traits like number of branches per plant, and fruit diameter, days to first fruit harvest, first fruiting node, internodal length. While low (<30) heritability observed for the trait number of ridges per fruit.

The genetic advance % of the mean (at 5% selection intensity) observed, the fruit yield per plant, number of marketable fruits per plant, number of fruits per plant, and number of pickings per plant exhibited high (>20) genetic advance as % of the mean. Plant height, first flowering node, average fruit weight, fruit length was moderate (10-20) GA % of the mean. Number of nodes per plant, internodal length, first fruiting node, number of branches per plant, and fruit diameter, days to 50% flowering, days to first flower, days to first fruit harvest and number of ridges per fruit on, exhibit low (<10) genetic advance.

According to Johnson *et al*., (1955) hypothesized that combining heritability estimations with genetic advance as % of the mean would be more successful in determining the effects of picking the best accession. High heritability coupled with substantial genetic advance as a percentage of the mean for traits such as the number of fruits per plant, number of marketable fruits per plant, number of pickings per plant, and fruit yield per plant suggests that these traits are predominantly controlled by additive genetic factors. Consequently, selection would be advantageous for enhancing these parameters in breeding programs. Table 73 presents corroborating findings that support the current results.

**Table 73. Characteristics summary exhibiting genetic advance and Heterosis**

| Characters | Heritability | GA% M | Similar kind of results found by |
|---|---|---|---|
| FFN | High | Moderate | Vani *et al*., (2021) and Singh *et al*., (2023), |
| FFRN | Moderate | Low | Keure *et al*., 2017 |
| DFF | High | Low | Kumar *et al*., (2023) and Awasthi *et al*., (2023) |
| D50F | High | Low | Prakash *et al*., (2022) and Kharat *et al*., (2022) |
| DFFH | Moderate | Low | Raval *et al*., (2018) and Kharat *et al*., (2022) |
| PH | High | Moderate | Kharat *et al*., (2022) and Pundir *et al*., (2022) |
| INL | Moderate | Low | Pattnaik *et al*., (2023) |
| NB | Moderate | Low | Syad *et al*., (2023) |
| NON | High | Low | Raval *et al*., (2018) |
| FL | High | Moderate | Reddy *et al*., (2022) and Karmata *et al*., (2023) |
| FD | Moderate | Low | Reddy *et al*., (2022) and Alemu, (2022) |
| NRG | Low | Low | Tulasiram *et al*., 2017 |
| NFP | High | High | Mohammed *et al*., (2022) and Kharat *et al*., (2022) |
| NMF | High | High | Priyanka *et al*., (2018) and Kumar *et al*.,(2019) |
| AFW | High | Moderate | Prakash *et al*., (2022) and Pattnaik *et al*., (2023) |
| NPS | High | High | Komal *et al*., (2022) |
| FYP | High | High | Prakash *et al*., (2022) and Pattnaik *et al*., (2023) |

### 5.2 MORPHOLOGICAL DIVERSITY (Mahalanobis $D^2$)

In this study, $D^2$ analysis was employed to evaluate genetic divergence through multivariate analysis among fifty-five okra genotypes. The aim was to identify suitable genotypes for a line x tester mating program.

The degree of variety in the crop determines the effectiveness of any crop development effort with several goals. To understand the diversity spectrum, it is necessary to assemble and assess divergence amongst genotypes. Knowledge of genetic divergence in available cultivars is critical and crucial in the selection of parents to be employed in hybridization programmes to achieve optimum genetic recombination. The Mahalanobis $D^2$ statistic serves as a valuable tool for assessing genetic divergence among genotypes and establishing connections between clustering patterns and geographic origin. Previous studies, notably by Bhatt (1970), have demonstrated the effectiveness and utility of this multivariate approach in measuring genetic diversity.

### 5.3.1 Group Constellation

Among these clusters, Cluster I was the largest, comprising thirty-four genotypes, followed by Clusters III with seventeen genotypes. Clusters II, IV, V, VI, and VII each contained one genotype. Several researchers have previously documented genetic diversity in the okra, Kumar *et al*., (2023) observed five clusters among 75 okra genotypes, Saleem *et al*., (2023) observed 3 distinct Clusters among the 24 genotypes of okra.

### 5.3.2 Inter and intra cluster divergence

An examination into the estimations of intra and inter-cluster genetic diversity revealed that genotypes within the same cluster exhibit minimal genetic distance from each other concerning distinct traits. Consequently, the probability of generating superior segregates through crossing individuals from the same cluster is limited. It would be more practical to cross genotypes from clusters with significant inter-cluster distances.

The average $D^2$ value of intra and inter-cluster distances is given in table 18. The diversity within the cluster and among the clusters varied from the genetic differences within the same cluster, varied from 0.00 to 9.64. Cluster III had the highest genetic divergence within its genotypes. The inter-cluster distances, which estimate the variation across various clusters, varied between 7.89 and 20.22. The greatest distance between clusters was found between Clusters two and seven, similar results Mudhalvan and Senthilkumar, (2018) among the 5 clusters, cluster V and cluster I (6493.93) recorded maximum inter cluster and Kumar *et al*., (2023) observed among the 5 clusters, between I and V cluster (21.17) recorded maximum inter cluster distance in 75 okra genotypes.

### 5.3.3 Cluster mean

To enhance the selection process for heterosis breeding, the mean values of clusters provide valuable insights. Cluster V germplasms, characterized by lower mean (desirable) values in traits such as first flowering node, first fruiting node, days to first flowering, days to 50% flowering, and days to first fruit harvest, are preferred. Conversely, traits with higher mean values like number of ridges per fruit, marketable fruits per plant, number of pickings, and fruit yield per plant are desirable.

### 5.3.4 Per cent contribution of characters towards divergence

According to the findings of this study, number of fruits per plant emerged as the most influential factor contributing to the variation among 55 genotypes, followed by plant height and average fruit weight. Therefore, when selecting parents for subsequent hybridization programs, it's crucial to consider number of fruits per plant. Similarly, Nanthakumar *et al*., (2021) also identified comparable results to divergence among 45 okra genotypes.

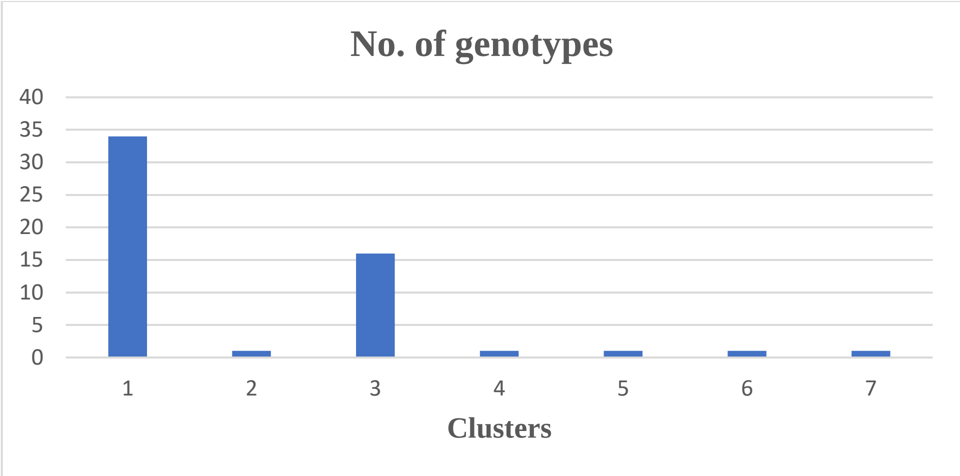



**Fig 2. Grouping clusters in okra 55 genotypes**


**Fig 3. Cluster mean per fruit yield**

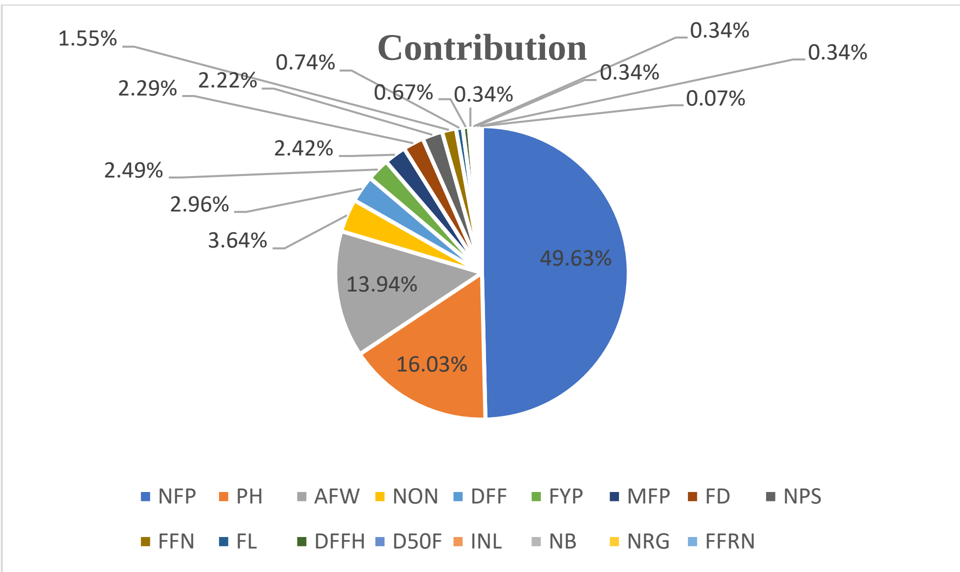



**Fig 4. Contribution of various characters towards diversity**

## II. STUDIES ON HETEROSIS AND COMBINING ABILITY

### 5.4 Analysis of variance

The ANOVA for the setup implicated significant treatment variations for all seventeen, results showed mean sum of square owning to treatments recorded significant for every trait studied in all of the environmental and also pooled conditions similar results observed Pithiya *et al*., (2019), Chavan *et al*., (2021) and Chaudhary *et al*., (2023). In crosses mean sum of square of all the seventeen traits were significance in all the environments and pooled analysis. Parent vs Crosses in all the three environments, days to first flowering and internodal length are significance, in pooled analysis all seventeen traits are significance except average fruit weight, variations in the performance of both parents and hybrids substantiated the existence of heterosis across the majority of the studied traits.

### 5.5 Mean performance of parents and hybrids

Selecting parents for a hybridization program is simple when it comes to inherited traits that are governed by just a few of genes. However, when it comes to complex qualities such as fruit yield and its components in okra, which are influenced by multiple genes, selecting suitable parents becomes a significant challenge (Ranjani, (2019)). The mean findings across different environments indicated that Kashi Kranti exhibited superior fruit yield per plant among females, while Kashi Pragati showed superiority among males, along with other yield components. Hybridization and selection outcomes are largely contingent upon the careful selection of suitable parents with desirable traits.

The Kashi Kranti x Kashi Pragati hybrid stood out as the top performer yield among the 50 hybrids analyzed in pooled data. Its exceptional performance can be attributed to a combination of yield-enhancing characteristics such as days to first flowering, days to 50% flowering, days to first fruit harvest, plant height, number of nodes, fruit length, number of marketable fruits, number of pickings and number of fruits/plant.

### 5.5 Magnitude of heterosis

The use of heterosis to increase yield in many crops is a cheap and simple strategy since heterotic crossings may produce transgressive segregants for economic features in advanced generations (Ranjani, (2019). Genetic heterosis is a complicated process that is determined by the balance of additive, dominance and their interplay (Manubhai, 2017). The primary goal of heterosis breeding is to increase agricultural productivity and create better performing hybrids.

The proportion of success was determined by the selection of better parents. As a result, the current research was designed to define the main yield traits using 10 (10 lines and 5 testers) parents employing a line x tester mating design. The genetic material obtained from crossing of parents are evaluated (15 parents + 50 $F_1$s + 1 check) and the obtained data were analysed for estimating the heterosis.

For the first flowering node desirable (negative) and significant heterobeltiosis combinations were recorded for E1, E2, E3 and pooled analysis were twenty, twelve, six and twelve respectively, while top performing hybrids in pooled analysis were, VRO-4 x Kashi Pragati followed by VRO-4 x IC052321 and Kashi Kranti x Kashi Pragati, where in standard heterosis four, three, three, and three desirable crosses were recorded for E1, E2, E3, pooled analysis and top performing hybrids for pool analysis were VRO-4 x Kashi Pragati, Kashi Kranti x Kashi Pragati, VRO-4 x IC052321 and IC052302 x Kashi Pragati. Similar observations recorded previously by Reddy *et al*., 2013 and More *et al.,* (2015).

First fruiting node negative and significant heterobletisosis crosse were recorded five, six, four and ten crosses for E1, E2, E3 and pooled analysis respectively, top desirable performing crosses in pooled analysis were, VRO-4 x EC169452 followed by VRO-4 x Kashi Pragthi and Kashi Kranti x Kashi Pragati. In standard heterosis fifteen, six, seven and twenty-two three desirable crosses recorded for E1, E2, E3 and pooled analysis, top performing hybrids for pool analysis were VRO-4 x Kashi Pragati, Kashi Kranti x Kashi Pragati and VRO-4 x EC169452. Similar results showed Chowdhury and Kumar, (2019), Kerure and Pitchaimuthu, (2019).

Days to first flowering trait desirable and significant over better parent hybrids were recorded three, fourteen, three and four for E1, E2, E3 and pooled analysis, top desirable performing crosses in pooled analysis were, Kashi Kranti x IC052310 followed by Salekeerthi x EC169452 and IC052299 x EC169452, while in standard heterosis thirty, twenty, twenty-three and twelve desirable crosses were identified for E1, E2, E3 and pooled analysis, top performing hybrids for pool analysis were Kashi Kranti x IC052310, Salekeerthi x EC169452 and IC052299 x EC169452. The results concur with those published earlier by Makdoomi *et al.,* (2018), Rynjah *et al*., (2020) and Shwetha *et al*., (2021).

For days to 50% flowering heterobeltiosis notably, in E1, E2, E3, and the pooled analysis, four, eleven, two, and five crosses respectively demonstrated this desirable trait. Among the top-performing crosses in the pooled analysis were Kashi Kranti x Kashi Pragati followed by Kashi Kranti x IC052321 and Salkeerthi x IC052321 were top hybrids., while in over better parent ten, fifteen, fifteen, and seven desirable crosses identified for E1, E2, E3 and pooled analysis, cross combinations Kashi Kranti x Kashi Pragati, VRO-4 x Kashi Pragati and IC052299 x Kashi Pragati were top hybrids. The present findings are in close association with results reported by Kharat *et al*., (2022), Sood *et al*., (2022), Chaudhary *et al*., (2023), and Shinde *et al*., (2023).

Days to first fruit harvest trait desirable and significant over better parent hybrids were recorded eighteen, eighteen, three and five for E1, E2, E3 and pooled analysis respectively, top desirable performing crosses in pooled analysis were, IC045993 x IC052321 followed by IC052299 x EC16945 and IC052299 x Kashi Pragati. In standard heterosis fifteen, five, eleven and five desirable crosses recorded for E1, E2, E3 and pooled analysis, top performing hybrids for pool analysis were Kashi Kranti x IC052310, IC058235 x IC052321 and IC052299 x IC052321, Kashi Kranti x Kashi Pragati. Similar observations were reported earlier for days to firs fruit harvest by Vekariya *et al*., (2020), Narkhede *et al*., (2021) and Mundhe *et al*., (2023).

The number of crosses, which observed significant positive heterosis for plant height were four, eight, two, three crosses for better parent heterosis in E1, E2, E3 and pooled analysis respectively, top desirable crosses recorded for heterobeltiosis for pooled analysis were IC058710 x EC169459, IC058710 x IC052310 and IC058710 x EC169452, while in stranded heterosis ten, seven, six, and seven desirable crosses identified for E1, E2, E3 and pooled analysis, IC052302 x Kashi Pragati followed by IC058710 x EC169459 and IC058710 x IC052310 top crosses. Similar kind of results founded by Kharat *et al*., (2022), Chaudhary *et al*., (2023) and Shinde *et al*., (2023).

For internodal length, positive and significant heterobletiosis crosses were recorded in twenty-four instances for E1, thirteen for E2, four for E3, and four for the pooled analysis. The top-performing crosses in the pooled analysis were Kashi Kranti x IC052310, followed by Kashi Kranti x Kashi Pragati, and IC045993 x EC169459. In terms of standard heterosis, there were five, eleven, four, and sixteen desirable crosses recorded for E1, E2, E3, and the pooled analysis, respectively. The top-performing hybrids in the pooled analysis were Kashi Kranti x IC052310, Kashi Kranti x Kashi Pragati, and IC045993 x EC169459. These findings are consistent with observations reported by Anyaoha *et al*. (2022), Kharat *et al*. (2022), and Maurya *et al*. (2022).

The number of crosses, which observed significant positive heterosis for number of branches/plants was twenty-five, four, six and eleven for better parent heterosis in E1, E2, E3 and pooled analysis respectively, top desirable performing crosses for pooled analysis were, Pusa Sawani x EC169459 followed by IC045993 x Kashi Pragati and Salekeerthi x EC169459, whereas in standard heterosis eighteen, ten, four, eleven desirable crosses were recorded for E1, E2, E3 and pooled, top performing hybrids for pool analysis were IC045993 x Kashi Pragati, IC045993 x IC052321, IC058235 x IC052310, and Kashi Kranti x Kashi Pragati. Similar findings recorded early researchers like Satish *et al*., 2017, Hadiya *et al*., (2018) and Patel *et al*., (2021).

Number of nodes/plant trait desirable and significant over better parent hybrids were recorded thirteen, seven, three and three for E1, E2, E3 and pooled analysis respectively, top desirable performing crosses in pooled analysis were, IC045993 x IC052321 followed by IC052299 x EC16945 and IC052299 x Kashi Pragati. In standard heterosis seven, thirteen, ten and fourteen desirable crosses recorded for E1, E2, E3 and pooled analysis, top performing hybrids for pool analysis were IC045993 x IC052321, IC052299 x EC169459 and IC052299 x Kashi Pragati. Similar observations were reported earlier for number of nodes/plant by Vekariya *et al*., (2020), Narkhede *et al*., (2021) and Mundhe *et al*., (2023).

Another yield attributing components is fruit length desirable and significant heterobeltiosis combinations were recorded for E1, E2, E3 and pooled analysis were sixteen, seven, five and four respectively, while top performing hybrids in pooled analysis were, Kashi Kranti x Kashi Pragati followed by Kashi Kranti x EC169459 and IC052302 x Kashi Pragati, while in standard heterosis six, seven, three and sixteen desirable crosses were recorded for E1, E2, E3, pooled analysis and top performing hybrids for pool analysis were Kashi Kranti x Kashi Pragati, Kashi Kranti x EC169459 and Kashi Kranti x IC052321. Similar observations were reported earlier for fruit length by Anyaoha *et al*., (2022) and Kharat *et al*., (2022).

For the fruit diameter desirable and significant heterobeltiosis combinations were recorded for E1, E2, E3 and pooled analysis were twenty, six, five and five respectively, while top performing hybrids in pooled analysis were, Kashi Kranti x Kashi Pragati followed by IC058235 x Kashi Pragati and Salekeerthi x EC169459, where in standard heterosis eleven, six, six, and five desirable crosses were recorded for E1, E2, E3, pooled analysis and top performing hybrids for pool analysis were Kashi Kranti x Kashi Pragati , IC045993 x Kashi Pragati and Salekeerthi x EC169459 were top hybrids for significant and positive standard heterosis for fruit diameter. Similar observations were reported earlier for fruit diameter by Anyaoha *et al*., (2022), Kharat *et al*., (2022), Mundhe *et al*., (2023) and Shinde *et al*., (2023).

The study recorded twenty, eight, six, and six desirable and significant hybrids over the better parent for the number of ridges per fruit in E1, E2, E3, and the pooled analysis, respectively. The top-performing crosses in the pooled analysis were Kashi Kranti x IC052310, followed by Hisar Naveen x Kashi Pragati and IC045993 x IC052310. For standard heterosis, eleven, five, fifteen, and twelve desirable crosses were identified for E1, E2, E3, and the pooled analysis, respectively. The top-performing hybrids in the pooled analysis were Kashi Kranti x IC052310, VRO-4 x Kashi Pragati, and IC058235 x IC052321. These findings are consistent with previous research by Padadalli *et al*. ((2019)), Kharat *et al*. (2022), and Shinde *et al*. ((2023)).

Number of crosses, observed significant positive heterosis for number of fruits/ plant was six, two, three, eight crosses for better parent heterosis in E1, E2, E3 and pooled analysis respectively, top desirable crosses recorded for pooled analysis were IC045993 x EC169452, IC045993 x IC052321 and IC045993 x IC052310, in stranded heterosis eleven, twelve, five and two desirable crosses were recorded for E1, E2, E3, pooled analysis and top performing hybrids for pool analysis were Kashi Kranti x Kashi Pragati and Kashi Kranti x IC052321. Similar findings were reported earlier by Anyaoha *et al*., (2022), Mundhe *et al*., (2023) and Shinde *et al*., (2023).

Number of marketable fruits/plant positive and significant over better parent hybrids were recorded seven, four, four and four for E1, E2, E3 and pooled analysis respectively, top desirable performing crosses in pooled analysis were, IC052302 x EC169452 followed by Hisar Naveen x IC052310 and IC058235 x EC169459, while in stranded heterosis eleven, seven, three and five desirable crosses were recorded for E1, E2, E3, pooled analysis and top performing hybrids for pool analysis were IC052302 x EC169452, Hisar Naveen x IC052310 and Kashi Kranti x Kashi Pragthi. Likewise results observed previously by Reddy *et al*., (2014) and Kumar *et al*., (2016).

For average fruit weight desirable and significant over better parent hybrids were recorded four, four, three and three for E1, E2, E3 and pooled analysis respectively, top desirable performing crosses in pooled analysis were, IC058710 x EC169459 followed by IC052299 x IC052321, IC058710 x EC169452, in stranded heterosis twenty-one, twenty nine, fifteen and nine desirable crosses were recorded for E1, E2, E3, pooled analysis and top performing hybrids for pool analysis were Pusa Sawani x Kashi Pragati, IC052299 x IC052321 and VRO-4 x Kashi Pragthi. Results are in accordance with the findings of Sood *et al*., (2022) and Shinde *et al*., (2023).

Number of pickings/plant positive and significant over better parent hybrids were recorded three, three, three and four for E1, E2, E3 and pooled analysis respectively, top desirable performing crosses in pooled analysis were IC052299 x IC052310 followed by IC052299 x EC169452, IC052299 x Kashi Pragthi. In stranded heterosis four, four, fifteen and twenty-two desirable crosses were recorded for E1, E2, E3, pooled analysis and top performing hybrids for pool analysis were Kashi Kranti x Kashi Pragati, IC052299x EC169459 and Kashi Kranti x EC169459. Similar observations were reported earlier for number of pickings per plant by Zate *et al*., (2021) and Harsiddhi and Mehta, (2023).

For the fruit yield/plant positive and significant heterobeltiosis combinations were recorded for E1, E2, E3 and pooled analysis were three, four, three and eight respectively, while top performing hybrids in pooled analysis were, IC058710 x EC169459 followed by IC058710 x IC052321 and IC058710 x Kashi Pragthi, where in standard heterosis four, six, eight, and thirteen desirable crosses were recorded for E1, E2, E3, pooled analysis and top performing hybrids for pool analysis were Kashi Kranti x Kashi Pragati, Kashi Kranti x EC169459 and Kashi Kranti x IC052321 were top hybrids for significant and positive standard heterosis for fruit yield/plant. The results were in accordance with the prior works done by Kharat *et al*., (2022) and Mundhe *et al*., (2022) and Shinde *et al*., (2023).

The hybrids chosen based on the magnitude of both heterosis (heterobeltoisis and standard heterosis) in pooled analysis mentioned in Table 74. The hybrids IC058710 x EC169459, Kashi Kranti x Kashi Pragati, and IC052302 x EC169452 recorded top performers for both heterobeltiosis and standard heterosis in fruit yield per plant. Utilizing hybrid vigor in one or more yield-related traits can notably enhance crop performance compared to existing hybrids or varieties, even though achieving manifestation of heterosis for all traits in a single cross like Heterobeltisois and stranded heterosis might be challenging (Hosamani *et al*., 2008).

**Table 74. Top hybrids based on heterobeltoisis and standard heterosis for seventeen characters in pooled analysis**

| Characters | Crosses | Best cross combination for heterosis |
|---|---|---|
| First flowering node | 3 | VRO-4 x Kashi Pragati, VRO-4 x IC052321 and Kasi Kranthi x Kashi Pragati |
| Frist fruiting node | 11 | IC058710 x EC169452, VRO-4 x EC169452, VRO-4 x IC052310, VRO-4 x Kashi Pragati, VRO-4 x IC052321, IC052299 x Kashi Pragati, Kasi Kranthi x Kashi Pragati, Salekerthi x Kashi Pragati, IC052302 x EC169452, IC052302 x EC169459 and IC052302 x Kashi Pragati |
| Days to first flower | 4 | IC052299 x EC169452, Kasi Kranthi x IC052310, Salekerthi x EC169452 and IC058235 x EC169452 |
| Days to 50% flowering | 3 | VRO-4 x Kashi Pragati, Salkeerthi x IC052321 and Kashi Kranti x Kashi Pragati |
| Days to first fruit harvest | 5 | IC052299 x IC052321, Kasi Kranthi x IC052310, Salekerthi x IC052321, Kasi Kranthi x Kashi Pragati, and IC058235 x IC052321 |
| Plant height (cm) | 3 | IC058710 x EC169452, IC058710 x IC052310 and IC058710 x EC169459 |
| Internodal length (cm) | 4 | IC045993 x EC169459, Pusa Sawani x IC052321, Kasi Kranthi x IC052310 and Kasi Kranthi x Kashi Pragati |
| Number of branches per plant | 8 | IC045993 x IC052310, Pusa Sawani x EC169459, IC045993 x Kashi Pragati, IC045993 x IC052321, IC052299 x Kashi Pragati, Salekerthi x EC169459, IC058235 x IC052310 and IC058235 x IC052321 |
| Number of nodes per plant | 3 | IC045993 x IC052321, IC052299 x EC169459 and IC052299 x Kashi Pragati |
| Fruit length (cm) | 4 | Kasi Kranthi x EC169459, Kasi Kranthi x Kashi Pragati, IC052302 x IC052310 and IC052302 x Kashi Pragati |
| Fruit diameter (mm) | 4 | IC045993 x Kashi Pragati, IC052299 x EC169452, Kasi Kranthi x Kashi Pragati and IC058235 x Kashi Pragati |
| No .of ridges per fruit | 5 | IC045993 x IC052310, VRO-4 x Kashi Pragati, Kasi Kranthi x IC052310, Kashi Kranthi x Kashi Pragati, and Hisar Naveen x IC052310 |
| Number of fruits per plant | 1 | Kasi Kranthi x Kashi Pragati |

| | | |
|---|---|---|
| Number of marketable fruits per plant | 3 | Kashi Kranti x Kashi Pragati, Hisar Naveen x IC052310 and IC052302 x EC169452 |
| Average fruit weight (g) | 2 | IC058710 x EC169459 and IC052299 x IC052321 |
| Number of pickings per plant | 2 | IC052299 x IC052310 and IC052299 x EC169459 |
| Fruit yield per plant (g) | 3 | IC058710 x EC169459, Kasi Kranthi x Kashi Pragati and IC052302 x EC169452 |

## 5.6 COMBINING ABILITY

General combining ability (GCA) primarily arises from additive genetic effects and is considered stable or fixable. In contrast, specific combining ability (SCA) is associated with non-additive genetic effects, which can result from dominance, epistasis, or both, and is inherently non-fixable. The present study employs the Line x Tester method to assess combining abilities.

### 5.6.1 ANOVA for combining ability

In all the environments and pooled analysis all the crosses mean sum of square were significant among the seventeen traits. In pooled analysis the mean square values attributable to line x tester were significant for all character's similar results recoded Narkhede *et al*., (2021) and Palve *et al*., (2021). The mean square values owing to lines were significant all traits except first fruiting node, days to first flowering, days to 50% flowering, days to first fruit harvest, fruit length and average fruit weight, and the mean square values due to testers was significant for first flowering node, internodal length, number of nodes, average fruit weight and fruit yield/ plant in pooled analysis.

Understanding the combining ability effects of parent plants is crucial for selecting superior parents to be used in further breeding programs. However, it is important to note that finding one exceptional parent that performs well for all traits can be challenging, as combining abilityeffects can vary across different traits. Selecting parents for hybridization plays a vital role in crop improvement programs, and evaluating their performance in trials can provide insights into their relative superiority. Therefore, in any effective breeding program, choosing parents based on their combining ability is a prerequisite.

Overall, the results categorized the parents into three groups basedon their general combining ability effects: good, average, and poor combiners. Parents with desirable and significant effects were considered good general combiners, those with desirablebut non-significant effects were considered average general combiners, and parents with significant but undesirable effects were classified as poor general combiners mentioned in Table 75. According to general combing ability in E1, E2, E3 and pooled analysis for parents Kashi Kranti VRO-4 in lines and EC169459, Kashi Pragati in tester effective general combiners for the majority of the characters tested.

**Table 75. Summary of general combining ability effects of parents for various traits in pooled analysis of okra**

| Parents | FFN | FFRN | DFF | D50F | DFFH | PH | INL | NB | NON | NRG | FL | FD | NFP | MFP | AFW | NPS | FYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IC058710 | P | A | A | A | A | A | P | P | P | P | P | A | P | P | G | A | P |
| IC045993 | P | A | P | A | A | G | G | G | A | G | A | A | G | G | P | G | A |
| Pusa Sawani | P | P | G | A | A | A | A | G | G | P | A | P | P | P | G | P | P |
| VRO-4 | G | G | A | A | G | G | A | P | G | G | G | G | A | A | G | G | A |
| IC052299 | A | A | G | G | A | A | A | A | A | A | A | A | A | A | G | A | A |
| Kashi Kranti | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G |
| Salekerthi | A | P | A | A | A | A | A | A | P | P | A | G | A | A | G | A | G |
| IC058235 | A | P | A | P | P | P | A | G | A | A | A | A | A | A | G | P | A |
| Hisar Naveen | A | A | A | A | A | P | A | P | P | A | A | P | A | A | G | P | A |
| IC052302 | G | G | P | P | A | P | P | P | A | A | P | P | P | P | G | P | P |
| EC169452 | A | A | P | A | P | A | P | P | G | P | P | A | P | P | P | P | A |
| IC052310 | P | P | P | P | P | P | A | A | P | A | A | A | P | P | P | P | P |
| EC169459 | P | P | A | G | G | A | A | A | G | P | A | G | G | G | G | G | G |
| Kashi Pragati | G | G | G | G | G | G | G | A | A | G | G | G | G | G | G | G | G |
| IC052321 | G | A | A | P | P | A | P | A | P | A | A | P | A | A | G | P | A |

**G:** Good**, A: Average, P: Poor, FFN:** First flowering node**, FFRN:** First fruiting node**, DFF:** Days to first flowering**, D50F:** Days to 50% flowering**, PH:** Plant height**, INL:** Inter nodal length**, NB:** Number of branches**, NON:** Number of nodes/plant**, FL:** Fruit length**, FD:** Fruit diameter**, NRG:** Number of ridges**, NFP:** Number of fruits/plant**, MFP:** Marketable fruits/plant**, AFW:** Average fruit weight**, NPS:** Number of pickings/plant and **FYP:** Fruit yield/plant

In the pooled analysis, VRO-4, Kashi Kranti, and IC052302 exhibited good general combining abilities for traits such as the first flowering node and first fruiting node. Conversely, Pusa Sawani, IC052299, Kashi Kranti, and Kashi Pragati emerged as good combiners for days to first flowering, whereas for days to 50% flowering IC052299, Kashi Kranti, EC169459, Kashi Pragati were good combiners, for days to first fruit harvest VRO-4, Kashi Kranti, EC169459, Kashi Pragati recorded good combiner, for plant height Hisar Naveen, IC045993, Kasi Kranthi and Kashi Pragati and for internodal length Kashi Kranti, IC045993 and Kashi Pragati recorded good combiners, whereas for number of branches Kashi Kranti, VRO-4, Pusa Sawani, EC169459, EC169452 observed good combiners, for number of nodes Kashi Kranti, VRO-4, Pusa Sawani, EC169459, EC169452 and for number of ridges VRO-4,Kasi Kranthi and Kashi Pragati, for fruit length Kashi Kranti, VRO-4 and Kashi Pragati recorded good combiner, while for fruit diameter VRO-4, Kashi Kranti, Salkeerthi, EC169459 and Kashi Pragati were recorded good combiner, for number of fruits plant, number of markable fruits/plant and number of pickings Kasi Kranthi, IC045993, EC169459 and Kashi Pragati, Kashi Pragati parents were recorded good combiners, for average fruit weight Pusa Sawani Kashi Pragati and IC052321 were good combiners, while Kashi Kranti, Sale Keerthi, and EC169459 demonstrated strong combining abilities for fruit yield per plant. The findings suggest that parents' genes act additively, offering potential for their utilization in hybridization program, Similarly Wakode *et al*., (2016), Chirag *et al*., (2023) and Shinde *et al*., (2023), found a strong general combining ability (GCA) effect and high per se performance in okra for various traits.

### 5.6.3 Specific combining ability

The presence of intra or inter allelic interaction may be the cause of the strong *sca* effects, which can be taken advantage of in often cross-pollinated crops like okra where commercial hybrid seed production is feasible. The high sca however, might be the result of the accumulation of dominant genes from both of its parents if the crossing parents are successful general combiners. For heterosis breeding, hybrids that have desirable and significant evidenceof better parent heterosis, as well as sca effects and gca performance, are advised. In order to identify superior segregants, hybrids with non-significant sca effects and parents with significant *gca* effects are helpful.

In pooled analysis for first flowering node two crosses recorded desirable significant sca effect, top desirable crosses were IC058710 x EC169452 and IC045993 x EC169452 involved poor x average and poor x average combiners respectively. Similar kind of results recoded previously Reddy *et al*., 2013, Wakode *et al*., (2016) and Tiwari *et al*., (2016).

For first fruiting node negative and significant *sca* effect two crosses recorded for pooled analysis, top desirable crosses were IC058710 x EC169452 and Kashi Kranti x Kashi Pragati were involved average x average and good x good combiners respectively, Similar observations were reported earlier for first flowering node by Sharma *et al*., 2012 and Reddy *et al*., 2013

This study seven crosses identified significant and desirable *sca* effect for days to first flowering in pooled analysis, top desirable crosses were IC052302 x IC052310, Salekerthi x Kashi Pragati and IC052302 x EC169452 involved poor x poor, average x good and poor x poor combiners respectively. Similar kind of results observed previously Wakode *et al*., (2016), Tiwari *et al*., (2016) and Maurya *et al*., (2022).

In pooled analysis for days to 50% flowering six crosses recorded desirable significant *sca* effect, *i.e.* VRO-4 x Kashi Pragati, Kashi Kranti x Kashi Pragati and IC052302 x EC169452 and involved average x good, good x good and poor x poor combiners respectively. Similar kind of results recoded previously by Keerthana *et al.*, (2021), Anyaoha *et al*., (2022) and Shinde *et al*., (2023).

Days to first fruit harvest seven crosses were recorded desirable and significant *sca* effect for pooled analysis, top desirable crosses were Kasi Kranthi x Kashi Pragati, IC052302 x EC169452 and IC045993 x Kashi Pragati involved good x good, average x poor and average x good combiners respectively. Similar findings recorded early researchers Verma *et al.*, (2016), Narkhede *et al.*, (2021) and Shinde *et al*., (2023).

This study seven crosses identified significant and negative *sca* effect for plant height in pooled analysis, top desirable crosses were IC058235 x IC052310, IC052302 x IC052321 and Pusa Sawani x IC052321 involved poor x poor, poor x average and average x average combiners respectively. The results concur with those published earlier by Anyaoha *et al*., (2022), Kharat *et al*., (2022) and Mundhe *et al*., (2023).

In a pooled analysis on internodal length, three crosses exhibited significant *sca* effect, top combinations such as Pusa Sawani x IC052321 demonstrated average x poor combiners, while IC045993 x EC169459 involved a pairing of good x average combiners, and Kasi Kranthi x Kashi Pragati represents good x good combiners. These findings align with prior research conducted by Anyaoha *et al*., (2022), Kharat *et al*., (2022) and Maurya *et al*., (2022).

This study four crosses identified significant and desirable *sca* effect for number of branches/plants, top desirable crosses were Salekeerthi x EC169452, VRO-4 x IC052321 and IC058235 x IC052310 involved average x poor, poor x average and good x average combiners respectively. Similar kind of results observed previously by Tiwari *et al*., (2016), Satish *et al*., 2017, Hadiya *et al*., (2018) and Patel *et al*., (2021).

For number of nodes/plant two crosses were observed positive and significant *sca* effect, top desirable combinations were Hisar Naveen x IC052310 and Pusa Sawani x EC169452 involved poor x poor and good x good respectively. The results were in accordance with the prior works done by Vekariya *et al*., (2020), Narkhede *et al*., (2021) and Kharat *et al*., (2022).

In this present study number of ridges/fruit four crosses were recorded desirable and significant *sc*a effect, top desirable crosses were Pusa Sawani x IC052310, IC058235 x Kashi Pragati involved IC045993 x IC052310 and VRO-4 x Kashi Pragati involved Poor x average, average x good, good x average and good x good respectively. Similar findings recorded early researchers like Gowda *et al*., (2018), Padadalli *et al*., (2019) and Anyaoha *et al*., (2022).

In this investigation four crosses exhibited significant and positive *sca* for fruit length, top desirable crosses were IC058235 x EC169452, Pusa Sawani x EC169452 and Kasi Kranthi x EC169459 involved average x poor, average x poor, good x average respectively. Similar kind observations were reported earlier for fruit length by Anyaoha *et al*., (2022), Kharat *et al*., (2022) and Maurya *et al*., (2022)

For fruit diameter six cross combinations exhibited significant and desirable *sca* effect for pooled analysis, top desirable hybrids were Salekeerthi x EC169459, IC045993 x Kashi Pragati and IC052299 x EC169452 involved good x good, average x good and average x average respectively. The results concur with those published earlier by Anyaoha *et al*., (2022), Mundhe *et al*., (2023) and Shinde *et al*., (2023).

In pooled analysis for number of fruits/ plant five crosses were recorded desirable significant *sca* effect, top desirable crosses were Pusa Sawani x IC052310, Kashi Kranti x IC052321 and Kashi Kranti x IC052321 involved poor x poor, good x average and good x average combiners respectively. Similar kind of results recoded previously by Kharat *et al*., (2022), Mundhe *et al*., (2023) and Shinde *et al*., (2023).

This study four crosses identified significant and positive *sca* effect for number of marketable fruits/plant, top desirable crosses were Pusa Sawani x IC052310, VRO-4 x IC052321 and IC052299 x EC169452 involved poor x poor, average x average and average x poor combiners respectively. The results concur with those published earlier by Reddy *et al*., 2013, Devi *et al*., 2017 and Palve *et al*., (2021).

Average fruit weight eight crosses were recorded desirable and significant sca effect, best performing crosses were IC052299 x IC052321, IC052302 x IC052310 and Salekerthi x IC052310 involved good x average, good x poor and good x poor combiners respectively, Similar findings recorded early researchers like Narkhede *et al*., (2021), Kharat *et al*., (2022) and Maurya *et al*., (2022).

In this present study number of pickings/plant four crosses were recorded desirable and significant sca effect, top desirable crosses were Kasi Kranthi x Kashi Pragati, Pusa Sawani x IC052310 and IC058710 x IC052321 involved good x good, Poor x poor and average x poor respectively.

In pooled analysis four crosses observed desirable and significant sca effect for fruit yield/ plant, top desirable crosses were Pusa Sawani x IC052310, IC045993 x IC052310 and IC045993 x EC169452 involved poor x poor, average x poor and average x average respectively. Likewise results observed for fruit yield/plant by Palve *et al*., (2021), Kousalya *et al*., (2021), Narkhede *et al*., (2021) and Chirag *et al*., (2023).

Based on the analysis of specific combining ability (SCA) effects, the present investigation suggests that no single cross combination consistently demonstrates high SCA effects across all the studied traits. Moreover, the crosses displaying elevated SCA effects didn't consistently feature parents with high general combining ability (GCA) effects, underscoring the significance of inter-allelic interactions in trait expression. Additionally, it was observed that crosses exhibiting higher SCA effects for fruit yield may not necessarily exhibit high SCA effects for yield component traits.

**Table 76. Summary of top general combiner parents and best performing hybrids, including *sca* effects and standard heterosis for pooled analysis**

| Character | Best performing GCA parent | | Best performing hybrid | SCA effect | Stranded heterosis |
|---|---|---|---|---|---|
| | Line | Tester | | | |
| First flowering node | VRO-4 | Kashi Pragati | IC058710 x EC169452 | -3.65** | -6.63 |
| Frist fruiting node | VRO-4 | Kashi Pragati | IC052302 x IC052310 | -0.316** | -9.68** |
| Days to first flowering | Kashi Kranti | Kashi Pragati | IC052302 x IC052310 | -1.280** | -6.76 |
| Days to 50% flowering | Kashi Kranti | Kashi Pragati | VRO-4 x Kashi Pragati | -1.493** | -7.25** |
| Days to first fruit harvest | VRO-4 | EC169459 | Kashi Kranti x Kashi Pragati | 1.536** | -4.32 |
| Plant height (cm) | VRO-4 | Kashi Pragati | IC058235 x IC052310 | 4.761** | 6.31 |
| Internodal length (cm) | Kashi Kranti | Kashi Pragati | Pusa Sawani x IC052321 | 0.543 | 22.84** |
| Number of branches per plant | IC058710 | Kashi Pragati | Salekeerthi x EC169452 | 0.222* | 13.53* |
| Number of nodes per plant | Kashi Kranti | EC169459 | Hisar naveen x IC052310 | 0.813 | 5.18 |
| Fruit length (cm) | Kashi Kranti | Kashi Pragati | IC058235 x EC169452 | 0.930 | 12.03** |
| Fruit diameter (mm) | VRO-4 | EC169459) | Salekeerthi x EC169459 | 1.846 | 11.41* |
| No .of ridges per fruit | VRO-4 | Kashi Pragati | Pusa Sawani x IC052310 | 0.266 | 9.33* |
| Number of fruits per plant | Kashi Kranti | EC169459 | Pusa Sawani x EC169459 | 1.730 | -2.86 |
| Number of marketable fruits per plant | Kashi Kranti | EC169459 | Pusa Sawani x IC052310 | 1.60 | 1.81 |
| Average fruit weight (g) | Pusa Sawani | Kashi Pragati | IC052299 x IC052321 | 1.190 | 12.62** |
| Number of pickings per plant | Kashi Kranti | EC169459 | Kasi Kranthi x Kashi Pragati | 1.244 | 34.92** |
| Fruit yield per plant (g) | Kashi Kranti | Kashi Pragati | Pusa Sawani x IC052310 | 19.356 | -1.36 |

## 5.7 Estimation of Gene Action

The variance resulting from GCA is smaller compared to that of SCA, as demonstrated by the following table, therefore the GCA-SCA variance ratio is expected to be below one. As a result, each trait within study proved non-additive form of gene action these for heterosis breeding. Many genes regulate the yield trait, which manifests itself in a complicated way. Breeders need to comprehend how genes function in order to choose the best breeding strategies and eventually increase the productivity of the crop and traits that contribute to yield. There are three kinds of gene actions that influence trait expression: additive, dominance, and epistasis. Improvement of crops and selection techniques are advised when additive gene action is controlling. Conversely, allelic & non-allelic interactions between genes are linked to dominance & epistasis gene effects. Creating composite varieties or taking advantage of heterosis can be helpful in certain circumstances. Therefore, while choosing suitable breeding techniques, breeders can benefit much from the understanding of gene action. The findings suggest that $\sigma^2$ sca, surpassed $\sigma^2$ gca, across all traits in all the three environments and pooled analysis. This points to a dominance of non-additive genetic effects in the manifestation of all 17 traits examined. Similar findings recorded in okra all the traits were non additive gene action previously by Vekariya *et al.*, (2020), Keerthana *et al*., (2021) Kousalya *et al*., (2021) and Maurya *et al*., (2022).

**Table 77. Top three hybrids based on mean performance of fruit yield per plant with standard heterosis, *gca* effects, *sca* effects and component traits showing significant desired heterosis in pooled analysis**

| Hybrids | Fruit yield/plant | SCA effect | GCA effect | | Heterosis stranded check | Significant and desirable traits over heterosis |
|---|---|---|---|---|---|---|
| | | | Lines | testers | | |
| Kashi Kranti x Kashi Pragati | 399.38 | 4.47 | 33.31** | 17.919** | 12.69** | First flowering node, first fruiting node, days to 1st flowering, days to 50 % flowering, plant height, internodal length, number of nodes, no. of branches, fruit length, fruit diameter, no. of fruits, no.of. marketable fruits, number of pickings and fruit yield/ plant |
| Kashi Kranti x EC169459 | 385.02 | -10.535 | 33.31** | 17.259** | 16.89** | First flowering node, days to first flowering, inter node, number of nodes, fruit length, marketable fruits, no. of pickings and fruit yield/ plant |
| Salkeerthi x EC169459 | 369.38 | 1.063 | 6.542* | 17.259* | 7.49** | Fruit length, fruit diameter and number of pickings |

**III. Validation of selected parents and hybrids for stability (G x E) analysis**

One of the primary goals of any plant breeding effort is to choose genotypes that are consistently high yielding throughout a variety of environments/seasons/dates of sowing. This selection is often inefficient owing to genotype x environment interactions and genotypes failing to perform similarly in diverse contexts. The interaction between genotype and environment is significant in plant breeding because it influences genetic gain as well as the prescription and selection of cultivars with broad adaptability (dacruz *et al*., 2009, Prakash *et al*., (2017) and Vekariya *et al*., (2019).

The term "environment" refers to the combination of physical, chemical and biological variables. Plant breeders depend largely on G x E interactions for producing superior cultivars (Falconer, 1952). According to Nath and Dasgupta (2013), minimal levels of interactions are desirable for certain characters to optimize stable performance across a variety of circumstances, although high levels of interactions are advantageous and may be explored in other situations. G x E interaction implies the possibility for genetic differentiation of populations under protracted selection in multiple environments if no genotype possesses superior in all contexts (Kang 2020). The 15 parents and 50 crosses were assessing their stability under three different sowings *viz*., 4$^{th}$March, 4$^{th}$ and April, 4$^{th}$ May.

**5.8. Regression Model (Eberhart and Russell, 1966)**

Because of the G x E interaction, identifying stable genotypes is challenging. Several efforts have been made to define genetic behaviours in response to diverse surroundings. Finlay and Wilkinson's (1963) statistical technique have shown to be beneficial in measuring phenotypic stability in genotype performance. Eberhart and Russell updated this regression analysis (1966). They proposed deviation from regression ($S^2$di), which accounted for unpredictability in genotype responses to various environments.

**5.8.1 Analysis of variance**

The approach proposed by Eberhart and Russell (1966) was used in this work to investigate the differential G x E interaction of selected hybrids, in order to access the stability of individual hybrids.

The findings showed that mean squares related to genotypes were very significant for all characteristics and fulfilled the stability criteria. According to the pooled analysis of variance, except number of nodes, fruit length, number of nodes, number of fruit/plant and fruit yield/plant in the individual environment impact were significant. In this study Environments + (Genotype x Environment) demonstrated significant difference among all parameters. Genotype x Environment (linear) all traits were significant except fruit yield per plant. The pooled deviation significant all traits except number of nodes and number of pickings. When examined environment (linear) revealed a significant difference in all characteristics. These significant differences indicate that each genotype performed differently across various environments, Namita *et al*., (2014), Jijabrao (2015) and Patil *et al.,* (2017).

**5.8.2 Stability parameters**

Eberhart and Russell, define an ideal genotype may be characterized as having high mean (x=μ) performance with unit regression coefficient (bi=1) and minimum deviation from regression ($S^2$di=0). Accordingly, the mean (x) and deviation from regression ($S^2$di) are considered as measures of stability and linear regression (bi) has been used for evaluating the genotypes response.

**4.8.2.1 First flowering node**

Among parents and hybrids, none of the parent recorded ideal stable. However, in hybrids VRO-4 x IC052310, IC052302 x IC052310 and IC052302 x EC169459 carried low mean compared to grand mean, had regression coefficient values close to unity (bi=1) with small deviation from regression suggesting that they were stable and ideal, these hybrids wider adaptation over environment.

In parents and hybrids, none of the parent recorded below average stability and in hybrids IC058710 x EC169452, VRO-4 x EC169459, VRO-4 x IC052321, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x IC052321, Salkeerthi x IC052321, Hisar Naveen x IC052321 and IC052302 x IC052321 exhibited low mean compared to grand mean paired with greater value of regression coefficient higher than unity (>1) with degree from regression near to zero, indicates below average stability. These genotypes with high stability and better in favourable environments.

Whereas, parents and hybrids IC058710, IC045993, IC052299, Pusa Sawani Salkeerthi, IC058235, Hisar Naveen, IC052302, Kashi Pragati, IC052321 in parents and IC045993 x EC169452, VRO-4 x EC169452, VRO-4 x Kashi Pragati, IC052299 x Kashi Pragati, Kashi Kranti x Kashi Pragati, Salkeerthi x Kashi Pragati, IC058235 x Kashi Pragati, IC052302 x EC169452 and IC052302 x Kashi Pragati in hybrids exhibited low mean value with regression coefficient less than unity (bi<1) and minimum deviation from regression indicate above average stability. Those genotypes consistently perform well across different environmental conditions with minimal variation in their performance. Likewise, Jindal *et al*., (2008) and Vekaraya *et al*., (2022) found varied responses of genotypes with respect to stability parameters for first flowering node in okra.

#### 4.8.2.2 First fruiting node

Among parents and hybrids, none of the parent recorded ideal stable and however in hybrids IC058235 x Kashi Pragati, Hisar Naveen x Kashi Pragati, carried low mean compared to grand mean, unit regression coefficient (bi=1) and minimum deviation from regression they were stable, perfect. This hybrid and parents are suited for all environmental situations and is considered stable and perfect genotypes.

In this study, the parents VRO-4, IC052302 along with hybrids IC058710 x IC052321, VRO-4 x IC052321, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x IC052321, Hisar Naveen x Kashi Pragati, Hisar Naveen x IC052321and IC052302 x IC052321 exhibits low mean compared to grand mean with regression coefficient above unity, with minimum deviation from regression ($S^2di \sim 0$), demonstrating below average stability. These genotypes are particularly sensitive to changes in their environment and demonstrate a finely tuned adaptability to favourable environmental conditions.

Whereas, parents and hybrids IC058710, Pusa Sawani, Hisar Naveen, IC045993, IC052299, Salkeerthi, IC058235, IC052321 in parents and IC058710 x EC169452, IC058710 x Kashi Pragati, IC045993 x EC69459, VRO-4 x EC169452, VRO-4 x IC052310, VRO-4 x Kashi Pragati, IC052299 x Kashi Pragati, Hisar Naveen x IC052310, IC052302 x EC169452, IC052302 x EC69459 and IC052302 x Kashi Pragati in crosses exhibited low mean compared to grand mean paired with regression coefficient below the unity with minimal deviation from regression, can we credited for the enhanced resilience due to good stability. Likewise, Jindal *et al*., (2008) and Vekaraya *et al*., (2022) found varied responses of genotypes with respect to stability parameters for first fruiting node in okra.

#### 4.8.2.3 Days to first flowering

In this study Pusa Sawani in parents and VRO-4 x Kashi Pragati in crosses carried low mean compared to grand mean, regression coefficient *i.e*., (bi=1), and minimal degree from regression suggesting that they were stable and ideal. These genotypes consistently perform well across diverse environmental conditions, showing minimal variation in their performance.

The hybrids Salekeerthi x EC169459, IC058235 x EC169459 and IC052302 x Kashi Pragati carried greater mean compared to grand mean, regression coefficient close to unity *i.e.*, (bi=1), and minimal degree from regression indicate that they were stable but not ideal. This suggests that these hybrids, while potentially advantageous in some traits or under certain conditions, do not exhibit superior overall performance compared to the average.

Among parents and hybrids IC052299, Hisar Naveen in parents and IC058710 x Kashi Pragati, Pusa Sawani x IC052310, Pusa Sawani x IC052321, VRO-4 x EC169452, VRO-4 x EC169459, IC052299 x IC052310, IC052299 x EC169459, IC052299 x Kashi Pragati, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x Kashi Pragati, Salkeerthi x IC052321, IC058235 x EC169452, IC058235 x Kashi Pragati, Hisar Naveen x IC052321, IC052302 x EC169452, IC052302 x IC052310 in crosses exhibited low mean compared to grand mean paired with regression coefficient above the unity (bi>1) with minimal degree from regression ($S^2$di~0), demonstrating below average stability, these genotypes exhibit inconsistent performance across environments, showing greater sensitivity to environmental variations.

In contrast, parents and crosses VRO-4, Kashi Kranthi, IC058235, IC052302, Kashi Pragathi in parents and in crosses IC045993, and in crosses IC045993 x Kashi Pragathi, IC045993 x IC052321, Pusa Swami x Kashi Pragathi recorded low mean compared to grand mean paired with regression coefficient less than unity with minimal degree from regression ($S^2$di~0), demonstrating above average stability. These genotypes exhibit consistent and reliable performance across a diverse range of environmental condition and characterized by their ability to maintain high levels of productivity regardless of variations. Similar results recorded for days to first flowering in okra Kumar *et al*., (2018) and by Fayaz *et al*., (2022).

#### 4.8.2.4 Days to 50% first flowering

In parents none of them identified as ideally stable. However, the crosses IC045993 x Kashi Pragati, IC052299 x EC169452, IC052299 x IC052310, Kashi Kranti x EC169459 and Kashi Kranti x IC052321 had regression coefficient (bi) values close to unity with small deviation from regression suggesting that they were ideal and stable, this indicates that these hybrids are both ideal and stable, reliably performing well across various environments with minimal performance variation.

While parents and crosses involving Kashi Kranti as one of the parents, along with crosses IC058235 x IC052310, IC058235 x EC169459, IC052299 x EC169452, IC058235 x Kashi Pragati, and IC052302 x IC052321, recorded higher mean value, regression coefficient close to unity, and minimal degree from regression revealed stable but not ideal stability. This indicates that these hybrids, although potentially beneficial in certain traits or under specific conditions, do not demonstrate superior overall performance compared to the mean performance.

Among parents and hybrids IC052299, Hisar Naveen, IC052302 in parents and IC058710 x Kashi Pragati, Pusa Sawani x EC169452, Pusa Sawani x IC052310, Pusa Sawani x Kashi Pragati, Pusa Sawani x IC052321, VRO-4 x EC169459, IC058235 x EC169452 in crosses exhibited low mean compared to grand mean paired with regression coefficient above unity (bi>1) with minimal degree from regression ($S^2$di~0), demonstrating below average stability and sensitive to environmental changes. Theses genotypes may pose challenges in achieving consistent performance across different environmental conditions, their limited adaptability and susceptibility to fluctuations.

The parents and crosses IC045993, Pusa Swani, VRO-4, EC169459, Kashi Pragati, in parents and, IC058710 x IC052321, IC045993 x EC169452, IC045993 x EC169459, VRO-4 x Kashi Pragati, IC052299 x EC169459, IC052299 x Kashi Pragati, Salkeerthi x EC169459, Salkeerthi x Kashi Pragati, Hisar Naveen x EC169459, IC052302 x EC169452 in crosses recorded low mean compared to grand mean paired with regression coefficient is below the unity (bi<1) with minimal degree from regression ($S^2$di~0), which is a direct results of the above average stability in varying climatic conditions. Similar findings recorded by Ariyo *et al*., (1990) and Kumar *et al*., (2018).

#### 4.8.2.5 Days to first fruit harvest

In this study parents and hybrids, none of the parent were recorded ideal stable, however in cross combinations IC058710 x EC169459, IC052302 x EC169452 carried low mean compared to grand mean, regression coefficient close to unity *i.e*., (bi=1), and minimal degree from regression *i.e*., ($S^2$di~0), suggesting that they were indicated fair and ideal stability. These genotypes consistently perform well across various environments, showing minimal fluctuations in their performance.

While in parents and hybrids none of the parent recorded stable but not ideal and in crosses IC045993 x EC169452, Kashi Kranti x IC052321 carried greater mean compared to grand mean, regression coefficient close to unity and minimal degree from regression suggesting that they were stable, not perfect, t these hybrids, while potentially advantageous in some traits or under certain conditions, do not exhibit superior overall performance compared to the mean.

Among parents and hybrids VRO-4, IC052299 in parents and in crosses Pusa Sawani x IC052310, VRO-4 x EC169459, IC052299 x EC169459, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Salkeerthi x Kashi Pragati, Hisar Naveen x IC052321, IC052302 x IC052310, IC058235 x EC169452 exhibited low mean compared to grand mean paired with high regression coefficient above the unity (bi>1) with minimal deviation from regression ($S^2$di~0), which contributes to lower yields partly due to their below average stability when faced with climatic variations.

In contrast, both parents and crosses, including IC058710, Pusa Sawani, Hisar Naveen, and EC169459 among parents, and VRO-4 x EC169459, IC058710 x Kashi Pragati, IC045993 x EC169459, IC045993 x Kashi Pragati, VRO-4 x EC169452, VRO-4 x IC052310 and VRO-4 x Kashi Pragati in hybrids exhibited low mean compared to grand mean paired with regression coefficient less than unity regression coefficient lower then unity with insignificant degree from regression ($S^2$di~0), which results in consistent performance due to above average stability across multiple environments. Likewise results observed in okra by Jindal *et al*., (2008), Fayaz *et al*., (2022) and Patel *et al*., (2023).

**4.8.2.6 Plant height**

Whereas, parents and crosses VRO-4 and Kashi Kranti x Kashi Pragati respectively recorded high mean with regression coefficient (bi) values close to unity with small deviation from regression ($S^2$di~0) suggesting that they were ideal and stable. Those genotypes exhibit minimal variation in their performance, demonstrating resilience to environmental fluctuations and stresses.

In this study parent Salkeerthi carried low mean compared to grand mean, regression coefficient close to unity, and minimal degree from regression suggesting that they were indicated stability but not ideal.

Among the parents and hybrids IC052299 in parents and IC058710 x EC169459, IC058710 x Kashi Pragati, IC045993 x EC169452, IC045993 x Kashi Pragati, IC045993 x IC052321, VRO-4 x IC052310, VRO-4 x IC052321, IC052299 x EC169459, IC052299 x Kashi Pragati, IC052299 x EC169459, Salkeerthi x Kashi Pragati, Salkeerthi x IC052321, IC052299 x Kashi Pragati, IC058235 x IC052310, IC058235 x EC169459, IC052302 x Kashi

Pragati and IC052302 x IC052321 recorded higher mean coupled with higher regression coefficient above the unity and minute degree from regression recorded below average stability. Those genotype performance varies significantly across different environments.

While parents and crosses IC045993, Pusa Swani, Kashi Kranti, IC058235, Kashi Pragati and IC058710 x EC169452, IC058710 x IC052310, IC045993 x EC169459, Pusa Sawani x EC169452, Pusa Sawani x Kashi Pragati, Pusa Sawani x IC052321, VRO-4 x EC169452, Salkeerthi x EC169459 and Hisar Naveen x Kashi Pragati in cross combinations recorded higher mean value along regression coefficient lower than unity and a small deviation from regression suggesting above average stability. These genotypes consistently demonstrate remarkably stable performance across diverse environmental conditions. Similarly, Dabhi (2010), Hamid and Hafez (2012), and Manubhai (2017) found varied responses of genotypes with respect to stability parameters for plant height in okra.

**4.8.2.7 Number of branches/plants**

In this study none of the parent were recorded ideal stable and however in crosses IC052299 x IC052321 had minimal deviation from regression ($S^2di$~0), regression close to unity (bi=1) with a higher mean compared general mean, suggesting ideal and stable, these cross exhibits minimal variation in their performance, which is attributed to less fluctuations due to external factors.

While in parents and crosses Pusa Sawani in parents and IC052299 x IC052310, Hisar Naveen x IC052321and IC052302 x Kashi Pragati in crosses carried low mean compared to grand mean, regression coefficient *i.e.*, (bi=1), and minimal D.F.R *i.e.*, ($S^2di$~0), suggesting that they were indicated stable but not ideal.

Among parents and hybrids IC058710, IC045993, Kashi Kranti, IC058235, Hisar Naveen, IC052302, EC169452 in parents and IC058710 x EC169459, IC045993 x IC052310, VRO-4 x IC052321, IC052299 x Kashi Pragati, Salkeerthi x EC169452, IC058235 x IC052310, Salkeerthi x IC052321, IC058235 x EC169452, Hisar Naveen x Kashi Pragati in crosses recorded higher mean coupled with high regression coefficient i.e., (bi>1) and minimal deviation from regression recorded below average stability. Thes genotypes may pose challenges in achieving consistent performance across different environmental conditions.

Whereas the parents and crosses, none of the parent recorded above average stability and in crosses IC045993 x Kashi Pragati, IC045993 x IC052321, Pusa Sawani x EC169452, Pusa Sawani x IC052310, Pusa Sawani x EC169459, Pusa Sawani x Kashi Pragati, Pusa

Sawani x IC052321, IC052299 x EC169452, IC052299 x EC169459, Kashi Kranti x EC169452, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x EC169459, IC058235 x EC169459, IC058235 x IC052321 recorded higher mean value alongside regression coefficient lower than unity (bi<1) and a small D.F.R ($S^2$di~0), resulting enhance performance due to above average stability across multiple environments. Jijabrao (2015) and Manubhai (2017) found varied responses of genotypes with respect to stability parameters for the number of branches per plant in okra.

#### 4.8.2.8 Internodal length

Whereas none of the parent and crosses recorded ideal stable. However, among them, Kashi Kranti in parents and IC052299 x IC052310 in crosses carried low mean compared to grand mean, regression coefficient close to unity and minimal deviation from regression suggesting that they were indicated stable but not ideal suggesting, these genotypes exhibit minimal variation in their performance, demonstrating resilience to environmental fluctuations and stresses.

Among parents none of the parent recorded above average stability and in cross combinations IC045993 x EC169459, IC045993 x IC052321, Pusa Sawani x EC169459, Pusa Sawani x IC052321, IC052299 x EC169459, IC052299 x IC0169459, Kashi Kranti x EC169452, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x EC169452, Salkeerthi x IC052310, Hisar Naveen x EC169452 and Hisar Naveen x IC052310 recorded higher mean coupled with high regression coefficient i.e., (bi>1) and small degree from regression recorded below average stability. This contributes to the inconsistent performance of these genotypes under changing environmental conditions.

In contrast, parents and crosses IC045993, Pusa Sawani, VRO-4, IC052299, IC058235, Hisar Naveen, EC169459, IC052302 and IC052321 in parents and IC045993 x IC052310, IC052299 x Kashi Pragati, Salkeerthi x Kashi Pragati, IC058235 x IC052310, IC052302 x Kashi Pragati and Hisar Naveen x Kashi Pragati in crosses recorded higher mean value along regression coefficient lower than unity (bi<1) and a small deviation from regression suggesting above average stability. These genotypes exhibit consistent and reliable performance across a diverse range of environmental condition and characterized by their ability to maintain high levels of productivity regardless of variations. Similarly varied responses of genotypes with parameters for internodal length in okra by Dabhi *et al*., (2010), Javia *et al*., (2014), Vekariya *et al*., (2019) and Patel *et al*., (2023).

### 4.8.2.9 Number of nodes per plant

Whereas, none of the parent and crosses recorded ideal stable. While in crosses IC052302 x IC052310 carried low mean compared to grand mean, regression close to unity and minimal deviation from regression i.e., ($S^2$di~0), suggesting they were indicated stable but not ideal. Stable but not ideal suggests that while these hybrids perform consistently across all environments, their overall performance does not exceed the mean performance.

Among parents and hybrids IC045993, IC052299, Kashi Kranti, IC058235, Hisar Naveen, IC052302 in parents and IC045993 x EC169452, Pusa Sawani x Kashi Pragati, VRO-4 x EC169459, VRO-4 x IC052321 and Kashi Kranti x IC05231 in crosses recorded higher mean coupled with high regression coefficient *i.e.*, (bi>1) and minimum D.F.R *i.e.*, ($S^2$di~0) recorded below average stability, which leads to poor resilience of these genotypes across different environments.

Among parents and hybrids Pusa Sawani, VRO-4 in parents and IC045993 x EC169459, Pusa Sawani x EC169452, Pusa Sawani x EC169459, VRO-4 x EC169452, IC052299 x EC169452, IC052299 x EC169459, IC052299 x Kashi Pragati, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x EC169452, IC052302 x EC169452 cross combinations recorded higher mean value along with regression coefficient lower than unity and a small deviation from regression suggesting above average stability. These genotypes show enhanced resistance to environmental fluctuations, thereby boosting their ability to adapt specifically to low-yielding environments. Similar findings are also reported by Jijabrao (2015) and Manubhai (2017).

### 4.8.2.10 Fruit length

Among parents and hybrids, EC169459 in parents and none of the cross recorded high mean, unity regression coefficient (bi=1) and minimum deviation from regression ($S^2$di~0) indicate ideal and stable, these genotypes exhibit minimal variation in their performance, demonstrating resilience to environmental fluctuations and stresses.

Whereas, parents and hybrids IC058710, IC045993, Pusa Sawani, VRO-4, IC052299, Kashi Kranti, IC058235, Hisar Naveen, IC052321 in parents and Pusa Sawani x IC052310, VRO-4 x IC052310, Kashi Kranti x Kashi Pragati, Salkeerthi x EC169459, IC052302 x IC052310, IC052302 x Kashi Pragati in crosses recorded higher mean coupled with high regression coefficient *i.e.,* (bi>1) and small deviation *i.e.,* ($S^2$di~0) indicated below average stability, those genotype performance varies significantly across multiple environments.

Among the Parents and crosses Salkeerthi in parents and IC045993 x EC169459, IC045993 x Kashi Pragati, Pusa Sawani x EC169452, Pusa Sawani x Kashi Pragati, VRO-4 x EC169452, VRO-4 x EC169459, VRO-4 x Kashi Pragati, VRO-4 x IC052321, IC052299 x IC052310, IC052299 x EC169459, IC052299 x IC052321, Kashi Kranti x EC169459,Kashi Kranti x IC052321, Salkeerthi x IC052310, Salkeerthi x Kashi Pragati, IC058235 x EC169452, IC058235 x IC052321, Hisar Naveen x EC169452, and Hisar Naveen x IC052321 in cross combinations recorded higher mean value along regression coefficient lower than unity (bi<1) and a small D.F.R ($S^2di$~0), which is a direct results of the above average stability in varying climatic conditions. Those genotypes consistently perform well across different environmental conditions with minimal variation in their performance. These findings agree with those of Senthilkumar (2011), Javia, (2014) and Jijabrao (2015) and Patil *et al.*, (2017).

### 4.8.2.11 Fruit diameter

In parents and hybrids none of the parent and crosses recorded ideal stabile. While in hybrids IC045993 x IC052321 carried regression coefficient close to unity *i.e.*, (bi=1), low mean compared to grand mean, and minimal deviation from regression suggesting that they were indicate stable but not ideal, it conveys that while these hybrids exhibit steady performance in various conditions, their overall outcomes do not exceed the average.

Among parents and hybrids none of the parent recorded below average stability and in crosses IC058710 x EC169452, Pusa Sawani x IC052321, VRO-4 x IC052310, VRO-4 x EC169459, VRO-4 x Kashi Pragati, VRO-4 x IC052321, IC052299 x IC052310, IC052299 x EC169459, Salkeerthi x Kashi Pragati, IC058235 x EC169459, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Salkeerthi x Kashi Pragati, IC058235 x EC169459 had higher mean coupled with higher regression coefficient *i.e.*, (bi>1) and minimum deviations from regression *i.e.*, ($S^2di$~0) indicated below average stability. Theses genotypes may pose challenges in achieving consistent performance across different environmental conditions, their limited adaptability and susceptibility to fluctuations.

Inn this study parents IC045993, VRO-4, IC052299, Hisar Naveen, IC052310, IC052321 and while in cross combinations IC058710 x EC169459, IC045993 x Kashi Pragati, VRO-4 x EC169452, Kashi Kranti x IC052310, Salkeerthi x EC169459, IC058235 x Kashi Pragati combinations recorded higher mean value alongside regression coefficient lower than unity (bi<1) and a small D.F.R ($S^2di$~0) indicate above average stability, these genotypes demonstrated a higher resistance to environmental changes, enhancing their adaptability specifically to low-yield environments. Similar results recorded by Vekariya *et al*., (2019) and Zate *et al*., (2020).

**4.8.2.12 Number of ridges**

Among parents and hybrids none of the parent and crosses recorded ideal stable. While parents and hybrids, VRO-4 in parents and IC058710 x IC052321, IC045993 x EC169452, IC045993 x EC169459, VRO-4 x EC169459, VRO-4 x Kashi Pragati, Pusa Sawani x EC169459, VRO-4 x IC052321, IC052299 x IC052310,IC045993 x IC052321, Kashi Kranti x IC052310, IC052299 x EC169459, IC052299 x Kashi Pragati, IC052299 x IC052321, Kashi Kranti x EC169452, Kashi Kranti x IC052321, Salkeerthi x Kashi Pragati, IC058235 x Kashi Pragati in crosses recorded higher mean coupled with higher regression coefficient i.e., (bi>1) and small deviation ($S^2$di~0) indicated below average stability, in this genotypes exhibit unstable performance across environments, showing greater sensitivity to environmental variations.

Among the parents and crosses, IC058710, Salkeerthi, Hisar Naveen, IC052302, EC169459 in parents and in crosses IC045993 x Kashi Pragati, IC045993 x Kashi Pragati, Salkeerthi x EC169459, IC058235 x EC169459, Kashi Kranti x Kashi Pragati, Hisar Naveen x EC169459, Hisar Naveen x Kashi Pragati higher mean value along regression coefficient lower than unity (bi<1) and a small deviation from regression suggesting above average stability. Similar results recorded by Prakash *et al*., (2017) and Manubhai *et al*., (2020) and Fayaz *et al*., (2022).

**4.8.2.13 Number of fruits per plant**

Among parents and hybrids, IC052299 in parents and Kashi Kranti x EC169459 in crosses recorded minimal deviation from regression ($S^2$di~0), regression coefficient (bi=1) with a higher mean compared general mean, suggesting ideal and stable, this genotype maintains relatively consistent yields or trait expression across different environments over time.

Cross combination IC058710 x Kashi Pragati carried regression coefficient close to unity, low mean compared to grand mean, and minimal deviation *i.e*., ($S^2$di~0), suggesting that they were indicated fair and stabile but not ideal.

In parents and hybrids IC045993, Pusa Sawani, VRO-4, Kashi Kranti, IC058235 in parents and IC058710 x IC052321, IC045993 x EC169452, IC045993 x EC169459, IC045993 x IC052321, Pusa Sawani x EC169459, VRO-4 x EC169459, VRO-4 x IC052321,IC052299 x

IC052310, IC052299 x EC169459, Kashi Kranti x EC169452, Kashi Kranti x IC052310, Kashi Kranti x IC052321, Salkeerthi x EC169452, Salkeerthi x Kashi Pragati, IC058235 x Kashi Pragati, IC058235 x Kashi Pragati and IC058235 x IC052321 in crosses had higher mean coupled with higher regression coefficient *i.e.*, (bi>1) and minute D.F.R *i.e.*, ($S^2$di~0) indicated below average stability, this genotypes are higher sensitivity to environmental changes and greater specificity of adaptability to favourable environment condition.

Among the Parents IC058710, Salkeerthi, Hisar Naveen, IC052302 and in crosses IC045993 x EC169452, IC045993 x IC052310, IC045993 x Kashi Pragati, IC052299 x EC169452, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Salkeerthi x EC169459, IC058235 x EC169459 in hybrids recorded higher mean value along with regression coefficient lower than unity (bi<1) and a small D.F.R ($S^2$di~0) suggesting above average stability. these genotypes provide a measurement of greater resistance to environmental change and thus increases the specificity of adaptability to low yielding environment. Ariyo (1990), Jindal *et al*. (2009) and Manubhai *et al*., (2020) found varied responses of genotypes with respect to stability parameters for number of fruits per plant in okra.

#### 4.8.2.14 Number of marketable fruits

In this study none of the parent and crosses recorded ideal stable. However, the IC058710 x EC169452 cross carried low mean compared to grand mean, R.C i.e., (bi=1), and minimal deviation from regression, suggesting that they were indicated stable but not ideal.

Among parents and hybrids IC045993, VRO-4, Kashi Kranti, IC058235, IC052302 in parents and IC058710 x IC052321, IC045993 x EC169459, Pusa Sawani x EC169459, VRO-4 x EC169459, VRO-4 x IC052321, IC052299 x EC169459, IC052299 X Kashi Pragati, Kashi Kranti x EC169452, Kashi Kranti x IC052321, IC058235 x Kashi Pragati, IC058235 x IC052321 and Hisar Naveen x Kashi Pragati in crosses recorded higher mean coupled with higher regression coefficient *i.e.*, (bi>1) and small deviation *i.e.*, ($S^2$di~0) recorded below average stability, in this genotypes exhibit unstable performance across environments, showing greater sensitivity to environmental variations

Whereas, IC058710, Pusa Sawani, IC052299, Salkeerthi, Hisar Naveen in parents and IC045993 x Kashi Pragati, IC045993 x Kashi Pragati, IC045993 x IC052321, Kashi Kranti x IC052310, Kashi Kranti x EC169459, Kashi Kranti x Kashi Pragati, Salkeerthi x EC169459 and IC058235 x EC169459, Hisar Naveen x EC169459 in cross combinations recorded a minute deviation from regression ($S^2$di~0), higher mean value with regression coefficient lower than unity (bi<1) and suggesting above average stability, in this genotypes consistent performance across various environments ensures reliable yields, reduces risks, and enhances adaptability to changing conditions by minimizing the impact of environmental stresses, likewise results observed previously by Jindal *et al*., (2008), Manubhai *et al*., (2020) and Sanwal *et al*., (2021)

**4.8.2.15 Average fruit weight**

In this study none of the parent and crosses recorded ideal stable. However, among the parents, IC045993, VRO-4, IC058235 and IC058710 x Kashi Pragati, IC045993 x EC169459, Pusa Sawani x EC169459, Pusa Sawani x IC052321, VRO-4 x EC16945, VRO-4 x Kashi Pragati, IC052299 X Kashi Pragati, Kashi Kranti x EC169452, Kashi Kranti x EC169459, Salkeerthi x IC052321, IC058235 x EC169452, IC058235 x Kashi Pragati, IC052302 x Kashi Pragati, IC058235 x IC052321 and IC052302 x IC052321 in cross combinations had higher mean coupled with higher regression coefficient *i.e*., (bi>1) and minute deviation indicated below average stability, in this genotypes with below-average stability exhibit inconsistent performance across environments, showing greater sensitivity to environmental variations.

Among the Parents and crosses, , IC058710, Pusa Swani, Salkeerthi, Kashi Kranti, Kashi Pragati in parents and IC058710 x EC169459, Pusa Sawani x Kashi Pragati, VRO-4 x IC052321, Kashi Kranti x Kashi Pragati, Salkeerthi x IC025310, Salkeerthi x EC169459, Hisar Naveen x EC169459 IC052299 x IC052321, IC052302 x IC052310, and Hisar Naveen x Kashi Pragati in crosses recorded higher mean value alongside regression coefficient lower than unity (bi<1) and a small deviation from regression ($S^2di\sim0$) suggesting above average stability, these genotypes provides they offer increased resilience to environmental fluctuations, improving their ability to adapt to low-productivity environments. Similar varied responses of genotypes with respect to stability parameters of average fruit weight by Verkairya *et al*., (2019) and Zate *et al*., (2022).

**4.8.2.16 Number of pickings per plant**

The parents IC058710 had minimal degree from regression, regression coefficient (bi=1) with a higher mean compared general mean, suggesting ideal and fair stability those, genotypes relatively consistent performance across different environments, seasons, and management practices.

Among parents and hybrids, IC045993, Pusa Sawani, VRO-4, Salkeerthi, Hisar Naveen in parents and in crosses IC058710 x IC052310, IC045993 x EC169459, IC058710 x EC169459, IC045993 x IC052310, IC045993 x EC169459, IC045993 x Kashi Pragati, Pusa

Sawani x IC052310, Pusa Sawani x EC169459, VRO-4 x EC169459, VRO-4 x Kashi Pragati, VRO-4 x IC052321, Kashi Kranti x ICEC169459, IC058235 x EC169459, IC052299 x IC052310, IC052299 x EC169459, Kashi Kranti x EC169452, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, Salkeerthi x IC052310, Salkeerthi x EC169459, Hisar Naveen x EC169459 and Hisar Naveen x Kashi Pragati had higher mean coupled with greater value of regression coefficient (bi>1) and small deviation from regression ($S^2$di~0) indicated below average stability, in those genotypes with below-average stability exhibit unstable performance across environments.

Whereas, parents and crosses IC052299, Kashi Kranti, IC058235 in parents and in crosses IC058710 x IC052321, Kashi Kranti x IC052310, Salkeerthi x EC169452 and Salkeerthi x Kashi Pragati recorded higher mean value along with regression coefficient lower than unity (bi<1) and a small deviation from regression ($S^2$di~0) suggesting above average stability. In average stability provide a measurement of greater resistance to environmental change, thereby enhancing their specificity of adaptability to unfavourable conditions.

#### 4.8.2.17 Fruit yield per plant

Among parents and hybrids IC058235 and Pusa Sawani x EC169459 respectively had higher mean compared to general mean, unit regression coefficient (bi=1) and minimum deviation from regression ($S^2$di~0) indicate suggesting ideal and fair stable, these genotypes exhibiting stable consistently perform well across diverse environments with minimal variation in their performance

Whereas, parents and hybrids IC045993, VRO-4, Kashi Kranti, Hisar Naveen in parents and IC058710 x Kashi Pragati, Pusa Sawani x Kashi Pragati, IC045993 x Kashi Pragati, VRO-4 x EC169459, VRO-4 x Kashi Pragati, VRO-4 x IC052321, IC052299 x EC169459, IC052299 x EC169459, IC052299 x Kashi Pragati, IC058235 x Kashi Pragati, Kashi Kranti x EC169452 and Kashi Kranti x EC169459 in crosses recorded higher mean coupled with higher than unity regression coefficient *i.e.*, (bi>1) and small deviation from regression i.e., ($S^2$di~0) indicated below average stability. In those genotypes with below-average stability exhibit inconsistent performance across environments. They may perform well under certain conditions but poorly under others, showing greater sensitivity to environmental variations.

In contrast, parents and crosses IC058710, Pusa Sawani, IC052299 in parents IC058710 x EC169459, IC052299 x IC052321, Kashi Kranti x IC052310, Kashi Kranti x Kashi Pragati, Kashi Kranti x IC052321, IC045993 x EC169459, IC058235 x EC169459, IC058235 x

EC169459, Hisar Naveen x Kashi Pragati, IC058235 x IC052321, IC052302 x Kashi Pragati, Salekerthi x EC169459, Salekerthi x Kashi Pragati, Salekerthi x IC05232, Hisar Naveen x Kashi Pragati, IC052302 x Kashi Pragati and Hisar Naveen x EC169459 in hybrids recorded higher mean value with regression coefficient lower than unity (bi<1) and a small degree from regression ($S^2$di~0) suggesting above average stability. Genotypes with above-average stability consistently perform well across a wide range of environments. They demonstrate minimal genotype × environment interaction, meaning their performance remains relatively consistent to environmental variation. Likewise results for fruit yield previously reported by various studies *viz.*, Jindal *et al*., (2008), Dabhi *et al*., (2010), Javia *et al*., (2014), Jiabao (2015), Patil *et al*., (2017), Manubhai *et al*., (2020), and Rang *et al*., (2023) in okra.

**Table 78. Eberhart and Russel stable genotypes among the parents and hybrids**

| Characters | Parents | Crosses |
|---|---|---|
| First flowering node | - | VRO-4 x IC052310, IC052302 x IC052310 and IC052302 x EC169459 |
| Frist fruiting node | - | IC058235 x Kashi Pragati, Hisar Naveen x Kashi Pragati |
| Days to first flowering | Pusa Sawani | VRO-4 x Kashi Pragati |
| Days to 50% flowering | - | IC045993 x Kashi Pragati, IC052299 x EC169452, IC052299 x IC052310, Kashi Kranti x EC169459 and Kashi Kranti x IC052321 |
| Days to first fruit harvest | | IC058710 x EC169459, IC052302 x EC169452 |
| Plant height (cm) | VRO-4 | Kasi Kranthi x Kashi Pragati |
| Internodal length (cm) | - | - |
| Number of branches per plant | - | - |
| Number of nodes per plant | - | - |
| Fruit length (cm) | EC169459 | - |
| Fruit diameter (mm) | - | - |
| No .of ridges per fruit | - | - |
| Number of fruits per plant | IC052299 | Kasi Kranti x EC169459 |
| Number of marketable fruits /plant | - | - |
| Average fruit weight (g) | Pusa Sawani | - |
| Number of pickings per plant | IC058710 | IC058235 x EC169459 |
| Fruit yield per plant (g) | IC058235 | Pusa Sawani x EC169459 |

## IV. CHARACTERIZATION OF GENOTYPES BASED ON MORPHOLOGICAL DESCRIPTOR

The characterization of germplasm provides information on the characteristics possessed by each genotype, ensuring maximal use of the germplasm collection by end users. Morphological characters are the oldest and most used genetic markers and they may still be appropriate for certain germplasm management applications. Morphological characterization is the initial stage in the description, classification and arrangement of germplasm collections. Plant characterization identifies unique accessions required by gene bank curators and plant breeders. Landraces, germplasms, genotypes and local cultivars must be morphologically characterized by vegetable breeders seeking novel trait genes. The characterization of genetic resources is the means of selecting, differentiating, or distinguishing accessions depending on their character or quality (traits). Qualitative trait characterization of newly collected germplasm is necessary for crop improvement. It also gives information on genetic diversity for agricultural development, use of plant genetic resources and conservation.

The genotypes of okra characterized upon 10 qualitative characters in this study and showed broad variation for most qualitative traits which allows for the identification of promising lines of okra. In this study conducted 55 genotypes in variability study and 65 genotypes for stability analysis (15 parents and 50 hybrids)

### 5.9 Characterization of okra parents and their hybrids based on morphology

#### 5.9.1 Leaf characters:

In the study, majority of genotypes for variability and stability (Parent & Hybrid) analysis exhibited a shallow depth leaf lobing. Deeply lobed leaf trait includes deeply clefts with less surface area per leaf, shallow leaf lobing refers to leaves with indentations or lobes that are not deeply incised into the leaf surface and narrowly lobed leaf traits include narrowly clefts with greater surface area per leaf. Leaf lobing depth affects both photosynthesis and insect load. These findings are consistent with a previous study by Singh *et al*. in (2015).

#### 5.9.2 Colouring of various plant parts:

In the present study, variation was expressed in all colour traits studied. The pigmentation of the vegetative (stem and leaf) and reproductive (flower and fruit) organs is remarkably diverse in this study. The pigmentation of the stems, flowers and fruits of the plants in the research was studied. In the variability and stability analysis among parent and hybrid genotypes, the majority exhibited a stem colour that was predominantly green with a purple tinge. Similar results for stem colour previously by Saifullah *et al*., (2009) and Teaman *et al*., (2022).

In the variability study, the majority of genotypes exhibited petals that were predominantly yellow in colour, in the stability i.e. parent and hybrid study, the majority of genotypes displayed petals that were predominantly cream in colour. Similar kind of results for petal colour by Oppong-Sekyere *et al*., 2011and Kaur *et al*., (2023). In this present investigation among selected 15 (stability) parent genotypes and in variability study the majority of mature fruits were characterized by a dark-green colour and in hybrids, the predominant colour observed for mature fruits was green colour. Oppong-Sekyere *et al*., (2011) and Mohammed *et al*., (2017).

Colour traits in okra include vegetative and reproductive structures. These colour features indicate pigmentation in the genotypes' organs. identified qualitative colour features that are seldom changed by environmental conditions. Due to colour variances, colour attributes are difficult to quantify, even in a homogenous accession colour combinations are frequent in okra, with the green or red background being impacted by other colours. Due to the complexity of pigmentation genetics, it is rare to discover a perfectly homogenous accession.

**5.9.3 Pubescence (hairiness/spininess) of fruit:**

In the study, the majority of genotypes analyzed for variability and stability, both among parent and hybrid genotypes, exhibited fruit pubescence was slightly rough in texture. The study also found that environmental factors, as well as the age of the fruit, influenced the degree of hairiness on the fruit surface, fruit pubescence helped reduce pest attachment. Likewise, results for fruit pubescence observed by Saleem *et al*., (2018) and Teaman *et al*., (2021).

**5.9.4 Fruit characterization**

In the study, fruit characteristics like surface between ridges, fruit axis, shape of apex and constriction of basal part expressed large diversity in parents and crosses. The fruit surface between the ridges and fruit axis majority of genotypes for variability and stability (Parent & Hybrid) analysis exhibited flat surface and straight respectively. In this study, fruit shape of apex narrow acute recorded for variability and stability (Parent & Hybrid) analysis. Fruit characteristics provides valuable insights into fruit quality, disease resistance, yield potential, post-harvest handling, and consumer preferences. Similar kind of fruit observations recoded by Teaman *et al*., (2021) and Pallakki *et al*., (2022).

### 5.9.5 Plant habitat and Seed colour

Plant habit the majority of genotypes analyzed for variability and stability, both among parent and hybrid genotypes, exhibited erect type. Plant habit can affect pest and disease susceptibility. Erect plants may be less prone to certain soil-borne diseases due to better air circulation and reduced contact with soil. Similar kind of results observed by Saifullah *et al*., (2009), Binalfew *et al*., (2016) and Teaman *et al*., (2021).

For seed shape majority of majority of genotypes for variability and stability (Parent & Hybrid) analysis exhibited a round shape. Seed shape traits provides insights into the adaptation of crops to different environmental conditions. Certain seed shapes may confer advantages in specific climates or soil types, and quantitative assessment helps identify genotypes with optimal seed shapes for different growing environments. Saifullah *et al*., (2009) also observed comparable outcomes for seed shape.

## 5.10 FORWARD-LOOKING VISION OF RESEARCH

**5.10.1 Genetic Improvement through Hybrid Breeding:** The goal of hybrid breeding in okra is to produce superior varieties with enhanced yield potential. By utilizing heterosis, breeders aim to create hybrids that outperform traditional open-pollinated varieties in terms of yield, size, and uniformity. Future breeding programs must also address climate resilience, focusing on developing hybrids capable of withstanding abiotic stresses such as drought, heat, and salinity. Additionally, okra's susceptibility to pests and diseases like yellow vein mosaic virus (YVMV) and jassids demands the integration of resistance genes through hybridization, facilitated by tools like marker-assisted selection (MAS).

**5.10.2 Advances in Breeding Tools and Practices:** Incorporating genomic selection (GS) using genome-wide markers can accelerate hybrid development by predicting the breeding value of lines and testers, reducing the time needed for field trials. Moreover, CRISPR-Cas9 and other gene-editing technologies provide opportunities to rapidly introduce desirable traits such as disease resistance or improved fruit quality. To maximize breeding efficiency, combining ability studies through line x tester mating design help identify the best parental lines for hybrid development. Sustainable breeding, focused on low-input hybrids and nutritional enhancement, and data-driven approaches using AI and phenotyping, are critical for future okra breeding. Public-private partnerships will ensure the large-scale testing and dissemination of these hybrids, driving the industry forward.

*CHAPTER - 6*

# SUMMARY& CONCLUSION

An investigation was carried out on “Study on Phenotypic characterization along with $F_1$ okra hybrid analysis for heterosis, combining ability and stability” to obtain first-hand information of fifty- five okra genotypes based on genetic variability, association, and genetic diversity analysis. Based on diversity analysis the parents were selected and crossed to estimate the extent of heterosis and combining ability by using a line x tester mating system involving ten lines and five testers. Parent and hybrids were found out the stable hybrid (s) upon the selected ones across three different environments (early, timely and late sowing). The experiments were carried out during 2021 to 2023. The experiment was conducted at experimental farm, Dept. of Genetics & Plant Breeding, School of Agriculture, Lovely Professional University, Phagwara, Kapurthala, Punjab. The salient features of the results of present study are summarized below.

1. The mean sum of squares according to genotypes were highly significant (P 0.05 and P 0.01) for all 17 characteristics in the analysis of variance, indicating that the material under consideration exhibited substantial genetic variability.
2. The results indicated that the phenotypic coefficient of variation (PCV) was marginally higher than the genotypic coefficient of variation (GCV) for all the traits suggests environmental have influence on traits.
3. The traits *viz*., the number of fruits per plant, number of marketable fruits per plant, and fruit yield per plant, had high magnitude of GCV, PCV and a high heritability (bs) coupled with a high genetic advance as % of the mean and were more effective in estimating the impact of selecting the best accession.
4. Using Mahalanobis $D^2$ analysis, classified the samples into seven clusters, with the largest being cluster I, which compose 34 germplasm. Only one germplasm was found in Clusters II, IV, V, VI, and VII. The inter-cluster distance was highest between clusters II and VII, whereas the intra-cluster distance was greatest in Cluster III.
5. The most important character contributing towards divergence was number of fruits per plant. Cluster V genotypes exhibited least mean value are desirable in these traits, such as the first flowering node, first fruiting node mean, days to first flowering and days to 50% flowering, days to first fruit harvest and high mean value desirable traits like

number of ridges per fruit, marketable fruits per plant, number of pickings mean value, and fruit yield per plant.

6. Based on the morphological diversity, a total of 15 (10 lines and 5 testers) parents were selected for the crossing in line x tester mating design. IC058710, IC045993, Pusa Swami, VRO-4, IC052299, Kashi Kranthi, Salekeerthi, IC058235, Hisar Naveen, and IC052302 are selected as lines. EC169452, IC025310, EC169459, Kashi Pragathi, IC052321 are selected as testers. From the 10 lines and 5 testers, the crossing programme was done to obtain 50 hybrids.
7. ANOVA illustrated that the mean sum of squares owing to treatments and crosses recorded significance (P 0.05 and P 0.01) for all the 17 characters. Positive general combining ability effects for fruit yield per plant were observed for Kashi Kranthi in lines and Kashi Pragati, EC169459 in the testers and in hybrids, positive specific combining ability were observed for IC052302 x EC169452, IC045993 x EC169452, IC045993 x IC052310, Pusa Swami x IC052310 in pooled analysis.
8. Based on heterosis (heterobeltoisis and standard heterosis) the cross IC058710 x EC169459, Kashi Kranthi x Kashi Pragathi and IC052302 x EC169452 resulted high fruit yield per plant along with other fruit related characters in pooled analysis. Hence, these hybrid combinations can be utilized for commercial exploitation.
9. Positive general combining ability effects for fruit yield per plant were observed for Kashi Kranthi in lines and Kashi Pragati, EC169459 in the testers and in hybrids, positive specific combining ability were observed for IC052302 x EC169452, IC045993 x EC169452, IC045993 x IC052310, Pusa Swami x IC052310 in pooled.
10. When comparison was made between combining ability and heterosis, it was observed that hybrids could be obtained from parents with any combinations of gca *i.e.*, high x low, low x low and may result in transgressive segregants due to the additive genetic system in the case of a good combiner and the complementing epistatic effect in the event of a poor combiner.
11. Combining ability analysis revealed that most of the traits studied, the variances for SCA were greater than GCA, this indicates that non-additive gene action plays a dominant role in the expression of these seventeen traits
12. Stability ANOVA illustrated that variations owning to genotypes among all traits were significant, stability analyses were carried out for the parents and hybrids *viz.*, IC058235, and Pusa Swami x EC169459 is the best hybrid in overall environments for fruit yield per plant.

## CONCLUSION

Based on the findings of the entire study, the cross between Kashi Kranti x Kashi Pragati are found to have higher mean performance, above average stable over environments, combining ability estimates better, and have a higher percentage of standard heterosis for the majority of the characters. As a result, these hybrid combinations can be used for commercial purposes. It is also clear that the high degree of non-additive gene action observed in the current study favours heterotic breeding.

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