Assessment of heterosis and combining ability studies on yield and quality parameters in Okra [*Abelmoschus esculentus* (L.) Moench]

Thesis Submitted for the Award of the Degree of

DOCTOR OF PHILOSOPHY

in

Horticulture -Vegetable Science

By

Mohita Srivastava
Registration Number: 12014551

Supervised by
Dr. Khushboo Kathayat
(22214)
Department of Horticulture
(Assistant Professor)
Lovely Professional University

Co-Supervised by
Dr. Talekar Nilesh Suryakant
(23498)
Department of Genetics and Plant Breeding
(Assistant Professor)
Lovely Professional University

LOVELY PROFESSIONAL UNIVVERSITY, PUNJAB
2024

<u>**DECLARATION**</u>

I, hereby declared that the presented work in the thesis entitled "Assessment of heterosis and combining ability studies on yield and quality parameters in Okra [*Abelmoschus esculentus* (L.) Moench]" in fulfilment of degree of **Doctor of Philosophy (Ph. D.) Horticulture (Vegetable Science)** is outcome of research work carried out by me under the supervision of Dr. Khushboo Kathayat, working as Assistant Professor in the Department of Horticulture, School of Agriculture of Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

(Signature of Scholar)

Name of the scholar: Mohita Srivastava

Registration No.: 12014551

Department/School: Horticulture, School of Agriculture

Lovely Professional University,

Punjab, India

CERTIFICATE - I

This is to certify that the work reported in the Ph.D. thesis entitled **"Assessment of heterosis and combining ability studies on yield and quality parameters in Okra [*Abelmoschus esculentus* (L.) Moench]"** submitted in fulfillment of the requirement for the award of degree of **Doctor of Philosophy (Ph.D.) Horticulture (Vegetable Science)** in the Department of Horticulture, is a research work carried out by Mohita Srivastava, 12014551 is a bonafide record of her original work carried out under our supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

(Signature of Supervisor) **(Signature of Co-supervisor)**

Name of Supervisor	Dr. Khushboo Kathayat	Name of Co-supervisor	Dr. Talekar Nilesh Suryakant
Designation	Assistant Professor	Designation	Assistant Professor
Department/School	Department of Horticulture School of Agriculture	Department/School	Department of Genetics and Plant Breeding School of Agriculture
University	Lovely Professional University	University	Lovely Professional University

CERTIFICATE-II

This is to certify that the work reported in the Ph.D. thesis entitled "**Assessment of heterosis and combining ability studies on yield and quality parameters in Okra [*Abelmoschus esculentus* (L.) Moench]"** submitted by **Mohita Srivastava (Registration No.12014551)** to Lovely Professional University, Phagwara in the partial fulfillment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY (Ph.D.)** in the discipline of **Horticulture (Vegetable Science)** has been approved by Advisory Committee after oral examination of the student in collaboration with an external examiner.

Chairperson, Advisory Committee
Department of Horticulture, Lovely Professional University.Phagwara-144411

External Examiner

Head
Department of Horticulture, **Lovely Professional University.Phagwara-144411**

Dean
School of Agriculture, **Lovely Professional University.Phagwara-144411**

ACKNOWLEGEMENT

I extend my profound gratitude to the Almighty for bestowing upon me the strength andresilience to embark on this academic journey.

I am thankful to the, Dean ***Dr. Ramesh Sadawarti*** *School of Agriculture,* ***Dr. Anis Ahmed Mirza****, Head of the department for their and the, for providing a conducive academic environment. Your leadership has fostered an atmosphere of learning and growth.*

I express my sincere thanks to my advisor, ***Dr. Khushboo Kathayat****, Assistant professor Department of Horticulture for your guidance, mentorship, and insightful feedback. Your expertise and encouragement have been instrumental in the development of this thesis and co-advisor,* ***Dr. Talekar Nilesh Suryakant****, Assistant professor, Departmentof Genetic and Plant breeding for your valuable contributions and collaborative spirit.*

To my parents, Father ***Mr. Kripadish Chandra Srivastava*** *and Mother* ***Mrs. Poonam Srivastava*** *& all family your unwavering support, sacrifices, and boundless love have been the driving force behind my accomplishments. I am truly grateful for the values you instilled in me and the encouragement that has shaped my path.*

I would like to acknowledge my respected faculties, Dr. Amit Kotiyal, Dr. Vishal Johar, Dr Deven Verma, Dr Ajay Kumar Pandav, Dr. Rajni Rajan and Prof. Jatinder Singh for their support and encouragement throughout this academic journey.

I would like to express my sincere thanks to ***Dr. Suhel Mahendi,*** *for statistical analysis of the data and also providing the tremendous support, clearing all the doubt and all possible help apart from this. I learned a lot from him.*

I would like to express my gratitude to my dynamic and wonderful my beautiful and ever ready department juniors Vinay Kumar Mashkey and Diskha Choudary for their inspiration, encouragement and co-operation at various aspects

My sincere thanks to all technical and non-technical staff of Department of Horticulture

*I extend my deepest gratitude to my beloved husband**, Mr. Amit Shakti** and my daughter **Navya Srivastava**. Their unwavering love, steadfast encouragement, and boundless patience have been my greatest support throughout this challenging yet rewarding journey. His belief in my abilities has been a constant motivator, and his understanding and my dedicated study sessions has made all the difference. Thank you for being my rock, my confidant, and my biggest cheerleader. This thesis is as much yours as it is mine, and I am profoundly grateful to have you by my side.*

Place: LPU, Phagwara **Mohita Srivastava**

Date:

CONTENTS

LIST OF TABLES

LIST OF FIGURES AND PLATES

ABBREVIATIONS USED AND THEIR EXPANDED FORM

Symbols or Abbreviation	**:**	**Expansion/ Stand for**
@	:	at the rate
&	:	and
ANOVA	:	analysis of variance
cm	:	Centimetre
cv.	:	cultivar
C.D.	:	Critical difference
℃	:	Degree Celsius
d.f.	:	Degrees of freedom
DAT	:	days after transplanting
et al.	:	et alia (and others)
e.g.	:	exempli gratia (for example)
GA	:	Genetic Advance
GCV	:	Genotypic coefficient of variation
g	:	gram
ha	:	hectare
HB	:	Heterbeltiosis
i.e.	:	id est (that is)
kg	:	kilogram
Fig.	:	Figure
Ma×.	:	Maximum
µg	:	microgram
Min.	:	Minimum
M.S.S.	:	Mean sum of squares
mg	:	milligram
mL	:	millilitre
MT	:	Metric Ton

%	:	per cent
PCV	:	Phenotypic coefficient of variation
No.	:	Number
Se_m ±	:	Standard error of mean
viz.,	:	videlicet (namely)
MPH	:	Mid parent heterosis

ABSTRACT

The present investigation entitled **"Assessment of heterosis and combining ability studies on yield and quality parameters in Okra [*Abelmoschus esculentus* (L.) Moench]"** by Line × Tester mating design was undertaken to investigate the extent of heterosis, combining ability, stability parameter. The field trial was conducted in the Vegetable Research Field, Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab. Fifteen germplasm of okra were collected from NBPGR, New Delhi. These parents (germplasm) were crossed in line × tester mating design (15 lines and 4 testers) to obtain 60 F_1s. These F_1s along with their parents and check were evaluated in randomized block design (RBD) with three replications during two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2). The data were recorded on different quantitative and qualitative traits *viz.,* plant height, days to first flowering, days to first fruit set, days to first picking, number of flowers per plant, number of first fruiting nodes, pod yield per plant, ascorbic acid content, mucilage content, etc. Analysis of variance revealed significant differences present among hybrids, parents, parent × hybrid (parent hybrid interaction), treatment × environment, parent × environment, hybrid × environment and parent × hybrid × environment for all the 25 traits under study. Hence, the differences significant for variability denotes the chances of better selection and utilization of parental lines and tester for growth, quality and yield enhancement.

On the basis of GCA for growth parameters, EC 169472 and EC 169467 represent the best performing lines and Kashi Pragati showed best tester while for yield attributes the lines EC 169453 and IC 128029 comes up with the best result along with testers Kashi Kranti. On the basis of SCA, crosses *viz*., EC 169453 × Arka Anamika and IC 128023 × Kashi Lalima and for the crosses EC 169472 × Kashi Kranti and EC 169467 × Arka Anamika showed best performing heterbeltiosis and the crosses EC 169453 × Kashi Kranti and IC 128023 × Kashi Kranti and IC 169453 × Kashi Lalima showed best as standard heterosis. The ratio of $\sigma^2 A/\sigma^2 D$ serves as an indicator, with a ratio less than one indicating non-additive gene action and a ratio greater than one reflecting additive gene behavior.

The parental lines and a tester having good GCA for growth, yield and quality attributes indicate they are individually contributing in a positive way towards all traits under study. The crosses made up of such superior parental lines and testers results into exceptionally high yield as compared to other hybrids. This is due to their specific combination and non-additive gene action which results in higher SCA. In the study, we find that GCA measures the inheritance and genetic quality of parental lines and tester for specific traits whereas, SCA assess the interaction or compatibility between parental line and tester in respective hybrids. Trait specific expression of gene is noted for every character which can be utilized for hybrid development and also for further breeding programs.

Keywords:- Okra, *Abelmoschus esculentus* (L.) Moench, Heterosis, SCA, GCA, Heterbeltiosis, Gene action

CHAPTER 1

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is an edible vegetable crop popular for its green tender fruits grown throughout India during summer and rainy season. Its cultivation ranges throughout the tropical and sub-tropical zones and also in the hottest areas of the temperate zones for its fibrous edible fruits or pods (Solankey *et al*., 2010).

Vegetables are recognized as a "protective supplementary food" due to their content of essential minerals, vitamins, and amino acids crucial for the normal functioning of human metabolic processes. Okra is a good source of nutrition and minerals, providing 1.9 g of protein, 0.2 g of fat, 0.7 g of minerals, 0.4 g of carbohydrates, and significant amounts of key elements such as 66 mg of calcium, 43 mg of magnesium, 1.5 mg of iron, 6.9 mg of sodium, 10.3 mg of copper, 30 mg of sulfur, 8 mg of oxalic acid, 88 I.U. of vitamin A, 63 I.U. of vitamin B, 13 mg of thiamine, 0.1 mg of riboflavin, and 0.6 mg of nicotinic acid (Gopalan *et al*., 2007; Babel and Yadav, 1971 and Rekhi, 1976).

Okra possesses a unique fiber that plays a role in regulating blood sugar levels. The fiber found in okra is essential for ensuring the proper functioning of the intestine (Kumar *et al*. 2013). Okra leaves are utilized in the preparation ofmedicinal compounds known for their soothing and anti-inflammatory properties (Mehta, 1959).

In addition to its role as a food product, the plant serves various other purposes, such as being utilized in the paper industry and functioning as a purifier in the production of jaggery. Moreover, it is believed to have beneficial effects against genitourinary disorders, spermatorrhoea, and chronic dysentery (Krishnamurthy, 1994). The mature fruits and stem of the plant find application in the paper industry, while the plant extract serves as a purifyingagent in the manufacturing of jaggery.

Okra also contains mucilage (1.6 g/100 g of pod) *i.e*., thick and slimy substance present in fresh pods. It is a polysaccharide, acidic in nature associated with proteins and other biomolecules (Woolfe *et al*., 1977). Okra mucilage has medicinal property and can also be utilized for food and non-food products.

Okra is a polyploid plant with chromosome number 2n=130 and spread to North Africa and the Middle East (Datta and Naug, 1968). It belongs to the Malvaceae family,related to hibiscus and cotton, and originated near Ethiopia. It has spread to North Africa and Middle East. The origin of okra is near Ethiopian region and during the course of evolution it spread out to North African and Middle East part of the world (Tindall 1983; Lamont 1999).

Globally, okra is grown on an area of 5.31 lakh hectares with a production of 6.46 lakh tons at a productivity of 1,216.57 kg per hectare (Anonymous, 2021). The countries where okra is grown include India, USA, Nigeria, Mexico, Pakistan, etc. Among all countries, India ranks first in okra production with 4.65 lakh tons, accounting for 72% of the total world production. Andhra Pradesh is the leading producer of okra followed by West Bengal in terms of area, production and productivity (78.9 thousand hectares area, production of about 1184.2 thousand tons with a productivity of 15 tons/hectare and area of 74 thousand hectares, production of 862 thousand tons with a productivity of 11.70 tons/hectare respectively (Anonymous, 2020).

Abelmoschus esculentus is a heat tolerant vegetable crop that prefers temperatures between 20°-35°C. It is grown on a variable soil with a well-drained sandy loam richin organic matter with adequate drainage property and an optimal pH of 6-6.5 (Akinyele *et al*., 2007).

Okra is an annually growing plant with a life cycle of 90 to 100 days. It has an erect stem with branching, alternate leaves, and auxiliary flowers. It grows in variable heights from 0.5 to 4 meters and is often cross pollinated by insects. The extent of cross pollination ranges from 4% to 42% (Kumar, 2006). It is cultivated for its edible and fresh fruits or pods which contain very good amount of nutrients. Okra is a potential foreign exchange crop accounts for almost 60% of the total fresh vegetables export from India (Rewale *et al*., 2003).

The potential of this crop is immense, and it is important to develop varieties and hybrids suitable for specific agro-climatic zones. To exploit the heterosis for potential yield components, knowledge of genetic architecture of fruit yield and its attributes is important. Without a broad genetic base of heterogeneous plant material, it is very difficult for plant breeders to produce cultivars that meet the changing needs regarding adaptation to growing conditions, resistance to biotic and abiotic stresses, product yield or specific quality requirements (Friedt *et al*., 2007).

The availability of genetic diversity is essential for successful crop improvement programs. Heterosis, combining ability and the nature of gene action for various traits can be used to predict the effectiveness of selection and understand the course of evolution. Exploitation of heterosis in okra has been acknowledged as a practical strategy, offering breeders an effective tool to enhance yield and other important traits. Heterosis is a special genetic mechanism where distant genotypes are brought together in a specific pattern to express their ability to make a dramatic shift in the magnitude ofa particular trait.

Heterosis, also known as hybrid vigor, is a phenomenon observed in the F_1 generation where there is an increase or decrease in vigor compared to its parents. The occurrence of hybrid vigor in okra was first reported by Vijayaraghavan and Warier in 1946. Heterosis is the superiority of the hybrid over its parents when considering the mean of the two parents, referred to as heterosis over mid-parent.

This phenomenon provides a valuable means for enhancing crop yield, disease and insect resistance, and combining ability traits. Recognizing its significance, plant breeding has considered heterosis as an important objective. In 1908, this phenomenon was referred to as the stimulus of heterozygosity. The ease of emasculation and the high percentage of fruit setting in okra suggest promising opportunities for exploiting its hybrid vigor. Overall, heterosis represents a crucial aspect of plant breeding, contributing to increased crop productivity, improved resistance to diseases and pests, and the incorporation of desirable traits.

The concept of general combining ability (GCA) and specific combining ability (SCA), as refined by Sprague and Tatum in 1942, has played a pivotal role in the advancement of inbred lines. Combining ability analysis of the parents and their crosses provides information on additive and dominance variances, which are important to decide the parents and crosses to be selected for eventual crosses and the appropriate breeding procedures to select desirable segregants. In the process of developing promising varieties through hybridization, the selection of suitable parents is a matter of significant concern.

Okra is vegetable crop where heterosis has been exploited successfully. The term heterosis was coined by Shull in 1948 which refers to a superiority or inferiority of F_1 hybrids in one or more characters over its parents. The magnitude of heterosis providesa basis for genetic diversity and a guide to the choice of desirable parents for developing superior F_1 hybrids. The extent of heterosis in okra in relation to yield and its components has earlier been reported by Poshiya and Shukla (1986), Kumbhani *et al.*(1993) and Khatik *et al.* (2012). The most important factor for determining the feasibility of hybridization is the nature and extent of heterosis and its exploitation. Toimprove the genetic yield potential of varieties and hybrids, it is important to test the parents for their combining ability and hybrid vigour. High yielding parents may not combine well to give good hybrids.

Sprague and Tatum (1942) introduced the concept of General Combining Ability (GCA) and Specific Combining Ability (SCA) as fundamental elements in understanding the outcomes of genetic crosses. General Combining Ability (GCA) refers to the average performance of the progeny of an individual when it is crossed with various other individuals. On the other hand, Specific Combining Ability (SCA) accounts for the deviation in performance of a cross from what would be anticipated based on the General Combining Ability (GCA) of the parents.

Phenotypic variation is a composite of three variables: genetic, environmental and Genotype × Environment interaction. It is a common practice to grow a series of genotypes in a range of different environments to predict their relative performance. A Genotype × Environment (G × E) interaction exists where the relative performance of varieties changes from environment to environment. The presence of G × E interaction is a major problem in getting a reliable estimate of heritability and it makes, it difficult to predict with greater accuracy rate of the genetic progress under selection for a given character.

Conventional methods of analyzing heterosis have been used for decades. In past, most of the improvements in okra were generally based on selection process or through hybridization for location adaptation. Morphological analysis is an effective method for knowing the magnitude of heterosis, but it can be altered due to environmental factors. However, statistical and biochemical analysis can separate the total variance in terms of different components of variance, providing estimates of variation in quantitative data due to environmental effect. However, with the utilization of statistical and biochemical analysis one can separate the total variance in terms of different components of variance which in turn provides the estimates of variation in quantitative data due to environmental effect. Considering the importance of the development of variety the following study was conducted with following objectives:

- ✓ To estimate heterobeltiosis and standard heterosis for fruit yield and itscomponents.
- ✓ To estimate general and specific combining ability (GCA and SCA) of theparents and crosses, respectively for fruit yield and its components.
- ✓ To estimate the nature and magnitude of gene action involved in the heritanceof various qualitative and quantitative traits.

CHAPTER 2
REVIEW OF LITERATURE

Numerous investigations have been carried out on the genetic aspects of horticultural crops, particularly vegetables. It is essential to gather information about the genetic makeup of quantitative traits, especially those contributing to yield, to effectively plan breeding programs. Biometrical techniques have been developed as valuable tools for understanding the genetics of different traits. The creation of commercial hybrids standsout as a significant means to substantially enhance crop yield. The knowledge of heterosis (hybrid vigor) and combining ability is crucial for plant breeders, aiding in the evaluation and selection of varieties and the formulation of appropriate breeding procedures for crop improvement.

The current study focuses on assessing heterosis, combining ability, and stability in okra, considering various pertinent characters. The review and presentation of findings are organized under the following headings:

- **To estimate heterobeltiosis and standard heterosis for fruit yield and its components**
- **To estimate general and specific combining ability (GCA and SCA) of the parents and crosses, respectively for fruit yield and its components.**
- **To estimate the nature and magnitude of gene action involved in the heritance of various qualitative and quantitative traits.**

2.1. To estimate heterobeltiosis and standard heterosis for fruit yield and its components

The phenomenon referred to as heterosis occurs when the offspring resulting from crosses between different species or within species exhibit greater fertility and productivity than either parent. Koelreuter (1766) was the first to observe and report this phenomenon in plants.

Mudhalvan & Senthilkumar (2021) made seven parent diallel including reciprocals.

The importance of both additive and non-additive gene action in the inheritance of all 11 traits under study was highlighted by the analysis of variance for combining ability. The estimations of the combining ability variances varied reciprocally for each of the 11 attributes examined. For the most of the characters the parents were found to be good general combiners. The hybrid Varsha Uphar × Thunder demonstrated strong per se performance along with high SCA effects. It also demonstrated high standard heterosis for fruit yield per plant. The hybrid Varsha Uphar × Pusa-7 achieved a standard heterosis for the trait fruit production per plant up to 79.16%. Reciprocal recurrent selection may be used to improve a population when there is reciprocal difference and both additive and non-additive gene action.

Rameshkumar *et al.* (2017) analyzed gene action of fruit yield and quality traits in okra (*Abelmoschus esculentus* (L.) Moench) through full diallel analysis of 30 F1 hybrids derived by crossing six parental lines and conclude that the preponderance of non-additive gene action for days to first flowering, node at which first flower appear, fruit length, fruit girth, plant height and number of fruits per plant and a preponderance of additive gene action number of branches, phenol, peroxidase and polyphenol oxidase. For fruit yield per plant, number of fruits per plant and plant height only dominant component of variance was observed which revealed the presence of non-additive gene action, hence, heterosis breeding is required to be followed for exploitation of these traits.

Akhtar *et al.* (2010) studied heterosis in 30 hybrids and reported that the maximum heterosis (55.20%) for fruit per plant, followed by number of branches per plant (47.21%), green fruit length (37.83%), plant height (35.22%), number of seeds per fruit (34.50%), number of fruits per plant (30.32%), green fruit weight (19.87%), days to 50% flowering (-17.03%), days to first flowering (-22.86%) and fruit diameter (-15.49%).

Dabhi *et al.* (2010) studied combining ability for 11 characters over three environment and observed that the preponderance of non-additive gene action in expression of days to first flower opening, number of nodes at first flowering, days to first picking, number of nodes per plant and fruit length, whereas additive type of gene action was predominant in expression of internodal length, plant height, 10-fruits weight, fruit girth, number of fruits per plant and fruit yield per plant.

Patel *et al.* (2010) while studying heterosis, heterobeltiosis and inbreeding depression for fruit yield and their attributes, reported that positive and significant heterobeltiosis was observed in KS-404 × HRB-108-2 and VRO-5 × GO-2 for fruit length and fruit yield per plant. Similarly, significant and positive relative heterosis has been depicted in KS-404 × HRB-108-2 for number of nodes per plant, number of fruits per plant, andfruit length and in VRO-5 × GO-2 for number of fruits per plant and fruit yield per plant. Moderate to high amount of inbreeding depression was observed for all the traits.

Singh and Kumar (2010) studied 21 F1's and F2's through diallel technique excluding reciprocals reported that the selection of okra crop can be based on the combination oftwo characters, i.e., length of first fruiting node 36 with length of fruit with width of fruit and number of fruits per plant for higher yield while the cross KS-401 × Pusa Sawani showed high specific combining ability effects as well as per se performance in F1 and F2 generations.

Prakash *et al*. (2002) conducted an experiment on two F2 populations, F1 hybrids in okra genotypes Parbhani Kranti and Arka Abhay in order to evaluate the genetic architecture of quantitative features. Parbhani Kranti outperformed Arka Abhay in terms of days to first blossom (44.90) and number of capsules/plant (16.60), while Arka Abhay was the best in terms of high seed yield/plant (62.89 g), length of capsule (12.64 cm), weight of capsule (15.66 g), and seed yield per capsule (3.71 g). The F1 hybrid PK × AA had the highest seed yield per plant (69.28 g), number of seeds per capsule (55.38 g), and capsule weight (20.20 g) of all the hybrids. There was noticeable heterosis in both generations.

Chauhan and Singh (2002) uses 20 lines and four testers, assessed 80 okra crosses and discovered heterosis over the better parent, standard check-1 (Parbhani Kranti), and standard check-2 (Pusa Sawani). Heterosis was also seen above conventional check-2 in cross combinations including DC-97 × P-7, Arka Anamika × Arka Abhay, Shagun ×Varsha Uphar, EMS-8 × P-7, DC-97 × Varsha Uphar, PSB-1 × Varsha Uphar, K-21 × P-7, and Arka Anamika × Arka Abhay.

Yadav *et al*. (2002) evaluated forty-five F_1 hybrids, they discovered significant heterosis in traits like the number of days till flowering, height of plant, no. of branches/plant, length of the first fruiting node, fruit width and length , no. of fruits per plant, and yield per plant when compared to the superior and economically advantageous parent.

Rani *et al*. (2002) showed significant and desirable heterobeltiosis in all the traits of okra, with Pusa Makhmali × HRB 9-2 demonstrated a significant heterotic response forthe node at which the 1st flower emerged, the no. of fruits per plant, the fruit wt., and theoverall yield.

Singh *et al.* (2002) found desirable heterobeltiosis for weight of the fruit in genotype 6302 × 6308, with 141 % for fruits length and 185 % for no. of fruits.

Rewale *et al.* (2003) investigated in okra for heterosis. The yield and yield contributing characteristics all showed positive significant heterotic effects. The majority of the highly heterozygous pairings included parents from different geographic regions. Days to fruit initiation, days to flowering, and days to maturity for green fruit showed favorable negative and significant heterotic effects in the crosses SOH-02 × P.K. and SOH-02 × G.F. Significant heterobeltiosis was seen in the crosses DVR-3 × G.G. for yield/ plant, pod per plant, nodes per plant, branches/plant, and height of the plant. Higher magnitude heterosis was also seen in the crosses JNDO-5 × P.K. (153.43%) andNOL-101 × G.G. (147.79%) over better parent.

Tripathi *et al.* (2004) used diallel mating design to study 4 × 4 crosses in okra, and the results showed heterosis above standard parents and inbreeding depression.

Singh *et al*. (2004) worked on line × tester mating to obtain 60 F1 hybrids by crossing fifteen female parents and 4 male parents of okra. The following characteristics were noted: the no. of branches/ plant, the no. of fruits/plant, 1st flowering node, days until 50% flowering, weight, length and diameter of the green pods, internodal length, and no. of fruits per plant. For the majority of the characters, there were very noticeable distinctions between the parents, crosses, parents vs. crosses, lines (females), testers (males), and lines vs. testers.

Borgaonkar *et al.* (2005) used an 8 × 8 diallel analysis to investigate heterosis in okra. With the exception of internodal length and plant height, the results demonstrated a significant difference between parents and hybrids for every attribute trait. Out of 28 crosses 10 revealed significant positive heterobeltiosis for the hybrids No. 129 × JNDO 5 (52.22%) exhibiting the high heterbeltiosis for yield/plant then No. 74 × JND0 5.

Vermani and Sagar (2006) conducted research on a line × tester involving 14 lines and 2 testers in okra. Their findings indicated that none of the cross-combinations exhibited desirable heterobeltiosis for all the characters concurrently. Specifically, the cross-combination of Pusa Makhmali × P-8 demonstrated the highest desirable heterobeltiosis for parameters such as fruit yield/ plant, nodes/plant, and plant height. On the other hand, the cross-combination of Dhira × Arka Anamika exhibited heterobeltiosis for inter-nodal length, fruits /plant, and length of fruit.

Nichal *et al.* (2006) conducted a 7 × 7 diallel analysis in okra. The analysis of variance revealed significant variations among both the parental lines and their hybrids concerning various traits such as days to flowering, height of plant, no. of primary branches, no. of fruiting nodes, no. of fruits/ plant, av. fruit weight, length of fruit, and fruit yield/ plant. The cross between VRO-3 and Arka Abhay exhibited the highest relative heterosis and heterobeltiosis for fruit yield/plant. Additionally, the crosses Arka Abhay × Arka Anamika and AKO-16 × Pusa A-4 demonstrated significant heterosis compared to the mid-parent, better parent, and the control cultivar, Pusa A-4.

Mamidwar and Mehta (2006) investigated a set of fourteen lines and three testers in okra. The study involved the estimation of mean values for crosses and heterosis over the better parent for a total of 42 hybrids. Notably, the cross between VRO-6 and Parbhani Kranti exhibited the highest level of heterosis at 55.57%, with Daftari-1 × Arka Abhay following closely with a heterosis of 54.31%.

Manivannan *et al.* (2007) conducted a study on heterosis over the better parent in okra. Noteworthy findings included significant heterobeltiosis in specific crosses:VRO-5 × IIVR-10 for height of plant, Arka Anamika × IIVR-10 for plant spread, Punjab Padmini × Pusa Sawani for the no. of leaves, Arka Anamika × VRO-6 for days to flowering, Punjab Padmini × VRO-5 for fruits/ plant, Pusa Sawani × Parbhani Kranti for weight of fruit, Pusa A-4 × VRO-5 for the no. of seeds / fruit, Arka Anamika × VRO-6 for 100-seed weight, and Pusa A-4 × VRO-6 for yield. Notably, the cross Pusa A-4× VRO-6 exhibited a higher mean value for yield /plant and sustained improvement over the check for the above mentioned traits.

Yadav *et al.* (2007) conducted an experiment in okra to assess heterosis over the standard parent Parbhani Kranti for both yield and yield components. The study coveredvarious traits, including days to flowering, height of plant, no. of branches/plant, no. of 1st fruiting nodes, length of the 1st fruiting node, no. of nodes/plant, internode length, length and width of fruit, tapering fruit length and no. of fruits /plant. The analysis of heterosis estimates for these yield components revealed that a significant increase inyield was primarily associated with increased plant height, no. of branches/ plant, higher no. of fruits/plant, and no. of nodes/ plant**.**

Amutha *et al.* (2007) conducted an assessment of relative heterosis, heterbeltiosis, and standard heterosis in okra, focusing on key traits such as the no .of branches, lengthof fruit, weight of fruit, and fruit yield. Notably, the cross between Arka Abhay and Punjab Padmini exhibited significant positive heterosis over both the better parent andthe standard parent for various characteristics. Specifically, notable increase found in weight of fruit (5.9%, 14.36%), length of fruit (13.5%, 16.75%), fruit yield by number (6.77%, 13.99%), and fruit yield by weight (14.48%, 31.40%) in this cross.

Shoba and Mariappan (2007) conducted a study involving five lines and two testers in okra. The observations for various traits including height of the plant, days to 1st flowering, no. of nodes per plant, length of fruit, girth of fruit, no. of fruits/plant, singlefruit wt., no. of seeds per fruit, 100-seed wt., crude fiber content, protein content, and yield per plant. The findings showed highly significant differences among the parent and genotypes for all the characters examined. Notably, the cross-combination IC 169340 × IC 112475 demonstrated the highest heterosis for all the studied characters.

Mehta *et al.* (2007) conducted a research project involving 42 okra hybrids, achieved through the crossbreeding of 3 testers with 14 lines. The investigation successfully identified several highly productive heterotic combinations, notably VRO-6 × Parbhani Kranti, VRO-4 × Parbhani Kranti, Daftari-1 × Arka Abhay, and Kaveri Selection × Ankur Abhaya, all of which demonstrated increased fruit yield per plant. The analysis further revealed that specific combining ability (SCA) variances for traits like days to fruit flower, days to 50% flowering, fruit weight, fruit length, plant height, number of seeds per fruit, and 100-seed weight were more pronounced than the general combiningability (GCA) variances for fruit yield per plant. This implies that hybrid okra holds considerable potential for optimizing overall fruit yield.

Dahake *et al.* (2007) assessed the level of heterosis concerning the superior parent anda standard control for both overall fruit yield and its individual components in okra. Thehybrid Hissar Unnat × Duptari 45 displayed the most significant degree of heterosis. Moreover, crosses like Parbhani Kranti × Arka Anamika and Arka Anamika × Ankur 40 were recognized as promising, given their noteworthy heterotic effects.

Kumar and Pathania (2007) conducted heterosis studies using a line × tester mating, involving 10 lines and 3 testers of okra. The investigation covered traits such as 1st

flowering node, internodal length, length of fruit, diameter of fruit, height of plant, fruits/ plant, fruit yield /plant, and fruit weight. The analysis of variance (ANOVA) revealed significant differences for most of the traits under study.

Desai *et al*. (2007) carried out an evaluation of heterosis concerning the better parent and a standard control for both overall fruit yield and its components in okra. Notably, the hybrid combination Hissar Unnat × Duptari 45 exhibited the highest level of heterosis, showing a 24.36% increase over the better parent and a 13.93% increase over the standard control for fruit yield per plant. Additionally, crosses like Parbhani Kranti × Arka Anamika and Arka Anamika × Ankur 40 were recognized as promising, demonstrating significant heterotic effects. These crosses were noted for their practical importance and potential for utilization in enhancing hybrid vigor in okra

Jaiprakashnarayan *et al*. (2008) conducted a Line × Tester analysis to evaluate the extent of heterosis for earliness and yield parameters in okra. Their findings revealed maximum heterosis over the better parent and standard parent in the desirable direction for various traits, including days to 50 % flowering, length of fruit, weight of fruit, no. of fruits /plant, and total yield / plant. This suggests that certain combinations exhibited significant positive heterotic effects, particularly in terms of early flowering and increased yield-related parameters.

Dabhi *et al*. (2009) investigation involved an examination of heterosis for fruit yield and its components in okra, utilizing a set of 12 lines and 4 testers. The analysis focused on crossbreeding in comparison to both the better parent and a standard control (Arka Anamika). The findings revealed that, concerning fruit yield, the highest heterosis was recorded at 20.04% (PB-266 × Arka Abhay) over the better parent and 32.08% (KS- 404 × Arka Abhay) over the standard check. Out of the 48 hybrids examined, four exhibited noteworthy positive heterosis over the better parent, while 31 surpassed the standard check for fruit yield across various environments.

Obi (2009) studied explored better parent heterosis in both direct and reciprocal crosses, employing nine early and late okra cultivars in Nigeria. The outcomes revealed highly significant instances of narrow and intermediate heterosis in most of the direct and reciprocal crosses. This implies that viable selections could be made from these hybrids to fulfill specific local okra quality requirements.

Jindal *et al.* (2010) employed a diallel mating design with twelve okra genotypes, generating 66 one-way hybrids. Notably, hybrids such as PB-1, NDO-10 × HRB-108- 2, HRB-107-4 × HU, and VRO-3 × S-2 were identified as commercially important, particularly in terms of earliness and yield.

Kumar and Sreeparvathy (2010) conducted an evaluation of five okra genotypes in a full diallel fashion. The results highlighted that the standard heterosis for fruit yield/ plant was highest in the hybrid MDU 1 × Hisar Unnat, reaching a value of 65.23 %. Ina related study, Patel *et al*. (2010) investigated the relative heterosis and heterobeltiosis for fruit yield and its attributes in six crosses of okra. The findings revealed significant heterosis over mid and better parent for all the traits studied. Notably, KS-404 × HRB-108-2 and VRO-5 × GO-2 exhibited significant and positive heterobeltiosis for fruit length and fruit yield per plant. Additionally, KS-404 × HRB-108-2 showed significant and positive relative heterosis for the number of nodes/plants, no. of fruits per plant, and length of fruit.

Ramya and Kumar (2010) conducted a study on heterosis in okra using diallel analysis(7 × 7) for traits such as the number of fruits per plant, fruit weight, fruit length, and fruit yield per plant. The analysis of variance revealed significant differences among the parents and hybrids for all the studied characters. Whereas, **Singh and Sanwal (2010)** estimated heterosis for yield and contributing traits, including the no. of primary branches/ plant, internodal length, days first flowering node, length of fruit, fruit diameter, weight of fruit, no. of fruits/ plant, and fruit yield/plant. In a related study, **Wammanda *et al.* (2010)** investigated the genetic basis of yield and itscomponents using a 9 × 9 diallel cross in okra, involving 36 F1 hybrids and the nine parents. They observed significant heterosis over better parents, and the mean performances of the hybrids were also noted to be high.

Khatik *et al.* (2012) involved the assessment of 36 okra crosses, utilizing 12 lines and 3 testers. The results indicated highly significant heterosis analysis of variances for all the traits under investigation. Particularly noteworthy were the cross combinations KS-423 × P.K., KS-453 × P.K., KS-439 × P.K., KS-427 × KS-410, KS-453 × KS-410, BO-2 × KS-404, and KS-439 × KS-404, which exhibited a substantial increase over the mid-parent for both yield and its contributing traits. The study suggested that these identified hybrids hold promise and could be further developed and utilized in upcoming breedingprograms aimed at enhancing yield and its components.

Aulakh *et al.* (2012) conducted an experiment to study the gene action and inheritance pattern for earliness and increased yield in okra. The F1 means of both the crosses were found to exceed both of their corresponding parental means, indicating over-dominance for traits such as days to 1st flowering, days to 1st fruit set, and total yield/plant. The researchers concluded that genetic improvement of okra concerning these traits can be achieved through hybridization.

Medagam *et al*. (2012) generated 45 F1 hybrids from 10 elite lines of okra with the aim of investigating heterosis. The average heterosis over the mid-parent for total yield per plant was 6.92%, while over the standard control, it was -15.44%. Likewise, for marketable yield per plant, the overall mean heterosis over the mid-parent was 6.64%,and over the standard control, it was -22.18%. Notably, crosses exhibiting negative heterosis, such as C19 (P3 × P5) for days to 50% flowering and C4 (P1 × P5) for the first flowering and fruiting node (-15.22%), were identified as significant for leveragingheterosis to achieve earliness in okra.

Das *et al*. (2013) conducted a study on breeding okra for higher productivity using a line × tester mating design. They focused on traits such as nodes at first flowering, fruitlength, fruit diameter, fruit weight, number of fruits per plant, and fruit yield per plant. The results showed significant heterosis over the better parent for all these characters, indicating potential for improvement in productivity through breeding. In a related study**, Jagan *et al.* (2013)** investigated heterosis for yield and yield components in okra using a line × tester mating design. They produced 60 hybrids by crossing four lines with 15 testers, analyzing characters such as plant height, days to 50 %flowering, 1st flowering node, no. of branches/plant, no. of fruits/plant, fruit length, fruit diameter , pod weight, and fruit yield /plant. The findings revealed significant heterosis over mid and better parents for all these characters. The analysis of variance indicated highly significant differences for most of the characters, suggesting the presence of genetic variability in the studied population**.**

Kumar *et al*. (2013) conducted a study to estimate heterosis for yield and its contributing characters in okra using line × tester analysis with a set of 8 parents (comprising 5 lines and 3 testers) to create 15 cross combinations. The results showed highly significant variances due to treatment for most of the characters studied, including plant height, no. of primary branches, no. of fruits/ plant, length of fruit, weight of fruit, internodal length, and yield /plant. Significant heterosis was observed for all these characters over mid, better, and standard parents, indicating the potential for genetic improvement in these traits through hybridization.

Lyngdoh *et al.* (2013) carried out an experiment to evaluate the extent of heterosis for growth characters in okra. The findings revealed a substantial and statistically significant magnitude of heterosis over both the superior parent and the commercial check, particularly in the desired direction for traits like height of plant, no. of branches/ plant, and internodal length. This implies that the hybrids exhibited significant enhancements in these growth-related characteristics compared to both the superior parent and the commercial check. The results underscore the potential for improving these traits through heterosis in the context of okra breeding.

Kishor *et al.* (2013) conducted a study in okra with the objective of identifying potential parents and superior crosses for yield and yield-related traits. The findings revealed noteworthy standard heterosis for yield per plant in specific crosses, includingHolavanalli × Mallapalli Local, Thirumala Local × Kattakada Local, Kannapuzha Local× Punjab Phalgani, and Thirumala Local × Mallapalli Local. Furthermore, the magnitude of heterobeltiosis for yield per plant was significantly superior in Holavanalli Local × Mallapalli Local and Thirumala Local × Kattakada Local. These two crosses also demonstrated significant heterosis for days to first flowering and the number of primary branches**.**

Obiadalla-Ali *et al.* (2013) involved two Egyptian and four exotic parental genotypes of okra. These genotypes were self-pollinated for one generation and were then crossed in a half diallel design to investigate heterosis for traits related to earliness, vegetative growth, and yield components, including days to 50% flowering, plant height, number of branches per plant, fruit weight, fruit length, and fruit diameter. The analysis revealed highly significant mean squares of genotypes for all studied traits, indicating substantial genetic variation among the genotypes studied. The majority of crosses showed significant heterosis estimates over the mid-parent for all the traits under investigation. In a related study by **Chaubey *et al.* (2014),** eight okra genotypeswere crossed in a line × tester mating design. The results observed highly significant and maximum negative heterosis over better parents (-12.27%) and mid-parent (- 9.17%) in the cross of HRB-9-2 × VRO-5 for days to 50% flowering. Conversely, the cross of DOV-91-4 × VRO-5 displayed highly significant and positive heterosis for fruit length over both mid-parent and better parent.

Pathak and Prabhat (2014) assessment of 52 F1 hybrids derived from 26 lines and two testers of okra. The hybrids, along with parental lines and a standard check (Punjab-8), were subjected to evaluation for yield and its attributing traits. Positive heterosis was observed, ranging from 1.09% to 66.07% for marketable fruit yield. The top five hybrids, KS-442 × POS-17 (66.07%), Arka Abhay × VRO-6 (59.81%), PB-266 × VRO-22 (52.14%), Arka Abhay × VRO-21 (51.96%), and KS-442 × POS-27 (49.1%), demonstrated the highest positive heterotic effects for marketable yield. Regarding the number of fruits, the hybrid PB-266 × VRO-22 exhibited the highest positive and significant (63.61%) heterosis over the better parent. Most hybrids displayed significant heterosis for fruit yield and also recorded significant heterosis for the number of fruits. However, only two crosses, Arka Abhay × POS-27 (-9.04%) and Arka Abhay × POS- 17 (-9.04%), showed significant heterosis over the better parent for early picking.

Nagesh *et al.* (2014) aimed to estimate the magnitude of heterosis and identify promising combiners for yield and quality parameters by generating 54 F1 hybrids (comprising 21 parents and a commercial check) through a line × tester mating design. The results highlighted that the cross KON-8 × IC90174 demonstrated the highest positive heterosis over both the better parent (107.90%) and the commercial check (92.42%) for total yield per hectare. Additionally, the crosses KON-8 × IC90174 (92.42%), KON-5 × AAN (45.83%), KON-16 × AAN (40.52%), KON-12 × AAN (35.07%), and KON-7 × IC90174 (27.11%) exhibited significant heterosis over the commercial check, listed in order of merit for total yield per hectare**.**

Tiwari *et al.* (2015) studied on okra during late kharif-2013 and summer-2014, the researchers employed a diallel mating involving five diverse parents to investigate heterosis for various horticultural traits. The analysis of variance revealed significant variability for yield and other component traits. VRO-6 showed superiority over other parents in per se performance for most traits, except for average fruit weight, fruit stalk length, and ascorbic acid. The cross-combination VRO-6 × GJO-3 was the sole F1 displaying significant heterobeltiosis as well as standard heterosis for yield per plant. In a related study by **Patel and Patel (2016)**, 45 genotypes, including 8 female, 4 male, and 32 resultant hybrids, along with one commercial check variety (GAO-5) of okra, were investigated. Line × tester analysis was employed to study the magnitude of heterosis. Significant differences were observed among parents and hybrids, indicating substantial genetic variation. Crosses such as JOL-09-8 × Pusa Sawani, JOL-10-17 × GJO-3, JOL-09-7 × Pusa Sawani, and AOL-10-18 × VRO-6 exhibited significant standard heterosis and high per se performance concerning fruit yield / plant.

2.2. To estimate general and specific combining ability (GCA and SCA) of the parents and crosses, respectively for fruit yield and its components

Combining ability refers to an individual's capability to pass on superior traits to its progeny through hybridization with other strains. The concept of general and specific combining ability, introduced by **Sprague and Tatum (1942)**. In 1957, **Kempthorne** developed the line × tester analysis, a meticulous tool for selecting parents in hybridization to establish a population. **Sundhari *et al.* (1992)** utilized this method to assess combining ability effects in okra, analyzing yield-related traits in si× inbred lines and their hybrids through a full diallel cross. The GCA/SCA ratios were found to be less than one, suggesting the influence of non-additive gene action on both yield and the number of fruits per plant.

Pal and Hossain (2000) conducted a combining ability analysis using a 7 × 7 diallel cross of okra, examining seed yield, various components of seed, and certain quality traits. Their findings indicated the significance of both additive and non-additive gene effects in the inheritance of the majority of these traits**.**

Nichal *et al.* (2000) found significant results through ANOVA in their combining ability analysis of okra, particularly for traits such as the no. of primary branches on themain stem, no. of fruits/ plant, weight and length of fruit, and yield/plant. The outcomes underscored the importance of both additive and non-additive genetic components in the observed variation. Notably, the combination Arka Abhay × Arka Anamika displayed the highest *per se* performance for yield and exhibited significant specific combining ability (SCA) effects for all traits. Through an evaluation based on*per se* performance, heterosis percentage, SCA effects of crosses, and general combining ability (GCA) effects of parents, the crosses Arka Abhay × Arka Anamika,AKO-16 × Pusa A-4, JNDO-5 × AKO-16, and Arka Abhay × Pusa A-4 were identifiedas superior combinations suitable for exploitation in heterosis breeding programs.

Sood and Kalia (2001) assessed combining ability in okra, focusing on various traits including fruit yield, fruits/ plant, days to 50% flowering, stem diameter, fruit length, diameter of fruit, 1st flowering node, and internodal length. IC-9856 demonstrated strong general combining ability, particularly for early flowering, dwarfness, andshorter internodal length. On the other hand, Parbhani Kranti, P-7, Harbhajan, Pusa Sawani, Arka Abhay, and Arka Anamika emerged as notable general combiners for fruit yield and its associated components.

Dhankhar and Dhankhar (2001) conducted a combining ability study on okra using a line × tester analysis, incorporating 20 female lines and 4 male testers. Their analysis revealed that IC-9856 exhibited strong general combining ability, particularly in terms of early flowering, dwarfness, and shorter internodal length.

Thippeswamy (2001) assessed 30 F1 hybrids resulting from crosses between five lines and six testers, focusing on yield and its components in okra. The estimation of general combining ability (GCA) effects for all 11 parents highlighted that IIHR-MS-5 and IIHR-MS-2 displayed the highest positive significant effects, signifying their effectiveness as good combiners for traits such as number of fruits per plant, total yield per plant, and fruit weight. Among the testers, Arka Anamika exhibited high GCA effects for total yield per plant and the node at which the first flower appeared, while Parbhani Kranti showed high GCA for fruit weight and fruit length. The study also identified significant specific combining ability (SCA) effects in the cross combination IIHR-MS-5 × 120-11-8-1 for days to first flower appearance. Commercially exploitable hybrids for marketable yield, a higher number of fruits per plant, and earliness were identified as IIHR-MS-2 × Arka Anamika and IIHR-MS-5 × Parbhani Kranti. The majority of crosses exhibited high SCA effects, primarily attributed to combinations of high × high, high × low and low × low crosses.

Rani *et al*. (2002) reported that the okra parents, namely Punjab-8, HRB 9-2, and Punjab Padmini, demonstrated strong general combining ability for traits such as the no. of fruits/ plant and total yield/ plant. The specific combining ability analysis revealed that the most promising crosses were VRO 3 × KS 404, Pusa Makhmali × Punjab-8, and Pusa Makhmali × VRO 3.

Singh and Singh (2003) conducted a study on combining ability for yield and yield components in 15 okra inbred lines. Their findings revealed that both general combining ability (GCA) and specific combining ability (SCA) were significant for most of the studied characters, including days to flowering, plant height, 1st fruiting node, internode length, no. of branches/plant, fruit length, fruit width, and no. of fruits/plant. This suggests the involvement of both additive and non-additive gene effects in the inheritance of these traits.

Ahlawat (2004) evaluated 15 female lines, 5 male lines, and their resulting 75 hybrids, alongside the standard hybrid check GOH-1, were evaluated for various traits such as the no. of branches/plant, fruit length, fruit weight, fruits/plant, and yield/plant. The study identified individuals with strong general and specific combining abilities for all these traits. Notably, non-additive gene action was found to play a predominant role in the e×pression of primary branches per plant and fruits/plant

Rajendra *et al.* (2005) conducted a study on six hybrids of okra and reported significant general and specific combining abilities for the examined traits. The result revealed that cultivar AB-2 was identified as a strong general combiner for the no. of days to flowering, no. of fruits/ plant, and yield /plant. Additionally, the cultivar AB-1 exhibited good general combining ability for the no. of days to flowering, no. of 1st fruiting nodes, no. of fruits/ plant, and yield / plant. The cultivar BO-2 showed good general combining ability for internode length, while Parbhani Kranti was recognized as a good general combiner for plant height, as well as length and width of the fruit.

Sushmita and Das (2005) conducted a combining ability analysis in okra using a 10 ×10 diallel cross, excluding reciprocals. The aim was to identify desirable parents and F1 cross combinations. Their findings indicated that variances attributed to general combining ability (GCA) and specific combining ability (SCA) were highly significant for various traits, including days to 50% flowering, internode length, no. of nodes/ plant, fruit length, fruit girth, no. of branches /plant, plant height, no. of fruits/ plant, and yield/plant.

Dahake and Bangar (2006) observed that the parents of okra *viz*., Arka Anamika, Hisar Unnat, and Shagun exhibited superior combining abilities for fruit yield/plant. In terms of crosses, the combinations Parbhani Kranti × Arka Anamika, Hisar Unnat × Duptari 45, and Duptari 45 × Ankur 40 were identified as the best specific combiners for both fruit yield per plant and the no. of fruits/ plant**.**

Naphade *et al.* (2006) conducted combining ability analysis in okra using a line × tester mating design. Among the parents, Tot-1494 and Tot-1502 demonstrated strong general combining abilities for traits such as fruit weight, no. of primary branches, and fruit yield /plant. Tot-1494 also exhibited good general combining ability for fruit length. Regarding specific combining abilities, the combination Parbhani Kranti × Tot-1494 was identified as the top performer for fruit yield, followed by AKO-73 × Tot- 1502 and Parbhani Kranti × Tot-1502.

Weerasekara *et al.*, (2008) conducted a study estimating combining ability effects in okra, focusing on various traits including days to 50% flowering, no. of branches/plant, plant height, no. of fruits/ plant, fruit diameter, fruit weight, no. of seeds/ fruit, and yield/ plant. The research involved a line × tester crossing program, generating 24 hybrids from crosses between eight lines and three testers. Notably, among the lines, KAO-25 and KAO-61, and among the testers, KAO-23 and KAO-AA, were identified as the best general combiners. Furthermore, three specific crosses, namely KAO-53 × KAO-18, KAO-35 × KAO-AA, and KAO-17 × KAO-AA, were found to be the most effective for yield /plant.

Srivastava *et al.* (2008) revealed that some parents demonstrated combining abilities for specific traits in okra. For days to 50% flowering, the parents IC 73352, Okra No. 6, Pb 8, VB 9101, and Punjab Padmini were identified as having high specific combining abilities. For the number of fruits per plant, Pb 8, IC 69117, IC 73352, and Arka Abhay showed significant specific combining abilities. In terms of fruit yield per plant, Punjab Padmini, VRO 3, Arka Abhay, Pb 8, and IC 69117 exhibited high specific combining abilities. Additionally, for fruit length, Punjab Padmini, VRO 3 × Arka Abhay, Pb 8, and IC 69117 were identified as parents with strong specific combining abilities. For fruit weight, the combination Pb 8 × IC 69117 exhibited high specific combining ability. Furthermore, BO-13 and IC-990049 were recognized as good general combiners for shorter internodal length, and Parbhani Kranti was noted for its strong combining ability for fruit length.

Javia *et al.* (2009) conducted an experiment with 49 entries, including 13 genetically diverse parents and their 36 crosses of okra generated by a line × tester mating design. The pooled analysis of variance for combining ability revealed significant mean squares for females, males, and females × males. Various traits such as internodal length, plant height, branches/ plant, fruit length, no. of fruits/ plant, and fruit yield/ plant were observed. ANOVA indicated the greater importance of non-additive gene action in the inheritance of all these traits. The study identified good general and specific combiners for these characters. The crosses exhibiting high positive or negative specific combining ability effects involved combinations of average × poor, average × good, poor × good, and poor × poor parents.

Singh *et al.* (2009) conducted an experiment on twelve diverse best homozygous cultivars of okra were crossed in a diallel fashion without reciprocals. For plant height, specific combinations producing desirable effects were P9 × P11, P9 × P12, P7 × P12, P7 × P11, and P1 × P6. The best combinations for the no. of branches were P4 × P8, followed by P2 × P3 and P2 × P7. Performance and desirable specific combining ability effects were observed in P2 × P7, P2 × P4, and P2 × P10 crosses for days to flowering. For days to first picking, P4 × P7 showed the highest specific combining ability effects. Combinations such as P5 × P6, P5 × P10, P2 × P9, and P4 × P6 were noted for the number of pods per plant, while P3 × P4, P5 × P6, P4 × P12, and P2 × P4 crosses exhibited good specific combining ability effects for pod size. The combination P1 × P9 was identified as the best for yield/ plant, with the highest and positive specific combining ability effect, indicating the importance of both additive and non-additive gene action.

Wammanda *et al.* (2010) investigated the genetic basis of yield and its components in okra using a 9 × 9 diallel cross involving 36 F1 hybrids and the 9 parents. The analysis revealed the presence of good general and specific combiners for all the studied characters. The mean performance of parents and crosses was deemed valuable for predicting both high generals combining ability of parents and the high specific combining ability effects, along with heterotic effects of the crosses.

Dabhi *et al.* (2010a) carried out combining ability studies in okra using a line × tester mating method, involving 12 lines and four testers across three environments for 11 characters. The findings indicated that the majority of superior combinations included at least one parent with a high general combining ability (GCA) effect for most of the traits studied.

Raghuvanshi *et al.* (2011) investigated combining ability for yield and its components in okra using a line × tester cross, which involved 6 lines and 5 testers. The characters examined included the 1^{st} flowering node, plant height, internodal length, no. of primary branches/plant, fruit weight, no. of fruits/plant, fruit length, fruit diameter, and fruit yield plant. The partitioning of variance due to crosses into lines, tester, and crosses revealed that the crosses' interaction component was highly significant for all characters, except for the 1^{st} flowering node, plant height, and fruit yield/ plant. Analysis of variance for combining ability showed that the ratio of general combining ability (GCA) to specific combining ability (SCA) mostly favored SCA in all the traits. This indicated the preponderance of non-additive gene effects in the genetic control of the studied traits.

Kumar *et al.* (2012) studied the combining ability of 32 hybrids for 13 traits in okra was investigated using a line × tester mating design with eight genetically diverse females and four males. Among the female lines, EC-169358 and Sel-1 exhibited good general combining abilities for pod yield and its major components. Notably, VRO-6 was the sole parent with a significant and positive general combining ability (GCA) effect for pod yield and its major components. Parbhani Kranti also stood out as a goodcombiner, particularly for pod yield and several component traits. For many of the traitsunder study, the parents EC-169358, Sel-1, VRO-6, and Parbhani Kranti were identifiedas good general combiners. As a result, these lines were suggested for use in hybridization to produce promising recombinants in future breeding programs.

Sharma and Singh (2012) studied that combining ability effects for various characters of okra, such as plant height, number of branches per plant, days to 50% flowering, node at which the 1st flower appears, internodal length, no. of seeds per fruit, fruit length, fruit weight, and no. of pods/plant, were estimated using a line × tester mating design. The analysis of variance showed highly significant differences among the treatments for all the parameters studied.

Srivastava *et al.* (2013) studied that combining ability in okra was assessed through line × tester analysis, along with the determination of heterosis magnitude. The study utilized eight parents, consisting of 5 lines and 3 testers with 15 cross combinations. The data encompassed nine characters, including plant height, internodal length, number of primary branches, days to first flowering, total no. of fruits/ plant, fruit length, fruit girth, fresh fruit weight, internodal length, and yield/ plant. Based on the general combining ability (GCA) effects across the nine characters, Arka Abhay, VRO-6, Hissar Unnat, and Punjab Padmini were identified as the most promising parents forimproving traits such as the no. of fruits per plant, fruit girth, and days to 50% flowering. The most promising crosses, exhibiting significantly positive specific combining ability (SCA) effects and standard heterosis for fruit yield, were Arka Abhay × Parbhani Kranti, Hissar Unnat × Punjab Padmini, VRO-6 × Parbhani Kranti, and VRO-6 × ArkaAnamika. These identified crosses were suggested for further exploitation in breeding programs aimed at developing high-yielding varieties (HYVs) with early maturity characteristics.

Adiger *et al.* (2013) reported combining ability effects in okra were estimated using a line × tester crossing program that involved 120 crosses produced by crossing 40 lines with three testers. The analysis of variance revealed significant differences among the crosses, lines, and testers for most of the traits. The contributions of lines as compared to testers were observed to be higher, and the magnitude of sca variance was higher than the GCA variance.

Jagan *et al.* (2013a) combining ability effects for various characters of okra were estimated using a line × tester mating design. The design involved 60 hybrids obtainedby crossing 4 lines with 15 testers. The study identified good general and specific combiners for all the traits studied. The analysis of variance for different sources of variation showed that mean sum of squares due to crosses, lines (females), and testers (males) were significant for all the traits, indicating the influence of these factors on the observed variations. In a related study by **Kishor *et al.* (2013a),** 15 crosses were evaluated using 5 lines and 3 testers of okra to estimate combining ability for characters such as days to 1^{st} flowering, no. of primary branches, plant height, no. of fruits/plant, fruit weight, fruit length, and yield / plant. The combining ability analysis in this study revealed a preponderance of non-additive gene action for most of the characters. This suggests that the genetic control of these traits in okra is influenced more by non- additive genetic effects than by additive effects.

Paul (2013) estimated the general combining ability in okra and identified several good general combiners for different traits. HRB-55, AOL- 09-17, AOL-09-2, and JOL-09-7 were recognized as good general combiners for fruit yield per plant. Specifically, AOL-09-17 was noted as a good combiner for the number of primary branches per plant, fruit length, fruit diameter, fruit weight, and number of fruits per plant. JOL-09-7 exhibited either good or average combining ability for all the characters. The specific combining ability (SCA) effects revealed that certain cross combinations, such as JOL-55-3 × HRB-55, JOL-09-8 × JOL-09-7, and JOL-09-8 × AOL-09-17, showed the highest SCA effect for fruit yield per plant. These combinations were considered the most promising for fruit yield and some related traits.Furthermore, the genotypes IC-332453 and Parbhani Kranti were identified as the best general combiners. The significance of mean squares for various sources of variation, including among parents, among hybrids, and parents vs. hybrids, indicated the importance of these factors for most of the traits studied.

Bhalekar *et al.* (2014) studied the general combining ability in okra using parents Phule Utkarsha, Parbhani Kranti and Arka Anamika. Specific combining ability studies indicated that the cross combinations viz., P1 × P7 (Phule Utkarsha × IC- 89948), P1 ×P3 (Phule Utkarsha × Arka Anamika), P2 × P7 (Parbhani Kranti × IC-89948), P3 × P8 (Arka Anamika × VRO-6), P2 × P8 (Parbhani Kranti × VRO-6), P2 × P5 (Parbhani Kranti × IC-282273) and P1 × P6 (Phule Utkarsha × IC-39139-A) were best specific combinations for most of the characters. The results contribute valuable information for understanding the combining ability of the specified parents and identifying promisingcross combinations for further breeding programs aimed at enhancing specific traits inokra.

Nagesh *et al.* (2014) in an experiment focused on okra, the researchers aimed to estimate the magnitude of heterosis and identify good combiners for yield and quality parameters. Using a line × tester mating design, they generated 54 F1 hybrids. Amongthe lines, KON-5 stood out as a good general combiner for various traits, including fruitlength, fruit diameter, average fruit weight, total yield per plant, total yield per hectare,number of fruits per plant, number of locules per fruit, and number of seeds per fruit. This indicates that KON-5 displayed positive combining ability for these traits, suggesting its potential as a valuable contributor to the development of high-performinghybrids in okra breeding programs.

An experiment was carried out by **Kumar *et al.* (2014)** with 12 parental lines of okra, involving 66 F1 hybrids based on a half-diallel cross design excluding reciprocals. The objective was to investigate the combining ability of okra concerning various characters. The traits under consideration included days to 50% flowering, 1^{st} flowering node, plant height, no. of branches/ plant, internodal distance, number of pods per plant,pod length, pod diameter, pod weight, no. of seeds/pod and 100-seed weight. Most of the characters exhibited significant SCA effects indicating predominance presence of non-additive gene action.

Katagi *et al.* (2015) conducted a combining ability analysis for fruit yield andcomponents in okra in a 6 × 6 diallel cross. They found a good general and specific combiner for all characters, such as days to 50% flowering, total pod yield/plant, fruit length, no. of primary branches/plant, no. of fruits/plant, diameter of fruit and 100-seed weight.

Vekariya *et al.* (2020) studied about heterosis, combining ability and gene interactionsover environments of parents and their crosses. The experimental material, consisting of eleven lines, five testers and their resultant 55 hybrids along with a commercial hybrid check “OH-102” of okra were sown in three different locations of south Gujarat viz., College farm, NMCA, NAU, Navsari (E1), Cotton Research Sub Station, NAU, Achhalia (E2) and Regional Rice Research Station, NAU. The hybrids viz., JOL-14-10 ×Arka Abhay, JOL-14-10 × GJO-3 and JOL13-05 × GJO-3 exhibited higher but non- significant standard heterosis for fruit yield at all locations. The estimates of GCA effects indicated that parents viz., JOL-14-10, GJO-3 and JOL-13-05 were good generalcombiners for fruit yield and its contributing traits. None of the hybrids exhibited higherper se performance, SCA effects and standard heterosis for fruit yield for all locations.

2.3. To estimate the nature and magnitude of gene action involved in the heritance of various qualitative and quantitative traits.

Plant breeders have long recognized the existence of differences in adaptability among genotypes, but effectively incorporating these distinctions into breeding programs has proven challenging. This variability is characterized as genotypic-environment interaction, indicating the lack of correspondence between genetic and non-genetic factors influencing development. **Comstock and Moll (1963)** statistically demonstrated the constraining effects of substantial genotype-by-environment (G × E) interaction on the effectiveness of selection programs. **Lewis (1954)** introduced the term 'Stability Factor' to quantify phenotypic stability, calculated as the ratio of mean values in high-yielding environments to those in low-yielding environments**. Finlay and Wilkinson (1963)** defined a stable variety based on its mean and regression values obtained across environmental means. These concepts and statistical approaches have been pivotal in understanding and addressing the challenges posed by genotypic- environment interaction in plant breeding.

Reddy *et al*. 2023 conducted a field investigation aimed at assessing distinctiveness, uniformity, and stability. They gathered qualitative data on 18 characteristics, focusing on both vegetative and reproductive traits during the years 2020-2021. The findings of the study highlighted considerable variability among genotypes for most qualitative traits, with the exception of specific characteristics such as plant growth habit, branching position, leaf blade color between veins, fruit type, and seed size. Notably, there was significant diversity observed in fruit-related characteristics across the genotypes studied. For instance, mature fruit color varied, with 8.3% exhibiting a yellowish-green hue, 23.3% being green, and 68.4% displaying a dark green coloration among the recorded genotypes.

Karadi & Hanchinamani (2021) estimated the amount of heterosis for the yield by using a mating design called line × tester, 54 F1 hybrids were produced. These F1s weretested in a randomized block design with two replications together with 21 parents, a commercial check (Mhyco-10), and other individuals. The yield and quality traits in parents and hybrids were significantly significant in the analysis of variance. This suggests that the various analyzed traits have a wide range of parents and hybrids. Sevenof the 54 cross combinations showed a significant and favorable heterosis over the superior parent. The heterosis over the economic parent was positive and substantial in 11 crosses. The crop has the potential to result in heterotic cross combinations, and these crosses can be employed to increase this crop's improvement. Five crosses—L43×T44, L22 × T36, L22 × T44, L53 × T36, and L31 × T23 were identified as having the ability to provide target fruit output per plant and other traits. In comparison to both better parents and the industry standard test for fruit yield per plant, the hybrid L43 × T44 displayed strong heterosis and per se performance. This suggests that the cross can be used for profit.

Nanthakumar *et al.* (2021) conducted the study at Adhiparasakthi Agricultural College farm, Kalavai, Vellore district of Tamil Nadu state during summer 2014. 24 F1 hybrids (EC755648, EC755653, EC 755654, IC52303, IC755652, IC111515) and three testers make up the experimental material (Arka Anamika, Parbhani Kranti, Pusa Sawani VRO 22). They were assessed in a randomized block design with three replications along with the commercial check ('Shakthi'). A total of 14 yield and yield contributing characters were observed. The findings implied that non-additive gene activity predominated for all of the attributes. Parent EC 755648 and Parbhani Kranti were important general combiners for yield among the parents, according to the overall analysis of GCA impacts; these can be exploited to develop hybrids in the future that have desirable features. For all of the examined qualities, significant positive SCA effects were discovered. EC755653 × Arka Anamika and IC111515 × Parbhani Kranti showed favorable standard heterosis percentage over the check Shakthi as well as goodSCA effects, per se performance for yield, and other significant yield-contributingqualities.

Rajani *et al.* (2021) studied the combining ability of six different lines of okra. For combining ability pooled analysis was carried out over three locations named HRS Lam, KVK Venkataramannagudem and KVK Vonipenta, Andhra Pradesh, India, which revealed differences among the treatments for all the characters significantly except fruit girth and test weight. The differences among the parents vs. hybrids were recordedto be significant for all the characters except for number of fruits per plant and fibre content. The lines HRB-9-2 and VRO-3 recorded significant positive GCA effects and were found to be promising general combiners for yield attributing traits. In respect of SCA effects, none of the 15 hybrids was found to be superior for all the traits under investigation whereas, only one cross i.e., 440-10-1 × HRB-9-2 recorded significant positive SCA effects for fruit yield per plant in okra.

Suganthi *et al.* (2020) conducted an investigation to assess six parents and thirty hybrids using the diallel mating method in order to explore the effects of general and specialized combining abilities as well as genetic analyses for different yield and yield- related traits. Diallel analysis revealed that all genotype variances for the characters were extremely significant, showing significant genetic variation among the parents under investigation. The parent Hissar Unnat was determined to be the superior parent based on GCA effects. MDU 1, Pusa Savani, and Arka Anamika were named as the following better parents. Based on average performance, Hissar Unnat Pusa Savani, Arka Anamika Arka Abhay, Kamini MDU 1, and Hissar Unnat MDU 1 were recognized as the top hybrids for taking advantage of heterosis. For the characters, days to 50% flowering, plant height at maturity, number of branches per plant, no. of fruits/plant, length of fruit, weight of fruit, and fruit yield/plant, the hybrids Hissar Unnat Pusa Savani, Arka Anamika Arka Abhay, and Hissar Unnat MDU 1 all had high positive significant SCA values. Several crossings containing these hybrids might be a worthwhile strategy for tangibly enhancing these features.

Duenk *et al*. (2020) investigated how the average effects of alleles vary significantly across different populations. The extent of these variations can be assessed through the additive genetic correlation between populations, which is influenced by both non-additive genetic effects and disparities in allele frequencies among populations.

Javiya *et al.* (2020) studied the combining ability for fruit yield and its contributing traits in okra. The experimental material consisted of eleven parents (8 linesand 3 testers) and 24 F1's produced from line × tester mating design and evaluated in randomized block design for seven characters The analysis of variance for combining ability revealed that the SCA variances were higher than their respective GCA variances for all the characters (except number of fruits per plant)confirmed the preponderance ofnon-additive gene action for most of the traits emphasized the utility of hybrid breedingapproach to exploit existing heterosis in okra The parents EC 169513, EC30563 and VRO-6 were identified as good general combiners for most of the characters including fruit yield per plant and can be exploited well in further breeding programme. The estimates of SCA effects revealed that the two cross combinations EC 169513 × GO-6 and EC 30563 × VRO-6 were observed most promising for fruit yield and some of its related traits which could be used as heterotic hybrids.

Devi *et al.* (2020) studied about gene action on ten genotypes in okra in line × tester mating design the analysis for variance for combining ability revealed that predominance of SCA variance over GCA variance indicated that their traits might be controlled predominantly by non-additive gene action. Among the lines Salem local, Theni local and Attur local and tester Dhivya 22 were considered as the best general combiners, while hybrids Salem local × Dhivya 22 and Attur local ×Dhivya 22 as good specific combiners for fruit yield and other fruit yield component traits. Biparental mating followed by recurrent selection might hasten the rate of genetic improvement of these traits in bhindi.

Abinaya *et al.* (2020) estimated the combining ability, nature of gene action and heterosis of the parents by adopting Line × Tester analysis, using seven lines and three testers. Fruit length, Fruit girth, Single Fruit yield, and Fruit Yield per Plant—four commercially significant traits were investigated. The lines Trichy Local and Mohanur Local, as well as the testers Arka Anamika, were discovered to be the greatest parents for the majority of the qualities examined. When it comes to hybrids, the grafts Trichy Local and Arka Anamika and Mohanur Local and Arka Anamika showed strong per se performance for fruit yield per plant. For all of the features, the analysis of variance revealed a substantial difference between the parents (lines and testers). The proportion of non-additive gene activity to additive gene action was also indicated by the GCA/SCA ratio.

Dabhi *et al.* (2010) studied estimating phenotypic stability for fruit yield and its component traits, 64 genotypes (comprising 48 hybrids and 16 parents) of okra were grown on three different dates. The non-significance of Genotype by Environment (linear) interaction against pooled deviation for most of the studied characters suggested that the performance of genotypes remained similar in their linear regression on the environmental index. Based on mean (X), regression coefficient (bi), and deviation from regression (S2di), the parents JOL-06(K)-2 and GO-2, as well as the hybrid JOL- 06(K)-2 × GO-2, were identified as stable and widely adapted for general cultivation of fruit yield and its components in okra. In another evaluation involving 35 okra genotypes across three different environments by **Ramya and Senthil Kumar (2010),** significant Genotype by Environment (G × E) interaction was observed for days to first flowering, number of fruits per plant, plant height, and single plant yield. The genotypes Pusa A4, Parbhani Kranti, Varsha Uphar, Punjab Padmini, Hissar Unnat, PB-266, CO- 1, Harbhajan, Arka Abhay, and AOL-03-01 were identified as having significantly higher regression coefficients and desirable mean values for the trait pod yield per plant.

Kachhadia *et al.* (2011) study on phenotypic stability for fruit yield and its component traits, 55 genotypes, consisting of 40 hybrids, 14 parents, and a standard check variety (GO-2) of okra, were cultivated over three different seasons. The Genotype by Environment (G × E) interactions were found to be significant for all the characters, except for fruit girth. The environmental indices indicated that the early summer season was the most favorable for fruit yield per plant and the majority of yield-contributing traits. Based on stability parameters, the parents JOL-06-S-7, JOL-1, and JOL-06-1, as well as the hybrids GO-2 × Parbhani Kranti and JOL-06-S-6 × HRB-55, were identified as stable with wider adaptability. This suggests that these genotypes exhibit consistent performance across different environments, making them suitable for cultivation in diverse conditions.

Akotkar *et al.* (2011) study testing twelve genotypes of okra in three different environments for the stability of eight yield-contributing traits, highly significant differences were observed over the tested environments. The fruit yield per plant exhibited the highest value for pooled deviation, while primary branches per plant had the lowest. Regarding regression values, genotypes behaved differently for different traits. Notably, among genotypes with significantly higher mean values, the genotype IC-433645 produced non-significant bi values and S2di, indicating stability in performance across environments. In another assessment of stability among 50 accessions of West African okra (*Abelmoschus caillei*) under three diverse ecological environments in Nigeria, regression coefficients of mean yields on the environmental index ranged from 0.5549 to 1.6667. OAA/96/175-5328, NGAE-96-011, and NGAE- 96-0060 were identified as superior genotypes.

Senthilkumar (2011) analyzed thirteen genotypes of okra to study Genotype Environment (G × E) interactions and identify stable genotypes (parents and hybrids) for seven fruit traits. The stability analysis of variance revealed significant pooled deviations for all traits except fruit length, indicating the predominance of the linear component. Stability parameter estimates showed that no genotypes were stable for all studied traits. Additionally, in a study involving 57 okra genotypes subjected to stability analysis in four environments/seasons for eleven yield and yield-contributing traits, highly significant G × E interaction was observed only for six traits. The rainy season was noted as favorable for fruit yield per plant, plant height, and fruit weight. Spring- summer season proved ideal for days to first flowering and days to first picking, while the summer season appeared to be best for the total number of pickings.

Hamed and Hafiz (2012) studied on investigating the genotypic stability of thirteen local okra genotypes across three different locations. Multi-environmental trials (MET) typically exhibit significant main effects and multiplicative genotype- environment interaction (G × E) effects. The findings revealed that genotype (G), environment (E), and their interaction were all statistically significant ($P < 0.01$). The Additive Main Effects and Multiplicative Interaction (AMMI) model proved to be highly effective for studying genotype-environment interaction (GEI). Interestingly, no single genotype demonstrated superior performance across all studied environments. The biplot analysis indicated that the genotypes BG9, BG6, BR27, and BR20 were particularly well-suited for cultivation in a wide range of environments. Additionally, the study highlighted the adverse impact of salt stress on the growth anddevelopment of okra plants.

Olayiwola and Ariyo (2013) The review emphasized the necessity of conducting multi-environment studies in plant breeding due to the observed variation in genotype responses to different environments. In a specific study, twelve okra genotypes were evaluated across three environments to investigate the impact of Genotype Environment Interaction (GEI) on seed yield. Utilizing GGE biplot and YSi techniques, NHGB/09/009A emerged as the genotype with the best combination of high yield and stability. Additionally, FUNAAB-11-4 and FUNAAB-11-6 were identified as having promising potential in this regard. The GGE biplot further revealed two mega- environments, Ibadan and Ayetoro, where FUNAAB-11-8 exhibited outstanding performance, and Abeokuta, where FUNAAB-11-3 was the best. Stability performance analysis involved 49 okra entries, including 13 genetically diverse parents and 36 crosses, using Javia's (2014) stability analysis. The analysis of variance for stability indicated highly significant differences among the genotypes for all traits when tested against the pooled error, pooled deviation, and G × E interaction. This highlighted the presence of variability among the genotypes in terms of stability performance.

Padadalli *et al. (*2019) developed thirty three hybrids by crossing 7 lines and 3 testersin L × T manner for about 26 parameters for the traits of productivity and quality. The variance due to parents vs. hybrids was also significant for all traits except plant heightat 45 DAS, internodal length 45 DAS, days to first flowering, fruit diameter and seed yield per plant. The lines L7, L1 and L3 may be utilized as parent stocks for breeding for, growth parameters, earliness, yield and quality traits etc., among the hybrids L3 × T2, L7 × T2, L3 × T3, L1 × T3 and L7 × T2 showed specific combiner for almost characters as per results due to its an F5 generation which attain homozygosity so, selection is effective for quality traits of fruits. The study showed the potential nutritional importance of okra and its role in improved nutrition.

Hadiya *et al.* (2018) conducted an experiment to study about the combining ability foryield and its contributing traits in okra. The experimental material consisted of seven parents and 21 F1s produced from diallel mating design excluding reciprocal crosses inrandomized block design for fourteen characters. The mean squares due to GCA, SCA effects were significant for fruit yield and yield contributing traits studied. None of the parents identified as good general combiner for fruit yield per plant but the parents AOL-10-22, VRO-6, HRB-55 and AOL-12-59 were identified as average general combiners for yield per plant and can be exploited well in further breeding programme. The estimates of sca effects revealed that the cross combinations AOL-10-22 × GAO- 5, AOL-10-22 × VRO-6, JDNOL-11-01 × Arka Anamika and HRB-55 × AOL-12-59 were observed most promising for fruit yield and some of its related traits couldbe used as heterotic hybrids.

Paul *et al.* (2017) studied about the okra to estimate the magnitude of gene action involved and to identify the good combiner for fruit yield and other yield attributing characters. 55 okra hybrids derived by crossing of 11parents in diallel mating design excluding reciprocals were studied to assess the combining ability and gene action andfound that the estimates of specific combining ability effects indicated that cross combinations JOL-55-3 × HRB-55 (56.786**), JOL-09-8 × JOL-09-7 (46.346**) and JOL-09-8 × AOL-09-17 (46.110**) were most significant for fruit yield per plant and related traits.

Kumar and Reddy (2016) conducted an experiment on six inbred lines (RNOYR-14, RNOYR-15, RNOYR-16 RNOYR -17, RNOYR-18, and RNOYR-24) and along with their 15 half-allele crosses were evaluated in a Randomized blocked design with three replications to determine the nature of gene action and combining ability for pod yieldand its component characters of okra. Combining ability analysis revealed that both general combining ability (GCA) and specific combining ability(SCA) variances were highly significant for majority of the agro-economic traits indicating the importance of both additive and non-additive gene actions. The ratio of GCA variance (σ2 GCA) to SCA variance (σ2 SCA) of less than unity.

Joshi *et al.* (2015) conducted a field experiment with 8 parents and 28 hybrids createdusing half-diallel with 3 replications. Two parents, AOL 10-8 and Arka Abhay, were identified as good general combiners for pod yield plant-1 out of a total of eight parents. For features like number of pod plants, pod yield plants, stalk length, and dietary fibrecontent at marketable stages, Arka Abhay was also shown to be a good general combiner. Parbhani Kranti, the parent, was noted as an effective combiner for several features. The crosses with strong SCA effects for pod yield also had high SCA effects for at least one other significant yield component, such as the number of pod plants perplant, the number of branches, the weight of the pods, etc.

Verma & Sood (2015) investigated using a half diallel analysis of 28 F1 hybrids produced by mating 8 parental lines. The current study showed a preponderance of additive gene action for days to first picking, first fruit producing node, internodal length, average fruit weight, and harvest duration, and a preponderance of non-additive gene action for days to 50% flowering, nodes per plant, fruit length, fruit diameter, plantheight, fruits per plant, and mucilage. Only one dominant component of variation was found for dry matter and fruit production per plant, indicating non-additive gene action. As a result, heterosis breeding must be used to take advantage of these qualities.

Nagesh *et al.* (2014) conducted breeding approaches using 21 parents and commercialcheck for estimating the magnitude of heterosis in okra genotypes for better quantitative and qualitative parameters. 54 F1s were made by utilizing line × tester mating fashion and analyzed for significant heterosis in compare with commercial check. The study shows relatively good scope of exploitation of hybrid vigor for commercial productionof okra.

Lyngdoh *et al.* (2013a) conducted experimental trial for identifying heterosis in near isogenic lines if okra cultivars using 18 lines and 4 testers s (Parbhani Kranti, Arka Anamika, VRO-5 and VRO-6) and there 72 F1s were compared against commercial check variety ((MHY-10). Result revealed maximum amount of heterosis for KO-6 × PK (-43.05%) for internodal length, for plant height it isKO-2 × PK (48.20%), KO-2 × AA (23.90%) for number of leaves, over the better parent and KO-6 × PK (56.07%) for plant height over commercial check variety.

Adiger *et al.* (2013) estimated combining ability of 43 cultivars of okra for various traits. The experiment generated 120 crosses by using line × tester mating system having 40 female lines and3 testers. Outcome showed higher SCA variance than GCA, implies presence of non- additive gene effect for almost all traits. The genotype PrabhaniKranti was reported as having good combining ability for parameters like plant height, branches/plant, fruit weight, pod length, yield pod/plant and yield/area which indicate the chances of utilization of this genotype in breeding programme for crop improvement.

Kumar *et al.* (2013) focused on estimating combining ability through line × tester analysis and evaluating the magnitude of heterosis by creating 15 cross combinations in a Randomized Block Design (RBD) with three replications, conducted during the summer and kharif seasons. Data pertaining to nine characteristics, including plant height, number of primary branches, days to first flowering, total number of fruits per plant, fruit length, fruit girth, fresh fruit weight, internodal length, and yield per plant, were utilized. Based on General Combining Ability (GCA) effects across the nine traits, Arka Abhay, VRO-6, Hissar Unnat, and Punjab Padmini were identified as the most promising parents for enhancing the number of fruits per plant, fruit girth, and days to 50% flowering. The most promising crosses, displaying significantly positive Specific Combining Ability (SCA) effects and standard heterosis for fruit yield, were Arka Abhay × Parbhani Kranti, Hissar Unnat × Punjab Padmini, VRO-6 × Parbhani Kranti, and VRO-6 × Arka Anamika.

Medagam *et al.* (2012) studied the Gene action and combining ability effects for yieldand its components of okra *(Abelmoschus esculentus*) through 10 × 10 half-diallel analysis. Forty-five single crosses were developed by crossing 10 lines of okra viz., P1 (IC282248), P2 (IC27826-A), P3 (IC29119-B), P4 (IC31398-A), P5 (IC45732), P6 (IC89819), P7 (IC89976), P8 (IC90107), P9 (IC99716) and P10(IC111443) in a half- diallel manner during summer. All 45 F1s along with their10 counterpart parental lineswere evaluated in a randomized block design with three replications and concluded that the parental lines P5 (IC45732), P6 (IC89819) and P7 (IC89976) were high general combiners for total and marketable yield per plant and other yield associated traits. Thecrosses C23 (IC29119-B × IC99716), C17 (IC27826-A × IC111443), C42 (IC89976 × IC111443) and C43 (IC90107 × IC111443) were superior specific combiners for totaland marketable yield/plant and other yield-related traits, which could be exploited for the production of F1 hybrids. The cross C42 (IC89976 × IC111443), having one of the parents with significantly positive general combining ability effect for total and marketable yield/plant, could be utilized in recombination breeding.

Reddy *et al.* (2012) studied 45 hybrids resulting through half diallel fashion and noticed that the preponderance of non-additive gene action involved in the inheritance of plant height, internodal length, days to 50% flowering, first number of marketable fruits per plant, total yield per plant and yellow vein mosaic virus infestation on fruits and plants and additive gene action involved in the inheritance of number of branches per plant and fruit and shoot borer infestation on fruits and shoots. The crosses IC29119-B × IC99716, IC27826-A× IC111443, IC89976 × IC111443 and IC90107 × IC111443 found with superior specific combining ability for total and marketable yield per plant.

Vachhani *et al.* (2011) studied the heterosis and inbreeding depression for fruit yield and yield components in F1 and F2 generations of 10 × 10 diallel crosses excluding reciprocals and reported that high magnitude of heterotic effects detected for fruit yield per plant, number of fruits per plant, 10-fruits weight and internodal length. The cross combination AOL-99-24 × Ajeet -121 expressed the highest heterobeltiosis along withhigh magnitude of inbreeding depression for fruit yield per plant.

Kumar (2011) studied 42 crosses from 7 × 7 diallel including reciprocals and found that the standard heterosis ranged from -23.95 to 55.96 per cent for fruit yield per plant.The cross Pusa A4 × Punjab Padmini exhibited the highest magnitude of heterosis (43.23 and 55.96%) for fruit yield per plant, (14.81 and 52.44%) for number of branches per plant, (13.52 and 29.78%) for number of fruits per plant over better parent and Sakthi.

Raghuvanshi *et al.* (2011) analyzed combining ability in 10 okra genotypes utilizing line × tester(6 × 4) method. Significant magnitude of GCA and SCA were observed for all selected characters signifies the gene action of both additive and non- additive types. Different parents were found to be good combiners of various different characters *viz.* HRB-55 (intermodal length), HRB-9-2 and VRO-6 (first flowering, pod length, yield/plant) whereas 3 cross combinations were found showing SCA for fruit yield/plant *viz.* HRB-9-2 × Arka Abhay, HRB55 × Arka Abhay and HRB-9-2 × P-7.

CHAPTER 3

MATERIALS AND METHODS

The present investigation entitled " **Assessment of heterosis and combining ability studies on yield and quality parameters in Okra [*Abelmoschus esculentus* (L.) Moench]**" by Line × Tester mating design was undertaken to investigate the extent of heterosis, combining ability and gene action. The field trial was conducted in the "Vegetable Research Field, Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab during 2022-23. The details of materials employed, methodologies applied and the techniques utilized during the period of experiment are detailed as follows:

3.1.1 Experimental Location

The Lovely Professional University is situated between 31^{o}15' North latitude, 75^{o} 42' East latitude at an altitude of 228 meters above the mean sea level (MSL). The total agriculture land of the district is 134 hectares. Major source of irrigation in tube wells, bore wells and then pump sets. Only 3% of land is irrigated by canal.

3.1.2 Climate and Weather

The temperature reaches above 40^{o} C during summer and during winter the temperature goes down below 10^{o} C. The area falls under sub humid region. During the first season of cultivation the maximum temp was observed during the month of July being the hottest month and January being the coldest month. However, during the second season of cultivation June was reported as the Hottest month The average rainfall is 719 mm. The highest rainfall is recorded during the month of July and the driest month is November (Fig.3.1)

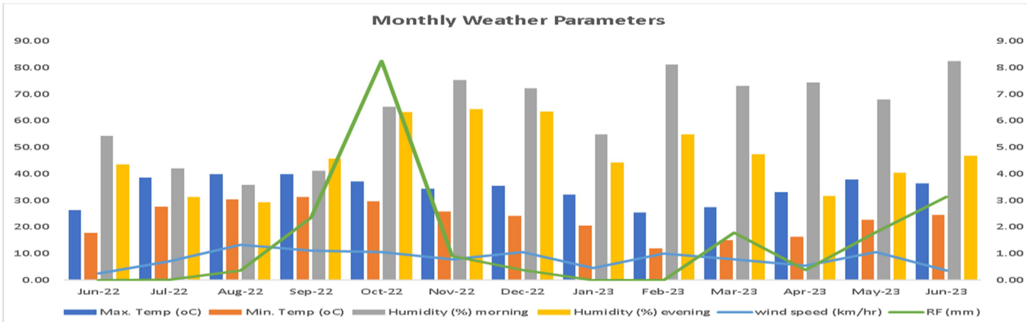

Fig 3.1 : Meteorological data recorded during experimental periods

3.2 Experimental materials and Design

Fifteen germplasms of okra were obtained from NBPGR, New Delhi, and subjectedto crosses with four testers. The breeding strategy involved a line × tester mating design, resulting in the generation of 60 F1 hybrids derived from nineteen parental sources, comprising 15 female lines and 4 testers during 2022-23. The evaluation of these F1 hybrids, along with their respective parents and check, was conducted using a randomized block design (RBD) with three replications during both the summer and rainy seasons. The details regardingthe specific lines, testers, and F1 hybrids are given to Table 3.1 and Table 3.2.

Table 3.1 The genotypes and their sources involved in the investigation

SN No.	Genotypes (Line)	Symbols	Source
1	IC 128021	L_1	NBPGR, New Delhi
2	IC128023	L_2	
3	IC 128024	L_3	
4	IC 128028	L_4	
5	IC 128029	L_5	
6	EC 169451	L_6	
7	EC 169453	L_7	
8	EC 169455	L_8	
9	EC 169459	L_9	
10	EC 169462	L_{10}	
11	EC169463	L_{11}	
12	EC 169464	L_{12}	
13	EC 169467	L_{13}	
14	EC 169470	L_{14}	
15	EC 169472	L_{15}	
Testers			
1	Kashi Pragati	T_1	IIVR, Varanasi
2	Kahi Lalima	T_2	
3	Kashi Kranti	T_3	
4	Arka Anamika	T_4	IIHR , Bengaluru
Check			
1	Punjab Suhawani	C_1	PAU, Ludhiana

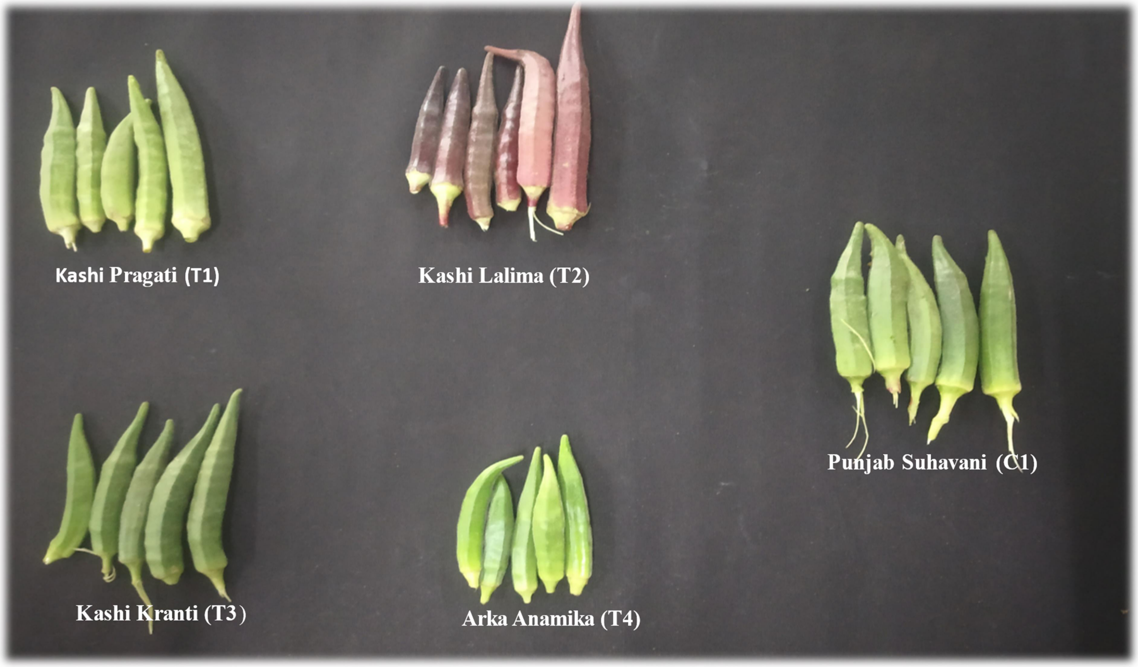

Fig 3.2 : Pod shape, size and colour of different testers and check

Fig 3.3: Growth, pod setting and seed harvesting of different lines

Table 3.2 List of Crosses obtained during the experiments during 2022-23

SN	Cross	Symbol	SN	Cross	Symbol
1.	IC128021×Kashi Pragati	L1×T1	31.	EC 169455 × Kashi Kranti	L8 ×T3
2.	IC 128021 × Kashi Lalima	L1×T2	32.	EC 169455 × Arka Anamika	L8 ×T4
3.	IC 128021 × Kashi Kranti	L1×T3	33.	EC 169459 × Kashi Pragati	L9 ×T1
4.	IC 128021 ×Arka Anamika	L1×T4	34.	EC 169459 × Kashi Lalima	L9 ×T2
5.	IC128023 × Kashi Pragati	L2×T1	35.	EC 169459 × Kashi Kranti	L9 ×T3
6.	IC128023×Kashi Lalima	L2×T2	36.	EC 169459 × Arka Anamika	L9 ×T4
7.	IC128023 × Kashi Kranti	L2×T3	37.	EC 169462×Kashi Pragati	L10×T1
8.	IC128023×Arka Anamika	L2×T4	38.	EC 169462 × Kashi Lalima	L10×T2
9.	IC 128024 × Kashi Pragati	L3×T1	39.	EC 169462×Kashi Kranti	L10×T3
10.	IC 128024 × Kashi Lalima	L3×T2	40.	EC 169462 × Arka Anamika	L10 ×T4
11.	IC 128024 × Kashi Kranti	L3×T3	41.	EC169463 × Kashi Pragati	L11 ×T1
12.	IC 128024 × Arka Anamika	L3×T4	42.	EC169463 × Kashi Lalima	L11 ×T2
13.	IC 128028 × Kashi Pragati	L4 ×T1	43.	EC169463 × Kashi Kranti	L11×T3
14.	IC 128028 × Kashi Lalima	L4 ×T2	44.	EC169463 × Arka Anamika	L11×T4
15.	IC 128028 × Kashi Kranti	L4 ×T3	45.	EC 169464 × Kashi Pragati	L12×T1
16.	IC 128028 × Arka Anamika	L4×T4	46.	EC 169464 × Kashi Lalima	L12×T2
17.	IC 128029 × Kashi Pragati	L5 ×T1	47.	EC 169464 × Kashi Kranti	L12×T3
18.	IC 128029×Kashi Lalima	L5 ×T2	48.	EC 169464 ×Arka Anamika	L12×T4
19.	IC 128029 × Kashi Kranti	L5×T3	49.	EC 169467 ×Kashi Pragati	L13×T1
20.	IC 128029 ×Arka Anamika	L5 ×T4	50.	EC 169467× Kashi Lalima	L13×T2
21.	EC 169451 × Kashi Pragati	L6 ×T1	51.	EC 169467×Kashi Kranti	L13 ×T3
22.	EC 169451 × Kashi Lalima	L6 ×T2	52.	EC 169467×Arka Anamika	L13 ×T4
23.	EC 169451 × Kashi Kranti	L6 ×T3	53.	EC 169470 × Kashi Pragati	L14 ×T1
24.	EC 169451 × Arka Anamika	L6 ×T4	54.	EC 169470 × Kashi Lalima	L14×T2
25.	EC 169453 × Kashi Pragati	L7 ×T1	55.	EC 169470 × Kashi Kranti	L14 ×T3
26.	EC 169453×Kashi Lalima	L7 ×T2	56.	EC 169470 × Arka Anamika	L14 ×T4
27.	EC 169453 × Kashi Kranti	L7 ×T3	57.	EC 169472 × Kashi Pragati	L15 ×T1
28.	EC 169453 × Arka Anamika	L7 ×T4	58.	EC 169472 × Kashi Lalima	L15 ×T2
29.	EC 169455 × Kashi Pragati	L8 ×T1	59.	EC 169472×Kashi Kranti	L15 ×T3
30.	EC 169455 × Kashi Lalima	L8 ×T2	60.	EC 169472 ×Arka Anamika	L15 ×T4

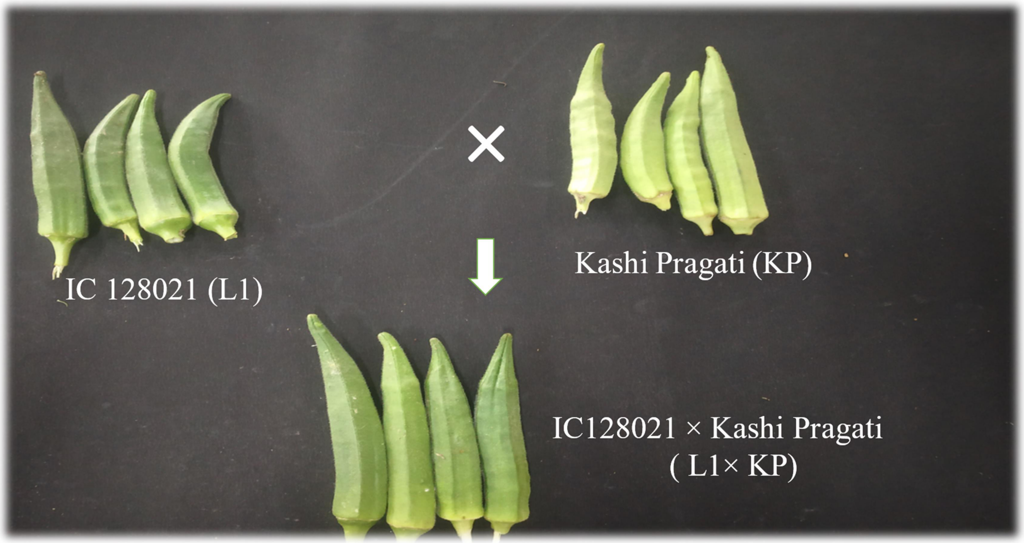

Fig 3.4: The pods of F1 developed between L1 and Kashi Pragati

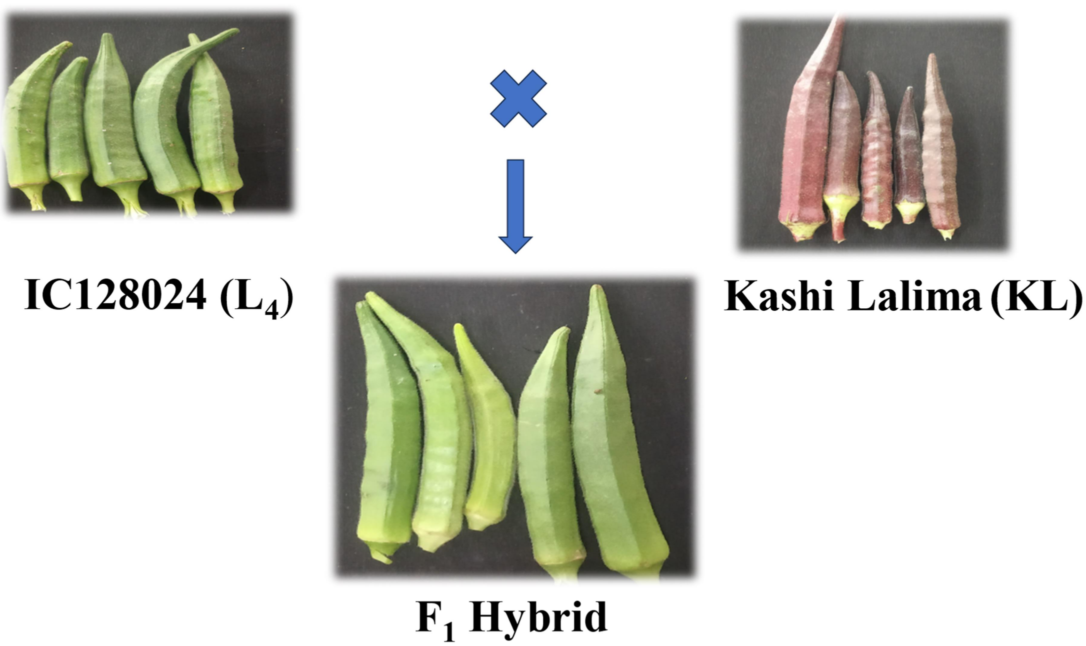

Fig 3.5: The pods of F1 developed between L4 and Kashi Lalima

3.4. METHODS

3.4.1. LAYOUT OF THE EXPERIMENT

The experiment was conducted during 2022-23. The crop was sown on spring summer season for attempting hybridization during the year 2022 and for evaluation the crop was sown during rainy and spring summer for 2022-23. The field was ploughed and prepared to a fine tilth. Prior to sowing, approximately 15-20 tons of Farm Yard Manure (FYM) were incorporated into the soil. For soils of average fertility, 36 kg of nitrogen (80 kg of urea) per acre was applied, with half of the nitrogen administered at sowing and the remaining as top - dressing after the first picking of fruits. Each genotype was sown in raised beds with aspacing of 60 × 30 cm, and two to three seeds were planted per hill. Thinning, carried out two weeks after seedling emergence, resulted in leaving one plant per hill. Irrigation and other cultural practices were implemented according to recommended guidelines of PAU, Ludhiana the detail of the environment taken under study are described in Table 3.3.

Table 3.3 Details of environments taken under study

Environments	Sowing time
Crossing block	Sown in spring summer season at 22nd March 2022
E_1	Sown in rainy season at 22nd August 2022
E_2	Sown in spring summer season at 22nd February 2023

3.4.2 Evaluation of parents, F1's and commercial F1 hybrid

The experimental material consisted of fifteen lines and four testers, 60 F_1 hybrids derived from (15 × 4) line × tester fashion and one commercial check. The details of the layout are given below:-

a) Evaluation of genotypes was done in spring summer and rainy season

E_1: Rainy season at 22nd August 2022

E_2: Spring summer season at 22nd February 2023

b) Treatments : 80 (15 lines + 4 Testers + 60 F_1 + commercial check).

c) Commercial check : Punjab Suhawani

d) Replication: Three

e) Design: Randomized block design (RBD)

f) Spacing: 60 cm (between rows) × 30 cm (between plants)

g) **Plot Size :** 2 m^2

h) **Number of rows per genotype:** 2

i) **Number of plants per row :** 6

j) **Agronomic practices:** As per recommendation of PAU, Ludhiana

k) **Plant Protection measures:** As and when required

3.5. HYBRIDIZATION PROGRAMME

All recommended cultivation practices were meticulously adhered to in order to ensure the cultivation of a high-quality crop. A total of 60 hybrids were developed through the crossbreeding of 15 female parents (lines) with each of the 4 male parents (testers). In the evening before their opening, flower buds of both male and female parents were carefully selected. To prevent pollen contamination from other parents, the chosen flower buds of male parents were covered with butter paper bags. Similarly, flower buds of female parents were emasculated and covered with butter paper bags to preventoutcrossing. Pollination was done in the morning, between 8:00 am and 10:00am, using the desired male parent's pollen. After pollination, female flower buds were once again covered with butter paper bags to prevent contamination and were tagged with details such as the male parent and the date of pollination. Concurrently, both male and female parents were self-pollinated by bagging flower buds with butter paper bags before the flowers opened. Crossed and self-pollinated fruits were harvested separately at the full maturity stage. The seeds were manually extracted and preserved in butter paper bags, each labelled with the details of the cross or entry number.

3.6. OBSERVATIONS RECORDED

All five randomly selected plants within each genotype and replication were subject to observation, and data were meticulously recorded on various quantitative characters. The subsequent quantitative traits were examined, and the observations were documented using the specified techniques. The treatment mean was computed for eachreplication based on the average values recorded and Laboratory analysis were done. The characters under study and the methods employed for observation are detailed below.

3.6.1 Quantitative traits

A. Growth Parameters:-

1. Plant height (cm)

The height of five randomly selected plants was measured, in centimeters, from the ground level to the tip at the time of final harvest.

2. Number of branches per plant

The total number of branches on randomly selected five plants was counted at the final harvest and the mean was calculated.

3. Stem: diameter at 10cm above the ground level (cm)

After 60 days of sowing, five plants were randomly chosen and measured using a Vanier scale. The measurements were categorized into three groups: a) Thin (< 2 cm), b) Medium (2-4 cm), and c) Thick (>4 cm) (Anonymous, 2009).

4. Leaf blade length (cm)

Five plants were randomly selected and measured after 60 days of sowing with the help of measuring scale they were classified into a) Short(<14cm) b) Medium (14-15 cm) c) Long (>15 cm) (Anonymous, 2009).

5. Leaf blade width (cm)

Five plants were randomly chosen and measured after 60 days of sowing with the help of measuring scale. They were classified into a)Short (<13 cm) b) Medium (13-20 cm) c) Long (>20 cm) (Anonymous, 2009).

6. Petiole length (cm)

After 60 days of sowing, five plants were randomly chosen and measured using a measuring scale. The measurements were then categorized into the following classes: a) Narrow (<20 cm), b) Medium (20-25 cm), and c) Broad (>25 cm) (Anonymous, 2009)

7. Days to first flowering

The numbers of days were taken from the date of sowing to onset of first appearance ofa flower on the plant from the five randomly selected plant and average was taken.

8. Days to first fruit set

The number of days were counted from the first day of sowing until the first fruit appears on the plant from the five randomly selected plant.

9. Days to first fruit picking

The number of days were counted from date of sowing to first picking from the five randomly selected plant.

B. Yield Parameters:-

1. Number of flowers per plant

The total number of flowers per plant were counted from the five randomly selected plant and mean values were worked out.

2. Number of pods per plant

The total weight of fruits harvested from five randomly selected plant throughout the picking period was recorded in grams, and the mean values were calculated.

3. Pod length (cm)

The length of tender fruit from five randomly selected plants was measured in centimeters (cm) from the base of calyx to tip of the fruit.

4. Number of first fruiting nodes

The node at which the first fruit set takes place from the base was counted for five randomly selected plant .

5. Number of nodes per plant

At the time of final picking, total number of nodes per plant from base to tip of the plant from five randomly selected plant was counted.

6. Number of ridges per pod

The fresh okra pod were taken and the number of ridges were counted by visual tracking along the pod length from five randomly selected plant.

7. Pod diameter (cm)

The diameter of the tender fruit from five randomly selected plant was measured in centimeters (cm) at the centre of the fruit with the help of a Vernier caliper.

8. Internodal length (cm)

The length of the internodes was measured in centimeters from first flowering to last picking from five randomly selected plant.

9. Average pod weight (g)

The average fruit weight was determined by dividing the total fruit weight by the total number of fruits harvested from all the pickings, yielding the average fruit weight for five randomly selected plant.

10. Pods yield/Plant (Kg)

The total number of fruits from five randomly selected plant across all pickings was recorded in grams, and these values were summed to obtain the total fruit yield per plant.

C. Biochemical Parameters:-

1. Ascorbic acid content (mg/100g)

The ascorbic acid content was determined using the 2,6-dichlorophenol indophenol Visual Titration Method according to the procedure outlined by Ranganna (1979). The standard solution of ascorbic acid was prepared by dissolving 100 mg of L-ascorbic acid in 100 ml of 3% metaphosphoric acid. Ten milliliters of this solution were then diluted to 100 ml with 3% metaphosphoric acid. The 3% metaphosphoric acid solution was prepared by dissolving 15 g of metaphosphoric acid in 500 ml of distilled water. For the preparation of the dye, 50 mg of the sodium salt of 2,6-dichloroindophenol was dissolved in 150 ml of distilled water containing 42 mg of sodium bicarbonate. The solution was then cooled, and the final volume was adjusted to 200 ml. To determine the dye factor, 5 ml of the standard ascorbic acid and 3% metaphosphoric acid solution were taken in a flask and titrated against the dye until a pink color that remains for at least 15 seconds was achieved. The dye factor was calculated using the following formula.:

Dye factor= 0.5/litre

The procedure involved blending ten grams of macerated sample with 3% metaphosphoric acid to make up the final volume to 100 ml. From this 100 ml solution, only 10 ml was extracted and titrated against the 2,6-dichlorophenol indophenol dye. The endpoint of the titration was determined by the presence of a rose-pink color that persisted for at least 15 seconds. The results were expressed in terms of milligrams of ascorbic acid per 100 grams of pulp. Therefore, the ascorbic acid content was calculated by using the following formula

$$Ascorbic\ acid\ \left(\frac{mg}{100g}\right) = \frac{Titre\ \times\ Dye\ factor\ \times\ Volume\ made\ up}{Aliquot\ of\ extract\ \times Weight\ of\ sample} \times 100$$

2. Acidity (%)

Acidity was measured in 5 g of sample, homogenized in 45 mL of distilled water and the solution containing the sample was titrated with 0.1 N NaOH until reaching the turning point of the phenolphthalein indicator (Ryan & Dupont, 1973).

$$Titratable\ acidity\ (\%) = \frac{Titre\ value\ \times Normality\ of\ NaOH\ \times Volume\ made\ up\ \times Eqt.Wt.of\ citric\ acid\ \times 100}{Weight\ of\ the\ sample\ \times Volume\ of\ sample\ taken\ \times 1000}$$

3. Dry matter content (%)

Procedure:

Dry matter was estimated according to the procedure given by Arora *et al*. (2008). 50 g of fresh and immature samples of okra from each entry per replication was taken, cut and put in pre-weighed empty petri-dishes separately. Then the petri-dishes contained the samples was kept in an oven at a temperature of 60°C for a period of 48 hours. After that the samples were taken out, petri-dishes were again weighed and the data was recorded.

Calculation:

Dry matter (%) = $\frac{W2-W1}{W} \times 100$

Where, W_2 = Weight of dried sample + Weight of Petri dish (g)

W_1=Weight of empty Petri dish (g)

W = Weight of sample taken (g)

4. Firmness (Kg/cm^2)

The fruit firmness was noted with the help of Pressure Tester "Penetrometer" from five randomly selected plant .It was recorded in units of Kg/cm^2.

5. **Chlorophyll Content (SPAD unit)**

The amount of chlorophyll content of plant leaves without damaging the leaf were measured by SPAD meter from five randomly selected plant.

6. **Mucilage content (%)**

Reagents used: Ethanol and acetone

Mucilage was extracted according to the procedure given by Woolfe et al. (1977). 25 g of fresh and immature fruit samples of okra was grounded in 125 ml of distilled water. Then it was filtered and centrifuged at 4000 g (- 6500 rpm) for a period of 15 minutes and the clear viscous solution was obtained. After that the clear viscous solution was heated to inactivate enzymes at a temperature of 70°C for 5 minutes. The mucilage was then precipitated with three equal volumes of ethanol (75 ml) and washing with more ethanol followed by acetone was done. The cream coloured solid was obtained and collected on pre-weighed Whatman's filter paper No. 1. Later it was dried under vacuum at 25°C for a period of 12 hours

Calculations: Rao and Sulladamath 1977

$$\text{Mucilage (\%)} = \frac{(W2 - W1)}{w} \times 100$$

Where,

W_2 = Weight of filter paper+ mucilage solid

after drying (g) W_1 = Weight of filter paper (g),

W = Weight of pod sample taken (g)

3.6.2. Qualitative Traits

1. **Stem color**

Five plants were randomly selected from each entry per replication and visually after 30 days Classified as (1) Green and (2) Red (Anonymous, 2009)

2. Stem: Intensity of green color

Five plants were randomly selected from each entry per replication and visually by single observation after 30 days Classified as (1) Light (2) Medium and (3) Dark (Anonymous, 2009).

3. Leaf blade: Color between the vein

Five plants were randomly selected from each entry per replication and visually by single observation after 30 days Classified as (1) Shallow (2) Medium and (3) Deep (Anonymous, 2009).

4. Vein: color

Five plants were randomly selected from each entry per replication and visually by single observation after 60 days Classified as (1) Light green (2) Purple (Anonymous, 2009).

5. Flower: Petal color

Five plants were randomly selected from each entry per replication and visually by single observation after 50 days Classified as (1)Cream(2) Yellow (3) Purple (Anonymous, 2009).

6. Flower: Petal base color (purple)

Five plants were randomly selected from each entry per replication and visually by single observation after 50 days Classified as (1) Inside only (2) Both sides (Anonymous, 2009).

7. Pod: Shape of apex

Five plants were randomly selected from each entry per replication and visually by single observation after 60 days Classified as (1) Narrow acute (2) Acute (3) Blunt (Anonymous, 2009).

8. Pod: Surface between the ridges

Five plants were randomly selected from each entry per replication and visually by single observation after 60 days Classified as (1) Concave (2) Flat (3) Convex (Anonymous, 2009).

9. Pod pubescence

Five plants were randomly selected from each entry per replication and visually by single observation after 60 days Classified as (1) Absent (2) Weak (3) Medium (4) Strong (Anonymous, 2009).

10. Seed: Color

Five dried pods were harvested after 90 days randomly from each entry per replicationand seed were extracted .The colour of the seed were classified as (1) Green (2) Brown(Anonymous, 2009).

11. Seed: Hairiness

Five dried pods were harvested after 90 days randomly from each entry per replication and seed were extracted .The hairiness of the seed were classified as (1) Absent (2) Present (Anonymous, 2009).

3.6 STATISTICAL ANALYSIS

The experimental data recorded for various characters were subjected to following biometrical analysis , specifically the Analysis of Variance

The analysis of variance (ANOVA) conducted using the method outlined by Panse and Sukhatme, (1967). The ANOVA was carried out and format of ANOVA is provided below.

Where,

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

Y_{ij} = Phenotypic observation of i^{th} entry j^{th} replication

μ = general population mean

g_i = effect of i^{th} entry

r_j = effect of j^{th} entry, and

e_{ij} = Error associated with i^{th} entry in the j^{th} replication

Table 3.4 Analysis of Variance for experimental design

Source of variation	Degreesof freedom	Sum of squares	Mean sum of squares(M)	F calculated	Expected mean square
Replications	(r-1)	Sr	Sr/(r-1)=Mr	Mr/Me	cle +gcr^{2}r
Entries	(g-1)	Sg	Sg/(g-1)=Mg	Mg/Me	cr^{2}e+rn^{2}gcr^{2}e
Error	(r-1) (g-1)	Se	Se/(r-1) (g-1)=Me		
Total	(rg-1)				

3.6.2 Estimation of heterosis

The extent of heterosis was assessed in comparison to mid-parental, better parental, and standard check values. This estimation involved calculating the percentage increase ordecrease of F1s over the mid-parent (MP), better parent (BP), and standard check (SC) using the methodologies described by Turner (1953) and Hayes *et al*., (1956).

Heterosis over mid parents = $\frac{\overline{F}_1 - \overline{MP}}{\overline{MP}}$

Heterosis over better parent = $\frac{\overline{F}_1 - \overline{BP}}{\overline{BP}}$

Heterosis over standard variety (check) = $\frac{\overline{F}_1 - \text{SV}}{\overline{\text{SV}}}$

Where,

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

$\overline{MP} = \frac{\overline{P}_1 + \overline{P}_2}{2}$

$\overline{P}_1$ = Mean performance of parent number 1

$\overline{P}_2$ = Mean performance of parent number 2

$\overline{\text{BP}}$ = Mean values of better parent

$\overline{\text{SV}}$ = Mean value of standard variety (check)

The percentage of Heterosis over mid parents, better parents (heterobeltiosis)and over standard variety (economic heterosis) was calculated as follows:

Per cent Heterosis over mid parent = $\frac{\overline{F}_1 - \overline{MP}}{\overline{MP}} \times 100$

Per cent heterosis over better parent = $\frac{\overline{F}_1 - BP}{\overline{BP}} \times 100$

Per cent heterosis over standard variety $\frac{\overline{F}_1 - \overline{\text{SV}}}{\overline{\text{SV}}} \times 100$

Test of significance of heterosis:

The test of significance of heterosis was done by the test as given below:

$$\text{S.E. of heterosis over mid parent} = \sqrt{S_1^2\left(\frac{1}{r}+\frac{1}{2r}\right)} \text{ or } \sqrt{\frac{3\sigma^2 e}{2r}}$$

Where, S_1^2 or $\sigma^2 e$ = error variance obtained by using F_1's and parent together.

r = number of replications.

$$\text{Calculated 't'} = \frac{\overline{F_1} - \overline{MP}}{\text{S.E. of heterosis over mid parent}}$$

The standard error of difference for comparing the value of better parent or useful/economic/standard heterosis was calculated as follows:

$$\text{S.E. of better parent /Economic/Standard heterosis} = \sqrt{S_1^2\left(\frac{1}{r}+\frac{1}{r}\right)} \text{ or } \sqrt{\frac{2\sigma^2 e}{r}}$$

$$\text{Calculated 't'} = \frac{\overline{F_1} - \overline{BP} \text{ or } \overline{SV}}{\text{S.E. of heterosis over BP or SV}}$$

The calculated 't' value was compared with table value of 't' at error d.f. (100)at P = 0.05 and 0.01.

The critical difference was computed by multiplying the standard error with therespective 't' value at error degrees of freedom at 5 and 1 per cent level of significance.

3.6.3 Combining Ability Analysis

The analysis of variance for combining ability was conducted following the method outlined by Kempthorne (1957). The treatment partitioning was performed intomales, females, and male-female combinations. The basic structure of the analysis of variance for combining ability was as follows:

(i) Estimate of general and specific combining ability variances

The general combining ability (gca) and specific combining ability (sca) variances were worked out as per the method given by Kempthorne, (1957).

σ^2 gca = Cov. (H.S.)

σ^2sca = Cov. (F.S.) – 2 Cov. (H.S.)

where,

Cov. (H.S.) = [(m_1-m_3) + (m_2-m_3)]/ r (f + m)

Cov. (F.S.) = [(m_1-m_4) + (m_2-m_4) + (m_3 – m_4)]/ 3r

+ [6r Cov. (H.S.) – r (f + m) Cov. (H.S.)]/ 3r

Table 3.5 Analysis for variance for line × tester

Source	d.f.	M.S.	Expected mean square
Replication	(r-1)	m_1	
Male	(m-1)	m_2	σ^2e + r [Cov (F.S.)-2Cov. (H.S.)] + fr [Cov. (H.S.)]
Female	(f-1)	m_3	σ^2e + r [Cov (F.S.)-2Cov. (H.S.)] + mr [Cov. (H.S.)]
Male × Female	(m-1) (f-1)	m_4	σ^2e + r [Cov (F.S.)-2Cov. (H.S.)]
Error	(r-1) (mf-1)		σ^2e
Total	(rmf-1)		

Where, r = Number of replications

m = Number of male parents

f = Number of female parents

m_1 = Mean squares among male parents

m_2 = Mean squares among female parents

m_3 = Mean squares among male × female parents

m_4 = Error variance

(ii) Estimates of components of variance

Cov. H.S. (male) or $\left[\hat{\sigma}^2 gm\right] = (m_1 - m_3) / fr$

Cov. H.S. (female) or $\left[\hat{\sigma}^2 gf\right] = (m_2 - m_3) / mr$

Cov. H.S. (average) or $\left[\hat{\sigma}^2 g\,(\text{average})\right] = [(m_1 - m_3) + (m_2 - m_3)] / r(f + m)\,mr$

$\hat{\sigma}^2\ gca = Cov.\ H.S. = \left[\frac{1+F}{4}\right] \sigma^2 A$ where,

$\hat{\sigma}^2 gf$ = Variance due to gca of females

$\hat{\sigma}^2 g$ = Variance due to gca (average)

$\hat{\sigma}^2 s$ = Variance due to sca

$\hat{\sigma}^2 D$ = Additive variance

$\sigma^2 D$ = Dominance variance

F = Inbreeding coefficients (F = 0 or 1)

(iii) Estimates of general and specific combining ability effects

The following mathematical model was applied to estimate the general andspecific combining ability effects of ijk^th^ observations:-

$\times_{ijk} = \mu + gi + gj + sij + eijk$

where,

μ = Population mean

gi = gca effect of the i^th^ male parent gj = gca effect of the j^th^ female parentsij = sca effect of the ij^th^ combination

eijk = Error associated with observation ×ijki = Number of male parents [1, 2…m]

j = Number of female parents [1, 2 …..f]k = Number of replications [1,2…..r]

The individual effects were estimated with the help of following relationship

where, ×….. = total of all hybrid combination

where ×i ….. = total of i^th^ male parent over all the females and replications.

$\hat{g}\ j = (\times j....../mr) - (\times......................................./mfr)$

where ×j…… = total of j^th^ female parent over all the males and replications.

where, ×ij = ij^th^ combination total over all replications.

The following restrictions apply on combining ability effects.

(i) $\sum_i \hat{g}\, i = 0$

$\sum_j \hat{g}\, j = 0$

(ii) $\sum \hat{s}\, ij = 0$ (for each i and j)

iv) Test of significance for general and specific combining ability effects

Standard error of effects were calculated as the square root of variance of effectsas given below

$$S.E.\left(\hat{g}\,i\right) = \sqrt{s^2 e / mr}$$

$$S.E.\left(\hat{g}\,j\right) = \sqrt{s^2 e / fr}$$

$$S.E.\left(\hat{g}\,ij\right) = \sqrt{s^2 e / r}$$

Standard error of difference between the values of two general and specificcombining ability effects were calculated as follows

$$S.E.\left(\hat{g}\,i - \hat{g}\,i\right) = \sqrt{s^2 e / mr}$$

$$S.E.\left(\hat{g}\,j - \hat{g}\,j\right) = \sqrt{s^2 e / fr}$$

$$S.E.\left(\hat{g}\,ij - \hat{g}\,ij\right) = \sqrt{s^2 e / r}$$

CHAPTER 4

EXPERINMENTAL RESULTS

The field experiment consisted of 15 okra germplasm and 4 testers which were crossed in Line × Tester mating design to produce 60 F_1's hybrids . The experiment was laid out in randomized block design in three replications with recommended package of practices during the year 2022 (Summer-E1) and 2023 (Rainy-E2). The components such as genotypic and phenotypic variation along with Heterobeltiosis & standard heterosisand genetic advance were focused during the experiment. The result of present investigation was explained under following headings.

4.1 Analysis of variance

4.2 Mean performance

4.3 Morphological Characterization

4.4 General and specific combining ability

4.5 Genetic advance

4.6 Heterbeltiosis and Standard Heterosis

4.7 Gene action

4.1 Analysis of variance

In the current investigation, during the initial year (2022) of the study, noteworthy variation within replications was observed to be statistically significant for various characteristics, including plant height, number of branches per plant, petiole length, days to first flowering, days to first fruit set, days to first fruit picking, Number of flowers per plant, number of pods per plant, pod length, number of first fruiting node, number of nodes per plant, pods diameter, internodal length, average pod weight , chlorophyll content, pod yield per plant, acidity, ascorbic acid content, dry matter content, firmness and mucilage content. However, in thesubsequent year (2023), traits such as stem diameter, leaf blade length, leaf blade width,and number of ridges per pod exhibited non-significant variance among all traits. The combined variance for replication demonstrated significant differences across all traits, with the exception of stem diameter, leaf blade length and width, and number of ridges per pod.

The presence of variation among the genotype express the significance of inheritance a particular trait, expressing gene, and also the performance of the hybrid. The Significant variations were observed in various traits, including plant height, days to first flowering, days to first fruit set, days to first fruit picking, number of flowers per plant, pods yield per plant,and pod yield per hectare, during both 2022 and 2023 seasons.

The variation observed during the present studies for both environments exhibits the significant levels among different characters such as plant height, number of branches per plant, stem diameter, leaf blade length and width, days to first flowering, days to first fruit set days to first fruit picking, number of flowers per plant, number of pods per plant, pod length, number of first fruiting node, number of nodes per plant, internodal length, average pod weight, chlorophyll content, pods yield per plant, acidity, ascorbic acid, firmness, mucilage content and pod yield. From the present table 4.1 (a to e) it was clearthat the significant level of variation for parents exhibit for most of the traits except leaf blade length, number of ridges per pod and acidity percent. Among all the hybrids and interaction between parents and hybrids the significant variation was observed for all the traits under studied.

The influence of environment was clearly noticed when interacted with treatments, parents, and hybrids. The significant levels of variation was noted among the interaction between parents versus hybrids and environment almost among most of the traits, except petiole length, pod diameter, acidity, ascorbic acid and dry matter content. The significant variation present within parents influence the expression of characters in hybrids. The differences between environment studied during the experiment shows its impact on the character expression.

Table 4.1(a) Analysis of variance of parents and hybrids (line × tester) for 2022 and 2023 in different traits of okra

Sources of variation	df	Plant height (cm)	Number branches per Plant	Stem diameter (cm)	Leaf blade length (cm)	Leaf blade width (cm)
Environments	1	378.95**	65.38**	71.25*	684.62*	240.10*
Treatment	78	395.16**	16.75**	12.78*	15.46	38.91
Parents	18	606.19**	23.14***	10.91**	9.17*	28.7**
Parents (Lines)	14	735.85*	25.75*	12.83**	9.91*	24.75*
Parents (Testers)	3	117.09*	15.39*	5.03**	8.21*	51.43*
Parent (Lines vs Testers)	1	258.29**	9.84**	1.67*	1.72*	15.74*
Hybrid	59	271.94*	9.41*	9.34	14.05	32.68
Parent vs. Hybrids	1	3866.85**	334.91**	249.64**	211.51**	589.58**
Treatments × Environments	78	1.26*	0.32*	0.40**	0.33**	0.22**
Parent × Environments	18	1.24**	0.06*	0.12*	0.13	0.12*
Hybrids × Environments	59	1.23**	0.34*	0.44*	0.32*	0.20*
Parent vs. Hybrids × Env.	1	3.16*	4.191*	3.26*	5.04*	3.70*
Error	312	0.84	0.15	0.19	0.13	0.12
Total	473	66.77	3.08	2.48	4.15	7.04

Table 4.1(b) Analysis of variance of parents and hybrids (line × tester) for 2022 and 2023 in different traits of okra

Sources of variation	df	Petiole Length (cm)	Days to first flowering	Days to first fruit set	Days to first fruit picking	Number of flowers per plant
Environments	1	79.22	779.39**	1667.04**	1233.78**	83.38**
Treatments	78	32.01*	139.5**	145.32**	159.02**	35.51**
Parents	18	25.90*	142.32**	138.43**	141.65**	50.03**
Parents (Lines)	14	23.13*	148.10*	139.77*	149.12*	54.44*
Parents (Testers)	3	37.09*	110.17*	99.17*	86.02*	46.06*
Parents (Lines vs Testers)	1	31.06*	157.85**	237.37**	203.90**	0.34**
Hybrids	59	28.93*	124.29*	130.48*	156.12*	25.48
Parent vs. Hybrids	1	323.28*	986.61**	1145.01**	643.14**	365.36**
Treatments × Environments	78	0.18**	0.44**	0.53**	0.52*	0.60**
Parent × Environments	18	0.18*	0.61**	1.10**	0.94**	1.21**
Hybrids × Environments	59	0.14	0.28*	0.29*	0.31**	0.26*
Parent vs. Hybrids × Env.	1	2.07	6.79*	4.83*	5.32*	9.45*
Error	312	0.10	0.27	0.32	0.32	0.39
Total	473	5.55	24.96	27.87	29.19	6.40

Table 4.1(c) Analysis of variance of parents and hybrids (line × tester) for 2022 and 2023 in different traits of okra

Sources of variation	df	Number of pods per plant	Pod length (cm)	Number of first fruiting node	Number of node per plant	Number of ridges per pod
Environments	1	72.58**	183.16**	84.63*	693.33*	58.81
Treatments	78	43.81**	11.01**	2.68*	54.72**	4.09*
Parents	18	45.44**	6.17**	2.34*	65.52**	3.27*
Parents (Lines)	14	43.96*	4.69*	1.71*	69.40*	3.27*
Parents (Testers)	3	55.05*	3.27*	4.89*	68.33*	4.23*
Parent (Lines vs Testers)	1	37.34**	35.58**	3.58**	2.78**	0.43*
Hybrids	59	38.17 *	11.13*	2.55*	48.20*	4.31*
Parent vs. Hybrids	1	347.68**	90.76**	16.54**	244.62**	5.81*
Treatments × Environments	78	0.37*	0.25*	0.06*	0.11**	0.016
Parent × Environments	18	0.71*	0.09**	0.26*	0.50**	0.061
Hybrids × Environments	59	0.27**	0.30**	0.32*	0.0001*	0.00001
Parent vs. Hybrids × Env.	1	0.04*	0.28*	0.08*	0.00005*	0.18*
Error	312	0.16	0.10	0.06	0.14	0.03
Total	473	7.59	2.32	0.67	10.60	0.83

Table 4.1(d) Analysis of variance of parents and hybrids (lines × tester) for 2022 and 2023 in different traits of okra

Sources of variation	df	Pod diameter (cm)	Internodal length (cm)	Average pod weight (g)	Chlorophyll content (SPAD unit)	Pods yield/Plant (Kg)
Environments	1	2.56	17.51**	228.00**	309.68*	0.001**
Treatments	78	0.70*	3.50*	44.68**	135.13*	0.011**
Parents	18	0.36*	2.97*	42.60**	140.84*	0.010**
Parents (Lines)	14	0.33*	2.70*	39.04*	131.58*	0.011*
Parents (Testers)	3	0.58*	4.22*	72.61*	229.34*	0.007*
Parent (Lines vs Testers)	1	0.16*	3.08*	2.38**	5.10*	0.0078*
Hybrids	59	0.74*	3.20*	40.30*	113.97*	0.010**
Parent vs. Hybrids	1	4.51*	30.61**	340.70**	1280.63**	0.054**
Treatments × Environments	78	0.01	0.01*	0.07**	0.06*	0.00002**
Parent × Environments	18	0.05	0.05*	0.32**	0.26*	0.00006**
Hybrids × Environments	59	0.0001	0.0004*	0.0003**	0.0007*	0.00009**
Parent vs. Hybrids × Env.	1	0.09	0.06*	0.10**	0.06	0.0003**
Error	312	0.03	0.03	0.06	0.08	0.00005
Total	473	0.15	0.64	7.91	23.01	0.0019

Table 4.1(e) Analysis of variance of parents and hybrids (lines × tester) for 2022 and 2023 in different traits of okra

Sources of variation	df	Acidity (%)	Ascorbic Acid (mg/100g)	Dry matter content (%)	Firmness(kg/cm^2)	Mucilage content (%)
Environments	1	0.12*	289.99**	383.34	85.92*	118.48*
Treatments	78	0.01007*	49.39**	70.19*	11.80*	154.70*
Parents	18	0.010	38.35*	76.48*	14.16*	192.49*
Parents (Lines)	14	0.010*	38.65*	76.54*	8.83*	161.80*
Parents (Testers)	3	0.012*	39.97*	42.06*	0.61*	42.82*
Parents (Lines vs Testers)	1	0.00051	29.37*	178.92*	129.50**	1071.25*
Hybrids	59	0.009*	48.49*	67.50*	11.03*	128.80
Parent vs. Hybrids	1	0.0326**	300.85*	115.32*	14.75*	1002.37*
Treatments × Environments	78	0.00062*	0.0362*	0.21*	0.0025*	0.039*
Parent × Environments	18	0.00027*	0.120	0.911	0.0026*	0.139*
Hybrids × Environments	59	0.00073*	0.002	0.002	0.0025*	0.002*
Parent vs. Hybrids × Env.	1	0.00051	0.51	0.00061	0.0065*	0.39*
Error	312	0.0003	0.04	0.17	0.043	0.055
Total	473	0.002	8.79	12.538	2.16	25.80

4.2. Mean Performance

4.2.1Growth Parameters:

4.2.1.1 Plant height (cm)

The data recorded from the table 4.2(a) showed that the parental line L15 recorded maximum plant height in both environment (122.8 cm and 123.2 cm) along with pooled (123.0 cm) respectively followed by line L13, (106.9 cm & 104.7 cm) with pooled (105.8 cm). The minimum plant height was recorded in both environments along with pooled in line L4 (78.6 cm, 77.6 cm and 78.1 cm) respectively. The range of plant height for parental lines for environment 1 varied from (78.6 cm to 122.8 cm) whereasfor environmental 2 its ranges from (77.6 cm to 123.2 cm) and in pooled data it was (78.1 cm to 123.0 cm) respectively. The maximum plant height noted in hybrids was recorded in and L15×T1 (125.1cm) in environment 1 (E1) subsequently in environment2 (E2) (124.9 cm) and also, for the pooled (125.0 cm) followed by hybrid L15×T3 (124.7cm) in E1 and in pooled (124.0 cm) whereas in L15×T2 (123.4 cm) in both the environment as well as pooled Fig.4.1.

The minimum plant height among hybrids was recorded in and L7×T4 (96.9 cm) in E1and in pooled (95.6 cm) whereas (94.4 cm) in E2 respectively. The range of plant height for hybrids in environment 1 varied from (93.6 cm to 125.1 cm) whereas for environmental 2 its ranges from (87.3 cm to 124.9 cm) and in pooled data it was(90.4 cm to 125.0 cm) respectively.

4.2.1.2 Number of branches per plant

The range for number of branches from table 4.2 (a) recorded that within parental lines varied from (3.8 to 9.8) for E1whereas for E2 it's ranges from (3.7 to 9.6) and in pooled (3.8 to 9.6) respectively. whereas in case of hybrids, for E1 the number of branches per plant ranges from (6.6 to 11.6) while for E2 it ranges from (6.2 to 10.8) and in pooled it varies from (6.5 to 11.1) respectively. The maximum number of branches per plant in parental lines, recorded in L7 (9.8) for environment 1 and in environment 2 (9.2). Kashi Pragati (T1) recorded maximum number of branches (9.6) in environment 2. In case of pooled data for number of branches parental line L7 recorded maximum number of branches (9.5) Fig 4.2 whereas Kashi Pragati (T1) recorded (9.6). Data recorded from hybrids revealed that, close L6×T2 (11.6) recorded maximum number of branches in environment one significantly followed by hybrids L5×T4, L6×T1 and L6×T3 (11.4). In environment 2, hybrid, L5×T4 recorded maximum number of branches (10.7). The data recorded for pooled e×plore that hybrid L6×T2 recorded maximum number of branches (11.1) followed by hybrid L5×T4 (11.0).

4.2.1.3 Stem diameter (cm)

The maximum stem diameter was recorded from the table 4.2(a) that within parental lines L12 (9.3 cm) and check Punjab Suhawani (10.8 cm) in environmental 1 while for environment 2 maximum stem diameter was observed for line L5 (9.2 cm) and L12 (9.2 cm) each and for check (10.6 cm) . The maximum pooled data recorded for stem diameter in tester and parental lines recorded for Punjab Suhawani (10.7 cm) and L12 (9.3 cm) respectively. The stem diameter in case of parental lines and tester varied from (4.7 to 10.8 cm), (3.7 to 10.6 cm) and (4.2 to 10.7 cm) for environment 1, 2 and pooled respectively. Hybrid L4×T4 recorded maximum stem diameter (11.5 cm, 11.0 cm and 11.3 cm) in E1, E2 and pooled respectively which was significantly followed by L5×T1 (11.0 cm) in environment1 while hybrid L8×T4 recorded maximum stem diameter (11.5 cm) in environment 2 and (11.2 cm) in pooled respectively. The minimum stem diameter was recorded for hybrid L13×T1 (5.4 cm, 4.9 cm and 5.1 cm) in E1, E2 and pooled respectively. The range of stem diameter in environment 1 varies from (5.4 to 11.5 cm), environment 2 it ranges from (4.9 to 11.5 cm) for pooled it was (5.1 to 11.3 cm) respectively.

4.2.1.4 Leaf blade length (cm)

The data recorded from the table 4.2 (b) that the leaf blade length in hybrids were recorded maximum in L15×T1 in both environment (15.1 & 14.9 cm) along with pooled data (15.0 cm) which was significantly followed by L11 ×T4 in environment one, two (13.8 & 13.7 cm) and pooled (13.8 cm) respectively. Among the other hybridsL11×T3 and L11×T2 express the best in both the environment and also in pooled. Theminimum leaf blade length was recorded in hybrid L13×T2 and L6×T2. The leaf blade length in environment 1 ranges from (7.3 to 15.1 cm), whereas in environment 2 it wasranges from (7.6 to 14.9 cm) and for pooled data it was varied from (7.5 to 15.0 cm). The data recorded for parental lines and tester for leaf blade length indicated that in environment 1 it was ranges from (9.4 to 14.6 cm) and environment 2 it was ranged from (7.3 to 12.7 cm) and in pooled data it was (8.4 to 13.7 cm) respectively. The maximum leaf blade length was recorded in line L15 (14.6 cm) significantly followed by tester Kashi Pragati (T1) (12.2 cm) and line L9 (11.8 cm) for environment 1 while, in environment 2 the maximum leaf blade length was recorded in line L15 (12.7 cm) significantly followed by Kashi Pragati (T1) (9.8 cm) which was closely followed by line L5 and L9 (9.5 cm). In case of pooled data line L15 exhibit maximum leaf blade length (13.7 cm) significantly followed by a Kashi Pragati (T1) (11.0 cm) which was closely followed by line L9 (10.7 cm) and L5 (10.6 cm) respectively.

4.2.1.5 Leaf blade width (cm)

The data recorded from the table 4.2 (b) for parental lines and tester for leaf blade width indicated that in environment 1 it was ranges from (10.6 to 19.1 cm) and environment 2 it was ranged from (9.5 to 18.9 cm) and in pooled data it was (10.1 to 19.0 cm) respectively. The maximum leaf blade length was recorded in line L15 (19.1 cm) significantly followed by tester Arka Anamika (T4) (18.2 cm) and line L14 (17.2 cm) for environment 1 while, in environment 2 the maximum leaf blade width was recorded for line L15 (18.9 cm) significantly followed by Arka Anamika (T4) (17.0 cm) which was closely followed by line L14 (16.0 cm) and tester Kashi Kranti (T3) (16.0 cm). In case of pooled data line L15 exhibit maximum leaf blade width (19.0 cm) significantly followed by a Arka Anamika (17.6 cm) which was closely followed by line L14 (16.6 cm). The minimum leaf blade width was recorded in line L8 and tester Kashi Lalima (T2) in both environments and also in pooled data. Leaf blade width in hybrids were recorded maximum in L15×T4 in both environment (22.5 & 21.3 cm) along with pooled data (21.9 cm) which was significantly followed by L12×T4 in environment one, two (21.5 & 20.3 cm) and pooled (20.9 cm) respectively. The minimum leaf blade width was recorded in hybrid L8×T2 and L6×T3 respectively. The leaf blade width in environment 1 ranges from (10.8 to 22.5 cm), whereas in environment 2 it was ranges from (9.2 to 21.3 cm) and for pooled data it was varied from (10.0 to 21.9 cm).

4.2.1.6 Petiole length (cm)

The data recorded from the table 4.2(b) for petiole length that in environment 1 it ranged from (7.4 to 14.3 cm), environment 2 indicated the length of petiole varied from (6.6 to 14.2 cm) whereas, in pooled data it was ranges from (7.0 to 14.3 cm) among parental lines and testers. The maximum length of petiole was recorded in tester Arka Anamika (T4) (14.3 cm, 14.2 cm and 14.3 cm) significantly followed by lines L15 (13.3 cm, 13.0 cm and 13.2cm) in E1, E2 & pooled respectively followed by line L10 and L7 while minimum length of petiole was recorded for the lines, L1 and L2 in environment one, two and pooled data respectively. Amongst the hybrids, L15×T4 recorded maximum petiole length (17.2 cm) significantly followed within same hybrid for environment 2 (16.5 cm) and in pooled (16.8 cm). Hybrid, L15 ×T2 followed the best and recorded (17.0 cm) length of petiole in environment 1, (16.3 cm) in an environment 2 whereas, (16.6 cm) for pooled data. The range for petiole length ranges from (8.8 to 7.2 cm), (8.0 to 16.5 cm) and (8.4 to 16.8 cm) in environment one, two and in pooled data respectively.

4.2.1.7 Days to first flowering

The information observed from table 4.2(c) that the minimum days recorded for early flowering under environment 1 noted in line L15 (43.0 days) significantly followed byline L5 (43.7 days) and tester Kashi Kranti (T3) (44.7 days). In environmental 2 theminimum days for flowering were noted for line L15 (44.2 days) significantly followed by Kashi Kranti (T3) (45.9 days) and line L5(46.0 days) while for pooled data minimum flowering days was recorded for line L15 (43.6 days) Fig 4.1, significantly followed by L5 (44.9 days) and Kashi Kranti (T3) (45.3 days) respectively. The range of days for first flowering for environment 1 varies from (43.0 to 59.7 days), for environment 2 it was ranged from (44.2to 62.3 days) and for pooled it was ranged from (43.6 to 61.0 days). The minimum daysfor flowering for hybrids were recorded for L11×T4 (41.3 days) significantly followedby hybrids L11×T2, L5×T1 and L5×T2 (41.4 days) respectively for environment one. For environment two, the minimum days for first flower appearance was noted for hybrid L11×T4, L11×T3 and L5×T2 (44.3 days) respectively. According to pooled data, it was noted that the minimum days the first flowering were noted under hybrids L11×T4 and L11×T2 (42.8 days). The range of the days to first flowering for environment 1 ranges from (41.3 to 59.5 days), for environment 2 it was (44.1 to 61.6 days) and in pooled data it ranges from (42.8 to 60.6 days).

4.2.1.8 Days to first fruit set

The minimum days for first fruit set was recorded from the table 4.2(c) that the line L15 (48 cm) significantly followed by Kashi Kranti (T3) (49.7 days) under environment 1, within environment 2 the minimum days for first fruit set was noted for line L15 (50.1 days) significantly followed by Kashi Kranti (T3) (52.0 days) and Kashi Pragati (T1) (53.0 days) respectively. The minimum days for first fruit set in pooled recorded for line L15 (49.1 days) followed by Kashi Kranti (T3) (50.9 days) and Kashi Pragati (T1) (51.7 days) respectively Fig 4.1. The range of days for first fruit set for environment 1 varied from (48.0 to 63.7 days), for environment 2 it was (50.1 to 67.3 days) and for pooled data it was (49.1 to 65.5 days) respectively. In case of hybrid's the range of days for fruit set varied from (46.1 to 64.7 days) in environment 1 while in environment 2 it was varied from (50.0 to 68.3 days) and for pooled it was ranged between (48.2 to 66.5 days) respectively. The hybrid L11×T4 recorded minimum daysto fruit set (41.6 days) significantly followed by hybrids L11×T3 (46.2 days) and L11×T2 (46.3 days). In environment 2, hybrid L11×T1 recorded minimum days for fruit set (50.0 days) significantly followed by hybrid L11×T4 (50.2 days) and hybrid L11×T3 (50.4 days). The pooled data noted minimum days first fruit set was recorded in hybrids L11×T1 and L11×T4 (48.2 days) significantly followed by hybrid L11×T3 (48.3 days) and L11×T2 (48.5 days) respectively.

4.2.1.9 Days to first fruit picking

The data revealed from the table 4.2 (c) that the hybrid L2×T2 recorded minimum days for first fruit picking(52.7 days) significantly followed by hybrid L1×T1, L4×T3, L5×T1 and L5×T2 (53.1 days) respectively in environment 1 while hybrid L1×T1 and L4×T2 recorded minimum days for first fruit picking in environment 2 (56.6 days). The pooled data for hybrids showed that, hybrid L2×T2 recorded minimum days to first fruit picking (54.7 days) significantly followed by hybrid L1×T1 (54.8 days). The range of days to first fruit picking for environment 1 varied from (52.7 to 73.0 days), in environment 2 it was (56.5 to 75.9 days) and for pooled it was (54.7 to 74.5 days) respectively Fig 4.1. The range of days for first fruit picking for parental lines and testers in environment 1 ranged from (55.0 to 70.3 days), in environment 2 it was ranged from (56.7 to 74.0 days) and for pooled it was varied from (55.9 to 72.2 days). The minimum days for first fruit picking was recorded in line L15 (55.0 days) significantly followed by tester Kashi Kranti (T3) (55.7 days) in environment 1.In case of environment 2 the minimum days for first fruit picking was noted under line L15 (56.7 days) followed by tester Kashi Kranti (T3) (57.7 days) while in pooled the minimum days were recorded for line L15 (55.9 days)significantly followed by Kashi Kranti (T3) (56.7 days).

4.2.2 Yield Parameters

4.2.2.1 Number of flowers per plant

The data presented in the table 4.2 (d) revealed that the range of number of flowers per plant within environment 1 for parental and tester lines was varied from (11.0 to 21.7) whereas for environment 2 it was (10.3 to 20.5) and in pooled it ranged between (11.2 to 21.1) respectively. The maximum number of flowers per plant was noted in line L7 (21.7) significantly followed by line L4 (21.0) and tester Kashi Pragati (T1) (17.7) for environment 1 while in environment 2 the maximum number of flowers per plant was recorded in line L7 (20.5) followed by line L4 (20.4), whereas in pooled line L7 noted maximumnumber of flowers per plant (21.1) followed by L4 (20.7) and Kashi Pragati (T1) (17.9) Fig. 4.1. In case of hybrids, within environment 1 the number of flowers per plant were ranged from (13.2 to 22.6) while for environment 2 it was varied from (12.8 to 21.6) and for pooled it ranged from (13.0 to 22.0). The hybrid L3×T4 recorded maximum number of flowers per plant i.e., (22.4, 21.6 and 22.0) in both environments along with pooled respectively. In environment 1 the best hybrid was significantly followed by hybrid L4×T1 (22.6) and L4×T2 (22.4) where as in environment 2 hybrid L6×T1 (21.4) recorded second best maximum number of flowers per plant followed by hybrid L4×T2 (21.3). In pooled data observation it was noted that, the maximum number of flowers per plant (21.9) was recorded for hybrids L4×T2 and L6×T1 respectively.

4.2.2.2 Number of pods per plant

The number of pods per plant is one of the most important traits contribute towards theyield . The data recorded from the table 4.2(d) that the parental lines and tester ranged for environment 1 varied between (9.0 to 18.0) and for environment 2 (8.4 to 18.3) while average of both environments ranged between (8.7 to 18.2). In case of hybrids, for environment 1 it was varied from (9.0 to 20.3) and for environment 2 it was (8.8 to 19.6) whereas for pooled data, it was laid between (8.9 to 20.0) respectively. The maximum number of pods per plant, was recorded for hybrid L2×T3 for both environments (20.3 & 19.6) and pooled (20.0) respectively followed by hybrid L15×T4 for environment 1 and pooled (19.8 &19.4) respectively Fig.4.1. Environment 2 recorded maximum number of pods per plant in hybrid L2×T3 (19.6) followed by hybrid L15×T4 (19.0). In case of parental lines and testers, the maximum number of pods per plant was recorded in line L2 for both environmentsand pooled (18.0, 18.3 and 18.2) respectively which was significantly followed by lineL12 in environment 1 (17.2), environment 2 (16.9) and pooled data (17.1) which was succeeded by line L9 (17.1,16.5 and 16.8) in both environment and pooled data respectively.

4.2.2.3 Pod length (cm)

The maximum pod length was recorded from the table 4.2 (d) for commercial check Punjab Suhawani (C1) (11.4 cm) significantly followed by line L8 (10.7 cm) within environment 1 while inenvironment 2 the maximum pod length was recorded in line L5 (10.1 cm) followed by Punjab Suhawani (C1) (9.7 cm) and line L8 (9.6 cm) whereas in case of pooled data, the maximum pod length was recorded in Punjab Suhawani (C1) (10.6 cm) significantly followed by line L5 (10.8 cm) and line L8 (10.2 cm) respectively. The range of pod length for environment 1, environment 2 and pooled was noted as (7.3 to 11.4 cm), (6.2 to 10.1 cm) and (6.8 to 10.8 cm) respectively. The maximum pod length was recorded for hybrids in L5×T3 and L5×T1 same as for environment 1 and environment 2 *viz*. (13.6 cm and 11.7 cm) whereas in pooled data hybrid L5×T3 recorded maximum pod length (12.8 cm) followed by hybrid L5×T1 (12.7 cm). In environment 1 the range of pod length varied from (7.6 to 13.6 cm), in environment 2 it was(6.3to 11.8 cm) and for pooled it ranges between (7.0 to 12.7 cm) respectively Fig. 4.1.

4.2.2.4 Number of first fruiting Node

The information observed from the table 4.2(e) that the range for number of first fruiting node for hybrids was varied from (4.2 to 7.0) in environment one while (3.4 to 6.2) in environment 2 whereas, (3.8 to 6.6) in average of both years (pooled). Hybrid L14×T2 expressed the best values for number of first fruiting node for both environments (4.2 and 3.4) and also in pooled (3.8) Fig. 4.1 which was significantly followed by hybrid L5×T2 showed same pattern of superiority within environments and pooled as (4.3) in environment 1, (3.4) in environment 2 and (3.8) in pooled data. The range of number of first fruiting node for parental lines and tester in environment 1 varied between (4.1 to 6.6) for environment 1and in environment 2 it was (3.0 to 5.8) and for pooled ranges between (3.6 to 6.2) respectively. The earliest fruiting node was observed in tester Arka Anamika (T4) (4.6), however among the lines L4 (4.2) followed by L1 (4.4) responded with earliest fruiting nodes in environment 1 . In environment 2, the earliest fruiting node among the lines L14 (3.0) followed by L1 & L11 (3.3) each and among testers Arka Anamika T4 (3.7) and in pooled among testers Akra Anamika (T4) (4.2) and however, among lines L14 (3.6) followed by L1 (3.8) and L5 (3.0 responded with earliest fruiting.

4.2.2.5 Number of nodes per plant

The range of nodes per plant was recorded from the table 4.2 (e) that for environment 1, parental and tester lines was varied from (18.4 to 29.1) whereas for environment 2 it was (16.2 to 26.2) and in pooled it ranged between (17.3 to 27.7) respectively. The maximum number of nodes per plant, was noted in line L11 (29.1) significantly followed by line L15 (27.5) and line L14 (26.6) for environment 1 while environment 2, L11 recorded maximum number of nodes per plant (26.2) followed by line L15 (25.6), whereas in pooled line L11 (27.7) followed by L15 (26.6) and line L14 (25.4). In case of hybrids, within environment 1 the number of nodes per plant were ranged from (19.3 to 31.9) while for environment 2 it was varied from (16.9 to 29.4) and the average of number of nodes per plant for both years *i.e.*, pooled ranged from (18.1 to 30.7). The hybrid L15×T1 recorded maximum number of nodes per plant in both environments along with pooled (31.9, 29.4 and 30.7) respectively. In environment 1 the best hybrid was significantly followed by hybrid L11×T1 (29.8, 27.4 and 28.6) and L14×T1 (29.4, 27.0and 28.2) both environments and pooled respectively.

4.2.2.6 Number of ridges per pod

The maximum number of ridges per pod from the table 4.2 (e) for environment 1 was recorded in line L13 (7.6) significantly followed by line L5 (7.4) while in environment 2 the maximum number of ridges per pod were noted in line L13 (6.3) followed by line L3 (6.1) and tester Kashi Kranti (T3) (5.9). The average of the both years expressed in pooled data were recorded in line L13 (6.7) significantly followed by line L3 (6.6) and tester Kashi Kranti (T3) (6.5) respectively. The range of number of ridges for environment 1, 2 and pooled wasrecorded as (5.1 to 7.4), (4.1 to 6.3) and(4.6 to 6.7) respectively. The data recorded forhybrids revealed that the maximum number of ridges per pod was noted in hybrid, L3×T3 for environment 1 and 2 along with pooled (8.1, 7.4 and 7.8) significantly followed by hybrid L3×T2 showed the same pattern as the best for both environments and also for pooled data (7.6, 7.0 and 7.3). The number of ridges per pod for hybrids ranges from (4.4 to 8.1) in environment 1, (3.8 to 7.4) in environment 2 and (4.1 to 7.8) in pooled data.

4.2.2.7 Pod diameter (cm)

The data recorded for pods diameter from the table 4.2 (f) for hybrids in environment1 ranges from (1.4 to 2.9 cm), (1.3 to 2.7 cm) in environment 2 whereas (1.4 to 2.8 cm) in pooled. Both environment (2.9 cm and 2.7 cm) and pooled (2.8 cm) showed maximum values for pod diameter in hybrid L8×T2 significantly followed by L15×T1 showed the same pattern as the best for both environments (2.8 cm and 2.6 cm) and pooled (2.7 cm) and also for L15×T3 in both environments (2.7 cm and 2.5 cm) and average of the both years (2.6 cm) respectively. The data recorded for parental lines and tester stated that the range of pod diameter for environment 1 varied from (1.44 to 2.16 cm) in environment 2 it was (1.20 to 2.20 cm) while for pooled it was (1.32 to 2.13 cm) respectively. The maximum diameter of pod recorded in line L10 (2.16 cm) significantly followed by line L8 (2.15 cm) and tester Kashi Kranti (T3) (2.08 cm) in environment 1. In case of environment 2 the maximum was noted in line L13 (2.20 cm) significantly followed by line L15 (2.00 cm) and tester Kashi Kranti (T3) (1.90 cm) whereas for pooled data the maximum pods diameter was recorded for line L13 (2.13 cm) significantly followed by tester Kashi Kranti (T3) (1.99 cm) and line L10 (1.98 cm) respectively.

4.2.2.8 Internodal length (cm)

The data revealed from the table 4.2 (f) that tester Arka Anamika (T4) recorded maximum internodal length (5.54 cm) significantly followed by line L15 (5.29 cm) in environment one. In case ofenvironment 2 the maximum internodal length was recorded in line L15 (5.20 cm) significantly followed by tester Arka Anamika (T4) (5.10 cm) and Kashi Lalima (T2) (4.80 cm). The pooled data revealed that tester Arka Anamika (T4) recorded significantly maximuminternodal length (5.32 cm) followed by line L15 (5.25 cm) respectively. The range ofinternodal length varied from (3.24 to 5.54 cm) environment 1 whereas it was (2.70 to 5.20 cm) in environment 2 while the range varied from (3.02 to 5.32 cm) in pooled. Both environment (6.6 cm & 6.3 cm) and pooled (6.5 cm) showed maximum values forinternodal length in hybrid L7×T4 significantly followed by hybrid L13×T4 showed the same pattern as the best for both environments (6.5 cm & 6.1 cm) and pooled (6.3 cm). The data recorded for internodal length for hybrids in environment 1 ranges from (3.5 to 6.6 cm), (3.2 to 6.3 cm) in environment 2 whereas (3.4 to 6.5 cm) in pooled.

4.2.2.9 Average pod weight (g)

The average pod weight observed from the table 4.2 (f) ranges in environment 1 for hybrids varied from (13.1 to 24.3 g) in environment 2 it was varied from (11.7 to 23.0 g) and for pooled , it ranges between (12.4 to 23.7 g). In environment 1, the maximum average pod weight was recorded in hybrid L14 ×T1 (24.3 g) significantly followed by hybrid L9×T1 (24.1 g), L8×T1 (23.3 g) and L7×T1 (22.9 g) respectively. In environment 2 the maximum average pod weight was recorded in hybrid L14×T1 (23.0 g) significantly followed byhybrid L9×T1 (22.8 g). The average data for both years *i.e.,* pooled noted that the maximum average pod weight was found for hybrid L14×T1(23.7 g) followed by L9×T1 (23.5 g) and hybrid L8×T1 (22.6 g) respectively Fig. 4.1. The range of average pod weight for parental lines and taster in environment 1lies between (11.6 to 21.5 g), in environment 2 it was between (9.7 to 19.8 g) while for pooled data it was ranges between (10.7 to 20.7 g). The maximum average pod weight was recorded for line L14(21.5 g) significantly followed by tester Kashi Pragati (T1) (20.5 g) and line L9 (19.5 g). Inenvironment 2 the same result was followed and line L14 recorded maximum average pod weight (19.8 g) followed by Kashi Pragati (T1) (18.8 g) and line L7 (17.3 g). The data regarding pooled expressed that the maximum average pod weight was noted in line L14 (20.7 g) followed by tester Kashi Pragati (T1) (19.7 g) respectively.

4.2.2.10 Pod yield/Plant (Kg)

The data recorded for pod yield/plant (Kg) from the table 4.2(g) for parental lines and tester in environment 1 ranges from (0.13 to 0.29 Kg), (0.10 to 0.28) kg in environment 2 whereas (0.12 to 0.28 Kg) in pooled. Both environment (0.29 kg and 0.28 Kg) and pooled (0.28Kg) showed maximum values for pod yield/plant (Kg) in line L7 significantly followed by line L2 showed the same pattern as the best for both environments (0.26 Kg & 0.255 Kg) and pooled (0.26 Kg) and also for line L4 (0.25 Kg & 0.23 Kg) in environment 1 and 2 respectively and (0.24 Kg) in pooled data Fig. 4.1. The range of pod yield/plant for hybrids in environment 1 range from (0.13 to 0.34 Kg) in environment2 it lies between (0.11 to 0.32 Kg) and for pooled it was range between (0.12 to 0.33 Kg). The hybrid L7×T3 recorded maximum values for pod yield/plant (0.34 Kg) significantly followed by hybrid L2×T3 (0.30 Kg), L7×T2 (0.29 Kg) and L7×T4 (0.28 Kg) respectively in environment 1. The data for environment 2 in hybrids maximum pod yield/plant was noted under hybrid L7×T3 (0.32 Kg) significantly followed by hybrid L2×T3 (0.29 Kg). The data expressed in pooled showed that maximum pod yield/plant was noted under hybrid L7×T3 (0.33 Kg) significantly followed by hybrid L2×T3 (0.30 Kg) and hybrid L7×T2 (0.28 Kg) respectively.

4.2.3 Biochemical Parameters:

4.2.3.1 Ascorbic acid content (mg/100g)

The information recorded from the table 4.2 (g) revealed that in the environment 1, the range of ascorbic acid content for parental lines and tester varied from (10.4 mg/100g to 18.8 mg/100g) while in environmental it was arranged between (8.6 mg/100g to 16.7mg/100g) and in pooled it was lies between (9.5 mg/100g to 17.8 mg/100g). Line L9 significantly expressed its superiority in as ascorbic acid content, in environment 1 and 2 (18.8 mg/100g & 16.7 mg/100g) and in pooled (17.8 mg/100g) respectively which wassignificantly followed by line L12 as the same pattern in both environment (17.7 mg/100g & 16.5 mg/100g) and in pooled (17.1 mg/100g). In case of hybrids, the range of ascorbic acid was varied from (11.5 mg/100g to 23.1 mg/100g) in environment 1, (10.0 mg/100g to 21.5 mg/100g) in environment 2 and (10.8 mg/100g to 22.3 mg/100g) in pooled. Hybrid L12×T1 significantly recorded maximum ascorbic acid in both environments (23.1 mg/100g & 21.5 mg/100g) and also in pooled (22.3 mg/100g) significantly followed the same pattern by hybrid L12×T4 in environment 1 (21.7 mg/100g), environment 2 (20.2 mg/100g) and in pooled (21.0 mg/100g) respectively Fig. 2.

Acidity (%)

The data recorded from the table 4.2(g) that maximum acidity (%) was noted for line L15 in both environments (0.28% & 0.25%) and in pooled it was (0.26%) which was significantly followed by line L5 following the same pattern in environment 1 (0.26%) in environment 2 (0.24%) and in pooled (0.25%) respectively. Line L7 and Arka Anamika (T4) also found to be superior following the best. The range for acidity (%) in environment one varied from (0.15 to 0.28%) in environmental it was (0.12 to 0.25%) while in pooled it was (0.14 to 0.26%) respectively. In case of hybrids, in environment 1 the range wasvaried from (0.15 to 0.33%) in environment 2 it ranges between (0.10 to 0.30%) and in pooled it was (0.13 to 0.32%) respectively. In environment 1 the maximum acidity (%) was recorded in hybrid L15×T4

(0.33%) significantly followed by hybrid L5×T4 (0.31%) and hybrid L7×T4 and L14×T4 (0.29%). In environment 2, maximum acidity (%) was noted for hybrid L15×T4 (0.29%) significantly followed by hybrid L5×T3 (0.27%) while in pooled Fig. 4.2 the maximum was recorded for hybrid L15×T4 (0.31%) followed by hybrid L5×T4 and L7×T4 (0.28%) respectively.

4.2.3.2 Dry matter content (%)

The data recorded from the table 4.2 (h) that in environment 1 the range of dry matter content for hybrids was varied from (15.9 to 29.5%) in environment 2 lies between (14.1 to 27.8%) while in pooled it was (15.0 to 28.7%). The maximum dry matter content was recorded in hybrid L5×T1 for both environments (29.5% & 27.8%) and also in pooled (28.7%) Fig. 4.2 which was significantly followedby hybrid L8×T1 following the same pattern in environment 1 and 2 (28.6% & 26.8%)and for pooled it was (27.7%) which was closely followed by hybrid L15×T1 (28.2%) in environment 1 (26.5%) in environment 2 and (27.4%) in pooled respectively. Among parental lines and tester, maximum amount of dry matter content was recorded for line L5 in both environments (29.2% & 26.6%) and in pooled (27.9%) significantly followed by line L15 with the same pattern in environment 1 (26.3%) in environment 2 (24.6% & 25.5%) in pooled respectively. The range of dry matter content for environment 1 varied from (15.7 to 29.2%) in environment 2 it was between (13.7 to 26.6%) while for pooled it was (14.8 to 27.9%) respectively.

4.2.3.3 Firmness (Kg/cm^2)

The data observed form table 4.2 (h) for firmness of okra in environment 1 for parental lines and tester ranges from (3.8 to 8.7 Kg/cm^2) in environment 2 it was between (3.0 to 7.9 Kg/cm^2) and (3.4 to 8.3 Kg/ cm^2) in pooled data respectively. The data revealed that, in environment 1 for parental lines and tester the superior values for firmness was noted under line L6 for both environments, (8.7 Kg/cm^2 & 7.9 Kg/cm^2) and also in pooled (8.31 Kg/cm^2) which was significantly followed with the same pattern by line L5 (8.2 Kg/cm^2) in environment 1 (7.4 Kg/cm^2) in environment 2, whereas (7.8 Kg/cm^2) in pooled closely followed by line L7 (7.9 Kg/cm^2 & 7.2 Kg/cm^2) in environment 1 and 2 while (7.5 Kg/cm^2) in pooled Fig. 4.2. In hybrids, the maximum firmness was recorded for L5×T2 in both environments (8.6 Kg/cm^2 & 7.8 Kg/cm^2) and in pooled (8.2 Kg/cm^2) significantly followed by hybrid L6×T4 for with same pattern (8.5 Kg/cm^{2}) in environment 1 (7.8 Kg/cm^{2}) in environment 2 and (8.2 Kg/cm^{2}) in pooled data. The hybrid L5×T4 made close counter with the best with values of (8.4 Kg/cm^{2}) in environment 1 (7.70 Kg/cm^{2}) in environment 2 and (8.0 Kg/cm^{2}) in pooled respectively. The firmness in hybrids was varied from (3.8 to 8.6 Kg/cm^{2}) in environment 1, (3.1 to 7.8 Kg/cm^{2}) in environment 2 and (3.4 to 8.2 Kg/cm^{2}) in pooled respectively.

4.2.3.4 Chlorophyll content (SPAD Unit)

The data recorded from the table 4.2 (h) that the range of chlorophyll content among hybrids in environment 1 varied from (36.0 to 56.1), (34.4 to 54.5) in environment 2 and (35.2 to 55.3) for pooled whereas, among parental lines and tester, the range of chlorophyll content lies between (32.1 to 51.8)in environment 1 (30.5 to 49.9) in environment 2 and (31.3 to 50.9) for pooled . In parental lines and tester, it was cleared form data that line L7 exhibit maximum chlorophyll content in both environments (51.8 & 49.9) and also in pooled (50.9) which was significantly followed by line L12 with the same pattern in both environments (46.0 & 44.5) and (45.3) in pooled closely followed by Kashi Pragati (T1) (45.8) in environment 1 (44.7) in environment 2 and (45.3) in pooled respectively. In case of hybrid, the maximum chlorophyll content was recorded for L7×T1 in both environments (56.1 & 54.5) and (55.3) in pooled significantly followed by hybrid L7×T3 (54.6) in environment 1 (53.0) in environment 2 and (53.8) in pooled respectively Fig. 4.2.

4.2.3.5 Mucilage content (%)

The range of mucilage content from table 4.2 (i) for parental lines and tester in environment 1 varied from(5.4 to 26.7%), (4.6 to 25.9%) for environment 1 and 2 whereas (5.0 to 26.3%) in pooled. The maximum mucilage content was recorded for line L15 (26.7%) in environment 1 (25.9%) in environment 2 while (26.3%) in pooled significantly followedwith the same pattern by tester Kashi Lalima (T2) (21.4%) in environment 1 (20.4%) in environment 2 and (20.9%) in pooled data. The data for hybrids revealed that maximum amount of mucilage content was noted for hybrid L15×T2 (30.5% & 29.5%)in environment 1 and 2 while (30.0%) in pooled significantly followed by hybrid L15×T1 (28.9% & 28.0%) in both environments and (28.5%) in pooled respectively Fig.4.2. The range of mucilage percent in environment 1 lies between (7.3 to 30.5%), (6.4 to 29.5%) in environment 2 while (6.9 to 30.0%) for pooled data.

Table 4.2 (a) Mean performance of Lines (females) and testers(males) for different traits in okraunder two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Parents	Plant height (cm)			Number of branches per plant			Stem diameter(cm)		
	E1	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1	86.9	85.7	86.3	4.4	4.0	4.2	5.8	5.6	5.7
L2	87.9	86.8	87.3	4.3	3.7	4.0	5.9	5.7	5.8
L3	89.8	89.2	89.5	4.3	4.0	4.2	7.4	7.0	7.2
L4	78.6	77.6	78.1	3.8	3.7	3.8	7.5	7.2	7.4
L5	88.1	84.6	86.4	7.8	7.2	7.5	9.2	9.2	9.2
L6	98.4	96.5	97.5	7.1	6.6	6.9	6.7	6.1	6.4
L7	94.1	92.6	93.4	9.8	9.2	9.5	7.6	7.2	7.4
L8	86.6	86.3	86.5	9.2	8.5	8.9	7.5	6.9	7.2
L9	95.4	93.8	94.6	5.3	5.0	5.2	6.4	5.6	6.0
L10	103.5	101	102.3	7.9	7.2	7.6	8.7	8.6	8.7
L11	104.9	103.7	104.3	5.5	5.3	5.4	6.2	5.5	5.8
L12	99.2	97.9	98.5	9.4	8.8	9.1	9.3	9.2	9.3
L13	106.9	104.7	105.8	7.8	7.5	7.7	4.7	3.7	4.2
L14	104.2	102	103.1	6.4	6.2	6.3	6.5	5.6	6.1
L15	122.8	123.2	123	9.5	9.0	9.3	5.6	5.0	5.3
T1	95.0	92.1	93.5	9.6	9.6	9.6	6.1	5.6	5.8
T2	99.4	98.2	98.8	7.4	7.0	7.2	7.5	7.1	7.3
T3	102.4	101.4	101.9	6.1	5.7	5.9	7.3	7.0	7.1
T4	104.4	102.8	103.6	6.7	6.6	6.7	8.5	7.6	8.0
C1	101.4	100.3	100.8	8.5	7.7	8.1	10.8	10.6	10.7
Max	122.8	123.2	123	9.8	9.6	9.6	10.8	10.6	10.7
Min	78.6	77.6	78.1	3.8	3.7	3.8	4.7	3.7	4.2
CD (0.05)	2.42	0.47	7.01	0.48	0.32	1.40	0.45	0.37	1.39
Hybrids									
L1×T1	104.5	101.7	103.1	7.9	6.2	7.1	8.5	8.2	8.3
L1×T2	104.7	102.9	103.8	9.1	7.5	8.3	8.6	9.1	8.8
L1×T3	100.4	98.4	99.4	10.8	9.5	10.1	7.9	6.7	7.3
L1×T4	96.7	95.1	95.9	8.4	6.7	7.5	9.9	8.9	9.4
L2×T1	104.7	101.8	103.2	11.0	10.6	10.8	7.8	7.1	7.4
L2×T2	106.6	104.3	105.4	8.7	6.5	7.6	9.7	8.2	9.0
L2×T3	100.5	98.4	99.5	8.4	7.7	8.1	8.5	7.4	8.0
L2×T4	97.0	94.5	95.7	9.1	7.7	8.4	8.7	8.1	8.4
L3×T1	103.9	101.6	102.7	8.7	7.6	8.1	9.4	8.4	8.9
L3×T2	107	104.3	105.6	10.4	9.7	10.1	8.9	7.6	8.2
L3×T3	100.9	99.6	100.2	8.4	6.9	7.7	10.5	9.2	9.9
L3×T4	96.8	94.2	95.5	8.4	7.6	8.0	9.5	8.1	8.8
L4×T1	104.7	102.4	103.5	9.1	7.8	8.5	8.8	7.9	8.4
L4×T2	93.6	87.3	90.4	8.1	6.4	7.3	9.6	8.2	8.9
L4×T3	100.7	98.6	99.7	9.0	8.8	8.9	10.5	10.1	10.3

L4×T4	97.3	94.6	95.9	11.2	10.4	10.8	11.5	11.0	11.3
L5×T1	104.7	102.7	103.7	9.1	7.6	8.3	11.0	9.8	10.4
L5×T2	100.9	98.5	99.7	8.7	8.0	8.4	9.0	7.3	8.1
L5×T3	100.5	98.7	99.6	8.7	7.5	8.1	9.7	8.6	9.2
L5×T4	96.0	94.4	95.2	11.4	10.7	11.0	9.7	8.2	9.0
L6×T1	103.6	102	102.8	11.4	10.1	10.8	9.5	8.6	9.1
L6×T2	101.1	98.8	100	11.6	10.5	11.1	10.3	9.1	9.7
L6×T3	100.8	99.0	99.9	11.4	10.3	10.8	9.6	7.8	8.7
L6×T4	99.3	98.6	98.9	8.4	7.6	8.0	8.7	7.8	8.2
L7×T1	104.6	102.4	103.5	8.0	7.6	7.8	10.4	9.2	9.8
L7×T2	105.9	103.5	104.7	8.7	7.7	8.2	9.1	7.4	8.3
L7×T3	100.6	98.7	99.6	8.7	8.4	8.6	9.7	9.5	9.6
L7×T4	96.9	94.4	95.6	9.2	8.6	8.9	9.7	9.6	9.6
L8×T1	103.6	102.4	103.0	9.3	8.4	8.8	9.4	8.5	9.0
L8×T2	105.9	104.8	105.4	8.1	6.5	7.3	10.3	8.9	9.6
L8×T3	101.2	98.7	99.9	8.6	7.6	8.1	9.5	8.1	8.8
L8×T4	96.9	94.7	95.8	10.7	10.1	10.4	11.0	11.5	11.2
L9×T1	103.8	102.3	103.0	10.5	10.5	10.5	10.5	10.5	10.5
L9×T2	105.7	104.3	105.0	9.6	8.3	9.0	9.6	8.2	8.9
L9×T3	100.7	99.4	100.1	9.6	8.4	9.0	10.4	8.5	9.4
L9×T4	98.0	95.9	96.9	11.0	10.5	10.8	7.4	6.4	6.9
L10×T1	103.7	101.9	102.8	8.6	8.3	8.5	9.4	9.4	9.4
L10×T2	105.9	104.6	105.3	7.4	6.9	7.1	9.1	7.7	8.4
L10×T3	104.9	103.2	104.1	8.3	7.7	8.0	10.5	9.2	9.8
L10×T4	104.5	102.6	103.5	9.4	8.6	9.0	8.9	8.1	8.5
L11×T1	105.0	103.4	104.2	11.0	9.9	10.5	8.6	7.2	7.9
L11×T2	106.1	104.4	105.2	10.6	10.8	10.7	9.7	8.3	9.0
L11×T3	105.4	103.9	104.7	10.6	9.2	9.9	10.0	9.6	9.8
L11×T4	105.6	104.4	105.0	10.3	10.3	10.3	9.4	7.8	8.6
L12×T1	103.7	102.8	103.3	9.8	9.5	9.6	7.6	6.8	7.2
L12×T2	106.1	104.3	105.2	8.4	7.7	8.0	8.5	7.9	8.2
L12×T3	101	98.6	99.8	7.6	7.2	7.4	8.3	7.8	8.1
L12×T4	100.7	99.0	99.8	8.8	8.1	8.5	10.5	9.3	9.9
L13×T1	108.6	106.7	107.7	8.3	7.6	8.0	5.4	4.9	5.1
L13×T2	108.7	106.5	107.6	8.5	7.8	8.1	6.4	5.9	6.2
L13×T3	108.5	108.8	108.6	7.7	7.2	7.4	6.9	6.5	6.7
L13×T4	108.7	107.4	108.1	7.9	7.0	7.5	7.6	7.2	7.4
L14×T1	106.0	104.6	105.3	8.5	8.1	8.3	7.4	7.0	7.2
L14×T2	105.9	104.4	105.1	8.0	7.3	7.7	8.0	7.5	7.7
L14×T3	105.8	103.8	104.8	6.6	6.3	6.5	6.1	5.9	6.0

L14×T4	98.3	94.4	96.3	7.4	7.2	7.3	7.6	7.1	7.4
L15×T1	125.1	124.9	125	11.3	10.4	10.8	6.8	6.5	6.7
L15×T2	123.4	123.4	123.4	8.3	7.9	8.1	7.2	6.4	6.8
L15×T3	124.7	123.2	124	8.3	7.6	7.9	7.8	7.2	7.5
L15×T4	123.7	122.5	123.1	8.5	7.7	8.1	8.1	7.5	7.8
Max	125.1	124.9	125	11.6	10.8	11.1	11.5	11.5	11.3
Min	93.6	87.3	90.4	6.6	6.2	6.5	5.4	4.9	5.1
CD (0.05)	1.94	0.34	2.37	0.82	0.33	1.10	1.01	0.32	0.96

Table 4.2 (b) Mean performance of Lines (females) and testers(males) for different traits in okraunder two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Parents	Leaf blade length (cm)			Leaf blade width (cm)			Petiole length (cm)		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	10.3	8.0	9.2	14.4	12.9	13.7	7.4	6.6	7.0
L2	10.2	7.8	9.0	15.1	13.9	14.5	7.6	6.9	7.3
L3	9.9	8.1	9.0	14.6	13.5	14.1	8.5	8.0	8.3
L4	9.5	7.9	8.7	15.4	14.4	14.9	8.1	7.4	7.8
L5	11.6	9.5	10.6	15.2	14.1	14.7	11.3	10.6	11
L6	9.6	8.0	8.8	13.5	12.2	12.9	8.6	8.2	8.4
L7	10.9	8.8	9.9	13.8	12.4	13.1	12.0	11.5	11.8
L8	9.5	8.0	8.8	10.6	9.5	10.1	10.2	9.3	9.8
L9	11.8	9.5	10.7	14.6	13.5	14.1	11.3	11.0	11.2
L10	11.2	9.1	10.2	16.7	15.3	16.0	12.0	11.1	11.6
L11	9.8	7.8	8.8	13.3	12.2	12.8	8.3	7.3	7.8
L12	11.3	8.9	10.1	13.5	12.2	12.9	11.1	11.3	11.2
L13	10.5	8.0	9.3	15.3	14.1	14.7	8.3	7.4	7.9
L14	11.5	9.4	10.5	17.2	16	16.6	8.6	8.4	8.5
L15	14.6	12.7	13.7	19.1	18.9	19.0	13.3	13.0	13.2
T1	12.2	9.8	11.0	16.2	15.1	15.7	10.4	9.5	10.0
T2	9.4	7.3	9.8	11.3	10.6	11.0	10.8	9.9	10.4
T3	10.6	8.9	8.9	17.0	16.0	16.5	8.6	8.3	8.5
T4	9.8	7.9	8.9	18.2	17.0	17.6	14.3	14.2	14.3
C1	11.4	9.1	10.3	15	14	14.5	9.3	9.2	9.3
Max	14.6	12.7	13.7	19.1	18.9	19.0	14.3	14.2	14.3
Min	9.4	7.3	8.4	10.6	9.5	10.1	7.4	6.6	7.0
CD (0.05)	0.57	0.34	1.04	0.56	0.32	1.84	0.50	0.38	2.13
Hybrids									
L1×T1	8.9	8.8	8.9	18.7	16.8	17.8	9.3	8.0	8.6
L1×T2	9.2	9.0	9.1	15.3	13.9	14.6	11.3	10.3	10.8
L1×T3	10.8	11.0	10.9	17.7	15.9	16.8	11.4	10.2	10.8
L1×T4	8.8	8.9	8.9	19.2	17.6	18.4	15.6	15.3	15.5
L2×T1	11.1	10.9	11.0	17.3	15.6	16.5	12.6	11.3	12.0
L2×T2	9.2	9.2	9.2	18.5	18	18.3	9.8	8.3	9.1
L2×T3	9.0	8.8	8.9	16.6	15.6	16.1	11.8	10.7	11.3
L2×T4	8.5	8.7	8.6	15.7	13.7	14.7	11.4	10.8	11.1
L3×T1	8.4	8.6	8.5	18.1	16.6	17.4	9.6	8.8	9.2
L3×T2	10.8	10.9	10.9	18.4	16.9	17.7	11.4	10.4	10.9
L3×T3	8.6	8.6	8.6	19.4	17.9	18.7	15.6	14.6	15.1

L3×T4	9.0	9.0	9.0	16.3	14.6	15.5	11.3	10.3	10.8
L4×T1	9.6	9.8	9.7	18.4	17.1	17.8	11.1	10.4	10.7
L4×T2	11.2	11.0	11.1	17.9	15.6	16.8	12.0	10.9	11.4
L4×T3	10.2	10.2	10.2	18.6	17.0	17.8	11.8	11.3	11.6
L4×T4	11.5	11.2	11.4	17.4	15.4	16.4	11.9	11.1	11.5
L5×T1	9.3	9.6	9.5	16.9	15.5	16.2	12.0	11.2	11.6
L5×T2	9.4	9.6	9.5	18.9	17.5	18.2	9.3	8.8	9.1
L5×T3	9.0	9.0	9.0	14.7	12.8	13.8	11.8	10.7	11.3
L5×T4	11.3	11.5	11.4	17.7	15.8	16.8	12.6	11.6	12.1
L6×T1	10.2	10.0	10.1	15.4	13.8	14.6	13.0	11.9	12.5
L6×T2	7.3	7.7	7.5	19.7	18.6	19.2	15.7	14.4	15.1
L6×T3	9.0	8.8	8.9	12.1	10.9	11.5	11.8	10.2	11.0
L6×T4	9.8	9.8	9.8	18.7	16.9	17.8	12.7	11.4	12.1
L7×T1	9.4	9.6	9.5	19.7	17.7	18.7	15.8	14.3	15.1
L7×T2	9.5	9.7	9.6	15.3	13.6	14.5	12.7	11.5	12.1
L7×T3	10.3	10.5	10.4	17.7	15.6	16.7	13.0	12.2	12.6
L7×T4	10.1	9.9	10.0	18.2	16.8	17.5	12.7	11.5	12.1
L8×T1	10.5	10.7	10.6	13.0	10.8	11.9	15.7	14.5	15.1
L8×T2	9.2	9.0	9.1	10.8	9.2	10.0	10.4	9.2	9.8
L8×T3	8.4	8.7	8.6	18.4	16.5	17.5	12.0	11.4	11.7
L8×T4	11.2	11.1	11.2	17.3	16.0	16.7	12.6	11.7	12.2
L9×T1	10.9	10.9	10.9	19.7	17.5	18.6	15.7	14.4	15.0
L9×T2	8.3	8.6	8.5	18.4	16.7	17.6	9.3	8.2	8.8
L9×T3	8.7	8.7	8.7	19.4	17.6	18.5	15.3	14.1	14.7
L9×T4	10.6	10.9	10.8	17.2	15.3	16.3	9.7	8.4	9.1
L10×T1	9.1	9.1	9.1	16.9	15.2	16.1	11.6	11.2	11.4
L10×T2	9.6	9.8	9.7	18.3	16.6	17.5	9.0	8.6	8.8
L10×T3	10.4	10.6	10.5	19.7	17.8	18.8	15.3	14.3	14.8
L10×T4	10.2	10.2	10.2	19.7	17.3	18.5	9.7	8.5	9.1
L11×T1	12.8	12.8	12.8	20.0	19.1	19.6	11.3	10.6	11.0
L11×T2	13.2	13.4	13.3	20.1	18.4	19.3	11.9	11.2	11.5
L11×T3	13.5	13.6	13.6	20.0	18.9	19.5	15.3	14.1	14.7
L11×T4	13.8	13.7	13.8	20.3	19.3	19.8	11.6	11.1	11.4
L12×T1	11.6	11.6	11.6	18.4	16.7	17.6	12.2	11.6	11.9
L12×T2	7.6	7.8	7.7	12.3	11.1	11.7	11.9	11.2	11.5
L12×T3	10.6	10.2	10.4	19.5	18.3	18.9	10.9	10.3	10.6
L12×T4	9.2	9.4	9.3	21.5	20.3	20.9	12.7	12.1	12.4
L13×T1	8.7	8.7	8.7	17.6	16.4	17.0	9.4	8.8	9.1
L13×T2	7.3	7.6	7.5	14.6	13.4	14.0	8.9	8.2	8.5

L13×T3	9.1	9.1	9.1	19.3	18.1	18.7	9.4	8.8	9.1
L13×T4	9.1	9.4	9.3	18.4	17.2	17.8	11.8	11.1	11.4
L14×T1	11.4	11.2	11.3	18.1	16.8	17.5	10.8	10.2	10.5
L14×T2	8.5	8.5	8.5	13.9	12.6	13.3	8.9	8.3	8.6
L14×T3	9.6	9.7	9.7	19.9	18.7	19.3	8.8	8.1	8.4
L14×T4	8.3	8.2	8.3	19.9	18.7	19.3	14.1	13.4	13.7
L15×T1	15.1	14.9	15.0	18.4	17.2	17.8	15.2	14.6	14.9
L15×T2	9.9	10.0	10.0	16.4	15.2	15.8	17.0	16.3	16.6
L15×T3	12.3	12.5	12.4	21.0	19.8	20.4	11.7	11.0	11.3
L15×T4	11.0	11.0	11.0	22.5	21.3	21.9	17.2	16.5	16.8
Max	15.1	14.9	15.0	22.5	21.3	21.9	17.2	16.5	16.8
Min	7.3	7.6	7.5	10.8	9.2	10.0	8.8	8.0	8.4
CD (0.05)	0.77	0.32	1.18	0.70	0.37	1.68	0.63	0.39	2.02

Table 4.2 (c) Mean performance of Lines (females) and testers(males) for different traits in okraunder two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Parents	Days to first flowering			Days to first fruit set			Days to first fruit picking		
	E1	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1	59.7	62.3	61	63.7	67.3	65.5	69.7	72.9	71.3
L2	48.3	50.2	49.3	52.3	55.0	53.7	58.3	60.7	59.5
L3	53.7	56.4	55.1	57.7	61.3	59.5	58.3	60.7	59.5
L4	51.0	53.7	52.4	55.0	59.0	57.0	63.7	67.0	65.3
L5	43.7	46.0	44.9	49.3	54.6	52.0	61.0	64.7	62.9
L6	51.0	51.9	51.5	56.0	58.3	57.2	60.12	59.23	61.56
L7	55.3	58.7	57.0	59.0	64.1	61.6	63.0	64.6	63.8
L8	49.0	50.9	50.0	53.7	57.5	55.6	66.0	71.0	68.5
L9	47.3	49.7	48.5	53.3	56.4	54.9	60.7	63.9	62.3
L10	54.0	55.7	54.9	60.0	63.2	61.6	60.3	62.7	61.5
L11	51.0	53.1	52.1	57.0	60.0	58.5	64.0	67.2	65.6
L12	55.7	58.5	57.1	61.7	65.5	63.6	68.7	71.7	70.2
L13	57.3	60.2	58.8	63.3	67.2	65.3	70.3	74	72.2
L14	48.3	50.3	49.3	54.0	57.5	55.8	61.0	63.4	62.2
L15	43.0	44.2	43.6	48.0	50.1	49.1	55.0	56.7	55.9
T1	46.3	47.7	47.0	50.3	53.0	51.7	57.3	59.9	58.6
T2	54.0	56.0	55.0	58.0	61.3	59.7	64.0	66.7	65.4
T3	44.7	45.9	45.3	49.7	52.0	50.9	55.7	57.7	56.7
T4	49.3	51.7	50.5	54.3	57.3	55.8	60.3	63.0	61.7
C1	51.7	54.7	53.2	56.7	60.6	58.7	62.7	65.8	64.3
Max	59.7	62.3	61.0	63.7	67.3	65.5	70.3	74.0	72.2
Min	43.0	44.2	43.6	48.0	50.1	49.1	55.0	56.7	55.9
CD (0.05)	1.29	0.56	4.56	2.10	0.35	4.43	2.03	0.32	4.20
Hybrids									
L1×T1	42.7	45.2	44	47.7	51.1	49.4	53.1	56.6	54.8
L1×T2	52.1	55.1	53.6	56.5	60.7	58.6	62.2	65.7	64.0
L1×T3	44.6	47.9	46.3	48.5	52.1	50.3	55.2	58.6	56.9
L1×T4	46.7	50.4	48.6	50.6	54.3	52.5	56.4	59.9	58.2
L2×T1	44.4	47.8	46.1	48.7	52.1	50.4	55.2	58.9	57.1
L2×T2	42.7	45.1	43.9	47.0	51.5	49.3	52.7	56.7	54.7
L2×T3	46.8	49.9	48.4	50.1	54.1	52.1	56.2	59.9	58.1
L2×T4	51.5	54.5	53.0	55.3	59.8	57.6	61.2	65.0	63.1
L3×T1	42.7	45.2	44.0	47.3	51.5	49.4	53.2	56.8	55.0

L3×T2	51.5	54.3	52.9	48.2	52.3	50.3	55.3	59.1	57.2
L3×T3	42.7	46.1	44.4	52.2	56.6	54.4	58.6	62.1	60.4
L3×T4	44.8	47.9	46.4	53.2	57.5	55.4	59.3	62.8	61.1
L4×T1	48.8	52.1	50.5	47.1	51.2	49.2	53.4	56.8	55.1
L4×T2	49.9	53.3	51.6	48.3	52.2	50.3	53.2	56.6	54.9
L4×T3	42.4	44.9	43.7	47.5	51.4	49.5	53.1	57.0	55.1
L4×T4	44.6	47.7	46.2	47.0	51.4	49.2	53.4	57.0	55.2
L5×T1	41.4	44.9	43.2	47.0	51.5	49.3	53.1	56.7	54.9
L5×T2	41.4	44.3	42.9	47.1	51.3	49.2	53.1	57.3	55.2
L5×T3	42.4	45.1	43.8	54.3	57.9	56.1	61.1	64.7	62.9
L5×T4	49.1	52.0	50.6	48.2	52.2	50.2	55.2	59.2	57.2
L6×T1	44.7	47.9	46.3	56.6	60.0	58.3	62.2	65.5	63.9
L6×T2	52.7	55.2	54.0	51.1	55.6	53.4	58.3	61.8	60.1
L6×T3	47.7	51.1	49.4	51.2	55.6	53.4	58.1	61.6	59.9
L6×T4	42.4	45.0	43.7	47.0	51.4	49.2	53.3	56.8	55.1
L7×T1	45.4	48.4	46.9	51.3	55.1	53.2	58.3	61.9	60.1
L7×T2	45.4	48.2	46.8	51.1	55.3	53.2	58.5	62.0	60.3
L7×T3	52.7	55.1	53.9	56.4	60.2	58.3	62.2	65.7	64
L7×T4	42.6	45.6	44.1	47.1	51.1	49.1	53.2	57.0	55.1
L8×T1	48.3	51.1	49.7	52.3	56.1	54.2	58.3	62.0	60.2
L8×T2	42.4	45.4	43.9	52.1	56.7	54.4	58.1	61.8	60.0
L8×T3	44.4	46.8	45.6	47.3	50.9	49.1	53.6	56.9	55.3
L8×T4	48.7	51.2	50.0	48.2	52.5	50.4	55.5	59.3	57.4
L9×T1	42.4	45.0	43.7	52.3	56.4	54.4	58.6	61.9	60.3
L9×T2	48.7	51.2	50.0	47.4	51.2	49.3	53.3	56.7	55
L9×T3	44.4	47.2	45.8	52.6	56.2	54.4	58.3	61.7	60.0
L9×T4	42.4	45.3	43.9	48.2	52.7	50.5	55.2	58.9	57.1
L10×T1	52.6	55.1	53.9	56.1	60.2	58.2	66.3	67.7	67.0
L10×T2	46.3	49.3	47.8	47.2	51.3	49.3	53.5	57.0	55.3
L10×T3	46.7	49.3	48.0	52.0	56.0	54.0	58.3	61.8	60.1
L10×T4	41.7	44.1	42.9	52.1	56.4	54.3	59.3	62.9	61.1
L11×T1	41.6	44.1	42.9	46.4	50.0	48.2	53.4	57.1	55.3
L11×T2	41.4	44.1	42.8	46.3	50.7	48.5	53.4	57.1	55.3
L11×T3	41.5	44.3	42.9	46.2	50.4	48.3	53.4	56.6	55.0
L11×T4	41.3	44.3	42.8	46.1	50.2	48.2	53.2	56.7	55.0
L12×T1	52.3	54.4	53.4	60.7	63.9	62.3	63.8	66.6	65.2
L12×T2	58.9	61.0	60.0	62.8	66.6	64.7	70.9	73.7	72.3
L12×T3	51.2	53.3	52.3	59.0	62.4	60.7	66.7	69.6	68.2
L12×T4	54.6	56.8	55.7	61.0	64.2	62.6	66.8	69.6	68.2

L13×T1	55.4	57.6	56.5	58.4	61.3	59.9	69.9	72.7	71.3
L13×T2	59.5	61.6	60.6	64.7	68.3	66.5	73.0	75.9	74.5
L13×T3	51.5	53.7	52.6	56.1	59.4	57.8	64.9	67.8	66.4
L13×T4	54.5	56.6	55.6	63.3	66.8	65.1	67.4	70.2	68.8
L14×T1	48.7	50.9	49.8	52.1	55.6	53.9	62.1	64.9	63.5
L14×T2	51.0	53.2	52.1	53.7	56.8	55.3	63.8	66.7	65.3
L14×T3	45.9	48.1	47.0	52.2	55.7	54.0	64.6	67.4	66.0
L14×T4	50.2	52.4	51.3	56.4	59.5	58.0	65.3	68.1	66.7
L15×T1	44.2	46.4	45.3	49.8	52.8	51.3	60.6	63.4	62.0
L15×T2	49.3	51.5	50.4	54.5	58.0	56.3	63.1	65.9	64.5
L15×T3	44.8	47.0	45.9	49.5	52.9	51.2	61.5	64.3	62.9
L15×T4	47.6	49.8	48.7	52.7	55.7	54.2	61.7	64.5	63.1
Max	59.5	61.6	60.6	64.7	68.3	66.5	73.0	75.9	74.5
Min	41.3	44.1	42.8	46.1	50.0	48.2	52.7	56.5	54.7
CD (0.05)	0.82	0.36	2.98	0.71	0.34	2.76	0.76	0.34	2.67

Table 4.2 (d) Mean performance of Lines (females) and testers(males) for different traits in okraunder two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Parents	Number of flowers per plant			Number of pods per plants			Pod length (cm)		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	17.0	17.3	17.2	15.4	13.7	14.6	8.4	7.2	7.8
L2	12.7	11.1	11.9	18.0	18.3	18.2	9.6	8.7	9.1
L3	16.7	15.5	16.1	14.3	13.8	14.1	10.5	8.6	9.5
L4	21.0	20.4	20.7	16.7	15.7	16.2	9.4	8.5	9.0
L5	15.0	14.2	14.6	12.1	11.9	12.0	11.4	10.1	10.8
L6	17.0	17.1	17.1	12.3	10.1	11.2	10.5	9.4	10.0
L7	21.7	20.5	21.1	16.2	16.0	16.1	9.6	8.4	9.0
L8	13.7	13.2	13.5	15.5	14.0	14.8	10.7	9.6	10.2
L9	11.3	12.5	11.9	17.1	16.5	16.8	8.6	7.2	7.9
L10	17.0	17.1	17.1	11.4	10.7	11.1	9.2	8.3	8.8
L11	11.0	11.4	11.2	16.2	15.8	16	10.4	9.2	9.8
L12	15.0	15.0	15.0	17.2	16.9	17.1	8.6	7.5	8.1
L13	14.7	13.5	14.1	10.7	9.9	10.3	10.3	9.2	9.8
L14	13.0	12.1	12.6	9.9	9.5	9.7	8.5	7.8	8.2
L15	15.7	16.8	16.3	15.3	15.2	15.3	9.7	8.8	9.3
T1	17.7	18.0	17.9	13.9	11.8	12.9	8.4	7.1	7.8
T2	12.3	10.3	11.3	9.0	8.4	8.7	9.2	7.9	8.6
T3	16.0	15.1	15.6	14.4	13.3	13.9	7.3	6.2	6.8
T4	15.7	16.5	16.1	15.9	15.9	15.9	8.6	7.2	7.9
C1	11.3	11.2	11.3	10.8	9.7	10.3	11.4	9.7	10.6
Max	21.7	20.5	21.1	18	18.3	18.2	11.4	10.1	10.8
Min	11.0	10.3	11.2	9.0	8.4	8.7	7.3	6.2	6.8
CD (0.05)	2.45	0.34	3.04	1.29	0.32	2.56	0.33	0.32	0.87
Hybrids									
L1×T1	18.5	17.3	17.9	17.3	16.2	16.8	9.3	7.5	8.4
L1×T2	18.9	17.7	18.3	17.7	16.4	17.1	10.9	9.3	10.1
L1×T3	19.0	18.3	18.7	17.2	15.6	16.4	10.0	8.6	9.3
L1×T4	16.6	15.3	16	19.4	18.6	19.0	11.0	9.9	10.5
L2×T1	18.3	17.4	17.9	19.6	18.7	19.2	11.2	9.9	10.6
L2×T2	17.3	16.6	17.0	19.6	18.5	19.1	11.2	9.5	10.3
L2×T3	14.6	13.6	14.1	20.3	19.6	20.0	11.3	9.8	10.5
L2×T4	17.7	16.0	16.9	15.8	15.7	15.8	11.9	11.0	11.5
L3×T1	17.6	16.2	16.9	16.3	15.4	15.9	12.3	10.4	11.3
L3×T2	18.1	17.5	17.8	15.4	14.5	15.0	12.6	10.6	11.6
L3×T3	17.6	16.1	16.9	17.9	16.8	17.4	12.7	11.1	11.9

L3×T4	22.4	21.6	22.0	18.4	17.6	18.0	11.0	8.9	10.0
L4×T1	22.3	20.4	21.8	18.7	17.6	18.2	11.3	9.9	10.6
L4×T2	22.4	21.3	21.9	18.6	17.4	18.0	10.8	9.2	10.0
L4×T3	17.4	16.3	16.9	16.8	15.5	16.2	12.4	11.8	12.1
L4×T4	18.8	17.5	18.2	15.3	14.7	15.0	12.5	11.0	11.8
L5×T1	16.4	15.1	15.8	14.9	13.5	14.2	13.6	11.7	12.7
L5×T2	18.4	17.1	17.8	16.6	16.0	16.3	12.2	11.3	11.8
L5×T3	18.7	17.4	18.1	14.6	13.5	14.1	13.6	11.7	12.8
L5×T4	22.3	21.1	21.7	17.6	17.7	17.7	11.3	10.1	10.7
L6×T1	22.3	21.4	21.9	18.4	17.3	17.9	11.6	10.4	11.0
L6×T2	16.4	15.0	15.7	17.7	16.6	17.2	11.6	9.8	10.7
L6×T3	14.7	13.3	14.0	16.7	15.5	16.1	11.4	9.6	10.5
L6×T4	17.4	16.5	17.0	18.6	17.6	18.1	9.3	7.9	8.6
L7×T1	17.3	16.1	16.7	18.7	17.7	18.2	10.1	7.9	9.0
L7×T2	13.5	13.2	13.4	18.5	17.7	18.1	9.0	7.9	8.5
L7×T3	18.7	18.1	18.4	13.8	12.0	12.9	9.6	8.7	9.2
L7×T4	18.5	17.0	17.8	13.1	12.2	12.7	9.4	8.6	9.0
L8×T1	18.3	17.2	17.8	13.6	12.5	13.1	9.1	8.4	8.8
L8×T2	16.7	16.5	16.6	18.3	17.4	17.9	11.5	10.0	10.8
L8×T3	17.2	16.6	16.9	18.6	17.5	18.1	8.3	7.5	7.9
L8×T4	18.3	17.5	17.9	19.3	18.7	19.0	9.6	8.9	9.3
L9×T1	16.7	15.4	16.1	19.6	18.6	19.1	9.3	8.8	9.1
L9×T2	17.7	17.0	17.4	15.6	14.4	15.0	11.6	10.5	11.0
L9×T3	17.6	15.9	16.8	17.5	16.3	16.9	11.9	10.7	11.3
L9×T4	18.7	17.8	18.3	14.9	14.4	14.7	11.6	10.7	11.2
L10×T1	16.6	15.1	15.9	12.5	11.2	11.9	11.8	10.5	11.2
L10×T2	18.3	17.3	17.8	15.3	14.7	15.0	9.4	9.1	9.2
L10×T3	17.4	15.1	16.3	17.0	16.5	16.8	9.6	7.9	8.8
L10×T4	14.9	13.3	14.1	11.0	10.6	10.8	10.4	9.9	10.1
L11×T1	18.7	17.1	17.9	17.4	16.8	17.1	11.3	9.9	10.6
L11×T2	17.3	16.6	17.0	16.6	15.9	16.3	11.4	10.2	10.8
L11×T3	16.4	15.4	15.9	16.7	15.3	16.0	11.2	9.2	10.2
L11×T4	17.4	16.1	16.8	16.4	15.5	16.0	11.7	9.8	10.7
L12×T1	17.3	16.7	17.0	18.4	18.1	18.3	8.4	7.4	7.9
L12×T2	14.0	13.7	13.9	12.3	12.0	12.2	8.6	7.6	8.1
L12×T3	19.5	18.8	19.2	16.0	16.0	16.0	7.8	7.1	7.5
L12×T4	18.6	18.0	18.3	18.8	18.4	18.6	9.0	7.9	8.5
L13×T1	18.6	17.7	18.2	11.7	11.0	11.4	9.6	8.2	8.9
L13×T2	13.2	12.8	13.0	9.8	9.6	9.7	10.9	10.0	10.4

L13×T3	17.0	16.4	16.7	13.5	12.7	13.1	8.3	6.8	7.6
L13×T4	18.5	17.8	18.2	15.7	15.3	15.5	9.5	8.4	9.0
L14×T1	17.0	16.6	16.8	13.0	12.7	12.9	9.0	8.0	8.5
L14×T2	15.5	14.7	15.1	9.0	8.8	8.9	9.6	8.7	9.2
L14×T3	17.1	16.6	16.9	14.2	13.6	13.9	7.6	6.3	7.0
L14×T4	18.3	17.4	17.9	14.9	14.7	14.8	9.4	8.5	9.0
L15×T1	21.5	20.8	21.2	17.5	16.5	17.0	9.6	7.9	8.7
L15×T2	15.1	14.4	14.8	14.2	14.2	14.2	9.8	9.1	9.5
L15×T3	19.1	18.4	18.8	17.0	17.0	17.0	8.4	7.7	8.1
L15×T4	21.1	20.2	20.7	19.8	19.0	19.4	10.0	8.5	9.2
Max	22.6	21.6	22.0	20.3	19.6	20.0	13.6	11.8	12.7
Min	13.2	12.8	13.0	9.0	8.8	8.9	7.6	6.3	7.0
CD (0.05)	0.76	0.34	1.76	0.71	0.33	1.76	0.74	0.33	0.85

Table 4.2 (e) Mean performance of Lines (females) and testers(males) for different traits in okraunder two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Parents	Number of first fruiting node			Number of nodes per plant			Number of ridges per pod		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	4.4	3.3	3.8	18.4	16.2	17.3	6.3	4.9	5.5
L2	5.1	4.2	4.7	25.3	22.9	24.1	5.2	4.1	4.6
L3	5.8	4.9	5.4	22.0	20.1	21.1	6.6	6.1	6.6
L4	4.2	3.7	4.0	21.5	18.1	19.8	5.8	4.3	4.7
L5	4.4	3.5	3.9	20.3	17.7	19.0	7.4	4.4	4.7
L6	5.1	3.6	4.3	23.5	21.0	22.3	5.8	4.1	4.6
L7	4.6	4.4	4.5	18.8	16.3	17.6	6.3	5.3	5.7
L8	4.7	3.8	4.3	18.5	16.3	17.4	5.1	5.4	5.7
L9	5.2	3.7	4.5	19.0	16.8	17.9	6.9	4.1	4.6
L10	4.6	4.5	4.6	22.3	18.5	20.4	5.7	4.2	4.6
L11	4.9	3.3	4.1	29.1	26.2	27.7	6.9	5.5	5.8
L12	5.8	4.7	5.2	21.0	18.5	19.8	6.1	5.2	5.6
L13	5.6	4.8	5.2	21.6	19.0	20.3	7.6	6.3	6.7
L14	4.1	3.0	3.6	26.6	24.1	25.4	6.7	4.0	4.5
L15	4.9	4.5	4.7	27.5	25.7	26.6	5.2	4.4	4.7
T1	5.3	4.1	4.7	26.1	24.3	25.2	6.2	5.2	5.6
T2	4.8	4.2	4.5	19.0	16.9	18.0	5.3	4.7	4.9
T3	6.6	5.8	6.2	22.7	20.1	21.4	6.3	5.9	6.5
T4	4.6	3.7	4.2	18.9	17.7	18.3	5.2	4.1	4.6
C1	5.2	4.2	4.7	20.3	18.0	19.2	5.8	5.3	5.7
Max	6.6	5.8	6.2	29.1	26.2	27.7	7.4	6.3	6.7
Min	4.1	3.0	3.6	18.4	16.2	17.3	5.1	4.1	4.6
CD (0.05)	0.78	0.35	0.76	1.21	0.33	2.94	0.14	0.36	0.73
Hybrids									
L1×T1	4.9	4.1	4.5	23.0	20.6	21.8	5.9	5.2	5.6
L1×T2	4.4	3.6	4.0	21.5	19.1	20.3	6.9	6.2	6.6
L1×T3	5.5	4.6	5.0	21.2	18.7	20.0	6.2	5.5	5.8
L1×T4	4.7	3.9	4.3	19.6	17.2	18.4	5.3	4.6	5.0
L2×T1	5.7	4.9	5.3	27.6	25.2	26.4	5.2	4.6	4.9
L2×T2	5.0	4.1	4.5	23.9	21.5	22.7	5.4	4.7	5.1
L2×T3	6.6	5.7	6.1	26.2	23.8	25.0	6.6	6.0	6.3
L2×T4	4.7	3.9	4.3	24.6	22.2	23.4	5.2	4.5	4.8
L3×T1	6.0	5.1	5.5	25.6	23.2	24.4	6.0	5.3	5.7
L3×T2	5.2	4.3	4.7	21.6	19.2	20.4	7.6	7.0	7.3
L3×T3	6.8	6.0	6.4	23.2	20.7	22.0	8.1	7.4	7.8
L3×T4	5.0	4.2	4.6	24.2	21.8	23.0	6.2	5.5	5.9

L4×T1	5.0	4.2	4.6	25.6	23.2	24.4	5.5	4.9	5.2
L4×T2	4.4	3.6	4.0	21.5	19.0	20.3	4.5	3.8	4.2
L4×T3	4.9	4.1	4.5	25.3	22.9	24.1	5.9	5.2	5.6
L4×T4	4.7	3.9	4.3	22.7	20.3	21.5	5.3	4.6	4.9
L5×T1	5.0	4.1	4.5	26.7	24.2	25.5	5.1	4.5	4.8
L5×T2	4.3	3.4	3.8	19.3	16.9	18.1	5.5	4.8	5.2
L5×T3	6.3	5.5	5.9	23.0	20.6	21.8	5.9	5.2	5.6
L5×T4	4.9	4.1	4.5	21.6	19.2	20.4	5.5	4.8	5.1
L6×T1	6.1	5.2	5.6	25.8	23.4	24.6	5.0	4.3	4.7
L6×T2	5.2	4.4	4.8	22.9	20.4	21.7	4.6	3.9	4.3
L6×T3	6.2	5.4	5.8	24.7	22.3	23.5	6.1	5.5	5.8
L6×T4	5.2	4.4	4.8	22.7	20.2	21.5	5.2	4.5	4.8
L7×T1	5.4	4.6	5.0	22.7	20.3	21.5	6.4	5.7	6.1
L7×T2	5.3	4.4	4.8	19.3	16.9	18.1	5.8	5.2	5.5
L7×T3	5.5	4.7	5.1	22.9	20.5	21.7	7.1	6.4	6.8
L7×T4	5.2	4.4	4.8	19.7	17.3	18.5	5.6	4.9	5.2
L8×T1	5.1	4.3	4.7	23.9	21.5	22.7	6.8	6.1	6.5
L8×T2	5.0	4.1	4.5	20.4	18.0	19.2	5.5	4.9	5.2
L8×T3	6.5	5.7	6.1	22.4	20.0	21.2	7.3	6.6	7.0
L8×T4	5.7	4.8	5.2	19.5	17.1	18.3	6.1	5.4	5.8
L9×T1	5.3	4.5	4.9	25.1	22.7	23.9	5.4	4.7	5.0
L9×T2	5.2	4.4	4.8	19.9	17.5	18.7	4.6	3.9	4.3
L9×T3	6.4	5.5	5.9	22.6	20.2	21.4	6.7	6.0	6.3
L9×T4	5.5	4.7	5.1	21.7	19.2	20.5	5.2	4.5	4.9
L10×T1	5.1	4.3	4.7	25.9	23.5	24.7	5.1	4.4	4.8
L10×T2	4.7	3.9	4.3	21.4	19.0	20.2	5.0	4.3	4.7
L10×T3	6.4	5.6	6.0	22.3	19.9	21.1	6.3	5.6	5.9
L10×T4	5.4	4.6	5.0	23.2	20.7	22.0	5.2	4.5	4.9
L11×T1	4.9	4.1	4.5	29.8	27.4	28.6	6.8	6.1	6.5
L11×T2	5.1	4.2	4.6	27.0	24.6	25.8	6.1	5.4	5.7
L11×T3	6.4	5.6	6.0	28.4	25.9	27.2	7.1	6.4	6.7
L11×T4	4.9	4.1	4.5	27.0	24.6	25.8	5.6	4.9	5.3
L12×T1	6.0	5.2	5.6	25.4	23.0	24.2	6.4	5.7	6.1
L12×T2	5.4	4.6	5.0	22.6	20.2	21.4	4.9	4.2	4.5
L12×T3	7.0	6.2	6.6	23.7	21.2	22.5	7.2	6.5	6.8
L12×T4	5.1	4.2	4.6	21.8	19.4	20.6	5.4	4.7	5.1
L13×T1	6.2	5.3	5.7	27	24.6	25.8	6.9	6.2	6.6
L13×T2	5.4	4.5	4.9	21.1	18.7	19.9	6.0	5.3	5.6
L13×T3	5.9	5.0	5.4	23.8	21.3	22.6	7.3	6.6	6.9

L13×T4	5.5	4.7	5.1	21.7	19.3	20.5	6.5	5.8	6.1
L14×T1	4.9	4.1	4.5	29.4	27.0	28.2	5.0	4.3	4.7
L14×T2	4.2	3.4	3.8	24.3	21.9	23.1	4.9	4.2	4.5
L14×T3	5.0	4.1	4.5	27.5	25.1	26.3	6.0	5.3	5.7
L14×T4	4.6	3.8	4.2	23.6	21.2	22.4	5.5	4.8	5.2
L15×T1	5.7	4.9	5.3	31.9	29.4	30.7	4.8	4.1	4.5
L15×T2	5.3	4.5	4.9	24.6	22.2	23.4	4.8	4.1	4.5
L15×T3	6.1	5.3	5.7	28.3	25.9	27.1	6.2	5.5	5.8
L15×T4	4.9	4.1	4.5	27.7	25.3	26.5	4.4	3.8	4.1
Max	7.0	6.2	6.6	31.9	29.4	30.7	8.1	7.4	7.8
Min	4.2	3.4	3.8	19.3	16.9	18.1	4.4	3.8	4.1
CD (0.05)	0.35	0.35	0.40	0.34	0.34	1.26	0.33	0.33	0.54

Table 4.2 (f) Mean performance of Lines (females) and testers(males) for different traits in okraunder two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Parents	Pod diameter (cm)			Internodal length (cm)			Average pod weight (g)		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	1.8	1.7	1.8	4.4	3.7	4.1	15.4	13.9	14.7
L2	1.5	1.4	1.5	3.5	2.7	3.1	14.7	12.8	13.8
L3	1.6	1.3	1.5	4.1	3.5	3.8	18.6	17.1	17.9
L4	1.5	1.6	1.5	3.7	3.3	3.5	16.5	14.7	15.6
L5	1.6	1.5	1.6	3.2	2.8	3.0	17.0	16.5	16.8
L6	1.7	1.8	1.8	4.2	3.6	3.9	15.5	13.8	14.7
L7	1.9	1.6	1.8	5.0	4.8	4.9	17.8	17.3	17.6
L8	2.2	1.7	1.9	4.7	4.3	4.5	16.6	15.6	16.1
L9	1.5	1.2	1.4	5.0	4.6	4.8	19.5	17.2	18.4
L10	2.2	1.8	2.0	4.7	4.2	4.4	15.4	14.1	14.8
L11	1.6	1.5	1.5	3.6	3.7	3.7	12.3	11.0	11.7
L12	1.7	1.2	1.5	4.7	4.3	4.5	15.5	14.2	14.9
L13	2.1	2.2	2.1	5.0	4.5	4.7	11.6	9.7	10.7
L14	1.5	1.3	1.4	3.9	3.4	3.7	21.5	19.8	20.7
L15	1.9	2.0	1.9	5.3	5.2	5.3	15.4	13.9	14.7
T1	2.0	1.6	1.8	3.7	3.2	3.4	20.5	18.8	19.7
T2	2.1	1.8	1.9	5.3	4.8	5.0	16.3	15.4	15.9
T3	2.1	1.9	2.0	4.5	4.1	4.3	14.2	12.7	13.5
T4	1.4	1.2	1.3	5.5	5.1	5.3	12.3	10.9	11.6
C1	1.7	1.4	1.6	5.5	4.8	5.2	18.1	16.7	17.4
Max	2.2	2.2	2.1	5.5	5.2	5.3	21.5	19.8	20.7
Min	1.4	1.2	1.3	3.2	2.7	3.0	11.6	9.7	10.7
CD (0.05)	0.21	0.32	0.32	0.29	0.33	0.69	0.81	0.31	2.52
Hybrids									
L1×T1	2.1	2.0	2.1	4.2	3.8	4.0	18	16.6	17.3
L1×T2	1.9	1.8	1.9	4.7	4.3	4.5	18.6	17.2	17.9
L1×T3	1.9	1.8	1.9	5.1	4.7	4.9	16	14.6	15.3
L1×T4	2.4	2.3	2.4	4.9	4.6	4.8	14.3	12.9	13.6
L2×T1	1.7	1.6	1.7	3.5	3.2	3.4	19.0	17.6	18.3
L2×T2	2.1	1.9	2.0	4.5	4.1	4.3	18.5	17.1	17.8
L2×T3	1.9	1.8	1.9	3.9	3.6	3.8	16	14.6	15.3
L2×T4	1.4	1.3	1.4	5.2	4.8	5.0	16.4	15.0	15.7
L3×T1	1.7	1.6	1.7	4.3	3.9	4.1	22.8	21.5	22.2
L3×T2	1.7	1.6	1.7	4.6	4.2	4.4	19.2	17.8	18.5
L3×T3	1.7	1.6	1.7	4.3	3.9	4.1	17.2	15.8	16.5
L3×T4	1.7	1.6	1.7	5.9	5.5	5.7	16.8	15.4	16.1

L4×T1	2.0	1.9	2.0	3.8	3.4	3.6	19.1	17.8	18.5
L4×T2	1.8	1.6	1.7	4.6	4.2	4.4	19.2	17.8	18.5
L4×T3	1.8	1.7	1.8	4.3	4.0	4.2	18.2	16.9	17.6
L4×T4	1.6	1.4	1.5	5.0	4.6	4.8	15.5	14.2	14.9
L5×T1	1.6	1.5	1.6	3.7	3.3	3.5	22.6	21.2	21.9
L5×T2	1.7	1.6	1.7	4.5	4.1	4.3	18.8	17.4	18.1
L5×T3	1.6	1.5	1.6	4.4	4.1	4.3	15.9	14.5	15.2
L5×T4	1.5	1.4	1.5	4.8	4.4	4.6	15.7	14.4	15.1
L6×T1	2.0	1.9	2.0	4.4	4.0	4.2	19	17.6	18.3
L6×T2	2.0	1.8	1.9	5.0	4.6	4.8	17.4	16	16.7
L6×T3	2.0	1.9	2.0	5.0	4.6	4.8	18.3	17	17.7
L6×T4	1.6	1.4	1.5	6.3	5.9	6.1	17.2	15.8	16.5
L7×T1	2.5	2.3	2.4	5.0	4.6	4.8	22.9	21.5	22.2
L7×T2	2.2	2.0	2.1	5.6	5.2	5.4	18.1	16.8	17.5
L7×T3	2.2	2.1	2.2	5.2	4.9	5.1	17.6	16.3	17.0
L7×T4	2.2	2.1	2.2	6.6	6.3	6.5	16.5	15.1	15.8
L8×T1	2.5	2.3	2.4	4.2	3.8	4.0	23.3	21.9	22.6
L8×T2	2.9	2.7	2.8	5.5	5.1	5.3	19.4	18.0	18.7
L8×T3	2.5	2.3	2.4	4.8	4.4	4.6	14.7	13.3	14.0
L8×T4	2.0	1.9	2.0	5.5	5.1	5.3	18.4	17.0	17.7
L9×T1	1.6	1.5	1.6	4.5	4.2	4.4	24.1	22.8	23.5
L9×T2	2.2	2.1	2.2	5.6	5.2	5.4	21	19.7	20.4
L9×T3	1.5	1.3	1.4	5.2	4.8	5.0	18.4	17	17.7
L9×T4	1.7	1.5	1.6	6.0	5.6	5.8	15.3	13.9	14.6
L10×T1	2.2	2.0	2.1	4.6	4.3	4.5	21.2	19.9	20.6
L10×T2	2.3	2.1	2.2	4.3	3.9	4.1	17.9	16.5	17.2
L10×T3	2.3	2.2	2.3	5.6	5.3	5.5	18.9	17.5	18.2
L10×T4	2.2	2.1	2.2	5.2	4.8	5.0	16.4	15	15.7
L11×T1	1.6	1.5	1.6	5.7	5.4	5.6	16.3	14.9	15.6
L11×T2	1.5	1.3	1.4	3.7	3.3	3.5	18.1	16.7	17.4
L11×T3	2.1	2.0	2.1	5.3	4.9	5.1	15.7	14.3	15.0
L11×T4	1.7	1.5	1.6	4.0	3.7	3.9	14.9	13.6	14.3
L12×T1	2.1	1.9	2.0	5.2	4.9	5.1	19.5	18.1	18.8
L12×T2	1.7	1.5	1.6	5.8	5.5	5.7	17.7	16.3	17
L12×T3	2.1	2.0	2.1	5.8	5.4	5.6	16.8	15.4	16.1
L12×T4	1.7	1.6	1.7	5.9	5.5	5.7	14.4	13.1	13.8
L13×T1	2.1	1.9	2.0	4.9	4.6	4.8	14.4	13.1	13.8
L13×T2	2.4	2.3	2.4	5.9	5.6	5.8	17.2	15.8	16.5
L13×T3	2.3	2.2	2.3	5.4	5.1	5.3	15.0	13.6	14.3

L13×T4	2.3	2.1	2.2	6.5	6.1	6.3	13.1	11.7	12.4
L14×T1	2.0	1.9	2.0	4.3	3.9	4.1	24.3	23.0	23.7
L14×T2	1.9	1.7	1.8	4.7	4.3	4.5	22.6	21.3	22.0
L14×T3	1.5	1.3	1.4	5.0	4.7	4.9	21.5	20.1	20.8
L14×T4	1.4	1.3	1.4	5.0	4.7	4.9	20.1	18.8	19.5
L15×T1	2.8	2.6	2.7	5.2	4.8	5.0	18.2	16.8	17.5
L15×T2	2.5	2.4	2.5	5.7	5.3	5.5	19.2	17.9	18.6
L15×T3	2.7	2.5	2.6	4.5	4.1	4.3	16.0	14.6	15.3
L15×T4	1.8	1.7	1.8	6.3	5.9	6.1	17.2	15.9	16.6
Max	2.9	2.7	2.8	6.6	6.3	6.5	24.3	23	23.7
Min	1.4	1.3	1.4	3.5	3.2	3.4	13.1	11.7	12.4
CD (0.05)	0.33	0.33	0.28	0.32	0.32	0.53	0.34	0.34	1.27

Table 4.2 (g) Mean performance of Lines (females) and testers(males) for different traits in okraunder two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Parents	Pods yield/Plant (Kg)			Ascorbic acid content (mg/100g)			Acidity (%)		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	0.21	0.19	0.20	12.3	10.6	11.5	0.19	0.15	0.17
L2	0.26	0.25	0.26	12.3	10.4	11.4	0.18	0.13	0.15
L3	0.24	0.21	0.23	10.5	8.7	9.6	0.16	0.12	0.14
L4	0.25	0.23	0.24	15.7	14.0	14.9	0.19	0.18	0.19
L5	0.18	0.15	0.16	13.4	12.0	12.7	0.26	0.24	0.25
L6	0.15	0.13	0.14	10.7	9.4	10.1	0.23	0.18	0.21
L7	0.29	0.28	0.28	16.4	14.4	15.4	0.25	0.23	0.24
L8	0.18	0.14	0.16	14.6	12.9	13.8	0.24	0.22	0.23
L9	0.16	0.13	0.14	18.8	16.7	17.8	0.17	0.15	0.16
L10	0.18	0.16	0.17	12.6	10.6	11.6	0.16	0.13	0.14
L11	0.14	0.10	0.12	15.6	13.6	14.6	0.18	0.17	0.17
L12	0.16	0.12	0.14	17.7	16.5	17.1	0.20	0.20	0.20
L13	0.21	0.19	0.2	16.6	14.6	15.6	0.16	0.13	0.14
L14	0.18	0.16	0.17	15.4	13.6	14.5	0.23	0.21	0.22
L15	0.21	0.17	0.19	11.5	10.1	10.8	0.28	0.25	0.26
T1	0.13	0.12	0.12	16.5	15.0	15.8	0.16	0.12	0.14
T2	0.18	0.15	0.16	12.4	10.6	11.5	0.18	0.16	0.17
T3	0.21	0.18	0.19	10.4	8.9	9.7	0.21	0.18	0.2
T4	0.2	0.18	0.19	12.4	11.0	11.7	0.25	0.24	0.24
C1	0.19	0.16	0.17	10.4	8.6	9.5	0.16	0.14	0.15
Max	0.29	0.28	0.28	18.8	16.7	17.8	0.28	0.25	0.26
Min	0.13	0.10	0.12	10.4	8.6	9.5	0.16	0.12	0.14
CD (0.05)	2.07	4.37	5.31	0.36	0.33	2.14	0.01	0.03	0.04
Hybrids									
L1×T1	0.19	0.17	0.18	15.9	14.3	15.1	0.17	0.15	0.16
L1×T2	0.21	0.20	0.20	13.0	11.4	12.2	0.15	0.08	0.11
L1×T3	0.22	0.2	0.21	11.7	10.2	11.0	0.24	0.2	0.22
L1×T4	0.21	0.19	0.20	14.7	13.1	13.9	0.2	0.13	0.16
L2×T1	0.26	0.24	0.25	17.2	15.7	16.5	0.17	0.17	0.17
L2×T2	0.28	0.26	0.27	14.6	13.0	13.8	0.18	0.16	0.17
L2×T3	0.30	0.29	0.30	12.7	11.2	12.0	0.21	0.16	0.19
L2×T4	0.28	0.24	0.26	14.4	12.9	13.7	0.23	0.2	0.21
L3×T1	0.24	0.21	0.22	14.9	13.3	14.1	0.15	0.14	0.15
L3×T2	0.27	0.25	0.26	11.5	10.0	10.8	0.19	0.17	0.18
L3×T3	0.27	0.23	0.25	11.7	10.2	11.0	0.2	0.17	0.18
L3×T4	0.26	0.22	0.24	12.8	11.3	12.1	0.22	0.22	0.22

L4×T1	0.24	0.22	0.23	18.5	17.0	17.8	0.19	0.2	0.19
L4×T2	0.24	0.22	0.23	15.3	13.7	14.5	0.18	0.14	0.16
L4×T3	0.27	0.23	0.25	14.7	13.2	14.0	0.21	0.21	0.21
L4×T4	0.27	0.25	0.26	17.0	15.4	16.2	0.23	0.2	0.21
L5×T1	0.15	0.12	0.13	17.4	15.9	16.7	0.25	0.25	0.25
L5×T2	0.2	0.17	0.18	15.2	13.7	14.5	0.25	0.18	0.21
L5×T3	0.23	0.21	0.22	12.8	11.4	12.1	0.26	0.27	0.27
L5×T4	0.24	0.21	0.22	16.6	15.1	15.9	0.31	0.25	0.28
L6×T1	0.14	0.12	0.13	14.5	13	13.8	0.21	0.19	0.2
L6×T2	0.2	0.18	0.19	13.4	11.8	12.6	0.23	0.19	0.21
L6×T3	0.21	0.18	0.2	11.8	10.3	11.1	0.25	0.23	0.24
L6×T4	0.21	0.18	0.19	13.1	11.6	12.4	0.28	0.27	0.27
L7×T1	0.26	0.23	0.24	18.6	17.1	17.9	0.24	0.22	0.23
L7×T2	0.29	0.27	0.28	17.1	15.6	16.4	0.25	0.18	0.21
L7×T3	0.34	0.32	0.33	15.2	13.7	14.5	0.27	0.23	0.25
L7×T4	0.28	0.25	0.26	17.1	15.7	16.4	0.29	0.27	0.28
L8×T1	0.15	0.12	0.13	18.8	17.2	18.0	0.22	0.18	0.20
L8×T2	0.2	0.18	0.19	16.9	15.3	16.1	0.25	0.19	0.22
L8×T3	0.23	0.19	0.21	13.3	11.8	12.6	0.24	0.26	0.25
L8×T4	0.22	0.18	0.20	15.5	14.0	14.8	0.27	0.25	0.26
L9×T1	0.15	0.13	0.14	21.1	19.6	20.4	0.18	0.17	0.17
L9×T2	0.19	0.17	0.18	21	19.4	20.2	0.2	0.17	0.18
L9×T3	0.2	0.16	0.18	18.6	17.0	17.8	0.23	0.19	0.21
L9×T4	0.21	0.19	0.20	21.2	19.6	20.4	0.23	0.19	0.21
L10×T1	0.17	0.14	0.15	14.3	12.8	13.6	0.18	0.14	0.16
L10×T2	0.19	0.16	0.17	13.1	11.5	12.3	0.19	0.13	0.16
L10×T3	0.21	0.19	0.2	12.9	11.4	12.2	0.21	0.17	0.19
L10×T4	0.24	0.21	0.22	14.6	13.1	13.9	0.24	0.25	0.25
L11×T1	0.15	0.13	0.14	18.4	16.9	17.7	0.20	0.16	0.18
L11×T2	0.19	0.17	0.18	14.0	12.4	13.2	0.18	0.16	0.17
L11×T3	0.2	0.17	0.19	16.1	14.6	15.4	0.22	0.18	0.20
L11×T4	0.17	0.14	0.15	17.0	15.6	16.3	0.24	0.25	0.24
L12×T1	0.13	0.11	0.12	23.1	21.5	22.3	0.21	0.19	0.20
L12×T2	0.19	0.17	0.18	21.2	19.6	20.4	0.21	0.15	0.18
L12×T3	0.22	0.20	0.21	19.4	17.9	18.7	0.25	0.21	0.23
L12×T4	0.2	0.16	0.18	21.7	20.2	21.0	0.27	0.24	0.25
L13×T1	0.19	0.16	0.17	18.1	16.5	17.3	0.17	0.15	0.16
L13×T2	0.24	0.22	0.23	15.7	14.1	14.9	0.17	0.16	0.16
L13×T3	0.25	0.21	0.23	12.9	11.4	12.2	0.20	0.16	0.18

L13×T4	0.25	0.21	0.23	17.2	15.8	16.5	0.24	0.25	0.25
L14×T1	0.17	0.15	0.16	17.4	15.9	16.7	0.22	0.17	0.20
L14×T2	0.18	0.16	0.17	15.5	14.0	14.8	0.22	0.18	0.20
L14×T3	0.2	0.16	0.18	13.1	11.5	12.3	0.26	0.21	0.23
L14×T4	0.21	0.19	0.20	17.2	15.7	16.5	0.29	0.25	0.27
L15×T1	0.23	0.20	0.21	15.2	13.7	14.5	0.25	0.23	0.24
L15×T2	0.25	0.22	0.23	13	11.4	12.2	0.21	0.19	0.20
L15×T3	0.27	0.25	0.26	11.7	10.2	11.0	0.28	0.22	0.25
L15×T4	0.25	0.22	0.23	13.5	12.1	12.8	0.33	0.29	0.31
Max	0.34	0.32	0.33	23.1	21.5	22.3	0.33	0.3	0.32
Min	0.13	0.11	0.12	11.5	10	10.8	0.15	0.1	0.13
CD (0.05)	3.47	3.65	4.71	0.33	0.33	1.58	0.03	0.02	0.03

Table 4.2 (h) Mean performance of Lines (females) and testers(males) for different traits in okraunder two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Parents	Dry matter content (%)			Firmness (kg/cm^2)			Chlorophyll content (SPAD unit)		
	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1	19.7	17.3	18.5	6.7	5.8	6.2	35.4	33.8	34.6
L2	18.9	17.6	18.3	6.8	5.9	6.3	35.9	35.2	35.6
L3	21.7	20.5	21.1	7.6	6.8	7.2	36.5	34.9	35.7
L4	16.9	16.6	16.8	7.1	6.3	6.7	42.7	40.7	41.7
L5	29.2	26.6	27.9	8.2	7.4	7.8	37.0	36.2	36.6
L6	24.4	20.3	22.4	8.7	7.9	8.3	38.4	36.8	37.6
L7	18.7	16.6	17.7	7.9	7.2	7.5	51.8	49.9	50.9
L8	26.1	24.5	25.3	7.8	7.0	7.4	39.2	37.6	38.4
L9	20.0	18.3	19.2	7.1	6.3	6.7	37.8	35.7	36.8
L10	23.4	22.3	22.9	7.7	6.8	7.2	38.8	37.1	38
L11	17.7	16.9	17.3	4.9	4.0	4.4	41.1	39.3	40.2
L12	19.8	17.9	18.9	5.4	4.6	5.0	46	44.5	45.3
L13	18.7	16.8	17.8	5.8	5.0	5.4	43.3	41.6	42.5
L14	17.6	15.8	16.7	4.7	3.9	4.3	41.7	40.7	41.2
L15	26.3	24.6	25.5	6.1	5.4	5.7	33.4	31	32.2
T1	21.9	20.2	21.1	4.3	3.5	3.9	45.8	44.7	45.3
T2	17.8	15.5	16.7	4.6	3.7	4.1	32.1	30.5	31.3
T3	15.7	13.8	14.8	3.8	3.0	3.4	44.2	42.4	43.3
T4	17.8	15.9	16.9	4.2	3.4	3.8	39.4	38.1	38.8
C1	15.8	13.7	14.8	4.9	4.1	4.5	41.0	39.7	40.4
Max	29.2	26.6	27.9	8.7	7.9	8.3	51.8	49.9	50.9
Min	15.7	13.7	14.8	3.8	3.0	3.4	32.1	30.5	31.3
CD (0.05)	1.78	0.36	3.19	0.35	0.35	0.73	1.05	0.34	4.88
Hybrids									
L1×T1	21.9	20.0	21.0	6.8	5.9	6.3	44.5	42.9	43.7
L1×T2	19.7	17.8	18.8	7.3	6.4	6.8	37.6	36.0	36.8
L1×T3	18.2	16.4	17.3	6.9	6.1	6.5	43.5	41.8	42.7
L1×T4	20.1	18.2	19.2	7.9	7.1	7.5	41.2	39.6	40.4
L2×T1	21.4	19.6	20.5	7.5	6.6	7.0	45.3	43.7	44.5
L2×T2	19.2	17.4	18.3	7.2	6.4	6.8	37.9	36.3	37.1
L2×T3	16.6	14.8	15.7	7.1	6.2	6.6	46.7	45.1	45.9
L2×T4	18.8	17.1	18	8.1	7.3	7.7	43.3	41.7	42.5
L3×T1	23.9	22.1	23	7.6	6.8	7.2	44.2	42.6	43.4
L3×T2	22.5	20.7	21.6	7.3	6.4	6.8	37.9	36.3	37.1
L3×T3	21.6	19.8	20.7	7.3	6.5	6.9	46.9	45.3	46.1
L3×T4	22.2	20.4	21.3	8.1	7.3	7.7	41.0	39.4	40.2
L4×T1	20.7	18.9	19.8	7.36	6.5	6.93	49.6	48	48.8

L4×T2	18.9	17.1	18	7.46	6.6	7.03	41.6	40	40.8
L4×T3	18	16.2	17.1	7.43	6.6	7.02	48.7	47.1	47.9
L4×T4	20.8	19	19.9	7.89	7.0	7.45	45.3	43.6	44.5
L5×T1	29.5	27.8	28.7	8.04	7.2	7.62	47.1	45.5	46.3
L5×T2	27.8	26	26.9	8.6	7.8	8.2	39.5	37.9	38.7
L5×T3	20.1	18.4	19.3	7.54	6.8	7.17	43	41.4	42.2
L5×T4	27	25.2	26.1	8.48	7.7	8.09	41.5	39.8	40.7
L6×T1	26.9	25.1	26	8.3	7.4	7.85	43.5	41.9	42.7
L6×T2	23.4	21.6	22.5	8.49	7.6	8.05	39.0	37.4	38.2
L6×T3	21.6	19.9	20.8	7.82	7.0	7.41	42.4	40.8	41.6
L6×T4	24.1	22.3	23.2	8.59	7.8	8.2	42.6	41	41.8
L7×T1	23.3	21.5	22.4	7.63	6.8	7.22	56.1	54.5	55.3
L7×T2	20.1	18.3	19.2	8.14	7.3	7.72	49.6	48.0	48.8
L7×T3	18.4	16.7	17.6	7.68	6.9	7.29	54.6	53	53.8
L7×T4	21.3	19.6	20.5	8.41	7.6	8.01	53.7	52.1	52.9
L8×T1	28.6	26.8	27.7	7.85	7.0	7.43	43.9	42.3	43.1
L8×T2	23.9	22.1	23	7.84	7.0	7.42	38	36.4	37.2
L8×T3	21.8	20	20.9	7.51	6.7	7.11	46.8	45.2	46
L8×T4	27.4	25.7	26.6	8.18	7.4	7.79	43.9	42.3	43.1
L9×T1	22.1	20.2	21.2	7.6	6.7	7.15	44.1	42.4	43.3
L9×T2	19.6	17.8	18.7	7.62	6.8	7.21	39.6	38	38.8
L9×T3	17.2	15.4	16.3	7.18	6.3	6.74	41.9	40.2	41.1
L9×T4	20.9	19.1	20	8.17	7.3	7.74	41	39.4	40.2
L10×T1	25.2	23.4	24.3	5.87	5.0	5.44	44.7	43.1	43.9
L10×T2	23.3	21.5	22.4	5.45	4.6	5.03	41.4	39.8	40.6
L10×T3	20.7	18.9	19.8	4.67	3.8	4.24	46.2	44.6	45.4
L10×T4	26.7	25	25.9	5.57	4.8	5.19	42.2	40.6	41.4
L11×T1	19.6	17.8	18.7	5.03	4.2	4.62	48.1	46.5	47.3
L11×T2	19.4	17.6	18.5	5.22	4.3	4.76	39.5	37.9	38.7
L11×T3	15.9	14.1	15	4.33	3.5	3.92	46.5	44.8	45.7
L11×T4	20.1	18.4	19.3	5.09	4.3	4.7	42.4	40.8	41.6
L12×T1	22.7	20.9	21.8	5.5	4.6	5.05	49.4	47.8	48.6
L12×T2	23.2	21.3	22.3	5.05	4.2	4.63	43.7	42.0	42.9
L12×T3	21.9	20.1	21.0	5.21	4.4	4.81	48.5	46.8	47.7
L12×T4	19.0	17.2	18.1	5.31	4.5	4.91	46.9	45.3	46.1
L13×T1	20.7	18.8	19.8	5.72	4.8	5.26	48.3	46.7	47.5
L13×T2	19.2	17.4	18.3	4.84	3.9	4.37	40.6	39	39.8
L13×T3	17.9	16.0	17.0	5.53	4.6	5.07	46.9	45.2	46.1

L13×T4	17.4	15.6	16.5	5.7	4.9	5.3	43.9	42.3	43.1
L14×T1	20.5	18.7	19.6	4.63	3.8	4.22	48.1	46.5	47.3
L14×T2	19.4	17.6	18.5	5.17	4.3	4.74	41.5	39.9	40.7
L14×T3	16.7	14.9	15.8	4.64	3.8	4.22	46.1	44.5	45.3
L14×T4	20.9	19.2	20.1	5.79	5.0	5.4	43.3	41.7	42.5
L15×T1	28.2	26.5	27.4	5.46	4.6	5.03	36.3	34.7	35.5
L15×T2	26.8	25.0	25.9	5.2	4.3	4.75	36.0	34.4	35.2
L15×T3	24.3	22.5	23.4	5.74	4.9	5.32	39.5	37.8	38.7
L15×T4	27.7	26.0	26.9	3.88	3.1	3.49	36.7	35.1	35.9
Max	29.5	27.8	28.7	8.6	7.8	8.2	56.1	54.5	55.3
Min	15.9	14.1	15	3.88	3.1	3.49	36	34.4	35.2
CD (0.05)	0.33	0.33	1.95	0.33	0.33	0.45	0.33	0.33	1.55

Table 4.2 (i) Mean performance of Lines (females) and testers(males) for different traits in okraunder two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Parents	Mucilage content (%)		
	E1	E2	Pooled
L1	12.1	11.2	11.7
L2	12.3	10.5	11.4
L3	8.5	7.0	7.8
L4	8.2	7.1	7.7
L5	5.4	4.6	5.0
L6	12.3	11.1	11.7
L7	8.3	7.0	7.7
L8	10.3	9.4	9.9
L9	6.5	5.0	5.8
L10	7.3	6.2	6.8
L11	11.6	10.3	11
L12	6.6	5.4	6.0
L13	7.1	5.7	6.4
L14	12.6	11.9	12.3
L15	26.7	25.9	26.3
T1	15.4	14.4	14.9
T2	21.4	20.4	20.9
T3	18.2	17.5	17.9
T4	16.1	15.2	15.7
C1	21.8	20.4	21.1
Max	26.7	25.9	26.3
Min	5.4	4.6	5.0
CD (0.05)	0.52	0.36	3.57
Hybrids			
L1×T1	14.3	13.3	13.8
L1×T2	18.4	17.4	17.9
L1×T3	16.7	15.7	16.2
L1×T4	13.5	12.5	13
L2×T1	16.4	15.4	15.9
L2×T2	19.3	18.3	18.8
L2×T3	15.7	14.7	15.2
L2×T4	17.0	16.0	16.5
L3×T1	13.9	12.8	13.4
L3×T2	17.3	16.3	16.8
L3×T3	14.9	13.9	14.4
L3×T4	12.0	11.1	11.6

L4×T1	13.9	13.0	13.5
L4×T2	17.2	16.2	16.7
L4×T3	12.6	11.6	12.1
L4×T4	14.2	13.2	13.7
L5×T1	9.2	8.2	8.7
L5×T2	12.4	11.4	11.9
L5×T3	11.6	10.7	11.2
L5×T4	9.9	9.0	9.5
L6×T1	16.4	15.5	16.0
L6×T2	19.2	18.2	18.7
L6×T3	16.9	16.0	16.5
L6×T4	15.5	14.6	15.1
L7×T1	12.9	12.0	12.5
L7×T2	18.6	17.6	18.1
L7×T3	11.5	10.6	11.1
L7×T4	11.0	10.1	10.6
L8×T1	16.3	15.3	15.8
L8×T2	19.5	18.5	19.0
L8×T3	17.4	16.5	17.0
L8×T4	15.7	14.8	15.3
L9×T1	9.0	8.0	8.5
L9×T2	13.9	12.9	13.4
L9×T3	8.2	7.2	7.7
L9×T4	7.3	6.4	6.9
L10×T1	11.8	10.8	11.3
L10×T2	14.6	13.6	14.1
L10×T3	13.0	12.0	12.5
L10×T4	11.9	11.0	11.5
L11×T1	16.9	15.9	16.4
L11×T2	19.3	18.2	18.8
L11×T3	14.4	13.4	13.9
L11×T4	13.4	12.5	13.0
L12×T1	9.6	8.6	9.1
L12×T2	13.7	12.7	13.2
L12×T3	11.3	10.4	10.9
L12×T4	9.4	8.4	8.9
L13×T1	15.6	14.6	15.1
L13×T2	19.1	18.1	18.6
L13×T3	14.8	13.8	14.3

L13×T4	11.3	10.4	10.9
L14×T1	17.0	16.0	16.5
L14×T2	18	17.0	17.5
L14×T3	14.4	13.5	14
L14×T4	13.7	12.8	13.3
L15×T1	28.9	28.0	28.5
L15×T2	30.5	29.5	30.0
L15×T3	27.1	26.2	26.7
L15×T4	26.5	25.6	26.1
Max	30.5	29.5	30
Min	7.3	6.4	6.9
CD (0.05)	0.35	0.35	1.55

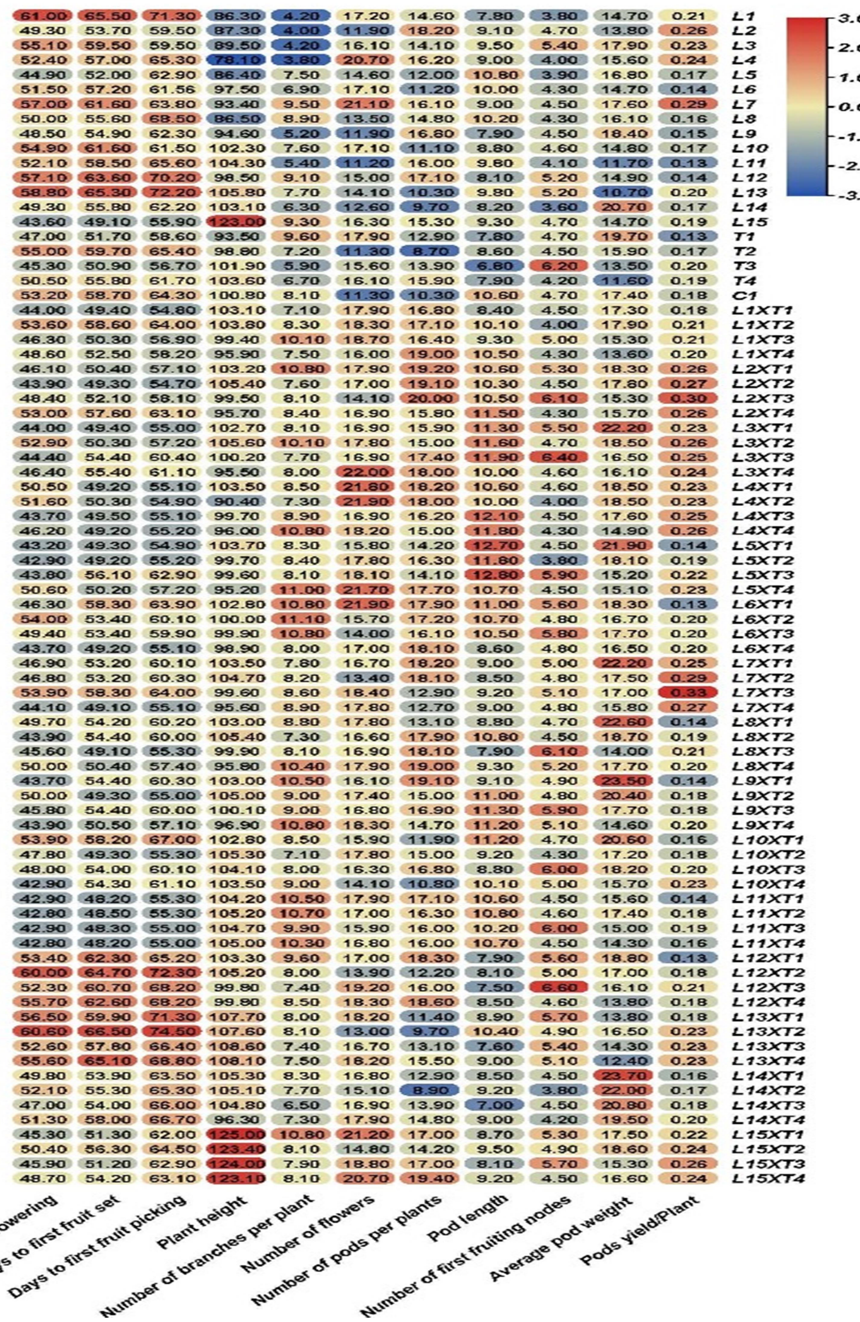

Fig.4.1 Heat map of mean performance for yield and yield attributing traits

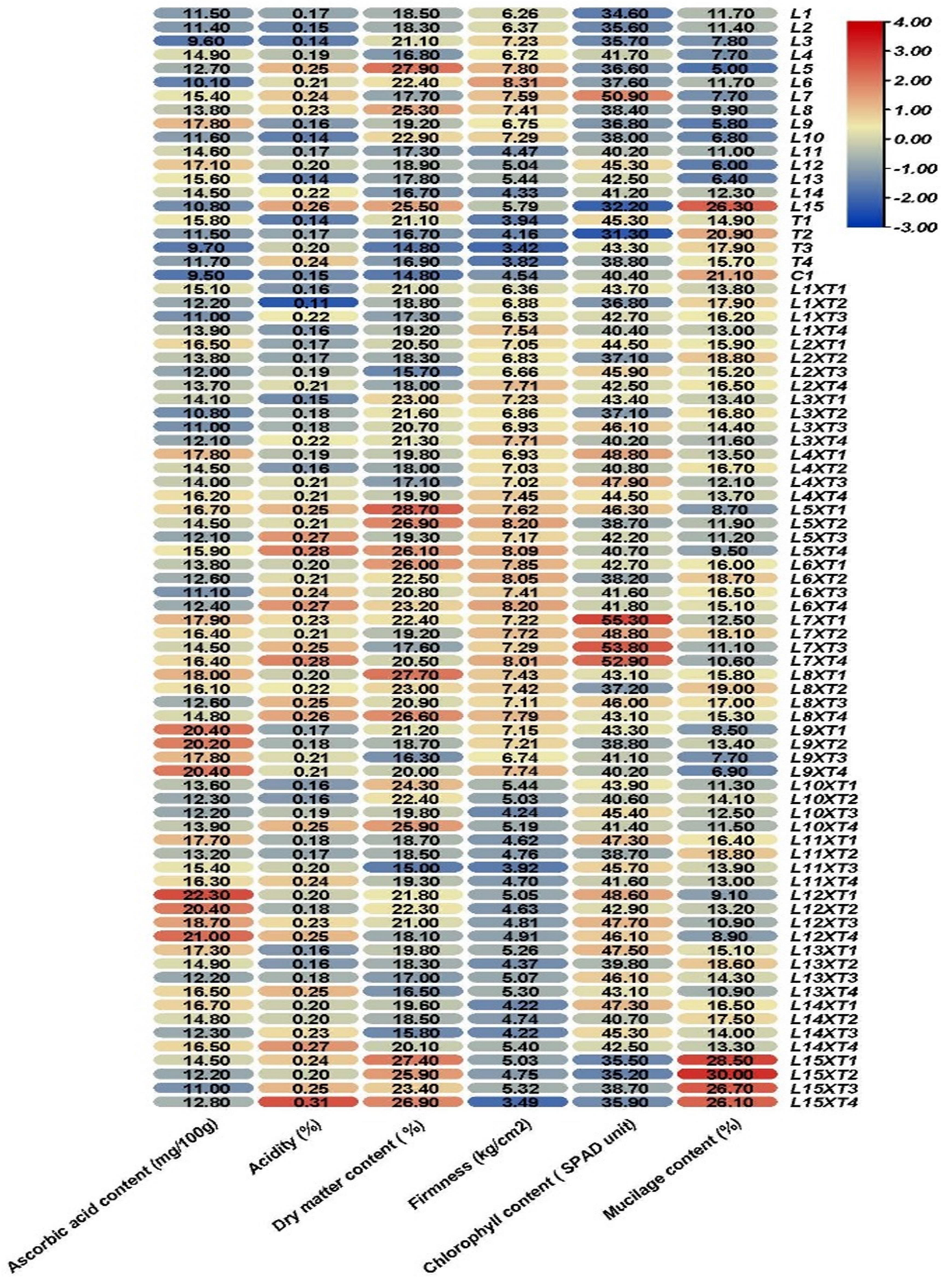

Fig. 4.2 Heat map of mean performance for biochemical parameters

4.3 Morphological Characterization

The parents and hybrids displayed a wide range of variability across the studied traits, as detailed in Table 4.3 (a &b). Stem color in parents exhibited 80% green and 20% red, while hybrids showed 92% green and 8% red. Stem intensity for parents included 25% light, 60% medium, and 15% dark, while hybrids displayed 27% light, 30% medium, and 43% dark. Leaf blade color between the veins was 90% green and 10% red for parents, while hybrids showed 90% green and 10% red. Vein color in parents had frequencies of 80% light green, 10% dark green, and 10% purple, whereas hybrids showed frequencies of 87% light green, 12% dark green, and 0% purple. Flower petal color for parents was 40% cream and 60% yellow, whereas hybrids showed 13% cream and 87% yellow. Petal base color for parents was 95% on both sides and 5% inside only, while hybrids showed 92% on both sides and 8% inside only. Pod shape ape× forparents was 55% narrow acute, 40% acute, and 5% flat, while hybrids displayed 73% narrow acute, 13% acute, and 14% blunt. Pod surface between ridges in parents was 45% concave and 55% flat, whereas hybrids showed 30% concave and 70% flat. Pod pubescence for parents was 30% weak, 30% medium, and 40% strong, whereas hybrids displayed 32% weak, 46% medium, and 22% strong. Seed color for both parents and hybrids was 100% green, while seed hairiness in parents was 30% present and 70% absent, and hybrids showed 90% present and 10% absent.

Table 4.3 (a) Morphological characters studied of okra in different parental lines

Genotype	Stem Colour	Stem: Intensity of green colour	Leaf blade: Colour between the vein	Vein colour	Flower: Petal Colour	Flower: Petal basecolour	Pod: Shapeof apex	Pod: Surface between the ridge	Pod Pubescence	Seed Colour	Seed Hairiness
IC 128021 (L1)	Red	Light	Green	Light Green	Cream	Both Sides	Acute	Concave	Weak	Green	Present
IC 128023 (L2)	Green	Medium	Green	Light Green	Cream	Both sides	NarrowAcute	Concave	Weak	Green	Present
IC 128024 (L3)	Green	Medium	Green	Light Green	Cream	Both sides	Acute	Flat	Weak	Green	Present
IC 128028 (L4)	Green	Medium	Green	Light Green	Cream	Both sides	NarrowAcute	Flat	Strong	Green	Present
IC 128029 (L5)	Green	Medium	Green	Light Green	Yellow	Both Sides	NarrowAcute	Concave	Strong	Green	Absent
EC 169451 (L6)	Red	Light	Green	Light Green	Yellow	Both Sides	Acute	Flat	Medium	Green	Present
EC 169453 (L7)	Green	Medium	Green	Light Green	Yellow	Both Sides	Acute	Concave	Strong	Green	Absent
EC 169455 (L8)	Green	Dark	Green	Light Green	Cream	Both Sides	Acute	Flat	Strong	Green	Absent
EC 169459 (L9)	Green	Dark	Green	Light Green	Yellow	Both sides	NarrowAcute	Flat	Strong	Green	Present
EC 169462(L10)	Red	Light	Red	Light Green	Yellow	Both sides	NarrowAcute	Flat	Medium	Green	Absent
EC 169463 (L11)	Green	Medium	Green	Light Green	Yellow	Both sides	Narrow Acute	Concave	Weak	Green	Absent
EC 169464(L12)	Green	Dark	Green	Light Green	Yellow	Both Sides	Flat	Concave	Weak	Green	Absent
EC 169467(L13)	Green	Medium	Green	Light Green	Cream	Both Sides	NarrowAcute	Flat	Medium	Green	Absent
EC 169470(L14)	Green	Medium	Green	Light Green	Cream	Both Sides	Acute	Concave	Strong	Green	Absent
EC169472(L15)	Green	Medium	Green	Light Green	Cream	Both Sides	Acute	Concave	Strong	Green	Absent
Kashi Pragati(KP)	Green	Light	Green	Light Green	Yellow	Both sides	NarrowAcute	Flat	Weak	Green	Absent
Kashi Lalima(KL)	Red	Medium	Red	Purple	Yellow	Both sides	NarrowAcute	Flat	Medium	Green	Absent
Kashi Kranti(KK)	Green	Medium	Green	Dark Green	Yellow	Both sides	NarrowAcute	Flat	Medium	Green	Absent
Arka Anamika (AA)	Green	Light	Green	Purple	Yellow	Inside only	NarrowAcute	Flat	Medium	Green	Absent

Punjab Subhani (PB)	Green	Medium	Green	Dark Green	Yellow	Both sides	Acute	Concave	Strong	Green	Absent
Frequency	**Green=80%**	**Light=25%**	**Green=90%**	**Light Green=80%**	**Cream=40%**	**Inside only=5%**	**Narrow Acute=55%**	**Concave=45%**	**Weak=30%**	**Green=100%**	**Present=30**
	Red=20%	**Medium=60%**	**Red=10%**	**Dark Green=10%**	**Yellow=60%**	**Both Sides=95%**	**Acute=40%**	**Flat=55%**	**Medium=30%**	**Brown=0%**	**Absent=70**
		Dark=15%		**Purple=10%**			**Flat=5%**		**Strong=40%**		

Table 4.3 (b) Morphological characters in different crosses of okra

Cross	Stem Colour	Stem: Intensity of green colour	Leaf blade: Colour between the vein	Vein colour	Flower: Petal Colour	Flower: Petal base colour	Pod: Shape of ape×	Pod: Surface between the ridge	Pod Pubescence	Seed Colour	Seed Hairiness
L1×T1	Green	Medium	Green	Light Green	Yellow	Both sides	Acute	Flat	Medium	Green	Absent
L1×T2	Red	Light	Green	Green	Cream	Both sides	Narrow acute	Flat	Weak	Green	Absent
L1×T3	Green	Dark	Green	Light Green	Yellow	Both sides	Narrow Acute	Flat	Medium	Green	Absent
L1×T4	Green	Dark	Green	Light Green	Yellow	Both Sides	Narrow Acute	Concave	Weak	Green	Absent
L2×T1	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Weak	Green	Absent
L2×T2	Green	Dark	Green	Light Green	Yellow	Both Sides	Blunt	Concave	Strong	Green	Absent
L2×T3	Green	Medium	Green	Light Green	Yellow	Both Sides	Narrow Acute	Concave	Strong	Green	Absent
L2×T4	Green	Medium	Green	Light green	Yellow	Both sides	Narrow Acute	Flat	Weak	Green	Absent
L3×T1	Green	Light	Green	Green	Cream	Both Sides	Narrow Acute	Concave	Strong	Green	Absent
L3×T2	Green	Medium	Green	Light Green	Cream	Both Sides	Blunt	Flat	Strong	Green	Absent
L3×T3	Green	Medium	Green	Light Green	Cream	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L3×T4	Green	Medium	Green	Light green	Yellow	Both Sides	Blunt	Concave	Weak	Green	Absent
L4×T1	Green	Light	Green	Purple	Yellow	Both Sides	Blunt	Concave	Strong	Green	Present
L4×T2	Red	Medium	Red	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L4×T3	Green	Medium	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L4×T4	Green	Light	Green	Light Green	Yellow	Both Sides	Acute	Concave	Strong	Green	Absent
L5×T1	Green	Medium	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Present
L5×T2	Green	Medium	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Present
L5×T3	Green	Dark	Green	Light Green	Yellow	Both Sides	Narrow Acute	Concave	Medium	Green	Absent

L5×T4	Green	Dark	Green	Light Green	Yellow	Inside only	Narrow Acute	Concave	Medium	Green	Present
L6×T1	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Concave	Strong	Green	Present
L6×T2	Red	Medium	Red	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Strong	Green	Present
L6×T3	Green	Dark	Green	Dark Green	Yellow	Both Sides	Narrow Acute	Concave	Weak	Green	Absent
L6×T4	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L7×T1	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Weak	Green	Absent
L7×T2	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L7×T3	Green	Medium	Green	Dark Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L7×T4	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Weak	Green	Absent
L8×T1	Green	Dark	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Weak	Green	Absent
L8×T2	Green	Medium	Green	Light Green	Yellow	Both Sides	Acute	Concave	Medium	Green	Absent
L8×T3	Green	Medium	Green	Light Green	Cream	Both sides	Narrow Acute	Flat	Strong	Green	Absent
L8×T4	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L9×T1	Green	Dark	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L9×T2	Green	Medium	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L9×T3	Green	Medium	Green	Dark Green	Cream	Both sides	Acute	Flat	Medium	Green	Absent
L9×T4	Green	Medium	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Weak	Green	Absent
L10×T1	Green	Dark	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Weak	Green	Absent
L10×T2	Red	Light	Red	Light Green	Yellow	Inside only	Acute	Flat	Strong	Green	Absent
L10×T3	Red	Light	Green	Light Green	Yellow	Both Sides	Blunt	Flat	Strong	Green	Absent
L10×T4	Green	Dark	Green	Light Green	Yellow	Inside only	Narrow Acute	Flat	Weak	Green	Absent
L11×T1	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Weak	Green	Absent

L11×T2	Green	Dark	Green	Light Green	Yellow	Both Sides	Blunt	Concave	Weak	Green	Absent
L11×T3	Green	Medium	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Weak	Green	Absent
L11×T4	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L12×T1	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L12×T2	Green	Dark	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Weak	Green	Absent
L12×T3	Green	Medium	Green	Light Green	Yellow	Both Sides	Narrow Acute	Concave	Medium	Green	Absent
L12×T4	Green	Dark	Green	Light Green	Yellow	Both Sides	Acute	Flat	Medium	Green	Absent
L13×T1	Green	Dark	Green	Light Green	Yellow	Inside only	Narrow Acute	Concave	Weak	Green	Absent
L13×T2	Green	Medium	Green	Light Green	Cream	Both Sides	Blunt	Concave	Weak	Green	Absent
L13×T3	Green	Dark	Green	Light Green	Yellow	Both Sides	Blunt	Concave	Medium	Green	Absent
L13×T4	Green	Dark	Green	Light Green	Yellow	Both Sides	Blunt	Flat	Weak	Green	Absent
L14×T1	Green	Medium	Green	Light Green	Yellow	Both sides	Narrow Acute	Flat	Weak	Green	Absent
L14×T2	Green	Medium	Red	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L14×T3	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L14×T4	Green	Medium	Green	Dark Green	Yellow	Inside only	Narrow Acute	Flat	Medium	Green	Absent
L15×T1	Green	Medium	Green	Light Green	Cream	Both Sides	Acute	Flat	Strong	Green	Absent
L15×T2	Green	Medium	Green	Light Green	Yellow	Both Sides	Narrow Acute	Concave	Strong	Green	Absent
L15×T3	Green	Medium	Green	Dark Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
L15×T4	Green	Light	Green	Light Green	Yellow	Both Sides	Narrow Acute	Flat	Medium	Green	Absent
Frequency	**Green=92%**	**Light=27%**	**Green=93%**	**Light Green=87%**	**Cream=13%**	**Both Sides=92%**	**Acute=13%**	**Concave=30%**	**Weak=32%**	**Green= 100%**	**Present=90%**
	Red=8%	**Medium=30%**	**Red=7%**	**Dark Green=12%**	**Yellow=87%**	**Inside Only=8%**	**Narrow Acute=73%**	**Flat= 70%**	**Medium=46%**	**Brown= 0**	**Absent=10%**
		Dark= 43%		**Purple=0**			**Blunt=14%**		**Strong=22%**		

4.4 General Combining Ability & Specific Combining Ability

4.4.1 General Combining Ability

4.4.1.1 Growth Parameters

4.4.1.1.1 Plant height

The data revealed from Table 4.4(a) in case of plant height that line L15 significant for plant height in both environments (20.07 & 21.20) and in pooled (20.63) followed by line L13,(4.44) in environment 1 (5.07) in environment 2 and (4.82) in pooled respectively. Among testers Kashi Pragati (T1) recorded positive significant GCA in both environments one and two (1.83 & 1.94) while (1.88) for pooled followed by Kashi Lalima (T2) , (1.65 & 1.46) in environment one and two, whereas (1.55) in pooled data.

4.4.1.1.2 Number of branches per plant

The number of branches per plant recorded maximum GCA in Line L6 (1.52) followed by line L13 (1.05) in environment 1 while in environment 2 maximum GCA was recorded for line L11 (1.75) followed by line L6 (1.32) and in pooled line L11 express maximum GCA for line L11 (1.61) followed by line L6 (1.42) respectively. Kashi Pragati (T1) recorded maximum GCA in both environments (0.34 & 0.36) and also in pooled (0.35) followed by Kashi Kranti (T3) in environment 1 (0.30) while Arka Anamika (T4) for environment 2 (0.27) and in pooled (0.22) respectively.

4.4.1.1.3 Stem diameter

The selection of superior parents depends upon general combining ability for development of better hybrid for stem diameter the line L4 recorded maximum GCA under both environments (1.12 &1.19) and pooled (1.15), followed by line L8 with the same pattern for environment one (1.06) and environment 2 (1.15) also in pooled (1.10). Among testers only Arka Anamika (T4) exhibit significant and positive GCA. In environment 1, Arka Anamika (T1) recorded maximum GCA (0.24) while, (0.32) in environment 2 and (0.28) in pooled respectively.

4.4.1.1.4 Leaf blade length

The data revealed from leaf blade length showed the significant and positive GCA in line L11 (3.43) in environment 1, (3.34) in environment 2 while (3.38) in pooled followed by line L15 (1.63) in environment 1,(2.06) in environment 2 whereas (1.85) for pooled data. Kashi Pragati (T1) express as best tester among all and recorded significantly positive GCA for both environments, (0.36 and 0.46) and also in pooled (0.41) whichwas followed by Arka Anamika (T4), (0.25) in environment one, (0.16) in environment 2 and (0.20) in average of both years (Pooled).

4.4.1.1.5 Leaf blade width

The data presented in the table 4.4 (b) for leaf blade width showed that among the testers Arka Anamika (T4) expressed significant and positive GCA in both environments (0.84 & 0.78) and also for pooled (0.81) followed by Kashi Kranti (T3) with the same patternin both environments, (0.44 & 0.47) and in pooled (0.45) respectively. In parental linesL15 and L11 can be perform at the best in development of hybrids. Line L11 recorded maximum significant GCA (2.26& 2.61) in environment 1 & 2 while, (2.44) in pooleddata followed by line L15, (1.77 & 2.06) in both environments while (1.91) in pooled data.

4.4.1.1.6 Petiole length

The maximum and significant GCA for petiole length was recorded in line L15 (3.12) followed by line L7 (1.41) in environment 1, (3.39 & 1.15) for line L15 and L7 in environment 2 while L15 (3.25) followed by line L7 (1.28) respectively in pooled. Among testers Arka Anamika (T4) showed significant and maximum GCA in both environments (0.36 & 0.41) & also for pooled (0.39) followed with the same pattern byKashi Kranti (T3), (0.24) in environment 1, (0.22) for environment 2 and (0.23) in pooled.

4.4.1.1.7 Days to first flowering

The parameters for days to first flowering, the earliness is important for any hybrid andit can be possible when one of parent had this heritable character. The negative GCA considered as the best for earliness. Line L15 showed better in both environments (-0.53 &-1.05) & in pooled (-0.79) which was followed by line L7 with the same patternin both environments (-1.06 & -1.09 while in pooled it was (-1.07) respectively. Arka Anamika (T4) signifies negative GCA over Kashi Kranti (T3) in environment 1 (-0.17and -1.03)and environment 2 (-0.41 & -1.04) and also in pooled (-0.16 & -1.04) respectively.

4.4.1.1.8 Days to first fruit set

The significant and negative GCA for days to first fruit set was noted at the best for Kashi Pragati (T1) in both environments (-0.13& -0.32) and also in pooled (-0.22) followed by Kashi Kranti (T3) (-0.13) in environment 2 and (-0.09) in pooled. In case of parental lines,line L11 signify maximum negative GCA in both environments (-5.47 &-5.27) andin pooled (-5.37) followed by line L4 with the same pattern in environment 1 (-4.24), in environment 2 (-4.07 & -4.15) for average of both years (pooled).

4.4.1.1.9 Days to first fruit picking

The data recorded for days to first picking from table 4.5(c) that significant and negative maximum value noted under line L4 (-5.49) in environment 1, (-5.28) in environment 2 while (-5.38) in pooled followed by line L11 (-5.44) in environment 1, (-5.25) in environment 2 while (-5.35) for pooled data. In case of testers, Arka Anamika (T4) recorded maximum negative values for both environments (-0.34 & -0.25) and (-0.29) for pooled data respectively. Beyond the best, line L5 (-3.15), L2 (-2.43) and line L9 (-2.43) can be utilize as parental line for hybrid development to embody earliness trait.

4.4.1.2 Yield Parameters

4.4.1.2.1 Number of flowers per plant

The data recorded for number of flowers per plant is given in the table 4.5(c) which showed the positive and significant GCA was recorded under line L4 (2.43 & 2.14) in environment 1 and 2 andalso in pooled (2.28) followed by line L15 (1.31 & 1.58) in both environments and (1.44) in pooled respectively. Among the testers ma×imum positive GCA was noted forArka Anamika (T4) in both environment (0.76 & 0.66) and also in pooled (0.71) followed by Kashi Pragati (T1) with the same pattern in both environments (0.65 & 0.54) while (0.59) in pooled data.

4.4.1.2.2 Number of pods per plant

The number of pods per plant showed the significant and maximum GCA forline L2 in both environments (2.48 & 2.57) and (2.52) in pooled followed by line L1 (1.55 & 1.20) in both environments and (1.38) in pooled respectively. Among testers Arka Anamika (T4) recorded maximum significant GCA in environment one (0.26) followed by Kashi Kranti (T3) (0.19) and Kashi Pragati (T1) (0.18), in environment 2 only Arka Anamika (T4) noted significant positive GCA (0.52) while in pooled Kashi Kranti (T3) and Kashi Pragati (T1) recorded maximum significant GCA (0.11) each.

4.4.1.2.3 Pod length

The pod length recorded maximum significant GCA within parental lines in line L5 (2.18) in environment 1, (1.95) in environment 2 and (2.07) in pooled followed by lineL3 (1.62) in environment 1 line L4 (1.21) in environment 2 and also in pooled (1.23) respectively. Beyond the best lines, L2, L6, L9 and L11 recorded significant positive GCA in both environments along with pooled for pod length and can be used to inherited this character into hybrids. Among testers only Kashi Lalima (T2) exhibit significant positive GCA in both environments (0.22 & 0.27) and (0.25) in pooled. Arka Anamika (T4) recorded significant positive GCA only for environment 2 (0.11).

4.4.1.2.4 Number of first fruiting Node

The data recorded for number of first fruiting nodes showed from the table 4.4 (d) thatLine L12 noted the maximum significant GCA in both environments (0.50 & 0.66) andin pooled (0.58) followed by line L3 (0.37 & 0.50) in environment 1 & 2 while (0.43) in average of both year (Pooled) whereas among testers, Kashi Kranti (T3) recorded maximum significant GCA for number of first fruiting node (0.72) in environment 1,(0.69) in environment 2 and (0.70) in pooled.

4.4.1.2.5 Number of nodes per plant

The data recorded for nodes per plant revealed that maximum significant GCA among parental lines was recorded in line L11 in both environments (4.14 & 4.18) and also in pooled (4.15) followed by line L14 (2.33 & 2.30) for environment 1 and 2 and (2.33) for pooled data followed by line L2 following the same pattern (1.68 &1.75) in both environment and (1.71) in pooled data. Among the testers, Kashi Pragati (T1) recorded maximum significant GCA for both environments (2.47 & 2.45) and (2.46) in pooled followed by Kashi Kranti (T3) with the same pattern in both environments (0.46 & 0.64) and (0.55) for pooled data.

4.4.1.2.6 Number of ridges per pod

The number of ridges per pod showed the maximum and significant GCA among testers was noted in Kashi Kranti (T3) for both environments (0.81 & 0.89) and also in pooled (0.85). Among the parental lines, the maximum significant GCA was noted in environment 1 for line L3 (1.15) followed by line L13 (0.80) and L8 (0.59) while in environment 2 the maximum significant GCA was recorded for line L3 (1.10) followed by line L13 (1.04) and line L8 (0.59) whereas for pooled data, the maximum significant GCA for number of ridges per pod recorded for line,L3 (1.12) followed by line L13 (0.92) and L8 (0.59) respectively.

4.4.1.2.7 Pod diameter

The pod diameter showed the significant and positive values for line L8 in both the environments (0.48 & 0.57) and in pooled (0.52) followed by line L15 (0.44 & 0.40) in environment 1 & 2 and (0.42) in pooled. Among the testers maximum positive and significant GCA was recorded for Kashi Lalima (T2) (0.06 & 0.14) forenvironment 1 and 2 and (0.10) in pooled data followed by Kashi Pragati (T1) in environment one (0.05) and in pooled (0.01) respectively.

4.4.1.2.8 Internodal length

The data presented in the table 4.4 (e) showed the positive and significant GCA for internodal length for parental lines in environment 1 for line L13 (0.72) followed by L12 (0.69) and L7 (0.63) while in environment 2 the maximum significant GCA were recorded for line L7 (0.78) followed by L12 (0.75), L9 (0.72) and L13 (0.51) whereas for pooled data maximum GCA was noted for line L12 (0.72) significantly followed by line L7 (0.71) and line L13 (0.61) respectively. Among tester, Arka Anamika (T4) revealed maximum significant GCA for internodal length in both environment (0.55 & 0.61) and (0.58) in pooled while Kashi Lalima (T2) noted significant and positive GCA in environment 2 (0.09) and pooled in (0.04) respectively

4.4.1.2.9 Average pod weight

The data revealed that for average pod weight significant and maximum GCA was recorded in line L14 (4.05 & 4.01) in environment 1 and 2 while (4.03) in pooled followed by line L9 with the same pattern (1.60 & 1.48) in both environments and (1.54) for pooled data. Among testers, maximum significant GCA was recorded in Kashi Pragati (T1) for both environments (2.21 & 2.20) and (2.21) in pooled followed by Kashi Lalima (T2) with the same pattern in both environments (0.75 & 0.70) while for pooled (0.73) respectively.

4.4.1.2.10 Pod yield/Plant

The data recorded for pod yield/plant for testers revealed that in environment 1, maximum significant GCA was observed for Kashi Kranti (T3) (0.018) followed by Arka Anamika (T4) (0.014) and Kashi Lalima (T2) (0.0014) respectively, while in environment 2 maximum significant GCA was noted for Kashi Kranti (T3), (0.023) followed by Arka Anamika (T4) (0.021) and in pooled maximum significant GCA was noted under Kashi Kranti (T3) (0.021) followed by Arka Anamika (T4) (0.01). Among the lines, data revealed that line L7 exhibit significant and positive GCA for both environments (0.06 & 0.07) and also in pooled in (0.07) followed by line L2 with the same pattern (0.05 & 0.06) for both environments and (0.05) for pooled data.

4.4.1.3 Biochemical Parameters

4.4.1.3.1 Ascorbic acid content

The data recorded for ascorbic acid content from the table 4.4(e) showed that the maximum significant GCA was recorded in line L12 (5.57 & 5.57) in both environments 1 and 2 while (5.57) in pooled followed by line L9(4.68 & 4.67) in both environments and (4.68) in pooled data, respectively. In testers, Kashi Pragati (T1) recorded maximum significant GCA in both environments (1.79 & 1.77)and also in pooled (1.78) followed by Arka Anamika (T4) (0.47) in environment 1, (0.51) inenvironment 2 and (0.49) in pooled data.

4.4.1.3.2 Acidity

The data presented for acidity from the table 4.4(f) showed that among the testers, Arka Anamika (T4) recorded maximum significant GCA in environment 1 and 2 (0.03 & 0.03) and also for pooled (0.03) followed by Kashi Kranti (T3) with the same pattern in both environments (0.01 &0.009) while (0.01) in pooled respectively. The data regarding parental lines revealedthat in environment 1 line L15 exhibit maximum GCA (0.04) followed by line L5 (0.04) and line L7 (0.03) respectively. Along with the line L14, L8 and L6 also possess significant positive GCA . In environment 2, maximum significant GCA was recorded in line L5 (0.04) followed by line L15 (0.03) while in pooled the maximum significant GCA was noted for line L5 (0.04) followed by line L15 (0.04) respectively.

4.4.1.3.3 Dry matter content

The significant maximum GCA for dry matter content within parental lines was notedin line L15 (4.97) in environment 1, (5.01) in environment 2 and (4.99) for pooled datafollowed by line L5 (4.31 & 4.36) in both environments and (4.34) in pooled respectively. In case of testers, maximum significant GCA for dry matter was recordedin Kashi Pragati (T1) for both environments (1.90 & 1.88) and also for pooled (1.89) followed with the same pattern by Arka Anamika (T4) (0.50 & 0.54) in environment 1 & 2 while (0.52) for pooled data.

4.4.1.3.4 Firmness

The data for firmness showed that general combining ability was recorded significantly and maximum within parental lines for line L6 (1.56 & 1.59) in environment 1 and 2 and (1.58) in pooled data followed by line L5 with the same pattern (1.43 & 1.47) in both environments and (1.45) in pooled data, respectively. Among testers only Arka Anamika (T4) exhibit significant and positive GCA for firmness in both environments (0.28& 0.32) and (0.30) in pooled.

4.4.1.3.5 Chlorophyll content

The data revealed for chlorophyll content presented in the table 4.4 (g) that maximum and significant in parental lines, recorded for line L7 (9.62 & 9.52) in environment 1 & 2 while (9.57) in pooled data, which was followed by line L12 with the same pattern for both environments(3.20 & 3.19) while (3.20) in pooled respectively. Among testers, Kashi Kranti (T3) exhibitmaximum and significant GCA (1.97) in environment 1, (2.05) in environment 2 and (2.01) in pooled data.

4.4.1.3.6 Mucilage content

The data recorded for mucilage content that among parental lines, line L15 recorded significant and maximum GCA (12.98) in environment 1, (13.02) in environment 2 and (13.00) in pooled followed by line L8 in both environments (1.96 & 1.98) and alsonoted in pooled (1.97). Lines L6, L2, L11 and L1 also recorded positive and significantGCA which can be utilized in development of superior hybrids. In case of testers. Kashi Lalima (T2) recorded positive and significant GCA for mucilage content (2.79) in environment 1, (2.76) in environment 2 and (2.77) in pooled data respectively.

Table 4.4 (a) Estimation of General combining ability (GCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Plant height			Number of branches per plant			Stem diameter			Leaf blade length		
Parents	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1	-2.62**	-2.77**	-2.71**	-0.12	-0.84	-0.48	-0.24	0.10	-0.07	-0.50**	-0.61**	-0.56**
L2	-1.97	-2.55	-2.34	0.13	-0.19	-0.02	-0.29	-0.39	-0.34	-0.67**	-0.63**	-0.65**
L3	-2.05**	-2.38**	-2.20**	-0.18	-0.35	-0.27	0.59	0.21	0.4	-0.46	-0.75	-0.61
L4	-5.10*	-6.56**	-5.74**	0.18	0.03	0.1	1.12**	1.19**	1.15**	0.52**	0.51**	0.51**
L5	-3.63**	-3.72**	-3.68**	0.30*	0.13 *	0.21 *	0.89**	0.37**	0.63**	-0.03	-0.09	-0.06
L6	-2.96	-2.69	-2.73	1.52**	1.32**	1.42**	0.53	0.19	0.36	-0.82**	-0.94**	-0.88**
L7	-2.18	-2.52	-2.36	0.52	-0.23	-0.37	0.74**	0.80**	0.77**	0.52	-0.09	0.21
L8	-2.26	-2.13	-2.18	-0.52**	-0.15*	-0.06	1.06 **	1.15**	1.10**	-0.348 *	-0.17*	-0.26*
L9	-2.13*	-1.80**	-2.07**	0.03	1.11**	1.07**	0.49	0.29	0.39	0.02	-0.26	-0.11
L10	0.56	0.78	0.66	1.03	-0.44	-0.59	0.51**	0.49**	0.50**	0.29	-0.1	0.09
L11	1.36**	1.74**	1.52**	-0.73**	1.75**	1.61**	0.47	0.12	0.3	3.43**	3.34**	3.38**
L12	-1.3	-1.13	-1.26	-0.52	-0.20	-0.36	-0.25	-0.13	-0.19	-0.85**	-0.28**	-0.56**
L13	4.44**	5.07**	4.82**	1.05**	-0.90**	-0.98**	-2.39**	-1.97**	-2.18**	-1.61**	-1.33**	-1.47**
L14	-0.18	-0.52	-0.31	1.51**	-1.08**	-1.29**	-1.71**	-1.24**	-1.47**	-1.11**	-0.62**	-0.86**
L15	20.07**	21.20**	20.63**	-0.04	0.06	0.01	-1.52**	-1.19**	-1.35**	1.63**	2.06**	1.85**
S.E. ±	0.34	0.06	0.17	0.14	0.05	0.07	0.18	0.05	0.09	0.13	0.05	0.07
CD (0.05)	0.68	0.12	0.34	0.29	0.11	0.15	0.36	0.11	0.18	0.27	0.11	0.14
Tester												
T1	1.83**	1.94**	1.88**	0.34**	0.36**	0.35**	-0.26	-0.10	-0.18	0.36**	0.46**	0.41**
T2	1.65**	1.46**	1.55**	0.21*	-0.33**	-0.27**	-0.06	-0.25	-0.15	-0.50**	-0.58**	-0.54**
T3	0.39	-0.22	-0.31	0.30**	-0.29**	-0.30**	0.08	0.03	0.05	-0.11	-0.04	-0.08
T4	-3.08**	-3.18**	-3.13**	0.18**	0.27**	0.22**	0.24 **	0.32**	0.28**	0.25**	0.16**	0.20**
S.E. ±	0.17	0.03	0.09	0.07	0.03	0.04	0.09	0.03	0.04	0.07	0.03	0.03
CD (0.05)	0.35	0.06	0.17	0.15	0.06	0.08	0.18	0.05	0.09	0.14	0.06	0.07

Table 4.4 (b) Estimation of General combining ability (GCA) for different traits in okra under two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Leaf blade width			Petiole length			Days to first flowering			Days to first fruit set		
Parents	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1	-0.08	-0.25	-0.16	-0.23	-0.31	-0.27	-0.49	-0.04	-0.26	-0.9	-1.03	-0.97
L2	-0.79**	-0.58**	-0.68**	-0.73**	-0.99**	-0.86**	-0.66	-0.37	-0.52	-1.44	-1.19	-1.31
L3	0.21	0.19	0.2	-0.17	-0.22	-0.2	-1.58	-1.32	-1.45	-1.49**	-1.10**	1.29**
L4	0.24	0.01	0.12	-0.45	-0.3	-0.37	-0.61**	-0.21	-0.41	-4.24**	-4.07**	-4.15**
L5	-0.76**	-0.89**	-0.83**	-0.69**	-0.67**	-0.68**	-3.46**	-3.11**	-3.29**	-2.56**	-2.35**	-2.45**
L6	-1.36**	-1.24**	-1.30**	1.16**	0.74**	0.95**	-0.15*	0.09*	-0.03*	-0.22	0.05	-0.08
L7	-0.09	-0.36**	-0.23*	1.41**	1.15**	1.28**	-0.48**	-0.37**	-0.43**	-0.23	-0.15*	-0.19*
L8	-2.95**	-3.14**	-3.05**	0.53	0.43	0.48	-1.06**	-1.09**	-1.07**	-1.72**	-1.49**	-1.61**
L9	0.84**	0.49**	0.66**	0.37	0.03	0.2	-2.57**	-2.51**	-2.54**	-1.61**	-1.46**	-1.54**
L10	0.81**	0.45**	0.63**	-0.71**	-0.59**	-0.65**	-0.19	-0.25	-0.22	0.13	0.4	0.26
L11	2.26 **	2.61**	2.44**	0.38	0.49	0.44	-5.56**	-5.54**	-5.55**	-5.47**	-5.27**	-5.37**
L12	0.1	0.28	0.19	-0.21	0.05	-0.08	7.21**	6.69**	6.95**	9.13**	8.69**	8.91**
L13	-0.33	-0.03	-0.18	-2.27**	-2.00**	-2.13**	8.20**	7.68**	7.94**	8.91**	8.37**	8.64**
L14	0.12	0.41**	0.26**	-1.48**	-1.21**	-1.34**	1.97**	1.45**	1.71**	1.87**	1.33**	1.60**
L15	1.77**	2.06**	1.91**	3.12**	3.39**	3.25**	-0.53**	-1.05**	-0.79**	-0.11	-0.71**	-0.41**
S.E. ±	0.12	0.06	0.07	0.11	0.07	0.06	0.14	0.06	0.08	0.12	0.06	0.07
CD (0.05)	0.24	0.13	0.13	0.22	0.14	0.13	0.29	0.12	0.15	0.25	0.12	0.13
Tester												
T1	-0.05	-0.1	-0.07	0.22	0.21	0.21	-0.63	-0.63	-0.63	-0.13*	-0.32**	-0.22**
T2	-1.23**	-1.14**	-1.19**	-0.84**	-0.85**	-0.84**	1.84	1.82	1.83	0.13	0.31	0.22
T3	0.44**	0.47**	0.45**	0.24**	0.22**	0.23**	-1.03**	-1.04**	-1.04**	-0.04	-0.13**	-0.09*
T4	0.84**	0.78**	0.81**	0.36**	0.41**	0.39**	-0.17*	-0.14**	-0.16**	0.04	0.13**	0.09*
S.E. ±	0.06	0.03	0.03	0.05	0.03	0.03	0.07	0.03	0.04	0.06	0.03	0.03
CD (0.05)	0.12	0.06	0.07	0.11	0.07	0.06	0.14	0.06	0.08	0.13	0.06	0.07

Table 4.4 (c) Estimation of General combining ability (GCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Days to first fruit picking			Number of flowers per plant			Number of pods per plants			Pod length		
Parents	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1	-2.03**	-1.93**	-1.98**	0.36	0.29	0.33	1.55**	1.20**	1.38**	-0.23	-0.39	-0.31
L2	-2.43**	-2.01**	-2.22**	-0.89	-0.96	-0.93	2.48**	2.57 **	2.52**	0.89**	0.80**	0.84**
L3	-2.19**	-1.91**	-2.05**	1.03	0.97	1.00	0.66	0.50	0.58	1.62**	1.04**	1.33**
L4	-5.49**	-5.28**	-5.38**	2.43**	2.14**	2.28**	1.01	0.74	0.87	1.26**	1.21**	1.23**
L5	-3.15**	-2.64**	-2.90**	1.08	0.80	0.94	-0.36	-0.36	-0.36	2.18**	1.95**	2.07**
L6	-0.78	-0.68	-0.73	-0.17	-0.30	-0.24	1.51**	1.19**	1.35**	0.48**	0.20**	0.34**
L7	-0.71	-0.44	-0.58	-0.85	-0.74	-0.79	-0.29	-0.64	-0.47	-0.96	-0.98	-0.97
L8	-2.38**	-2.14**	-2.26**	-0.23	0.09	-0.06	1.13**	0.99**	1.06**	-0.88	-0.53	-0.7
L9	-2.43**	-2.32**	-2.37**	-0.2	-0.34	-0.27	0.57	0.41	0.49	0.60**	0.93**	0.77**
L10	0.61	0.23	0.42	-1.05**	-1.66**	-1.36**	-2.36**	-2.29**	-2.32**	-0.22	0.13 *	-0.04
L11	-5.44**	-5.25**	-5.35**	-0.39	-0.56	-0.48	0.43	0.35	0.39	0.88**	0.53**	0.71**
L12	8.29**	7.77**	8.03**	-0.50	-0.07	-0.29	0.06	0.6	0.33	-2.04**	-1.73**	-1.89**
L13	10.04**	9.53**	9.78**	-1.02	-0.67	-0.85	-3.65**	-3.36**	-3.50**	-0.93	-0.87	-0.90
L14	5.19**	4.67**	4.93**	-0.88	-0.54	-0.71	-3.54**	-3.05**	-3.30**	-1.59**	-1.34**	-1.47**
L15	2.94**	2.42**	2.68**	1.31**	1.58**	1.44**	0.78	1.13	0.95	-1.07**	-0.95**	-1.01**
S.E. ±	0.13	0.06	0.07	0.13	0.06	0.07	0.12	0.05	0.07	0.13	0.05	0.07
CD (0.05)	0.27	0.12	0.14	0.26	0.12	0.14	0.25	0.11	0.13	0.26	0.11	0.14
Tester												
T1	-0.004	-0.15	-0.08	0.65**	0.54**	0.59**	0.18*	0.04	0.11*	0.001	-0.11**	-0.05
T2	0.06	0.15	0.1	-1.01	-0.75	-0.88	-0.64**	-0.59**	-0.62**	0.22**	0.27**	0.25**
T3	0.28	0.25	0.27	-0.39	-0.45	-0.42	0.19***	0.03	0.11**	-0.23	-0.27	-0.25
T4	-0.34**	-0.25**	-0.29**	0.76**	0.66**	0.71**	0.26 **	0.52**	0.15	0.003	0.11**	0.056
S.E. ±	0.07	0.03	0.03	0.07	0.03	0.03	0.06	0.03	0.03	0.06	0.03	0.03
CD (0.05)	0.14	0.06	0.076	0.13	0.06	0.07	0.13	0.03	0.07	0.13	0.06	0.07

Table 4.4. (d) Estimation of General combining ability (GCA) for different traits in okra under two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Number of first fruiting node			Number of nodes per plant			Number of ridges per pods			Pods diameter		
Parents	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1	-0.49**	-0.38**	-0.50**	-2.58**	-2.63**	-2.58**	0.22	0.41	0.22	0.11	0.20	0.11
L2	0.10	0.04	0.11	1.68**	1.75**	1.71**	-0.24	-0.26	-0.23	-0.186*	-0.13 *	-0.18*
L3	0.37**	0.50**	0.43**	-0.24	-0.23	-0.23	1.15**	1.10**	1.12**	-0.24**	-0.26**	-0.25**
L4	-0.61**	-0.58**	-0.61**	-0.10	-0.10	-0.10	-0.53	-0.46	-0.52	-0.17	-0.23	-0.16
L5	-0.28	-0.26	-0.28	-1.25**	-1.19**	-1.25**	-0.33	-0.47	-0.33	-0.35**	-0.22**	-0.34**
L6	0.29	0.16	0.29	0.12	0.11	0.12	-0.6	-0.54	-0.60	-0.07	-0.12	-0.06
L7	-0.03	-0.03	-0.02	-2.72**	-2.57**	-2.72**	0.38*	0.26*	0.38*	0.31**	0.19**	0.31**
L8	0.18	-0.02	0.17	-2.34**	-2.39**	-2.35**	0.59**	0.59**	0.59**	0.48**	0.57**	0.52**
L9	0.22	0.21	0.22	-1.56**	-1.67**	-1.56**	-0.38	-0.51	-0.39	-0.23**	-0.41**	-0.23**
L10	0.03	0.07	0.03	-0.69	-0.64	-0.69	-0.43	-0.42	-0.43	0.25**	0.50**	0.38**
L11	-0.04	0.04	-0.03	4.14**	4.18**	4.15**	0.54	0.48	0.53	-0.25**	-0.40**	-0.26**
L12	0.50**	0.66**	0.58**	-0.52	-0.65	-0.52	0.11**	0.14**	0.11**	-0.08	-0.07	-0.08
L13	0.33**	0.11**	0.22**	-0.49	-0.52	-0.49	0.80**	1.04**	0.92**	0.28**	0.36 **	0.32
L14	-0.70**	-0.68**	-0.71	2.33**	2.30*	2.33**	-0.49	-0.68	-0.50	-0.29***	-0.37**	-0.29
L15	0.12 *	0.13*	0.12	1.45	-2.63	-1.03	-0.78**	-0.66*	-0.78*	0.44**	0.40**	0.42**
S.E. ±	0.0636	0.0613	0.0642	0.0431	0.0609	0.0614	0.0422	0.0637	0.0597	0.0605	0.0607	0.0609
CD (0.05)	0.12	0.12	0.12	0.08	0.12	0.12	0.08	0.12	0.11	0.11	0.12	0.12
Tester												
T1	0.03	-0.01	0.01	2.47**	2.45**	2.46**	-0.07*	-0.03*	-0.05*	0.05**	-0.03**	0.01**
T2	-0.45*	-0.33*	-0.40*	-1.80*	-1.86*	-1.83*	-0.36*	-0.42*	-0.39**	0.06**	0.14**	0.10**
T3	0.72**	0.69**	0.70**	0.46**	0.64**	0.55**	0.81**	0.89**	0.85**	0.04	-0.03	0.006
T4	-0.30**	-0.34**	-0.32**	-1.13**	4.26**	1.56**	-0.37	-0.43	-0.40	-0.16	-0.08	-0.12
S.E. ±	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03
CD (0.05)	0.06	0.06	0.06	0.04	0.06	0.06	0.06	0.06	0.04	0.06	0.06	0.06

Table 4.4 (e) Estimation of General combining ability (GCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Internodal length			Average pod weight			Pods yield/Plant			Ascorbic Acid content		
Parents	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1	-0.28	-0.38	-0.27	-1.39**	-1.44**	-1.39**	-0.01	-0.01	-0.02	-1.93**	-1.98**	-1.96**
L2	-0.70**	-0.82**	-0.70**	-0.62	-0.55	-0.62	0.05**	0.06**	0.05**	-1.03	-1.05	-1.04
L3	-0.21	-0.25	-0.22	0.89**	0.92**	0.91**	0.03**	0.04**	0.04**	-3.01**	-3.04**	-3.03**
L4	-0.57**	-0.53**	-0.58**	-0.08	-0.09	-0.08	0.03	0.03	0.02	0.6	0.58	0.59
L5	-0.64**	-0.45**	-0.64**	0.14	0.19	0.13	-0.01	-0.02	-0.02	-0.25	-0.21	-0.23
L6	0.16	0.02	0.17	-0.13	-0.13	-0.12	-0.03**	-0.03**	-0.04**	-2.57**	-2.54**	-2.55**
L7	0.63*	0.78**	0.71**	0.68	0.84	0.68	0.06**	0.07**	0.07**	1.23**	1.26**	1.25**
L8	-0.007	-0.072	0.003	0.85**	0.80**	0.83**	-0.01	-0.01	-0.02	0.33	0.36	0.34
L9	0.34 **	0.72**	0.53**	1.60**	1.48**	1.54**	-0.03	-0.03	-0.02	4.68**	4.67**	4.68**
L10	-0.04	-0.06	-0.03	0.49	0.53	0.49	-0.01	-0.01	-0.02	-2.04**	-2.06**	-2.05**
L11	-0.3	-0.33	-0.31	-1.85**	-1.81**	-1.85**	-0.04	-0.04	-0.02	0.62	0.6	0.61
L12	0.69**	0.75**	0.72**	-1.00**	-1.15**	-1.00**	-0.03	-0.04	-0.04	5.57**	5.57**	5.57**
L13	0.72**	0.51**	0.61**	-3.17**	-3.20**	-3.17**	0.012 **	0.018 **	0.012**	0.21	0.19	0.20
L14	-0.21	-0.3	-0.22	4.05**	4.01**	4.03**	-0.03	-0.02	-0.02	0.03	0.04	0.04
L15	0.43**	0.42**	0.42**	-0.44	-0.40	-0.44	0.03	0.03	0.01	-2.44**	-2.41**	-2.43**
S.E. ±	0.05	0.0581	0.0601	0.0610	0.0608	0.0614	0.0020	0.0014	0.0057	0.0605	0.0605	0.0428
CD (0.05)	0.1155	0.1150	0.1189	0.1207	0.1204	0.1215	0.0039	0.0028	0.0113	0.1197	0.1197	0.0842
Tester												
T1	-0.48*	-0.58*	-0.53*	2.21**	2.20**	2.21**	-0.03**	-0.03**	-0.03**	1.79**	1.77**	1.79**
T2	-0.01	0.09**	0.04**	0.75**	0.70**	0.73**	0.0014**	0.0019**	0.0016**	-0.41	-0.44	-0.41
T3	-0.05	-0.13	-0.09	-1.02**	-0.85**	-0.94**	0.018**	0.023**	0.021**	-1.85**	-1.84**	-1.85**
T4	0.55**	0.61**	0.58**	-1.95**	-2.04**	-2.00**	0.014**	0.021**	0.012**	0.47**	0.51**	0.47**
S.E. ±	0.0301	0.0300	0.0310	0.0315	0.0314	0.0317	0.0010	0.0007	0.0029	0.0312	0.0312	0.0221
CD (0.05)	0.0596	0.0594	0.0614	0.0623	0.0621	0.0627	0.0020	0.0014	0.0058	0.0618	0.0618	0.0435

Table 4.4 (f) Estimation of General combining ability (GCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Acidity			Dry matter content			Firmness		
Parents	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1	-0.03**	-0.05**	-0.04**	-1.82**	-1.87**	-1.84**	0.54	0.49	0.52
L2	-0.02	-0.021	-0.02	-2.76**	-2.78**	-2.77**	0.76	0.74	0.75
L3	-0.03	-0.02	-0.02	0.78	0.75	0.76	0.87	0.84	0.86
L4	-0.02**	-0.01	-0.01	-2.17**	-2.18**	-2.18**	0.79	0.78	0.79
L5	0.04**	0.04**	0.04**	4.31**	4.36**	4.34**	1.43**	1.47**	1.45**
L6	0.01	0.02	0.02	2.22**	2.24**	2.23**	1.56**	1.59**	1.58**
L7	0.03**	0.03**	0.03**	-0.98	-0.95	-0.96	1.23**	1.26**	1.24**
L8	0.02	0.02	0.02	3.64**	3.67**	3.66**	1.11**	1.13**	1.12**
L9	-0.01	-0.01	-0.01	-1.85**	-1.87**	-1.86**	0.91	0.89	0.90
L10	-0.01	-0.02	-0.02	2.19**	2.17**	2.18**	-1.34**	-1.36**	-1.35**
L11	-0.01	-0.008	-0.01	-3.02**	-3.03**	-3.03**	-1.81**	-1.82**	-1.81**
L12	0.009	0.001	0.005	-0.1	-0.1	-0.1	-1.46**	-1.46**	-1.46**
L13	-0.02**	-0.01**	-0.02**	-2.99**	-3.01**	-3.00**	-1.28**	-1.30**	-1.29**
L14	0.024**	0.008	0.016**	-2.41**	-2.40**	-2.41**	-1.67**	-1.66**	-1.67**
L15	0.04**	0.03**	0.04*	4.97**	5.01**	4.99**	-1.66**	-1.62**	-1.64**
S.E. ±	0.0062	0.0044	0.0038	0.0598	0.0598	0.0423	0.0423	0.0598	0.0423
CD (0.05)	0.0123	0.0088	0.0075	0.1185	0.1185	0.0833	0.0833	0.1184	0.0833
Tester									
T1	-0.02	-0.01	-0.01	1.90**	1.88**	1.89**	-0.001	-0.02	-0.001
T2	-0.02	-0.03	-0.02	-0.01	-0.03	-0.02	0.002	-0.02	0.002
T3	0.01**	0.009**	0.01**	-2.40**	-2.39**	-2.39**	-0.28**	-0.27**	-0.28**
T4	0.03**	0.03**	0.03**	0.50**	0.54**	0.52**	0.28**	0.32**	0.28**
S.E. ±	0.0032	0.0023	0.0020	0.0309	0.0309	0.0218	0.0218	0.0309	0.0218
CD (0.05)	0.0064	0.0045	0.0039	0.0612	0.0612	0.0430	0.0430	0.0611	0.0430

Table 4.4. (g) Estimation of General combining ability (GCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	**Chlorophyll content**			**Mucilage content**		
Parents	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1	-2.21**	-2.00**	-2.20**	0.46**	0.41**	0.44**
L2	-0.57	-0.59	-0.56	1.81**	1.79**	1.80**
L3	-1.37	-1.41	-1.38	-0.74	-0.77	-0.76
L4	2.41**	2.47**	2.44**	-0.78	-0.79	-0.79
L5	-1.11	-1.24	-1.11	-4.524 **	-4.481 **	-4.50**
L6	-2.01**	-1.96**	-2.01*	1.75**	1.77**	1.76**
L7	9.62**	9.52**	9.57**	-1.77**	-1.74**	-1.75**
L8	-0.74	-0.74	-0.74	1.96**	1.98**	1.97**
L9	-2.27**	-2.43**	-2.27**	-5.66**	-5.67**	-5.67**
L10	-0.26	-0.27	-0.26	-2.42**	-2.44**	-2.43**
L11	0.23	0.13	0.22	0.73**	0.72***	0.73**
L12	3.20**	3.19**	3.20*	-4.26*	-4.25*	-4.26*
L13	1.01**	1.19**	1.01***	-0.06	-0.07	-0.07
L14	0.84**	0.73**	0.83**	0.52**	0.54**	0.53**
L15	-6.76**	-6.58**	-6.76**	12.98**	13.02**	13.00**
S.E. ±	0.0599	0.0598	0.0423	0.0636	0.0636	0.0450
CD (0.05)	0.1185	0.1185	0.0834	0.1259	0.1259	0.0886
Tester						
T1	-3.145	2.41	-0.36	-0.45	-0.47	-0.46
T2	-3.65*	-3.72*	-3.69*	2.79**	2.76**	2.77**
T3	1.97**	2.05**	2.01**	-0.56	-0.55	-0.55
T4	-0.64*	-0.73	-0.68	-1.77**	-1.73**	-1.75**
S.E. ±	0.0309	0.0309	0.030	0.0328	0.0328	0.0232
CD (0.05)	0.0612	0.0612	0.0610	0.0650	0.0650	0.0457

4.4.2 Specific Combining Ability

4.4.2.1 Growth Parameters

4.4.2.1.1 Plant height

The data revealed from table 4.5(a) in case of plant height observed that hybrid L4 ×T1 significant for plant height in both environments (3.80 and 4.68) and in pooled (4.24) followed by hybrid L11×T4,(3.17) in environment 1, (3.59) in environment 2 and (3.38) in pooled respectively. Hybrid L13×T4 recorded positive significant SCA inboth environments 1 and 2 (3.16) and (3.22) while hybrid L14×T4 (3.40) for pooled over the environment

4.4.2.1.2 Number of branches per plant

The data recorded for number of branches per plant for hybrid L1×T3 showed maximum and significant SCA (2.04) followed by hybrid L15×T1 (1.87), L5×T4 (1.74), L4×T4 (1.66) in environment 1 while in environment 2 maximum SCA was recorded for hybrid L1×T3 (2.32)followed by hybrid L3×T2 (2.08), L2×T1 (2.07) and in pooled hybrid express maximum SCA for hybrid L1×T3 (2.18) followed by hybrid L3×T2 (1.86) closely followed by hybrid L5 ×T4 (1.85) respectively.

4.4.2.1.3 Stem diameter

The selection of superior hybrids depends upon specific combining ability, for stem diameter hybrid L9×T1 recorded maximum SCA for both environments (2.42 and 2.23) and pooled (2.32) followed by hybrid L5×T1 with the same pattern for environment one (2.03) and environment 2 (1.43) also in pooled (1.76) and hybrid L4×T4 with for environment one (1.43) and environment 2 (1.36) also in pooled (1.26)respectively.

4.4.2.1.4 Leaf blade length

The data revealed that the significant and positive SCA for leaf blade length was recorded in hybrid L3×T2 (2.13) in environment 1, (2.25) in environment 2 while (2.19) in pooled followed by hybrid L15×T1 (1.97) in environment 1,(2.35) in environment 2 whereas (2.16) for pooled data. L1×T3 recorded significantly positive SCA for both environments, (1.79 and 1.59) and also in pooled (1.69) over the environment.

4.4.2.1.5 Leaf blade width

The data recorded for lead blade width from the table 4.5(b) that the hybrid L6×T2 expressed significant and positive SCA in both environments (4.36 & 4.67) and also for pooled (4.56) followed by L5×T2 with the same pattern in both environments, (3.10 & 3.24) and in pooled (3.17) respectively. The hybrids L2×T2 recorded maximum significant SCA (3.40 & 3.07) in environment 2 and in pooled data.

4.4.2.1.6 Petiole length

The maximum and significant SCA for petiole length was recorded in hybrid L10×T3,(3.63) followed by hybrid L3×T3 (3.38), L1×T4 (3.36) L6×T2 (3.26) in environment 1, (3.91 & 3.47) for hybrid L1×T4 and L10×T3 in environment 2 while for pooled (3.64) in L1×T4 followed by (3.55) in L10×T3, (3.36) in L3×T3 and in hybrid L6×T2 (3.26) respectively.

4.4.2.1.7 Days to first flowering

The earliness is essential for days to first flowering of any hybrid and it can be possiblewhen one of parent had this heritable character. The negative SCA considered as the best for earliness. The hybrid L2×T2, revealed better for both environments (-5.54 &-6.07) & in pooled (-5.80) which was followed by hybrid L8×T2 with the same pattern in both environments (-5.39 & -5.01) while in pooled it was (-5.20) respectively and hybrid L10×T4 (-4.99) in environment 1, (-5.25) in environment 2and (-5.12) in pooled data. hybrids such as L5×T2, L3×T1, L1×T1 also perform best for earliness.

4.4.2.1.8 Days to first fruit set

The significant and negative SCA for days to first fruit set was noted at the best for hybrid L10×T2 in both environments (-4.83 & -4.97) and also in pooled (-4.90) followed by L13 ×T3 (-4.51) in environment 1, (-4.45) in environment 2 and (-4.48) in pooled. Hybrids such as L6×T4 signify maximum negative SCA in both environments (-4.50 & -4.39) and in pooled (-4.45) followed by hybrid L7×T4 with thesame pattern in environment 1 (-4.41), in environment 2 (-4.45 & -4.43) for average ofboth years (pooled).

4.4.2.1.9 Days to first fruit picking

The data recorded from the table 4.5(c) for days to first picking, the that significant and negative maximum value noted under hybrid L10×T2 (-5.92) in environment 1, (-5.52) in environment 2 while (-5.72) in pooled followed by hybrid L7×T4 (-4.52) in environment 1,(-4.42) in environment 2 while (-4.47) for pooled data. The hybrid L6×T4 recorded maximum negative values for both environments (-4.33 & -4.31) and(-4.32) for pooled data respectively. Beyond the best, hybrid L13×T3, L1×T1, L3×T1,L8×T3 and L12 ×T1 can be utilize as hybrid for earliness trait for line development.

4.4.2.2 Yield Parameters

4.4.2.2.1 Number of flowers per plant

The data recorded from the table 4.5(c) the positive and significant SCA for number of flowers per plant was recorded under hybrid L6×T1 (3.98 & 4.29) in environment 1 and 2 andalso in pooled (4.14) followed by hybrid L4×T2 (3.07& 3.02) in both environments and (3.05) in pooled respectively. Among the others maximum positive SCA was noted forL3 ×T4 in both environments (2.69 & 3.06) and also in pooled (2.87) data.

4.4.2.2.2 Number of pods per plant

The number of pods per plant showed significant and maximum SCA for hybrid L7×T2 in both environments (3.14 & 3.37) and (3.25) in pooled followed by hybrid L10×T3 (2.83 & 3.25) in both environments and (3.04) in pooled respectively. Among other hybrids L13×T4 recorded maximum significant SCA in environment 1 (2.74) followedby L7×T1 (2.73) in environment 2 while in pooled L13×T4 recorded maximumsignificant SCA (2.69).

4.4.2.2.4 Pod length

The pod length recorded maximum significant SCA within parental hybrids in hybrid L8×T2 (1.65) followed by hybrid L10×T1 (1.52) and L5×T3 (1.17) in environment1 whereas (1.59) for hybrid L4×T3 followed by(1.29) in L10×T1 and (1.35) for L13×T2 in environment 2 while hybrid L10×T1 exhibit highest value (1.40) followed by L8×T2 (1.32) and L4×T3 (1.24) in pooled data, respectively

4.4.2.2.5 Number of first fruiting Node

The data recorded for number of first fruiting node showed the positive and significant SCA for hybrids from the Table 4.5 (d) in environment 1 for L5×T3 (0.49) followed by L12×T3 (0.43) and L8×T4 (0.39) while in environment 2 the maximum significant SCA what is recorded for hybrid L3×T3 (0.44) followed by L13×T2 (0.38), L7×T1 (0.35) and L9×T3 (0.32) whereas for pooled data maximum SCA was noted for hybrid L3×T3 (0.40) significantly followed by hybrid L5×T3 (0.37) and hybrid L13 ×T1 (0.31)respectively.

4.4.2.2.6 Number of nodes per plant

The data recorded for number of nodes per plant revealed that maximum significant SCA among hybrids was recorded in L1×T2 in both environments (1.99 & 1.62) and also in pooled (1.81) followed by hybrid L3 ×T4 (1.67 & 1.46) for environment 1 and 2 and (1.56) for pooled data followed by hybrid L5×T1 following the same pattern(1.54 & 1.16) in both environment and (1.35) in pooled data.

4.4.2.2.7 Number of ridges per pod

The data recorded for number of ridges per pod showed the maximum and significant SCA among hybrids was noted in L1×T2 for both environments (1.21& 1.11). Among the remaining hybrids, the maximum significant SCA was noted in environment 1 for hybrid L3×T2 (1.00) followed by hybrid L12×T1 (0.54) and L14×T4 (0.51) while in environment 2 the maximum significant SCA was recorded for hybrid L3×T2 (1.26) followed by hybrid L8×T1 (0.65) and hybrid L2×T2 (0.56) whereas for pooled data, the maximum significant SCA for number of ridges per pod was recorded for hybrid L1×T2 (1.16) followed by hybrid L3×T2 (1.13) and L8×T1 (0.55) respectively.

4.4.2.2.8 Pod diameter

The pod diameter showed the significant and positive values for hybrid L2×T3 in both environments (0.51 & 0.61) and in pooled (0.57) followed by hybrid L8×T2 (0.34 & 0.26) in environment 1 & 2 and (0.30) in pooled. Among the others maximum positiveand significant SCA was recorded for L11×T3 (0.34) and (0.24) for environment 1 and 2 and (0.28) in pooled respectively.

4.4.2.2.9 Internodal length

The data recorded from table 4.5 (e) the positive and significant SCA for internodal length was recorded for hybrids L11×T1 in both environments (1.54 & 1.84) also in pooled (1.69) followed by hybrid L10×T3 (0.73 & 0.59) in environment 1 and 2 and (0.66) in pooled. Hybrid L11×T3 and L1×T3 also perform significantly positive and can be utilized as hybrid.

4.4.2.2.10 Average pod weight

The data revealed that for average pod weight that the significant and maximum SCA among parental hybrids was recorded in hybrid L9×T1 (2.14 & 2.16) in environment 1and 2 while (2.15) in pooled followed by hybrid L10×T1 (2.20), L5×T1 (2.10), L7×T1 (1.89) in environment 1, L8×T1 (2.04), L13×T2 (1.72) & L5×T1 (1.72) in environment while L8×T1 (1.97) followed by L5×T1 (1.91) and L13×T2 (1.52) in pooled data respectively.

4.4.2.2.11 Pod yield/Plant

The data recorded for pod yield per plant for hybrids revealed that maximum and positive SCA was noted in hybrid L7×T4 (1.93 & 1.26) for both environments and also in pooled (1.60) followed by hybrid L7×T3 (1.47 & 1.14) for environment 1 and 2 while, (1.30) for pooled data. Among the other hybrids, data revealed that hybrid L7×T2 exhibit significant and positive SCA for both environments (1.24 & 0.95) and in pooled (1.09).

4.4.2.3 Biochemical Parameters

4.4.2.3.1 Ascorbic acid content

The maximum significant SCA for ascorbic acid content recorded in the table 4.5 (f) within hybrids was showed in L10×T4, (5.57 & 4.31) in both environments 1 and 2 while, (5.02) in pooled followed by hybrid L7×T4 (4.21 & 3.74) in both environments and (3.98) in pooled data, respectively. In rest hybrids, L12×T3 recorded maximum significant SCA in both environments (2.79 & 1.97) and also in pooled (2.34).

4.4.2.3.2 Acidity

The acidity content for hybrid L1×T3 recorded maximum significant SCA in environment 1 and 2 (0.04 & 0.04) and also for pooled (0.04) followed by L15×T4 with the same pattern in both environments (0.02 & 0.03) while (0.03) in pooled respectively. The data regarding other hybrids revealed that in environment 1 hybrid L8×T2 exhibit maximum SCA (0.02), in environment 2 maximum significant SCA wasrecorded in hybrid L10×T4 (0.04) followed by hybrid L13×T4 (0.03) while in pooled the maximum significant SCA was noted for hybrid L3×T2 (0.02) followed by hybrid L13×T4 (0.02) respectively.

4.4.2.3.2.1 Dry matter content

The dry matter content showed the significant maximum SCA within parental hybrids. The hybrid L12×T3 (2.57) in environment 1, (2.26) in environment 2 and (2.34) for pooled data followed by hybrid L10×T4 (2.22 & 2.25) in both environments and (2.24) in pooled respectively. In case of remaining hybrids, maximum significant SCA for drymatter content was recorded in L5×T2 for both environments (1.70 & 1.68) and also for pooled (1.69).

4.4.2.3.4 Firmness

The data recorded from the table 4.5 (g) the specific combining ability for firmness was recorded significantly and maximum within hybrids and L15×T3 (0.50 & 0.94) in environment 1 and 2 and (0.78) in pooled data followed by hybrid L10×T1 with the same pattern (0.48 & 0.47) in both environments and (0.47) in pooled data, respectively. Among others L14×T4 exhibit significant and positive SCA for firmness in both environments (0.45 & 0.45) and (0.45) in pooled.

4.4.2.3.5.1 Chlorophyll content

The maximum and significant Chlorophyll content in hybrids, recorded for L15×T2 (2.55 & 2.32) in environment 1 & 2 while (2.44) in pooled data, which was followed by hybrid L3×T3 with the same pattern for both environments (2.42 & 2.14) while (2.28) in pooled respectively. Among remaining hybrids, L5×T1 exhibit maximum andsignificant SCA (2.03) in environment 1, (2.04) in environment 2 and (2.03) in pooleddata.

4.4.2.3.5.2 Mucilage content

The data revealed that the hybrid L7×T2 recorded significant and maximum SCA for mucilage content (2.27) in environment 1, (2.26) in environment 2 and (2.27) in pooled followed by hybrid L2 ×T4 in both environments (1.68 & 1.67) and also noted in pooled (1.67). The hybrid L14 ×T1 recorded positive and significant SCA for mucilage content(1.66) in environment 1, (1.66) in environment 2 and (1.66) in pooled data respectively. Hybrids such as L15×T1, L13×T2, L11×T1, L9×T2, L1×T3 can be utilized for inherited traits among progenies in developing germplasm.

Table 4.5 (a) Estimation of Specific combining ability (SCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Plant height			Number of branches perplant			Stem diameter			Leaf blade length		
Hybrids	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1×T1	1.11	0.25	0.68	-1.48**	-1.59**	-1.53**	0.96	0.07	0.06	-1.04	-1.1	-1.07
L1×T2	1.44	1.94	1.69	0.25	0.35	0.3	-1.29	1.11	0.5	-0.19	0.16	-0.01
L1×T3	-0.76	-0.93	-0.84	2.04 **	2.32**	2.18 **	-0.45	-1.513	-1.18	1.79**	1.59**	1.69**
L1×T4	-1.79	-1.26	-1.53	-0.81	-1.08	-0.95	-1.38	0.33	0.62	-0.55	-0.64	-0.6
L2×T1	0.69	0.07	0.38	1.35 **	2.07**	1.71 **	0.45	-0.52	-0.57	1.45	1.07	1.26
L2×T2	2.71 **	3.09 **	2.90 **	-0.41	-1.25	-0.83	0.59	0.79	0.92	0.34	0.34	0.34
L2×T3	-1.28	-1.1	-1.19	-0.54	-0.16	-0.35	0.75	-0.34 *	-0.29	-0.61	-0.52	-0.56
L2×T4	-2.12 *	-2.05**	-2.09**	-0.39	-0.66	-0.52	-0.41 *	0.07	-0.05	-1.17	-0.9	-1.04
L3×T1	-0.06	-0.29 *	-0.18	-0.61	-0.76	-0.68	0.95 **	0.15	0.11	-0.79	-1.13	-0.96
L3×T2	3.14 **	2.93 **	3.06 **	1.64 **	2.08 **	1.86 **	-1.3	-0.47	-0.55	2.13 **	2.25 **	2.19**
L3×T3	-0.83	-0.103	-0.47	-0.26	-0.72	-0.49	0.88	0.89	0.86	-0.59	-0.67	-0.63
L3×T4	-2.28 **	-2.53**	-2.41**	-0.76	-0.6	-0.68	0.26	-0.57	-0.42	-0.74	-0.44	-0.59
L4×T1	3.80 **	4.68 **	4.24**	-0.58	-0.9	-0.74	0.49	-1.25	-1.12	-0.77	-1.17	-0.97
L4×T2	-7.15**	-9.91**	-8.53**	-1.03**	-1.55**	-1.29**	-1.64	-0.83	-0.63	1.3	1.01	1.15
L4×T3	2.06 **	3.14 **	2.60 **	-0.05	0.71	0.33	0.17	0.72	-0.63	-0.56	-0.33	-0.45
L4×T4	1.28	2.09	1.68	1.66**	1.74**	1.70 **	1.43 **	1.36 **	1.26 **	0.03	0.49	0.26
L5×T1	2.33	2.16	2.25	-0.71	-1.23	-0.97	2.03 **	1.43 **	1.76 **	-0.83	-0.76	-0.79
L5×T2	-1.29	-1.54	-1.41	-0.57	-0.07	-0.32	0.05	-0.91	-0.87	0.31	0.24 *	0.27
L5×T3	0.41	0.31 **	0.36	-0.45	-0.66	-0.55	-0.37	0.05	-0.08	-1.07	-0.9	-0.98
L5×T4	-1.45	-0.94	-1.19	1.74 **	1.97**	1.85 **	1.32	-0.58	-0.47	1.59 **	1.42**	1.51 **
L6×T1	0.58	0.44 **	0.513	0.34	0.14	0.24	-1.01	0.41	0.34	-0.27	0.45 **	0.08

L6×T2	-1.75 *	-2.27**	-2.01**	1.12 **	1.23**	1.17 **	0.06	1.01	0.91	0.13	-0.82	-0.34
L6×T3	-0.008	-0.35 *	-0.17	1	0.92	0.96	-1.52**	-0.56**	-0.29	-0.25	-0.21	-0.23
L6×T4	1.17	2.17	1.67	-2.46**	-2.30**	-2.38**	0.14	-0.86	-0.96	0.39	0.58	0.49
L7×T1	0.77	0.71 **	0.74	-0.96*	-0.83**	-0.89**	-0.32	0.38	0.65	-0.74	-0.78	-0.76
L7×T2	2.25 *	2.31 **	2.28 **	0.26	-0.04	0.11	-1.77	-1.27	-0.9	0.15	0.35	0.26
L7×T3	-1	-0.86	-0.93	0.36	0.65	0.51	0.24 *	0.53 **	0.2	0.34	0.57	0.45
L7×T4	-2.02 *	-2.17**	-2.09**	0.33	0.21	0.27	0.65	0.35	0.03	0.25	-0.16	0.04
L8×T1	-0.1	0.33 *	0.11	-0.22	-0.13	-0.18	-0.61	-0.63	-0.5	0.32	0.35 *	0.33
L8×T2	2.36 **	3.18**	2.77 **	-0.9	-1.26	-1.08	-0.93	-0.1	0.11	-1.03**	-0.32 **	-0.67***
L8×T3	-0.36	-1.23	-0.79	-0.24	-0.24	-0.24	0.54	-1.14	-0.9	-0.63	-1.09	-0.86
L8×T4	-1.89 *	-2.27**	-2.08**	1.37 **	1.64**	1.51	-0.87**	1.88 **	1.29**	1.35 **	1.07 **	1.21 **
L9×T1	-0.12	-0.11	-0.11	-0.02	0.7	0.34	2.42 **	2.23 **	2.32 **	0.41	0.68	0.54
L9×T2	2.02 *	2.40 **	2.21 **	-0.35	-0.76	-0.56	-1.02**	0.06	0.11	-1.03	-0.54	-0.8
L9×T3	-0.91	-0.86	-0.88	-0.25	-0.75	-0.5	0.45	0.04	0.44	-0.83	-1.06	-0.94
L9×T4	-0.98	-1.42**	-1.20*	0.63	0.81	0.72	-0.42**	-2.35**	-2.34**	1.45	0.96	1.2
L10×T1	-2.91**	-3.12**	-3.02	-0.17	0.11	-0.03	0.33	0.88	0.55	-1.18	-1.24	-1.21
L10×T2	-0.49	0.07	-0.21	-0.81	-0.66	-0.73	0.37	-0.63	-0.48	0.98	0.44	0.71
L10×T3	0.58	0.36 *	0.47	0.22	0.13	0.17	-1.72	0.53	0.72	0.26	0.71	0.48
L10×T4	2.83 **	2.68 **	2.75**	0.76	0.42	0.59	-0.68	-0.78	-0.79	-0.07	0.08	0.008
L11×T1	-2.41**	-2.56**	-2.48	0.008	-0.49	-0.24	-0.69	-0.92	-0.73	-0.72	-1.04	-0.88
L11×T2	-1.07	-1.15	-1.11	0.21	1.04	0.63	0.78	0.34	0.33	0.39	0.65	0.52
L11×T3	0.3	0.11	0.21	0.26	-0.56	-0.15	1.65	1.36	0.93	0.35	0.26 *	0.3
L11×T4	3.17 **	3.59 **	3.38**	-0.48	0.01	-0.23	-1.12	-0.77	-0.54	-0.02	0.13	0.05
L12×T1	-1.00	-0.27 *	-0.64	0.82	0.99	0.9	-0.01	-1.05	-0.93	1.2	1.4	1.3
L12×T2	1.55	1.64	1.59	-0.04	-0.07	-0.06	-1.79**	0.19	0.004	-0.86	-1.35	-1.11
L12×T3	-1.47	-2.34	-1.9	-0.75	-0.63	-0.69	0.24	-0.17	-0.35	0.18	0.46	0.32
L12×T4	0.92	0.97 **	0.95	-0.01	-0.28 *	-0.14	1.04 **	1.03 **	1.28 **	-0.51	-0.51	-0.51

L13×T1	-1.88 *	-2.56**	-2.22	-0.146	-0.15	-0.148	0.51	-1.11**	-1.02**	-0.3	-0.44	-0.37
L13×T2	-1.53	-2.3	-1.91	0.618 *	0.72**	0.66**	1.52 **	0.03	-0.01	-0.67	-0.53	-0.6
L13×T3	0.25	1.63 **	0.94	-0.12	0.08	-0.01	-1.15**	0.34 *	0.29	0.4	0.42	0.41
L13×T4	3.16 **	3.22 **	3.19 **	-0.34	-0.65	-0.5	-0.44	0.73 **	0.75*	0.57	0.54	0.55
L14×T1	0.13	0.83 **	0.48	0.51	0.45	0.48	0.08	0.2	0.28	1.32**	1.37 **	1.35**
L14×T2	0.25	1.11 **	0.68	0.57	0.42	0.5	-0.05	0.87	0.82	-0.37	-0.33**	-0.355
L14×T3	2.18 *	2.27 **	2.22 **	-0.7	-0.6	-0.65	-0.25	-0.99**	-1.11**	0.47	0.33 *	0.40 *
L14×T4	-2.57**	-4.22**	3.40 **	-0.38	-0.27 *	-0.33	0.05	-0.08	0.004	-1.42**	-1.37**	-1.40**
L15×T1	-0.93	-0.56**	-0.75	1.87 **	1.61**	1.74 **	0.25	-0.26 *	-0.32	1.97 **	2.35 **	2.16 **
L15×T2	-2.49**	-1.51**	-2.00**	-0.55	-0.16	-0.36*	-0.05	-0.21	-0.25	-1.59**	-1.53**	-1.56**
L15×T3	0.85	-0.06	0.39	-0.5	-0.48	-0.49	-0.09	0.24 *	0.25	0.75	0.44	0.6
L15×T4	2.57 **	2.14 **	2.35 **	-0.82	-0.96	-0.89	0.46**	0.23*	0.32	-1.14	-1.26	-1.2
S.E. ±	0.98	0.17	0.49	0.41	0.16	0.22	0.12	0.33	0.27	0.38	0.33	0.21
CD (0.05)	1.94	0.34	0.98	0.82	0.33	0.44	0.29	0.65	0.53	0.77	0.65	0.41

Table 4.5 (b) Estimation of Specific combining ability (SCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Leaf blade width			Petiole length			Days to first flowering			Days to first fruit set		
Hybrids	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1×T1	0.99	0.85	0.92	-2.84	-3.18	-3.01	-3.21**	-3.83**	-3.52**	-2.99**	-3.13**	-3.06**
L1×T2	-1.16	-1.01	-1.09	0.26	0.19	0.22	3.75**	3.64**	3.69**	5.51**	5.82**	5.67**
L1×T3	-0.48	-0.62	-0.55	-0.77	-0.92	-0.84	-0.85	-0.67	-0.76	-2.28**	-2.33**	-2.31**
L1×T4	0.65	0.78	0.71	3.36**	3.91**	3.64**	0.31	0.85	0.58	-0.23	-0.35	-0.29
L2×T1	0.32	0.01	0.16	1	0.85	0.92	-1.26**	-0.87**	-1.07**	-1.48**	-1.95**	-1.71**
L2×T2	2.75 **	3.40 **	3.07 **	-0.75	-1.13	-0.94	-5.54**	-6.07**	-5.80**	-3.41**	-3.21**	-3.31**
L2×T3	-0.85	-0.61	-0.73	0.14	0.18	0.16	1.46**	1.62**	1.54**	-0.11	-0.15	-0.13
L2×T4	-2.21**	-2.79**	-2.50**	-0.39	0.09	-0.14	5.34**	5.32**	5.33**	5.00**	5.31**	5.16**
L3×T1	0.12	0.17	0.14	-2.58**	-2.46**	-2.52**	-2.09**	-2.55**	-2.32**	-2.79**	-2.67**	-2.73**
L3×T2	1.55 **	1.55**	1.55**	0.25	0.27	0.26	4.20**	4.11**	4.16**	-2.18**	-2.46**	-2.32**
L3×T3	0.87	0.94	0.91	3.38**	3.34**	3.36**	-1.7	-1.19	-1.45	2.04**	2.24**	2.14**
L3×T4	-2.55**	-2.66**	-2.61**	-1.04	-1.15	-1.1	-0.41	-0.36	-0.38	2.93**	2.89**	2.91***
L4×T1	0.33	0.95	0.64	-0.85	-0.74	-0.79	3.03**	3.23**	3.13**	-0.22	-0.03	-0.12
L4×T2	1.07	0.48	0.78	1.11	0.83	0.97	1.63**	2.00**	1.82**	0.68*	0.35*	0.51*
L4×T3	0.11	0.25	0.18	-0.1	0.14	0.02	-2.98**	-3.54**	-3.26**	0.04	-0.02	0.01
L4×T4	-1.52**	-1.70**	-1.61**	-0.15	-0.23	-0.19	-1.67	-1.69	-1.68	-0.5	-0.29	-0.39
L5×T1	-0.07	0.17	0.05	0.36	0.45	0.41	-1.54**	-1.02**	-1.28**	-1.97**	-1.40**	-1.68**
L5×T2	3.10**	3.24**	3.17**	-1.27	-0.95	-1.11	-4.02**	-4.10**	-4.06**	-2.23**	-2.21**	-2.22**
L5×T3	-2.83**	-3.02**	-2.93**	0.125	-0.134	-0.005	-0.11	-0.44	-0.28	5.22**	4.82**	5.02**
L5×T4	-0.2	-0.39**	-0.3	0.783	0.63	0.71	5.68**	5.57 **	5.63**	-1.01**	-1.20**	-1.11**
L6×T1	-0.07	-1.16**	-1.10**	-0.53	-0.3	-0.42	-1.52**	-1.24**	-1.38**	5.27**	4.72**	5.00 **
L6×T2	4.36**	4.67**	4.56**	3.26**	3.25**	3.26**	3.95**	3.55**	3.75**	-0.53	-0.39	-0.46
L6×T3	-2.83**	-4.61**	-4.69**	-1.79**	-1.99**	-1.89**	1.86**	2.34**	2.10 **	-0.22	0.06	-0.08

L6×T4	-0.20	1.10**	1.24**	-0.93	-0.95	-0.94	-4.30**	-4.66**	-4.48**	-4.50**	-4.39**	-4.45**
L7×T1	-1.05**	1.89**	1.97**	2.05**	1.74**	1.90**	-0.47	-0.30	-0.38	-0.01	0.01	-0.001
L7×T2	2.76**	-1.18**	-1.18**	-0.001	-0.03	-0.02	-3.01**	-2.91**	-2.96**	-0.47	-0.48	-0.48
L7×T3	-4.77	-0.76	-0.63	-0.82	-0.42	-0.62	7.20**	6.81**	7.01**	4.91**	4.92**	4.92**
L7×T4	1.38 **	0.05	-0.15	-1.22**	-1.27**	-1.25**	-3.72**	-3.59**	-3.66**	-4.41**	-4.45**	-4.43**
L8×T1	2.05**	-2.19**	-2.01**	2.80**	2.59**	2.70**	3.03**	3.06**	3.04**	2.41**	2.37**	2.39**
L8×T2	-1.18**	-2.76**	-2.79**	-1.45**	-1.62**	-1.54**	-5.39**	-5.01**	-5.20**	2.00**	2.30**	2.15**
L8×T3	-0.49	2.88**	2.96**	-0.93	-0.54	-0.74	-0.55	-0.76	-0.65	-2.61**	-3.00**	-2.81**
L8×T4	-0.37	2.07**	1.83**	-0.41	-0.42	-0.41	2.91**	2.71**	2.81**	-1.80**	-1.68**	-1.74**
L9×T1	-1.82	0.8	0.94	2.92**	2.96**	2.94**	-1.42**	-1.52**	-1.47**	2.32**	2.56**	2.44**
L9×T2	-2.82**	1.10**	1.02**	-2.32**	-2.24**	-2.28**	2.37**	2.23**	2.30**	-2.87**	-3.25**	-3.06**
L9×T3	0.30	0.35	0.31	2.57**	2.62**	2.59**	0.96	1.04	1.00	2.54**	2.23**	2.38**
L9×T4	1.59 **	-2.25**	-2.29**	-3.17**	-3.34**	-3.25**	-1.90**	-1.75**	-1.82**	-1.98**	-1.54**	-1.76**
L10×T1	1.09**	-1.40**	-1.54**	-0.02	0.31*	0.14	6.44**	6.27**	6.30**	4.38**	4.56**	4.47**
L10×T2	0.95	0.97	0.91	-1.54**	-1.21**	-1.37**	-2.33**	-1.94**	-2.14**	-4.83**	-4.97**	-4.90**
L10×T3	0.27	0.61	0.62	3.63**	3.47**	3.55**	0.87*	0.92**	0.90**	0.23	0.17	0.2
L10×T4	-2.32**	-0.182	0.007	-2.06**	-2.58**	-2.32**	-4.99**	-5.25**	-5.12**	0.21	0.24	0.22
L11×T1	-0.06	0.24	0.088	-1.42**	-1.38**	-1.40**	0.74	0.52	0.63	0.32	0.02	0.17
L11×T2	1.26	0.6	0.93	0.173	0.29*	0.23	-1.91**	-1.90**	-1.90**	-0.11	0.02	-0.04
L11×T3	-0.55	-0.45	-0.5	2.53**	2.12**	2.33**	1.13**	1.13**	1.13**	-0.02	0.17	0.07
L11×T4	-0.65	-0.4	-0.52	-1.29**	-1.04**	1.16**	0.03	0.24	0.14	-0.18	-0.22	-0.2
L12×T1	0.51	0.23	0.37	0.05	0.07	0.06	-1.33**	-1.34	-1.34**	-0.03	-0.04	-0.04
L12×T2	-4.37**	-4.35**	-4.36**	0.78	0.80	0.79	2.78**	2.80**	2.79**	1.75**	1.98**	1.87**
L12×T3	1.13	1.22	1.17	-1.28**	-1.25**	-1.27**	-2.03**	-2.02**	-2.02**	-1.85**	-1.77**	-1.81**
L12×T4	2.72**	2.89**	2.80**	0.43	0.38	0.41	0.58	0.55	0.57	0.12	-0.16	-0.02
L13×T1	0.19	0.25	0.22	-0.65	-0.64	-0.64	0.83	0.83	0.83	-2.10**	-2.30**	-2.20**
L13×T2	-1.66**	-1.75**	-1.71**	-0.16	-0.14	0.15	2.39**	2.42**	2.40**	3.97**	4.04**	-2.20**

L13×T3	1.35**	1.33**	1.34**	-0.71	-0.68	-0.69	-2.64**	-2.64**	-2.64**	-4.51**	-4.45**	-4.48**
L13×T4	0.11	0.17	0.14	1.52**	1.47**	1.50**	-0.58	-0.60	-2.64	2.64**	2.71**	2.67**
L14×T1	0.18	0.23	0.20	-0.03	-0.02	-0.03	0.40	0.39 *	0.39 *	-1.36**	-0.94**	-1.15**
L14×T2	-2.83**	-2.92**	-2.87**	-0.87	-0.86	-0.87	0.17	0.20	0.18	-0.005	-0.39*	-0.19
L14×T3	1.54**	1.51**	1.53**	-2.13**	-2.17**	-2.11**	-2.00**	-1.99**	-2.00**	-1.34**	-1.06**	-1.20**
L14×T4	1.10**	2.14**	1.13 **	3.04**	2.99 **	3.02 **	1.42**	1.40**	1.41**	2.71**	2.40**	2.55**
L15×T1	-1.12	-1.07	-1.09	-0.26	-0.24	-0.25	-1.61**	-1.62**	-1.62**	-1.71**	-1.77**	-1.74**
L15×T2	-1.94**	-2.05**	-2.00**	2.55**	2.56**	2.56**	0.94	0.97	0.96	2.74**	2.85**	2.79**
L15×T3	1.00	0.97	0.99	-3.83**	-3.81**	-3.82**	-0.60	-0.60	-0.60	-2.02**	-1.82**	-1.92**
L15×T4	2.08**	2.14**	2.11**	1.54**	1.49**	1.52**	1.27**	1.25**	1.26**	1.00	0.74	0.87
S.E. ±	0.35	2.14	0.2	0.31	0.4	0.18	0.41	0.36	0.22	0.36	0.34	0.25
CD (0.05)	0.70	0.75	0.39	0.63	0.79	0.37	0.82	0.72	0.44	0.71	0.34	0.39

Table 4.5 (c) Estimation of Specific combining ability (SCA) for different traits in okra under two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Days to first fruit picking			Number of flowers per plant			Number of pods per plants			Pod length		
Hybrids	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1×T1	-3.63**	-3.55**	-3.59**	-0.36	-0.4	-0.38	-0.72	-0.55	-0.64	-1.01**	-1.19**	-1.10**
L1×T2	5.44**	5.38**	5.41**	1.64**	1.29**	1.47**	0.42	0.3	0.36	0.37	0.18	0.28
L1×T3	-1.83**	-1.83**	-1.83**	1.13**	1.62**	1.38**	-0.90	-1.12	-1.01	-0.07	0.02	-0.02
L1×T4	0.02	0.003	0.01	-2.42**	-2.51**	-2.46**	1.21**	1.37**	1.29**	0.71**	0.97**	0.84**
L2×T1	-1.10**	-1.04**	-1.07**	0.70	0.98	0.84	0.63	0.53	0.58	-0.16	-0.05	-0.11
L2×T2	-3.65**	-3.57**	-3.61**	1.37 **	1.46**	1.42**	1.41**	0.96**	1.18**	-0.44	-0.78	-0.61
L2×T3	-0.43	-0.49	-0.46	-2.00**	-1.89**	-1.95**	1.24**	1.44**	1.34**	0.08	0.007	0.04
L2×T4	5.19**	5.11**	5.15**	-0.07	-0.55	-0.31	-3.30**	-2.93**	-3.11**	0.52	0.82	0.67
L3×T1	-3.40**	-3.25**	-3.33**	-2.00**	-2.19**	-2.09**	-0.86	-0.71	-0.78	0.12	0.29	0.2
L3×T2	-1.37**	-1.23**	-1.30**	0.17	0.44	0.31	-0.98	-0.96	-0.97	0.21	0.02	0.12
L3×T3	1.71**	1.60**	1.65**	-0.86	-1.31	-1.08	0.74	0.68	0.71	0.79*	1.13**	0.96**
L3×T4	3.06**	2.89**	2.97**	2.69**	3.06**	2.87**	1.10**	0.99**	1.04**	-1.13**	-1.44**	-1.29**
L4×T1	0.12	0.11	0.12	1.69**	1.47**	1.58**	1.13**	1.25**	1.19**	-0.43	-0.46**	-0.45**
L4×T2	-0.14	-0.4	0.12	3.07**	3.02**	3.05*	1.89**	1.68**	1.79**	-1.20**	-1.55**	-1.38**
L4×T3	-0.40	-0.10	-0.25	-2.54**	-2.30**	-2.42**	-0.75	-0.84	-0.79	0.88**	1.59**	1.24**
L4×T4	0.42	0.38	-0.25	-2.22**	-2.20**	-2.21**	-2.28**	-2.09**	-2.19**	0.75	0.43	0.59
L5×T1	-2.55**	-2.59**	-2.57**	-3.23**	-3.12**	-3.17**	-1.20**	-1.73**	-1.47**	0.91**	0.60**	0.75**
L5×T2	-2.60**	-2.35**	-2.48**	0.45	0.2	0.33	1.33**	1.46**	1.39**	-0.68	-0.14	-0.41
L5×T3	5.17**	4.94**	5.06**	0.16	0.14	0.15	-1.54**	-1.74**	-1.64**	1.17**	0.74**	0.95**
L5×T4	-0.01	0.002	5.06	2.61**	2.76**	2.69**	1.41**	2.01**	1.71**	-1.39**	-1.20**	-1.30**
L6×T1	4.25**	4.22**	4.23**	3.98**	4.29**	4.14**	0.33	0.48	0.41	0.64*	1.12**	0.88**
L6×T2	0.25	0.18	0.22	-0.3	-0.78	-0.54	0.47	0.42	0.45	0.41	0.12	0.26
L6×T3	-0.17	-0.09	-0.13	-2.58**	-2.77**	-2.67**	-1.31**	-1.28**	-1.30**	0.59	0.39	0.49

L6×T4	-4.33**	-4.31**	-4.32**	-1.09	-0.74	-0.91	0.5	0.37	0.44	-1.64**	-1.64**	-1.64**
L7×T1	0.24	0.43	0.33	-0.33	-0.54	-0.44	2.50**	2.73**	2.62**	0.59*	-0.24*	0.17
L7×T2	0.4	0.23	0.31	-2.47**	-2.13**	-2.30**	3.14**	3.37**	3.25**	-0.76*	-0.65**	-0.71**
L7×T3	3.88**	3.75**	3.81**	2.05**	2.46**	2.25**	-2.41**	-2.89**	-2.65**	0.28	0.68	0.48
L7×T4	-4.52**	-4.42**	-4.47**	0.75	0.21	0.48	-3.23**	-3.21**	-3.22**	-0.11	0.22	0.05
L8×T1	1.95	2.14	2.04	0.01	-0.28	-0.13	-4.07**	-4.11**	-4.09**	-0.51	-0.23	-0.37*
L8×T2	1.65	1.64	1.64	0.05	0.28	0.16	1.51**	1.44**	1.48**	1.65**	0.99**	1.32**
L8×T3	-3.10**	-3.33**	-3.21**	0.001	0.11	0.05	0.97	0.96	0.96	-1.12**	-0.90**	-1.01**
L8×T4	-0.49	-0.46	-0.48	-0.06	-0.11	-0.08	1.59**	1.70 **	1.64**	-0.01	0.13	0.06
L9×T1	2.25**	2.26**	2.25**	-1.61**	-1.69**	-1.65**	2.51**	2.62**	2.57**	-1.79**	-1.25**	-1.52**
L9×T2	-3.11**	-3.21**	-3.16**	1.01**	1.28**	1.14**	-0.65	-0.89	-0.77	0.24	0.02	0.13
L9×T3	1.67	1.62	-3.16	0.33	-0.17	0.07	0.36	0.31	0.34	1.04**	0.78**	0.91**
L9×T4	-0.81	-0.67	-0.74	0.27	0.58	0.43	-2.22**	-2.04**	-2.13**	0.51	0.43	0.47
L10×T1	6.96**	5.50**	6.23**	-0.82	-0.61	-0.71	-1.60**	-2.07**	-1.83**	1.52**	1.29**	1.40**
L10×T2	-5.92**	-5.52**	-5.72**	2.51**	2.85**	2.68**	2.00**	2.02**	2.01**	-1.15**	-0.58**	-0.87**
L10×T3	-1.35**	-0.78**	-1.06**	0.95	0.35	0.65	2.83**	3.25**	3.04**	-0.44	-1.18**	-0.81**
L10×T4	0.3	0.79	0.54	-2.64**	-2.59**	-2.62**	-3.23**	-3.19**	-3.21**	0.08	0.47	0.27
L11×T1	0.08	0.35	0.22	0.6	0.24	0.42*	0.44	0.91	0.68	-0.05	0.27	0.11
L11×T2	-0.03	0.06	0.03	0.88	1.05	0.97	0.51	0.59	0.68	-0.25	0.12	-0.06
L11×T3	-0.24	-0.51	-0.38	-0.66	-0.48	-0.57	-0.28	-0.57	-0.43	0.05	-0.28*	-0.11
L11×T4	0.19	0.05	0.12	-0.82	-0.81	-0.82	-0.67	-0.93	-0.8	0.25	-0.12	0.06
L12×T1	-3.25**	-3.10**	-3.17**	-0.70	-0.61	-0.66	1.83**	1.90**	1.86**	-0.05	-0.01	-0.03
L12×T2	3.76 **	3.68**	3.72**	-2.34**	-2.34**	-2.34**	-3.44**	-3.52**	-3.48**	-0.09	-0.18	-0.13
L12×T3	-0.6	-0.58	-0.59	2.57**	2.44**	2.51**	-0.54	-0.16	-0.35	-0.39	-0.13	-0.26
L12×T4	0.09	0.02	0.04	0.48	0.5	0.49	2.15**	1.78***	1.97***	0.54	0.32	0.43
L13×T1	1.05**	1.20**	1.12**	1.07	1.01	1.04	-1.15***	-1.17**	-1.16**	0.02	-0.01	0.002
L13×T2	4.17 **	4.08**	4.12**	-2.57**	-2.60**	-2.58**	-2.26**	-1.97**	-2.12**	1.06**	1.35*	1.20**

L13×T3	-4.14**	-4.12**	-4.13**	0.6	0.63	0.62	0.67	0.51	0.59	-0.99**	-1.28**	-1.14**
L13×T4	-1.07**	-1.16**	-1.12**	0.88	0.96	0.92	2.74**	2.64**	2.69**	-0.08	-0.04	-0.06
L14×T1	-1.85**	-1.65	-1.77**	-0.63	-0.3	-0.47	0.03	0.15	0.09	0.09	0.18	0.13
L14×T2	-0.18	-0.26	-0.22	-0.42	-0.81	-0.62	-3.09**	-3.04**	-3.07**	0.5	0.55	0.53
L14×T3	0.36	0.38	0.37	0.51	0.74	0.63	1.22**	1.14**	1.18**	-1.07**	-1.27**	-1.17**
L14×T4	1.67**	1.58**	1.63**	0.53	0.37	0.45	1.83**	1.74**	1.79**	0.47	0.53**	0.50*
L15×T1	-1.13**	-0.98*	-1.05**	1.63**	1.78**	1.71**	0.17	-0.23	1.79	0.13	-0.3	-0.08
L15×T2	1.33**	-0.26*	1.29**	-3.05**	-3.24**	-3.15**	-2.25**	-1.88**	-2.06**	0.14	0.51	0.33
L15×T3	-0.49	-0.47	-0.48	0.31	0.41	0.36	-0.3	0.31	0.002	-0.8	-0.3	-0.55
L15×T4	0.29	0.2	0.25	1.10**	1.04**	1.07**	2.38**	1.80**	2.09**	0.52	0.09	0.3
S.E. ±	0.38	0.34	0.21	0.38	0.34	0.21	0.36	0.33	0.21	0.37	0.33	0.2
CD (0.05)	0.76	0.69	0.41	0.76	0.69	0.41	0.71	0.66	0.39	0.74	0.2	0.4

Table 4.5 (d) Estimation of Specific combining ability (SCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environments

Traits	Number of first fruiting node			Number of nodes per plant			Number of ridges per pod			Pod diameter		
Hybrids	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**	**E1**	**E2**	**Pooled**
L1×T1	0.001**	-0.25**	-0.12**	-0.79**	-0.66**	-0.81	-0.1	0.22	0.06	-0.04	0.27*	0.11*
L1×T2	-0.008	0.25*	0.12*	1.99**	1.62**	1.81**	1.21**	1.11**	1.16**	-0.21	-0.23	-0.22
L1×T3	-0.12	-0.16	-0.14	-0.62**	-0.25 *	-0.60**	-0.72**	-0.94**	-0.71**	-0.22	-0.09	-0.16
L1×T4	0.13*	0.16*	0.15*	-0.57**	-0.70**	-0.59**	-0.39*	-0.40*	-0.38	0.06	0.05	0.06
L2×T1	0.21	-0.05	0.07	-0.42	0.04	-0.41	-0.29*	-0.35*	-0.30*	-0.11	-0.01	-0.06
L2×T2	-0.07	0.15**	0.03**	0.13	-0.05	0.03	0.16	0.56**	0.36**	0.21	-0.29*	0.21
L2×T3	0.34**	-0.03	0.32	0.14	-0.03	0.05	0.217	0.009	0.11	0.51**	0.61**	0.57**
L2×T4	-0.48**	-0.06	-0.48	0.14	0.04	0.09	-0.08	-0.22	-0.15	-0.19	-0.29*	-0.18*
L3×T1	0.17	0.28*	0.17*	-0.48	-0.23	-0.49	-0.89**	-0.88**	-0.88	-0.06	0.2	0.07
L3×T2	-0.14	-0.43**	-0.13	-0.23	-0.17	-0.24	1.00**	1.26**	1.13**	-0.05	-0.13	-0.09
L3×T3	0.36**	0.44**	0.40**	-0.95**	-1.05**	-0.95**	0.30*	0.04*	0.29*	-0.04	-0.32	-0.03
L3×T4	-0.40**	-0.28*	-0.40*	1.67**	1.46**	1.56**	-0.41**	-0.42**	-0.41**	0.16	0.25*	0.15*
L4×T1	0.23	-0.02	0.1	-0.62**	-0.65**	-0.62**	0.29	0.44	0.29	0.17*	0.04*	0.11*
L4×T2	0.11	-0.19	-0.04	-0.52	-0.46	-0.51	-0.41**	-0.13**	-0.41**	-0.1	-0.26*	-0.1
L4×T3	-0.58**	-0.03**	-0.58**	1.07**	1.18**	1.08**	-0.19	-0.19	-0.19	-0.005	-0.05	-0.02
L4×T4	0.24	0.16	0.2	0.074	-0.061	0.007	0.31**	-0.12**	0.32**	-0.06	0.26**	0.10**
L5×T1	-0.18	0.15	-0.01	1.54**	1.16**	1.35**	-0.29*	-0.21*	-0.30*	-0.05	0.13	0.03
L5×T2	-0.39**	-0.23	-0.41	-1.56**	-1.50**	-1.56**	0.35**	0.10**	0.35**	0.03	-0.013	0.01
L5×T3	0.49**	0.24**	0.37**	-0.1	0.01	-0.04	-0.39**	-0.44**	-0.39**	-0.03	-0.36	-0.03
L5×T4	0.09	-0.15	-0.02	0.12	0.33**	0.1	0.33**	0.55**	0.44**	0.052	0.25	0.044
L6×T1	0.33**	-0.04	0.31	1.54**	-0.71	0.41*	-0.14	-0.24	-0.19	0.06	-0.19	-0.06
L6×T2	-0.008	-0.06	-0.03	-1.56**	0.74**	0.65**	-0.25 *	-0.05	-0.26*	0.01	-0.005	0.004

L6×T3	-0.19	0.14	-0.02	-0.1	0.16	0.02	0.08	0.21	0.15	0.08*	0.13*	0.11*
L6×T4	-0.13	-0.02	-0.07	0.12	-0.18	-0.03	0.31*	0.08**	0.31**	-0.16	0.05	-0.05
L7×T1	0.01**	0.35**	0.18**	-0.70**	-1.05**	-0.93**	0.26*	0.14*	0.28*	0.14	-0.01	0.06
L7×T2	0.36**	0.10**	0.36**	0.65	0.16	-0.02	-0.03	-0.06	-0.05	-0.16	0.3	-0.15
L7×T3	-0.53**	-0.51**	-0.53**	0.25*	0.91**	1.30**	0.07	0.40	0.05	-0.09	0.01	-0.04
L7×T4	0.15	0.05	0.10	-0.21	-0.02	-0.12	-0.30*	-0.48**	-0.31*	0.11*	-0.29*	0.21**
L8×T1	-0.50**	-0.19**	-0.49**	-0.11	-0.2	-0.15	0.45**	0.65**	0.55**	-0.05	0.20**	0.17*
L8×T2	-0.14	-0.04	-0.09	0.63**	0.75**	0.63**	-0.53**	-0.62**	-0.53**	0.34**	0.26**	0.30**
L8×T3	0.25*	0.26 *	0.25	0.40**	0.64**	0.39**	0.03	0.11	0.07	-0.01	-0.29*	-0.02
L8×T4	0.39**	-0.03*	0.18**	-0.92**	-1.20**	-0.92**	0.04	-0.14	-0.05	-0.28*	-0.17	-0.27
L9×T1	-0.32*	-0.06	-0.33	0.32	0.27	0.33	-0.004	-0.13	-0.07	-0.17	-0.11	-0.18
L9×T2	0.06	-0.18	-0.06	-0.58**	-0.59**	-0.58**	-0.48**	-0.38**	-0.48**	0.07	-0.05	0.02
L9×T3	0.02**	0.32**	0.17**	-0.20	0.25*	-0.22	0.38**	0.49**	0.39**	-0.30*	0.18**	-0.28
L9×T4	0.24	-0.07	0.08	0.46	0.07	0.48	0.1	0.03	0.06	0.084	-0.02	0.06
L10×T1	-0.36**	-0.22	-0.35	0.25	0.54	0.26	-0.20	0.10	-0.06	-0.14	-0.02	-0.08
L10×T2	-0.22	-0.07	-0.15	0.007	-0.191	-0.092	-0.01	-0.44**	-0.01	-0.04	0.09	0.02
L10×T3	0.29*	0.26*	0.29	-1.36**	-1.30**	-1.36**	0.05	0.16	0.11	0.06	0.13*	0.10
L10×T4	0.29*	0.03	0.29	1.10**	0.94**	1.08**	0.18*	0.17	0.17*	0.12*	-0.2	-0.04
L11×T1	-0.44**	-0.09	-0.44	-0.74**	-0.38**	-0.75**	0.49**	0.16**	0.49**	-0.13	-0.08	-0.11
L11×T2	0.16	0.18	0.17	0.76**	0.44**	0.76**	0.02	-0.25	-0.11	-0.30*	-0.09	-0.3
L11×T3	0.37**	0.10	0.37	-0.14	-0.27	-0.14	-0.12	0.39**	-0.12	0.34**	0.24**	0.28**
L11×T4	-0.09	-0.19	-0.14	0.12	0.21	0.13	-0.39**	-0.30*	-0.39**	0.09*	0.13*	0.10*
L12×T1	0.10	-0.11	-0.004	-0.44**	-0.67**	-0.44**	0.54**	0.46**	0.50**	0.11	-0.24*	0.12
L12×T2	-0.02	-0.13	-0.08	1.01**	0.98**	1.00**	-0.73**	-0.90**	-0.72**	-0.29*	0.14*	-0.28
L12×T3	0.43**	0.17**	0.30**	-0.17	-0.23	-0.2	0.37**	0.13	0.35**	0.18	-0.01	0.08
L12×T4	-0.51**	0.07	-0.51	-0.39**	-0.07	-0.39	-0.19	0.30*	-0.18	-0.004	0.10*	0.05
L13×T1	0.38**	0.23**	0.31**	1.15**	1.19**	1.17**	0.319 *	-0.09*	0.29*	-0.26*	-0.01	-0.27

L13×T2	0.08**	0.38**	0.23**	-0.48	-0.31	-0.48	-0.33*	-0.17*	-0.31**	0.06	-0.26*	0.05
L13×T3	-0.57**	-0.90**	-0.56**	-0.10	-0.26*	-0.12	-0.19	-0.13	-0.16	0.03	0.11	0.07
L13×T4	0.08	0.29*	0.1	-0.56**	-0.61**	-0.54**	0.21	0.40*	0.20*	0.15*	0.16*	0.16*
L14×T1	0.2	0.23	0.21*	0.73**	0.56**	0.73**	-0.25*	-0.27*	-0.25*	0.26*	0.04	0.26*
L14×T2	-0.02	0.014	-0.007	-0.08	0.02	-0.03	-0.1	-0.08	-0.1	0.10*	0.17*	0.13*
L14×T3	-0.44**	-0.34*	-0.45*	0.80**	0.41*	0.80**	-0.16	0.05	-0.05	-0.26*	-0.11	-0.25
L14×T4	0.27*	0.09*	0.27*	-1.44**	-1.00**	-1.44**	0.51**	0.29*	0.51**	-0.1	-0.09	-0.1
L15×T1	0.14	-0.18	-0.02	1.25**	0.79**	1.02**	-0.16	0.01	-0.07	0.27*	-0.19	0.28*
L15×T2	0.26*	0.19*	0.24*	-1.69**	-1.44**	-1.68**	0.13	0.06	0.1	0.10*	0.23**	0.19*
L15×T3	-0.11	0.04	-0.03	-0.30*	-0.15	-0.29*	0.27*	-0.32*	0.29*	0.18*	0.006	0.09*
L15×T4	-0.29*	-0.05*	-0.29*	0.74**	0.79**	0.75**	-0.24*	0.45**	0.29**	-0.46**	-0.20**	-0.45**
S.E. ±	0.17	0.35	0.12	0.14	0.17	0.12	0.16	0.12	0.11	0.17	0.34	0.12
CD (0.05)	0.35	0.71	0.25	0.29	0.34	0.23	0.33	0.25	0.23	0.33	0.67	0.23

Table 4.5 (e) Estimation of Specific combining ability (SCA) for different traits in okra under two environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Internodal length			Average pod weight			Pods yield/Plant		
Hybrids	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1×T1	-0.07	-0.44	-0.25	-0.94	-0.81	-0.87	0.19	0.22	0.2
L1×T2	-0.03	0.1	0.03	1.13**	0.78**	1.13**	0.20*	-0.84*	-0.31*
L1×T3	0.42*	0.64*	0.53*	0.27	0.61	0.29	0.22*	-0.1	0.05*
L1×T4	-0.31*	-0.31*	-0.30*	-0.46	-0.59	-0.47	0.21*	-0.30*	-0.04*
L2×T1	-0.25	-0.23	-0.26	-0.67	-0.19	-0.45	0.25**	0.43**	0.34**
L2×T2	0.22	0.18	0.2	0.26	0.07	0.27	0.28	-0.24	0.01
L2×T3	-0.29	-0.21	-0.28	-0.46	-0.63	-0.47	0.32	0.11	-0.01
L2×T4	0.32*	0.26*	0.33*	0.86	0.75	0.85	0.27	-0.13	-0.01
L3×T1	0.02	-0.06	-0.02	1.61**	1.88**	1.75**	0.23	-0.58	-0.17
L3×T2	-0.15	0.18	0.01	-0.55	-0.47	-0.56	0.27	0.1	0.02
L3×T3	-0.40**	-0.51**	-0.39**	-0.8	-0.91	-0.8	0.27**	1.62**	0.94**
L3×T4	0.53**	0.39**	0.54**	-0.26	-0.49	-0.24	0.26	-0.11	0.01
L4×T1	-0.13	-0.01	-0.07	-1.09*	-1.13*	-1.09*	0.24*	0.36**	0.32**
L4×T2	0.18	0.1	0.14	0.38	0.43	0.39	0.24	-0.2	-0.05
L4×T3	-0.02	-0.53	-0.007	1.24*	1.36*	1.25*	0.27	-0.46	-0.09
L4×T4	-0.01	0.44	-0.02	-0.53	-0.67	-0.55	0.26	-0.11	0.03
L5×T1	-0.14	-0.2	-0.17	2.10**	1.72**	1.91**	0.15	-0.2	-0.01
L5×T2	0.13	-0.08	0.02	-0.22	-0.17	-0.2	0.2	-0.64	-0.22
L5×T3	0.14*	0.15*	0.14*	-1.30*	-1.21*	-1.30*	0.22	0.57	0.4
L5×T4	-0.127	0.131	0.002	-0.56	-0.32	-0.57	0.24	0.21	0.01
L6×T1	-0.27	-0.4	-0.27	-1.19**	-1.22**	-1.18**	0.13	-0.29	-0.04
L6×T2	-0.17	-0.32	-0.16	-1.36**	-1.31**	-1.36*	0.20**	0.34**	0.27**
L6×T3	-0.14	0.24	-0.15	1.40**	1.34**	1.39**	0.2	0.12	0.01

L6×T4	0.59*	0.48*	0.54*	1.15**	1.19**	1.15**	0.217	0.134	0.001
L7×T1	-0.15	-0.04	-0.09	1.89**	1.77**	1.83**	0.26	0.13	0.03
L7×T2	0.02	0.009	0.01	-1.41**	-1.22**	-1.41**	1.24**	0.95**	1.09**
L7×T3	-0.33**	-0.48**	-0.31**	-0.13	-0.53	-0.12	1.47**	1.14**	1.30**
L7×T4	0.46**	0.52**	0.46**	-0.34	-0.01	-0.35	1.93**	1.26**	1.60**
L8×T1	-0.34**	-0.41**	-0.33**	1.89**	2.04**	1.97**	0.15**	-0.16**	0.01*
L8×T2	0.50**	0.20**	0.50**	-1.41**	-0.21**	-0.32*	0.20	0.29	0.24
L8×T3	-0.12	0.2	0.03	-0.13	-2.95***	-3.2	0.23	0.12	-0.01
L8×T4	-0.03	0.01	-0.008	-0.34*	1.13**	1.39**	0.22	0.11	0.16
L9×T1	-0.31	-0.15	-0.31	2.14**	2.16**	2.15**	0.15	-0.14	0.01
L9×T2	0.24	0.4	0.26	-0.32	0.59	0.57	0.19	0.72*	0.01
L9×T3	-0.05	-0.13	-0.09	-3.20	0.15	-0.30	0.19	-0.48	-0.20
L9×T4	0.12	-0.11	0.004	1.38**	-2.91**	-2.47**	0.21**	0.13**	0.18**
L10×T1	0.16	0.37	0.17	2.20**	0.71**	1.45**	0.17*	-0.67	0.03
L10×T2	-0.61	-0.47	-0.62	0.57**	-1.68**	-1.45**	0.19*	-0.44	-0.12
L10×T3	0.73**	0.59**	0.66**	-0.28*	1.40**	1.33**	0.21*	1.65**	0.93**
L10×T4	-0.28	-0.49	-0.26	-2.49	-0.43	-0.3	0.29**	0.43***	0.36**
L11×T1	1.54**	1.84**	1.69**	0.40**	-1.80**	-2.19**	0.30**	-0.53	-0.11
L11×T2	-0.99**	-0.97**	-1.01**	-1.45**	0.76**	1.09**	0.29	-0.13	-0.01
L11×T3	0.65**	0.42**	0.54**	1.33	0.32	0.45	0.213	-0.221	-0.004
L11×T4	-1.20**	-1.29**	-1.19**	-0.28	0.71	0.64	0.246*	-0.21**	-0.008
L12×T1	0.04*	0.19**	0.11**	-2.19	-0.06	0.18	0.153**	-0.958*	-0.445
L12×T2	0.183	-0.191	-0.004	1.09	-0.19	-0.18	0.18*	-0.11	0.03
L12×T3	0.14**	0.11**	0.12**	0.45	0.63	0.7	0.20*	0.61	0.41
L12×T4	-0.36	-0.11	-0.36	0.64	-0.37	-0.7	0.17*	0.45	0.313
L13×T1	-0.29	-0.43	-0.29	0.18	-2.68**	-2.70*	0.18*	-0.14**	-0.003
L13×T2	0.25	0.48	0.27	-0.17*	1.72**	1.52**	0.24**	0.88**	0.65**

L13×T3	-0.21	-0.04	-0.13	0.69**	0.91**	1.04**	0.24**	-0.66	-0.2
L13×T4	0.25*	-0.003	0.23	-0.7	0.04	0.14	0.25**	0.12**	0.05
L14×T1	-0.001	-0.15	-0.07	-2.71**	-0.2	-1.39**	0.16*	0.85*	0.03*
L14×T2	-0.031	0.001	-0.01	1.52**	-0.13	0.27	0.18	-0.23*	-0.03
L14×T3	0.32	0.4	0.33	1.06	-0.04	0.37	0.19**	-0.12**	-0.01
L14×T4	-0.28	-0.25	-0.28	0.12	0.38	-0.05	0.21*	0.61**	0.41**
L15×T1	0.22	0.15	0.19	-0.03	-2.18**	-1.73**	0.23*	0.15**	-0.003
L15×T2	0.27	0.37	0.27	-0.27*	1.05**	0.82**	0.24**	-0.39**	-0.07*
L15×T3	-0.83**	-0.85**	-0.82*	0.37	-0.48	-0.05	0.27**	-0.40**	-0.06
L15×T4	0.33**	0.32**	0.32**	-0.05*	1.60**	0.77**	0.25**	-0.79**	-0.38**
S.E. ±	0.16	0.32	0.11	0.17	0.34	0.12	0.005	3.502	0.004
CD (0.05)	0.32	0.65	0.23	0.34	0.68	0.24	0.011	6.936	0.007

Table 4.5 (f) Estimation of Specific combining ability (SCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Ascorbic Acid content			Acidity			Dry matter content		
Hybrids	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1×T1	-0.29	-0.42	-0.35	0.003	0.023 **	0.013	0.016	0.031	0.023
L1×T2	-0.83	-0.66	-0.71	-0.01	-0.02**	-0.02*	-0.23	-0.26	-0.25
L1×T3	1.78**	1.20**	1.53**	0.04**	0.04**	0.04**	0.59	0.65	0.62
L1×T4	1.05	-0.318	0.74	-0.02	-0.04**	-0.03**	-0.37	-0.41	-0.39
L2×T1	1.64**	1.05*	1.35**	-0.006	0.014	0.004	0.49	0.49	0.49
L2×T2	-0.18	-0.04	0.1	0.009	0.019 *	0.014	0.18	0.2	0.19
L2×T3	1.74**	0.34**	1.36**	0.001	-0.020 *	-0.01	0.011	0.001	0.005
L2×T4	1.14**	1.01**	1.10**	-0.004	-0.013	-0.008	-0.69	-0.7	-0.69
L3×T1	-0.05	-0.01	-0.04	-0.014	-0.015	-0.015	-0.54	-0.56	-0.55
L3×T2	-1.83	-0.01	-0.86	0.02	0.02**	0.02**	-0.027	0.011	-0.014
L3×T3	-2.57	-0.17	-0.76	-0.004	-0.016	-0.01	1.44**	1.43**	1.43**
L3×T4	0.53	0.02	-0.68	-0.005	0.007	0.002	-0.86	-0.86	-0.86
L4×T1	-2.23	1.62	0.83	0.013	0.02 **	0.02 *	-0.78	-0.76	-0.77
L4×T2	-1.45	-0.11	0.61	-0.002	-0.016	-0.009	-0.67	-0.68	-0.67
L4×T3	1.57	0.36	1.54	-0.007	0.018 *	0.006	0.82	0.83	0.82
L4×T4	-0.34**	-0.25**	1.68**	-0.004	-0.028*	0.006	0.63	0.61	0.62
L5×T1	1.56**	1.43	1.49	0.007	0.02**	0.016	1.52**	1.54**	1.53**
L5×T2	-0.1	0.32	0.33	-0.001	-0.02**	-0.015	1.70**	1.68**	1.69**
L5×T3	-1.09	-0.05	0.98	-0.016	0.027 **	0.005	-3.57**	-3.56**	-3.56**
L5×T4	-1.8	-0.09	-0.57	0.01	-0.023 *	-0.007	0.34	0.33	0.34
L6×T1	-2.57	0.03	0.23	-0.005	-0.018 *	-0.011	0.99	0.98	0.99
L6×T2	0.47	-0.02	-0.3	0.006	0.007	0.007	-0.58	-0.57	-0.58
L6×T3	-2.01	-0.22	-0.37	-0.005	0.002	-0.002	0.02	0.03	0.02

L6×T4	-1.38	0.4	0.43	0.004	0.009	0.006	-0.44	-0.43	-0.43
L7×T1	1.58**	1.01**	1.35**	-0.001	0.012	0.006	0.6	0.61	0.61
L7×T2	-0.29	-0.04	-0.14	0.007	-0.013	-0.003	-0.66	-0.66	-0.66
L7×T3	1.47**	1.87	1.63**	-0.001	-0.005	-0.003	0.02	0.01	0.01
L7×T4	4.21**	3.74**	3.98**	-0.005	0.006	0.001	0.03	0.03	0.03
L8×T1	-0.18**	0.10*	0.06	-0.003	-0.028**	-0.015	1.27**	1.25**	1.26**
L8×T2	-0.71	0.03	-0.48	0.02*	0.007	0.016	-1.49**	-1.47**	1.26**
L8×T3	1.80**	0.27**	1.42**	-0.016	0.032**	0.008	-1.24**	-1.23**	-1.24**
L8×T4	1.00	0.01	0.76	-0.007	-0.011	-0.009	1.46**	1.45**	1.46**
L9×T1	1.54	0.33	0.86	-0.008	0.002	-0.003	0.24	0.23	0.23
L9×T2	-0.04	0.98	0.56	0.009	0.024 **	0.017 *	-0.31	-0.29	-0.3
L9×T3	1.68**	-0.57**	1.07**	0.012	-0.002	0.005	-0.375	-0.37	-0.37
L9×T4	1.24	0.03	0.76	-0.013	-0.025**	-0.019 *	0.44	0.43	0.43
L10×T1	-0.46	-0.43	-0.44	-0.002	-0.022 *	-0.012	-0.68	-0.69	-0.69
L10×T2	-0.18	0.61	0.35	0.002	-0.007	-0.003	-0.64	-0.64	-0.64
L10×T3	-0.71	-0.66	-0.7	-0.003	-0.012	-0.007	-0.9	-0.91	-0.9
L10×T4	5.57**	4.31**	5.02**	0.003	0.041**	0.022 *	2.22**	2.25**	2.24**
L11×T1	1.62**	1.69**	1.64**	0.012	-0.008	0.002	-1.06**	-1.06**	-1.06**
L11×T2	1.22	-0.48	0.94	-0.01	0.006	-0.002	0.69	0.69	0.69
L11×T3	-0.46	0.85	0.43	-0.001	-0.019 *	-0.01	-0.48	-0.49	-0.48
L11×T4	-1.8	-0.85	-1.04	-0.002	0.021 *	0.01	0.85	0.86	0.85
L12×T1	-2.57**	1.48**	-1.76**	0.003	0.006	0.004	-0.85	-0.85	-0.85
L12×T2	1.62**	0.69**	1.37**	-0.006	-0.01	-0.008	1.48**	1.47**	1.48**
L12×T3	2.79**	1.97**	2.34**	0.006	0.002	0.004	2.57**	2.26**	2.34**
L12×T4	-0.19	0.98	0.54	-0.002	0.003	0.002	-3.19**	-3.19**	-3.19**
L13×T1	-0.71	-0.57	-0.61	-0.003	-0.014	-0.009	-0.013	-0.019	-0.016

L13×T2	1.82**	1.03	1.47**	-0.002	0.01	0.004	0.46	0.47	0.46
L13×T3	1.01	-0.43	0.56	-0.007	-0.032**	-0.019 *	1.46**	1.44**	1.45**
L13×T4	1.44	0.61	1.06	0.012	0.036**	0.024 **	-1.92**	-1.89**	-1.90**
L14×T1	-0.04	-0.66	0.33	-0.003	-0.014	-0.008	-0.75	-0.76	-0.76
L14×T2	1.54**	1.01	1.30**	-0.005	0.01	0.003	0.01	0.02	-0.76
L14×T3	1.22***	0.03	0.64	-0.002	-0.005	-0.004	-0.27	-0.27	-0.27
L14×T4	-1.46**	1.25**	-1.34**	0.01	0.009	0.009	1.01**	1.02**	1.01**
L15×T1	-1.80**	-1.47**	-1.65**	0.006	0.012	0.009	-0.45	-0.43	-0.44
L15×T2	-2.57**	-1.23**	-1.98**	-0.036	-0.01	-0.023**	0.082	0.059	0.07
L15×T3	0.47	0.45	0.46	0.002	-0.019 *	-0.008	-0.1	-0.11	0.07
L15×T4	-2.01**	-2.23*	-2.16**	0.028 *	0.032 *	0.030 **	0.47	0.49	0.48
S.E. ±	0.12	0.16	0.11	0.017	0.025	0.0108	0.16	0.33	0.11
CD (0.05)	0.36	0.43	0.29	0.034	0.049	0.0108	0.33	0.67	0.23

Table 4.5 (g) Estimation of Specific combining ability (SCA) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Firmness			Chlorophyll content			Mucilage content		
Hybrids	E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
L1×T1	-0.46**	-0.45 **	-0.46**	0.47	0.77	0.62	-0.94	-0.92	-0.93
L1×T2	0.07	0.05	0.06	-0.41	-0.48	-0.43	-0.1	-0.13	-0.11
L1×T3	-0.03	0.02	-0.002	-0.2	-0.43	-0.19	1.50 **	1.55 **	1.52**
L1×T4	0.42 **	0.37 **	-0.002	0.14	0.15	0.14	-0.45	-0.49	-0.47
L2×T1	0.007	0.007	0.007	-0.32	-0.4	-0.32	-0.19	-0.19	-0.19 *
L2×T2	-0.24 *	-0.22	-0.23 *	-1.77**	-1.33**	-1.77**	-0.61	-0.6	-0.6
L2×T3	-0.09	-0.1	-0.09	1.43 **	1.22**	1.42**	-0.87	-0.88	-0.87
L2×T4	0.32 **	0.32 **	0.32 **	0.65	0.5	0.67	1.68 **	1.67 **	1.67**
L3×T1	0.05	0.03	0.04	-0.61	-0.65	-0.61	-0.2	-0.22	-0.21 *
L3×T2	-0.29 *	-0.26 *	-0.28 **	-0.93	-0.64	-0.92	-0.06	-0.03	-0.04
L3×T3	0.02	0.01	0.01	2.42**	2.14 **	2.28**	0.97	0.96	0.97
L3×T4	0.22	0.22	0.01	-0.87	-0.84	-0.87	-0.71	-0.71	-0.71
L4×T1	-0.16	-0.14	0.01	0.99	1.12	0.98	-0.09	-0.07	-0.08
L4×T2	-0.07	-0.08	-0.08	-1.02	-0.73	-1.02	-0.05	-0.06	-0.06
L4×T3	0.17	0.18	0.18 *	0.45	0.45	0.44	-1.32 **	-1.32**	-1.32 **
L4×T4	0.06	0.05	0.05	-0.42	-0.83	-0.4	1.48 **	1.46**	1.47**
L5×T1	-0.12	-0.1	-0.11	2.03**	2.04 **	2.03**	-1.14**	-1.13**	-1.13**
L5×T2	0.43 **	0.41 **	0.42**	0.37**	0.15	0.37**	-1.18**	-1.20 **	-1.19**
L5×T3	-0.33 **	-0.32**	-0.32 **	-1.72**	-1.75 **	-1.72**	1.41**	1.43**	1.42**
L5×T4	0.02	0.01	0.01	-0.68	-0.44	-0.67	0.91	0.9	0.9
L6×T1	-0.003	-0.01	-0.01	-0.69	-0.83	-0.67	-0.12	-0.14	-0.13
L6×T2	0.19	0.19	0.19*	0.78	1.00	0.77	-0.59	-0.59	-0.59

L6×T3	-0.19	-0.18	-0.19 *	-1.42**	-1.30**	-1.42**	0.44	0.44	0.44
L6×T4	0.004	0.011	0.008	1.33 **	1.14**	1.32**	0.28	0.29	0.28
L7×T1	-0.33 **	-0.32 **	-0.33 **	0.26 *	0.11	0.28*	-0.14	-0.13	-0.14
L7×T2	0.17	0.17	0.17	-0.24 *	-0.28 *	-0.23*	2.27**	2.26**	2.27 **
L7×T3	-0.003	-0.006	-0.005	-0.87	-0.55	-0.89	-1.39 **	-1.39**	-1.39 **
L7×T4	0.16	0.16	0.16	0.85	0.72	0.85	-0.73	-0.73	-0.73
L8×T1	0.006	-0.012	-0.003	-1.57**	-1.42**	-1.55**	-0.49	-0.5	-0.49
L8×T2	-0.007	0.005	-0.001	-1.46**	-1.54 **	-1.46**	-0.56	-0.55	-0.55
L8×T3	-0.05	-0.038	-0.044	1.65**	1.74 **	1.69**	0.76	0.77	0.77
L8×T4	0.05	0.045	0.047	1.38 **	1.226**	1.38**	0.28	0.28	0.28
L9×T1	-0.038	-0.039	-0.038	0.12	-0.02	0.04	-0.13	-0.13	-0.13
L9×T2	-0.021	-0.002	-0.011	1.63 **	1.67 **	1.63**	1.52**	1.54**	1.53 **
L9×T3	-0.18	-0.18	-0.18 *	-1.74**	-1.60**	-1.73**	-0.89	-0.89	-0.89
L9×T4	0.24 *	0.22	0.23 *	-0.005	-0.049	-0.027	-0.49	-0.51	-0.5
L10×T1	0.48**	0.47 **	0.47 **	-1.25**	-0.92**	-1.26**	-0.59	-0.61	-0.6
L10×T2	0.06	0.05	0.05	1.45**	1.31**	1.45**	-0.99	-0.99	-0.99
L10×T3	-0.43**	-0.45**	-0.44**	0.57	0.56	0.59	0.75	0.74	0.74
L10×T4	-0.1	-0.07	-0.09	-0.77	-0.94	-0.79	0.83	0.86	0.85
L11×T1	0.11	0.11	0.11	1.64**	1.36**	1.47**	1.37**	1.37**	1.37**
L11×T2	0.29*	0.29 *	0.29 **	-0.93**	-1.19**	-1.08**	0.45	0.45	0.45
L11×T3	-0.29 *	-0.31 *	-0.30 **	0.36	0.52	0.46	-1.02**	-1.03**	-1.02**
L11×T4	-0.11	-0.1	-0.1	-1.07	-0.69	-0.98	-0.8	-0.79	-0.8
L12×T1	0.23	0.23 *	0.23*	-0.01	-0.19	-0.09	-0.92	-0.92	-0.92
L12×T2	-0.22	-0.22	-0.22 *	0.2	0.24*	0.21*	-0.09	-0.09	-0.09
L12×T3	0.23	0.23	0.23 *	-0.62	-1.03	-0.64	0.89	0.89	0.89
L12×T4	-0.24 *	-0.24 *	-0.24*	0.42	0.98	0.43	0.12	0.12	0.12

L13×T1	0.27 *	0.26 *	0.26 **	1.04**	0.73**	1.02**	0.88	0.88	0.88
L13×T2	-0.60**	-0.60**	-0.60**	-0.61	-0.75	-0.59	1.14**	1.14**	1.14**
L13×T3	0.36*	0.34*	0.35**	-0.02	0.46	-0.02	0.11	0.08	0.1
L13×T4	-0.032	-0.005	-0.018	-0.4	-0.44	-0.4	-2.14**	-2.11**	-2.13**
L14×T1	-0.42**	-0.43**	-0.43**	1.04**	1.22**	1.03**	1.66 **	1.66 **	1.66**
L14×T2	0.113	0.118	0.115	0.39	0.26	0.39	-0.59	-0.59	-0.59
L14×T3	-0.13	-0.14	-0.13	-0.62	-0.37	-0.6	-0.78	-0.79	-0.78
L14×T4	0.45**	0.45**	0.45**	-0.81	-1.12	-0.82	-0.28*	-0.27*	-0.28**
L15×T1	-0.42**	0.40**	0.39**	-3.14**	-2.91**	-3.02**	1.08**	1.09**	1.09**
L15×T2	0.11	0.1	0.11	2.55**	2.32**	2.44**	-0.52	-0.54	0.53
L15×T3	0.50**	0.94**	0.78**	0.34	-0.05	0.14	-0.57	-0.58	-0.58
L15×T4	-1.84**	-1.45**	-1.62**	0.24	0.63	0.43	0.01	0.03	0.02
S.E. ±	0.16	0.66	0.11	0.16	0.33	0.11	0.17	0.35	0.12
CD (0.05)	0.33	0.66	0.23	0.33	0.67	0.23	0.35	0.71	0.25

4.5 Genetic Variance

4.5.1 Growth parameters

4.5.1.1 Plant height

The data presented in table 4.6 & fig.4.3 that the genotypical variance (GV) in both environments and pooled was recorded (62.30, 67.70 and 65.00) while phenotypic variance (PV) was observed (62.80, 67.70 and 65.20) and environmental variance (EV) (0.54, 0.51 and 0.53) respectively . The broad sense heritability inenvironment 1 was (99.10%) while it was (99.3 %) in environment 2 and average of both year was (Pooled) (99.60%). The genetic advancement for both environment was (16.20 and 16.90) while (16.60) in pooled whereas genetic advance as percent of mean (15.80% and 16.80%) in both environment while (16.30%) for pooled respectively. The magnitude of additive variance was greater than dominant variance. Additive variance in both environment and pooled was recorded as (46.70, 51.80 and 49.30) while dominant variance was (20.10, 31.40 and 25.80) respectively. The contribution towards plant height trait was recorded maximum by lines in both environment and pooled (81.10%, 80.20% and 80.70%) while the tester contribution was (9.5%, 8.4% and 8.9%) whereas the interaction was (9.30%, 11.40% and 10.40%) respectively.

4.5.1.2 Number of branches per plant

The genetic advancement for number of branches per plant in both environment was (3.41, 3.37 and 3.39) in pooled whereas genetic advance as percent of mean (39.60% and 42.80%) in both environment while (41.20%) for pooled respectively. The magnitude of dominant variance was greater than additive variance. Additive variance in both environment and pooled was recorded as (0.89, 0.98 and 0.93) while dominant variance was (3.86, 5.57 and 4.72) respectively. The genotypical variance in both environments and pooled was recorded (2.83, 2.69 and 2.76) while phenotypic variance noticed (2.92, 2.71 and 2.81) and environmental variance (EV) (0.08, 0.09 and 0.08) respectively. The broad sense heritability in environment 1 was (97.10%) while it was (99.50 %) in environment 2 and in Pooled it was (98.30%). The contribution towards number of branches per plant was recorded maximum by lines inboth environment and pooled (45.80%, 36.30% and 41.00%) while the tester contribution was (4.9%, 5.9% and 5.4%) whereas the interaction was (49.30%, 57.80% and 53.50%) respectively.

4.5.1.3 Stem diameter

The genotypical variance (GV) in both environments and pooled was recorded (2.23, 2.15 and 2.19) while phenotypic variance (GV) noticed (2.35, 2.17 and 2.26) w h e r e a s environmental variance (EV) (0.11, 0.11and 0.11) respectively. The broad sense heritability in environment 1 was (95.10%) while it was (99.30 %) in environment 2 and average of both year was (Pooled) (97.20%). The genetic advancement for both environment was (3.00 & 3.01) and for pooled (3.01) whereas genetic advance as percent of mean (35.10% and 38.70%) in both environment while (36.90%) for pooled respectively. The magnitude of additive variance was lesser than dominant variance. Additive variance in both environment and pooled was recorded as (1.08, 0.85 and 0.96) while dominant variance was (2.55, 4.32 and 3.43) respectively. The contribution towards stem diameter was recorded maximum by lines in both environment and pooled (65.5%, 47.60% and 56.50%) while the tester contribution was (2.20%, 3.00% and 2.60%) whereas the interaction was (32.40%, 49.50% and 40.90%) respectively.

4.5.1.4 Leaf blade length

The data recorded for genotypical and phenotypical and environmental variance for leaf blade length in environment 1 was (2.70, 2.78 and 0.07) while in environment 2 it was (2.42 ,2.44 and 0.08) and for the pooled of both years was (2.56,2.61 and 0.08) respectively. The broad sense heritability in environment 1 recorded (97.20%) and in environment 2 it was (99.40%) while for pooled it was (98.30%). The genetic advancement and it’s percent of mean in environment 1 recorded (3.33 and 27.50%), forenvironment 2 it was noted (3.20 and 32.9%) while in pooled data it was (3.27 and 30.2%). The dominance variance was effectively higher than additive variance in both environments and also in pooled. The dominant and additive variance was ion environment 1(4.42 and 1.74) while in environment 2 it was (4.76 and 1.83) whereas for pooled it was recorded (4.59 and 1.79) respectively. The contribution of lines was quite higher for development of leaf blade length character then tester. In environment 1 lines, tester and its interaction was(60.2%, 4.9% and 34.9%) while in environment 2 it was (57.80%, 6.30% and 36.00%) and for average of both years (Pooled)it was (59.00%, 5.60% and 35.40%).

4.5.1.5 Leaf blade width

The genotypical variance (GV) in both environments and pooled was (6.47, 6.42 and 6.45) while phenotypic variance (PV) noticed (6.54, 6.43 and 6.49) whereas environmental variance (EV) recorded (0.06, 0.06 and 0.06) respectively. The broad sense heritability indicated, highly heritable nature of trait, in environment 1 was (99.00%) while it was (99.70 %) in environment 2 and average of each year was (Pooled) (99.40%). The contribution towards leaf blade width was recorded maximum for lines in both environment and pooled (27.60%, 29.60% and 28.60%) while the tester contribution was (11.6%, 10.8% and 11.20%) whereas the interaction was (60.70%, 59.60%and 60.20%) respectively. The magnitude of additive variance was lesser than dominant variance. Additive variance in both environment and pooled was recorded as (1.92, 1.87 and 1.90) while dominant variance was (4.48, 4.78 and 4.63) respectively. The genetic advancement for each environment was (5.22 & 5.21) and for pooled (5.21) whereas genetic advance as percent of mean (30.50%) and (33.20%) in both environment while (31.8%) for pooled respectively.

4.5.1.6 Petiole length

The contribution of lines was prominent for development of petiole length thentester. In environment 1 lines, tester and its interaction was (31.70%, 4.90% and 63.30%) while in environment 2 it was (30.1%, 5.3% and 64.6%) and for average of both years(Pooled) it was (30.90%, 5.10% and 64.00%). The data recorded for environmental, genotypical and phenotypical variance for petiole length in environment 1 was (5.38,5.43 and 0.05) while in environment 2 it was (5.24,5.26 and 0.04), the for pooled of both years it was (0.05, 5.31 and 5.35) respectively. The broad sense heritability in environment 1 recorded (99.00%) and in environment 2 it was (99.60%) while for pooled it was (99.30%). The genetic advancement and it's percent of mean in environment 1 recorded (4.76 and 41.00%), for environment 2 it was noted (4.71 and 43.60%) while in pooled data it was (4.73 and 42.30%). The dominance variance was effectively extortionate additive variance in both environments and also in pooled. Environment 1,dominant and additive variance was (17.20 and 2.36) while in environment 2 it was (17.40 and 2.32) whereas for pooled it was recorded (17.30 and 2.34) respectively.

4.5.1.7 Days to first flowering

The genetic advancement for days to first flowering, in both environment was (9.95 & 9.84) and for pooled (9.89) whereas genetic advance as percent of mean (20.70% and 19.50%) in both environment while (20.10%) for pooled respectively. The magnitude of dominant variance was eminent than additive variance. Additive variance in both environment and pooled was recorded as (15.90, 14.50 and 15.20) while dominant variance was (45.40, 45.80 and 45.60) respectively. The phenotypical varianceis close and higher then genotypical and environmental variance. The genotypical variance (GV) in both environments and pooled was recorded (23.50, 22.80 and 23.10) while phenotypic variance (PV) was observed (23.60, 22.80 and 23.20) whereas environmental variance (EV) (0.15, 0.12 and 0.14) respectively. The heritability percentage is very high for earlinessin flowering, which can be utilized for development of early hybrids and germplasm. The broad sense heritability in environment 1 was (99.30%) while it was (99.90%) in environment 2 and in pooled it was (99.60%). The contribution towards days to first flowering was recorded ma×imum by lines in both environment and pooled (56.30%, 53.10% and 54.70%) while the tester contribution was (5.80%, 6.10% and 6.00%) whereas the interaction was (37.90%, 40.70% and 39.30%) respectively.

4.5.1.8 Days to first fruit set

The genotypical variance is close and higher then phenotypical and environmental variance for days to first set. The genotypical variance (GV) in both environments and pooled was recorded (24.60, 23.70 and 24.10) while phenotypic variance (PV) noticed (24.80, 23.70 and 24.20) whereas environmental variance (EV) (0.20, 0.18 and 0.19) respectively. The contribution towards days to first set was recorded elevated by lines in both environment and pooled (69.50%, 66.70% and 68.10%) while the tester contribution was (0.05%, 0.29% and 0.17%) whereas the interaction was (30.50%, 33.00% and 31.80%) respectively. The genetic advancement for days to first set, in both environment was (10.20, 10.00 and 10.10) in pooled whereas genetic advance as percent of mean (19.30% and 17.70%) in both environment while (18.50%) for pooled respectively. The magnitude of dominant variance was eminent than additive variance. Dominant variance in both environment and pooled was recorded as (38.50, 38.90 and 38.70) while additive variance was (14.00, 12.70 and 13.30) respectively. The heritability percentage is very high for earliness in fruit setting. The broad sense heritability in environment 1 was (99.20%) while it was (99.90 %) in environment 2 and in pooled it was (99.60%).

4.5.1.9 Days to first fruit picking

The genetic advancement for days to first picking, in both environment was (10.70,10.40 and 10.50) in pooled whereas genetic advance as percent of mean (18.00% and 16.50%) in both environment while (17.3%) for pooled respectively. The magnitude of dominant variance was eminent than additive variance. Dominant variance in both environment and pooled was recorded as (39.60, 36.50 and 38.10) while additive variance was (18.40, 16.00, 17.20) respectively. The phenotypical variance is close and higher then genotypical and environmental variance. The genotypical variance (GV) for both environments and pooled was recorded was (27.10, 25.40 and 26.30) while phenotypic variance (PV) noticed (27.30, 25.40 and 26.40) whereas environmental variance (EV) (0.20, 0.17 and 0.18) respectively. The heritability percentage is very high for earliness in fruit picking, which can be utilized for development of hybrids for early market. The broad sense heritability in environment 1 was (99.3%) while it was (99.9%) in environment 2 and in pooled it was (99.6%). The contribution towards days to first fruit picking was recorded maximum by lines in both environment and pooled (74.2%, 73.2% and 73.7%) while the tester contribution was (0.19%, 0.18% and 0.19%) whereas the interaction was (25.6%, 26.6% and 26.1%) respectively.

4.5.2 Yield Parameters

4.5.2.1 Number of flowers per plant

The genotypical variance (GV) for number of flowers per plant in both environments and pooled was recorded (6.33, 6.08 and 6.21) while phenotypic variance (PV) noticed (6.85, 6.09 and 6.34) whereas environmental variance (EV) (0.25, 0.24 and 0.25) respectively. The broad sense heritability indicated, highly heritable nature of trait, in environment 1 was (96.20%) while it was (99.80%) in environment 2 and average of both year was (Pooled) (98.00%).The contribution towards number of flowers per plant was recorded maximum for lines in both environment and pooled (23.60%, 22.80% and 23.20%) while the tester contribution was (13.00%, 9.00% and 11.00%) whereas the interaction was (63.40%, 68.20% and 65.80%) respectively. The magnitude of additive variance was lesser than dominant variance. Additive variance in both environment and pooled was recorded as (3.20, 2.44 and 2.82) while dominant variance was (15.10, 16.30 and 15.70) respectively. The genetic advancement for both environment was (5.08, 5.07 and 5.08) in pooled whereas genetic advance as percent of mean (29.50% and 31.00%) in both environment while (30.20%) for pooled respectively.

4.5.2.2 Number of pods per plant

The data recorded for genotypical, phenotypical and environmental variance for number of pods per plant in environment 1 was (7.51,7.61 and 0.09) while in environment 2 it was (7.60,7.62 and 0.08) the pooled of both years was, (7.56 ,7.61 and 0.09) respectively. The broad sense heritability in environment 1 recorded (98.7%) and in environment 2 it was (99.8%) while for pooled it was (99.3%). The genetic advancement and it's percent of mean in environment 1 recorded (5.61 and 35.5%), for environment 2 it was noted (5.68 and 37.9%) while in pooled data it was (5.64 and 36.7%) respectively. The dominance variance was effectively higher than additive variance in both environments and also in pooled. Dominant and additive variancein environment1 was (16.40 and 1.68) while in environment 2 it was (18.90 and 3.05) whereas for pooled it was recorded (17.6 and 2.36) respectively. The contribution of lines was quite higher for development of number of pods per plant trait then tester. Inenvironment 1 lines, tester and its interaction was (47.8%, 2.2% and 50.1%)

while in environment 2 it was (43.3%, 2.6% and 54.2%) and for average of both years (Pooled)it was (45.5%, 2.4% and 52.1%) respectively.

4.5.2.3 Pod length

The broad sense heritability for pod length in environment 1 were recorded (97.2%) and in environment 2 (99.2%) while for pooled (98.2%). The genetic advancement andits percent of mean in environment 1 recorded (2.86 and 27.8%) for environment 2 it was noted (2.66 and 29.6%) while in pooled data it was (2.76 and 28.7%).Thedominance variance was close and higher with additive variance in both environments and also in pooled. The dominant and additive variance in environment1 was (0.75 and 0.70) while in environment 2 it was (3.23 and 1.15) whereas for pooled it was recorded (1.99 and 0.92) respectively. The contribution of lines was prominent for development of pod length then tester. In environment 1 lines, tester and its interactionwas (70.7%, 1.3% and 28.0%) while in environment 2 it was (63.5%, 2.6% and 33.9%)and for average of both years (Pooled) it was (67.1%, 2.0% and 31.0%). The data recorded for genotypical, phenotypical and environmental variance for pod length in environment 1 was (1.98, 2.03 and 0.057,) while in environment 2 it was, (1.69, 1.70 and 0.045) and for pooled of both years it was (1.83, 1.87 and 0.051) respectively.

4.5.2.4 Number of first fruiting Node

The genotypical variance (GV) in both environments and pooled was recorded (0.41, 0.43 and 0.42) while phenotypic variance (PV) noticed (0.42, 0.46 and 0.44) whereas environmental variance (EV) (0.025,0.022 and 0.023) respectively. The broad sense heritability for number of first fruiting node in environment 1 was (94.4%) while it was (96.6%) in environment 2 and average of both year was (Pooled) (95.5%). The genetic advancement for both environment was (1.29, 1.33 and 1.31) in pooled whereas genetic advance as percent of mean (24.3% and 29.8%) in both environment while (27.1%) for pooled respectively. The magnitude of additive variance was greater than dominant variance. Additive variance in both environment and pooled was recorded as(0.49, 0.42 and 0.45) while dominant variance was (0.11,0.06 and 0.09) respectively. The contribution towards number of first fruiting node was recorded maximum by testers in both environment and pooled (48.9%, 49.6% and 49.3%) while the tester contribution was(30.4%, 34.7% and 32.6%) whereas the interaction was (20.6%, 15.6% and 18.1%) respectively.

4.5.2.5 Number of nodes per plant

The data recorded for number of nodes per plant in environmental, genotypical and phenotypical variance in environment 1 was (0.078, 9.09 and 9.17) while in environment 2 it was (0.071, 9.25 and 9.26) the pooled of both years was (0.075, 9.17 and 9.22) respectively. The broad sense heritability in environment 1 recorded (99.2%) and in environment 2 it was (99.90%) while for pooled it was (99.50%). The genetic advancement and its percent of mean in environment 1 recorded (6.19 and 26.4%), forenvironment 2 it was noted (6.26 and 29.8%) while in pooled data it was (6.22 and 28.10%). The dominance variance was lesser than additive variance in both environments and also in pooled. The dominant and additive variance in environment 1 was (0.89 and 7.78) while in environment 2 it was (0.71 and 8.11) whereas for pooled it was recorded (0.80 and 7.95) respectively. The contribution of lines was higher for development of nodes per plant trait then tester. In environment 1 lines, tester and its interaction was (57.50%, 34.50% and 8.00%) while in environment 2it was (58.00%, 36.00% and 6.40%) and for average of both years (Pooled) it was (57.70%,35.20% and 7.20%) respectively.

4.5.2.6 Number of ridges per pod

The genotypical variance (GV) for number of ridges per pod showed in both environments and pooled was recorded (0.59, 0.79 and 0.69) while phenotypic variance (PV) noticed (0.62, 0.80 and 0.71) whereas environmental variance (EV) (0.03, 0.03 and 0.03) respectively. The broad sense heritability indicated, highly heritable nature of trait, in environment 1 was (94.20%) while it was (97.90%) in environment 2 and average of both year was (Pooled) (96.00%). The genetic advancement for number of ridges per pod in both environment was (1.53, 1.81 and 1.67) in pooled whereas genetic advance as percent of mean (26.30% and 35.70%) in both environment while (31.00%) for pooled respectively. The contribution towards total number of ridges was recorded maximum for lines in both environment and pooled (45.70%, 43.00% and 44.40%) while the tester contribution was (33.30%, 35.90% and 34.60%) whereas the interaction was (20.90%, 21.00% and 21.00%) respectively. The magnitude of additive variance was greater than dominant variance. Additive variance in both environment and pooled was recorded as (0.64, 0.78 and 0.71) while dominant variance was (0.20, 0.23 and 0.21) respectively.

4.5.2.8 Pod diameter

The broad sense heritability for pod diameter in environment 1 recorded was (88.6%) and in environment 2 it was (90.6%) while for pooled it was (89.6%). The genetic advancement and its percent of mean in environment 1 recorded (0.61 and 31.9%) for environment 2 it was noted (0.75 and 41.8%) while in pooled data it was (0.68 and 36.9%).The additive variance was superior with dominance variance in both environments and also in pooled. The dominant and additive variance in environment 1 was in (0.03 and 0.05) while in environment 2 it was (0.04 and 0.06) whereas for pooled it was recorded (0.03 and 0.05) respectively. The contribution of lines was prominent for development of pod diameter then tester. In environment 1 lines, tester and its interaction was (63.6%, 7.4% and 29.0%) while in environment 2 it was (69.4%,4.9% and 25.6%) and for average of both years (Pooled) it was (66.5%, 6.1% and 27.3%) respectively. The data recorded for genotypical, phenotypical and environmental variance for pod diameter in environment 1 was (0.10, 0.11 and 0.01) while in environment 2 it was (0.15, 0.16 and 0.01) and for pooled of both years it was(0.12, 0.14 and 0.01) respectively.

4.5.2.9 Internodal length

The genotypical variance (GV) for internodal length in both environments and pooled was recorded (0.56, 0.64 and 0.60)while phenotypic variance (PV) noticed (0.57, 0.66 and 0.61) whereas environmental variance (EV) (0.01, 0.01 and 0.01) respectively. The broad sense heritability in environment 1 was (97.60%) while it was (97.90%) in environment 2 and average of both years i.e., pooled was (97.70%). The genetic advancement for both environment was (1.52, 1.64 and 1.58) in pooled whereas genetic advance as percent of mean (31.30% and 36.60%) in both environment while (33.90%) for pooled respectively.The magnitude of additive variance was higher than dominant variance. Additive variance in both environment and pooled was recorded as (0.38, 0.51 and 0.44) while dominant variance was (0.24, 0.28 and 0.26) respectively. The contribution towards internodal length was recorded ma×imum by lines in both environment and pooled (41.10%, 38.70% and 39.90%) while the tester contribution was (25.80%, 29.10% and 27.40%) whereas the interaction was (33.10%, 32.20% and 32.60%) respectively.

4.5.2.10 Average pod weight

The contribution of tester was prominent but closer to lines for development of average pod weight. In environment 1 lines, tester and its interaction was (38.7%, 39.3% and 22.0%) while in environment 2 it was (39.0%, 39.2% and 21.8%) and for average of both years *i.e.*, pooled was (38.9%, 39.2% and 21.9%). The data recorded for genotypical, phenotypical and environmental variance indicated that phenotypical variance (PV) was higher and very close to genotypical variance (GV) for average pod weight in environment 1 was (7.31, 7.34 and 0.03) while in environment 2 it was (7.35,7.36 and 0.02) and for pooled of both years it was (7.33, 7.35 and 0.02) respectively. The broadsense heritability in environment 1recorded (99.6%) and in environment 2 it was(99.8%) while for pooled it was (99.7%). The genetic advancement and its percent of mean in environment 1 recorded (5.56 and 31.5%) for environment 2 it was noted (5.58 and 34.3%) while in pooled data it was (5.57 and 32.9%). The dominance variance was effectively extortionate additive variance in both environments and also in pooled.The dominant and additive variance in environment 1 was (8.24 and 7.89) while in environment 2 it was (8.03 and 6.57) whereas for pooled it was recorded (8.14 and 7.23) respectively.

4.5.2.11 Pod yield/Plant

The phenotypical variance (PV) is close and higher then genotypical and environmental variance for pod yield per plant. The genotypical variance (GV) in both environments and pooled was recorded (0.0024, 0.0018 and 0.0021) while phenotypic variance noticed (0.002, 0.001 and 0.002) whereas environmental variance (EV) was (0.012, 0.011 and 0.011) respectively. The contribution towards pod yield per plant was recorded elevated by lines in both environment and pooled (70.70%, 69.60% and 70.20%) while the tester contribution was (22.40%, 21.50% and 21.90%) whereas the interaction was (6.87%, 8.83% and 7.85%) respectively. The genetic advancement for pod yield per plant, in both environment was (0.09, 0.08 and 0.09) in pooled whereas genetic advance as percent of mean (45.50% and41.50%) in both environment while (43.50%) for pooled respectively. The magnitude of dominant variance was eminent than additive variance. Dominant variance in both environment and pooled was recorded as (0.002, 0.003 and 0.002) while additive variance was (0.0014, 0.0017 and 0.0016) respectively. The broad sense heritability inenvironment 1 was (94.60%) while it was (99.30%) in environment 2 and in Pooled it was (96.90%).

4.5.3 Biochemical Parameters

4.5.3.1 Ascorbic acid content

The broad sense heritability for ascorbic acid content presented in the table 4.6 & fig. 4.3 in environment 1 recorded (99.80%) and in environment 2 it was (99.50%) while for pooled it was (99.70%). The genetic advancement and its percent of mean in environment 1 recorded (5.97 and 39.1%), for environment 2 it was noted (5.99 and 43.70%) while in pooled data it was (5.98 and 41.40%). The additive variance was and higher than dominance variance in both environments and also in pooled. The dominant and additive variance in environment 1 was (0.61 and 6.30) while in environment 2 it was (0.62 and 6.28) whereas for pooled it was recorded (0.61 and 6.29) respectively. The contribution of lines was prominent for development of ascorbic acid then tester. In environment 1 lines, tester and its interaction was (72.30%, 22.20% and 5.14%) while in environment 2 it was (72.40%, 22.00% and 5.55%) and for average of both years *i.e*., pooled it was (72.30%, 22.10% and 5.34%) respectively. The data recorded for genotypical, phenotypical and environmental variance for ascorbic acid in environment 1 was (8.42 and 8.43 and 0.01) while in environment 2 it was (8.46, 8.48 and 0.01) and for pooled of both years it was (8.44,8.45 and 0.01) respectively.

4.5.3.2 Acidity

The broad sense heritability for acidity in environment 1 recorded was (92.6%) and in environment 2 it was (95.4%) while for pooled it was (94.0%). The genetic advancement and it's percent of mean in environment 1 was recorded (0.08 and 35.6%)for environment 2 it was noted (0.09 and 46.2%) while in pooled data it was (0.08 and 40.9%). The additive variance was lesser than dominance variance in both environments and also in pooled. The dominant and additive variance was in environment 1 (0.0030 and 0.0015) while in environment 2 it was (0.0020 and 0.0036) whereas for pooled it was recorded (0.0025 and 0.0026) respectively. The contribution of lines was prominent for acidity then tester. In environment 1 lines, tester and its interaction was (54.3%, 36.6% and 9.18%) while in environment 2 it was (38.9%, 39.3% and 21.9%) and for average of both years *i.e*., pooled it was (46.6%, 37.9% and 15.5%). The data recorded for genotypical, phenotypical and environmental variance for acidity in environment 1 was (0.0024,0.0029 and 0.0031) while in environment 2 it was (0.0031, 0.0022 and 0.0039) and for pooled of both it was (0.0028 and 0.0026 and 0.0035) respectively.

4.5.3.3 Dry matter content

The additive variance was effectively extortionate dominance variance in both environments and also in pooled. The additive and dominance variance in environment 1 was (8.43 and 1.71) while in environment 2 it was (8.42 and 1.52) whereas for pooledit was recorded (8.42 and 1.61) respectively. The contribution of lines was prominent but closer to the tester for development of dry matter content. In environment 1 lines, tester and its interaction was (57.20%, 21.90% and 10.90%) while in environment 2 it was(67.60%, 21.60% and 10.80%) and for average of both years i.e., pooled it was (67.40%, 21.70% and 10.90%). The data recorded for environmental, genotypical and phenotypical variance indicated that phenotypical variance was higher and very close to genotypicalvariance for dry matter, in environment 1 it was (0.09,12.00 and12.10) while in environment 2 it was (0.08, 11.90 and 12.40) and for pooled of both years it was (0.09, 12.00 and 12.20) respectively. The broad sense heritability in environment 1 recorded (99.20%) and in environment 2 it was (99.90%) while for pooled it was (99.60%). The genetic advancement and it's percent of mean in environment 1 recorded (7.20 and 33.20%) for environment 2 it was noted (7.12 and 36.20%) while in pooled data it was (7.16 and 34.70%) respectively.

4.5.3.4 Firmness

The genetic advancement for firmness, in both environment was (2.87, 2.56 and 2.72) in pooled whereas genetic advance as percent of mean (43.40% and 50.00%) in both environment while (46.70%) for pooled respectively. The magnitude of additive variancewas eminent than dominance variance. Additive variance in both environment and pooled was recorded as (0.83, 1.68 and 1.26) while dominant variance was (0.64, 0.55 and 0.59) respectively. The phenotypical variance is close and higher then genotypical and environmental variance. The genotypical variance (GV) in both environments and pooled was recorded (1.94, 1.97 and 1.95) while phenotypic variance (PV) noticed (1.97, 1.99 and

1.98) whereas environmental variance (EV) was showed (0.02, 0.01 and 0.01), respectively. The heritability percentage (broad sense) is very high and can be utilized for development of quality hybrids. The broad sense heritability in environment 1 was (99.70%) while it was (99.30%) in environment 2 and for pooled it was (99.5%). The contribution towards firmness was recorded maximum for lines in both environment and pooled (91.70%, 91.30%, and 91.50%) while the tester contribution was (2.25%, 2.74% and 2.50%)
whereas the interaction was (6.06%, 5.96% and 6.01%) respectively.

4.5.3.5 Chlorophyll content

The phenotypical variance is close and higher then genotypical and environmental variance for chlorophyll content. The genotypical variance (GV) for both environments and pooled was recorded (22.3, 22.1 and 22.2) while phenotypic variance (PV) noticed (22.5, 22.3 and 22.4) whereas environmental variance (EV) (0.04, 0.03 and 0.04), respectively. The contribution towards chlorophyll content was recorded elevated in lines in both environment and pooled (62.30%, 61.00%, and 61.70%) while the tester contribution was (30.90%, 32.80% and 31.80%) whereas the interaction was (6.81%, 6.23% and 6.52%) respectively. The genetic advancement for chlorophyll content, in both environment was (9.71, 9.68 and 9.70) in pooled whereas genetic advance as percent of mean (22.6%, and 23.4%) in both environment while (23.0%) for pooled respectively. The magnitude of additive variance was eminent than dominance variance. Dominant variance in both environment and pooled was recorded as (1.80, 1.65 and 1.73) while additive variance was (17.40, 18.00 and 17.70) respectively. The broad sense heritability in environment 1 was (99.8%) while it was (99.90%) in environment 2 and for pooled it was (99.9%) respectively.

4.5.3.6 Mucilage content

The phenotypical variance is close and higher then genotypical and environmental variance for mucilage content. The genotypical variance (GV) for both environments and pooled was recorded (25.90, 26.30 and 26.10) while phenotypic variance (PV) noticed (26.20, 26.50 and 26.40) whereas environmental variance (EV) (0.02, 0.01 and 0.01) respectively. The heritability in both environment and pooled data indicated the inheritance of this particular trait exhibit in every hybrid. The broad sense heritability in environment 1 was (99.90%)

while it was (99.90%) in environment 2 and for pooled it was (99.90%). The genetic advancement for mucilage content, in both environment was (10.4, 10.6 and 10.5) in pooled whereas genetic advance as percent of mean (71.90% and 77.90%) in both environment while (74.90%) for pooled respectively. The magnitude of additive variancewas eminent than dominance variance. Dominant variance in both environment and pooled was recorded as (1.22, 4.88 and 3.05) while additive variance was (13.90, 27.50 and 20.70) respectively. The contribution towards mucilage content was recorded elevated in lines in both environment and pooled (82.3%, 82.7% and 82.5%) while thetester contribution was (13.60%, 13.20% and 13.40%) whereas the interaction was(4.08%, 4.10% and 4.09%) respectively.

Table: 4.6 Genetic Parameters of okra genotype for different traits

Genotypes	Particulars	GV	PV	EV	h² (Broad Sense) %	Genetic Advancement	Gen.Adv as % of Mean	σ2A	σ2D	% contribution of		
										Lines	Testers	Interaction
Plant height (cm)	E1	62.30	62.80	0.54	99.10	16.20	15.80	46.70	20.10	81.10	9.50	9.30
	E2	67.70	67.70	0.51	99.30	16.90	16.8.0	51.80	31.40	80.20	8.40	11.40
	Pooled	65.00	65.2	0.53	99.60	16.60	16.30	49.30	25.80	80.70	8.90	10.40
Number of branches per plant	E1	2.83	2.92	0.08	97.10	3.41	39.60	0.89	3.86	45.80	4.90	49.30
	E2	2.69	2.71	0.09	99.50	3.37	42.80	0.98	5.57	36.30	5.90	57.80
	Pooled	2.76	2.81	0.08	98.30	3.39	41.20	0.93	4.72	41.00	5.40	53.50
Stem diameter(cm)	E1	2.23	2.35	0.11	95.10	3.00	35.10	1.08	2.55	65.50	2.20	32.40
	E2	2.15	2.17	0.11	99.30	3.01	38.70	0.85	4.32	47.60	3.00	49.50
	Pooled	2.19	2.26	0.11	97.20	3.01	36.90	0.96	3.43	56.50	2.60	40.90
Leaf blade length(cm)	E1	2.7	2.78	0.07	97.20	3.33	27.50	1.74	4.42	60.20	4.90	34.90
	E2	2.42	2.44	0.08	99.40	3.20	32.90	1.83	4.76	57.80	6.30	36.00
	Pooled	2.56	2.61	0.08	98.30	3.27	30.20	1.79	4.59	59.00	5.60	35.40
Leaf blade width(cm)	E1	6.47	6.54	0.06	99.00	5.22	30.50	1.92	4.48	27.60	11.60	60.70
	E2	6.42	6.43	0.06	99.70	5.21	33.20	1.87	4.78	29.60	10.80	59.60
	Pooled	6.45	6.49	0.06	99.40	5.21	31.80	1.90	4.63	28.6	11.20	60.20
Petiole length (cm)	E1	5.38	5.43	0.05	99.00	4.76	41.00	2.36	17.20	31.70	4.90	63.30
	E2	5.24	5.26	0.04	99.60	4.71	43.60	2.32	17.40	30.10	5.30	64.60
	Pooled	5.31	5.35	0.05	99.30	4.73	42.30	2.34	17.30	30.90	5.10	64.00
Days to firstflowering	E1	23.5	23.60	0.15	99.30	9.95	20.70	15.90	45.40	56.30	5.80	37.90
	E2	22.8	22.80	0.12	99.90	9.84	19.50	14.50	45.80	53.10	6.10	40.70
	Pooled	62.30	62.80	0.54	99.10	16.20	15.80	46.70	20.10	81.10	9.50	9.30
Days to first fruitset	E1	67.70	67.70	0.51	99.30	16.90	16.8.0	51.80	31.40	80.20	8.40	11.40
	E2	65.00	65.2	0.53	99.60	16.60	16.30	49.30	25.80	80.70	8.90	10.40
	Pooled	23.1	23.2	0.14	99.60	9.89	20.10	15.20	45.60	54.70	6.00	39.30
Days to first fruit picking	E1	24.6	24.8	0.2	99.20	10.20	19.30	14.00	38.50	69.50	0.05	30.50
	E2	23.7	23.7	0.18	99.90	10.00	17.70	12.70	38.90	66.70	0.29	33.00
	Pooled	24.1	24.2	0.19	99.60	10.10	18.50	13.30	38.70	68.10	0.17	31.80
Number of flowers per plant	E1	27.1	27.3	0.2	99.30	10.70	18.00	18.40	39.60	74.20	0.19	25.60
	E2	25.4	25.4	0.17	99.90	10.40	16.50	16.00	36.50	73.20	0.18	26.60
	Pooled	26.3	26.4	0.18	99.60	10.50	17.30	17.20	38.10	73.70	0.19	26.10
Number of podsper plants	E1	6.33	6.58	0.25	96.20	5.08	29.50	3.20	15.10	23.60	13.00	63.40
	E2	6.08	6.09	0.24	99.80	5.07	31.00	2.44	16.30	22.80	9.00	68.20
	Pooled	6.21	6.34	0.25	98.00	5.08	30.20	2.82	15.70	23.20	11.00	65.80
Pod length (cm)	E1	7.51	7.61	0.09	98.70	5.61	35.50	1.68	16.40	47.80	2.20	50.10

	E2	7.6	7.62	0.08	99.80	5.68	37.90	3.05	18.90	43.30	2.60	54.20
	Pooled	7.56	7.61	0.09	99.30	5.64	36.70	2.36	17.60	45.50	2.40	52.10
Number of firstfruiting node	**E1**	1.98	2.03	0.057	97.20	2.86	27.80	0.70	0.75	70.70	1.30	28.00
	E2	1.69	1.7	0.045	99.20	2.66	29.60	1.15	3.23	63.5	2.6	33.90
	Pooled	1.83	1.87	0.051	98.20	2.76	28.70	0.92	1.99	67.10	2.00	31.00
Number nodes perplant	**E1**	0.41	0.42	0.025	94.40	1.29	24.30	0.49	0.11	30.40	48.90	20.60
	E2	0.43	0.46	0.022	96.60	1.33	29.80	0.42	0.06	34.70	49.60	15.60
	Pooled	0.42	0.44	0.023	95.50	1.31	27.10	0.45	0.09	32.60	49.30	18.10
Number of ridgesper pod	**E1**	0.59	0.62	0.037	94.20	1.53	26.30	0.64	0.20	45.70	33.30	20.90
	E2	0.79	0.80	0.033	97.90	1.81	35.7	0.78	0.23	43	35.9	21.0
	Pooled	0.69	0.71	0.035	96.00	1.67	31.00	0.71	0.21	44.4	34.6	21.0
Pods diameter(cm)	**E1**	0.69	0.71	0.035	96.00	1.67	31	0.71	0.21	44.4	34.6	21.0
	E2	0.1	0.11	0.013	88.60	0.61	31.9	0.051	0.036	63.6	7.4	29.0
	Pooled	0.15	0.16	0.015	90.60	0.75	41.8	0.062	0.043	69.4	4.9	25.6
Internodal length(cm)	**E1**	0.12	0.14	0.014	89.60	0.68	36.9	0.057	0.039	66.5	6.1	27.3
	E2	0.56	0.57	0.013	97.60	1.52	31.3	0.38	0.24	41.1	25.8	33.1
	Pooled	0.64	0.66	0.014	97.90	1.64	36.6	0.51	0.28	38.7	29.1	32.2
Average Podweight (g)	**E1**	0.6	0.61	0.013	97.70	1.58	33.9	0.44	0.26	39.9	27.4	32.6
	E2	7.31	7.34	0.03	99.60	5.56	31.5	7.89	8.24	38.7	39.3	22.0
	Pooled	7.35	7.36	0.028	99.80	5.58	34.3	6.57	8.03	39.0	39.2	21.8
Pods yield/ Plant(Kg)	**E1**	7.33	7.35	0.029	99.70	5.57	32.9	7.23	8.14	38.9	39.2	21.9
	E2	0.0024	0.0026	0.012	94.60	0.099	45.5	0.0014	0.0023	70.70	22.4	6.87
	Pooled	0.0018	0.0019	0.011	99.30	0.087	41.5	0.0017	0.0034	69.6	21.5	8.83
Ascorbic Acid(mg/100g)	**E1**	0.0021	0.0023	0.011	96.90	0.093	43.5	0.0016	0.0029	70.2	21.9	7.85
	E2	8.42	8.43	0.017	99.80	5.97	39.1	6.3	0.61	72.3	22.2	5.14
	Pooled	8.46	8.48	0.014	99.50	5.99	43.7	6.28	0.62	72.4	22.00	5.55
Acidity (%)	**E1**	0.0024	0.0029	0.0031	92.60	0.08	35.6	0.0015	0.003	54.3	36.60	9.18
	E2	0.0031	0.0022	0.0039	95.40	0.09	46.2	0.0036	0.002	38.9	39.30	21.9
	Pooled	0.0028	0.0026	0.0035	94.00	0.08	40.9	0.0026	0.0025	46.60	37.90	15.5
Dry mattercontent (%)	**E1**	12.00	12.10	0.09	99.20	7.2	33.2	8.43	1.71	67.20	21.90	10.9
	E2	11.90	12.40	0.08	99.90	7.12	36.2	8.42	1.52	67.60	21.60	10.8
	Pooled	12.00	12.20	0.09	99.60	7.16	34.7	8.42	1.61	67.40	21.70	10.9
Firmness (kg/ cm^2)	**E1**	1.94	1.97	0.02	99.70	2.87	43.4	0.83	0.64	91.70	2.25	6.06
	E2	1.97	1.99	0.01	99.30	2.56	50.00	1.68	0.55	91.30	2.74	5.96
	Pooled	1.95	1.98	0.01	99.50	2.72	46.70	1.26	0.59	91.50	2.50	6.01
Chlorophyllcontent (SPAD unit)	**E1**	22.30	22.50	0.04	99.80	9.71	22.60	17.4	1.80	62.30	30.90	6.81
	E2	22.10	22.30	0.03	99.90	9.68	23.40	18.00	1.65	61.00	32.80	6.23
	Pooled	22.20	22.40	0.04	99.90	9.70	23.00	17.70	1.73	61.70	31.80	6.52
Mucilage content(%)	**E1**	25.90	26.20	0.02	99.90	10.40	71.90	13.90	1.22	82.30	13.60	4.08
	E2	26.30	26.50	0.01	99.90	10.60	77.900	27.50	4.88	82.70	13.20	4.10
	Pooled	26.10	26.40	0.01	99.90	10.50	74.9	20.70	3.05	82.50	13.40	4.09

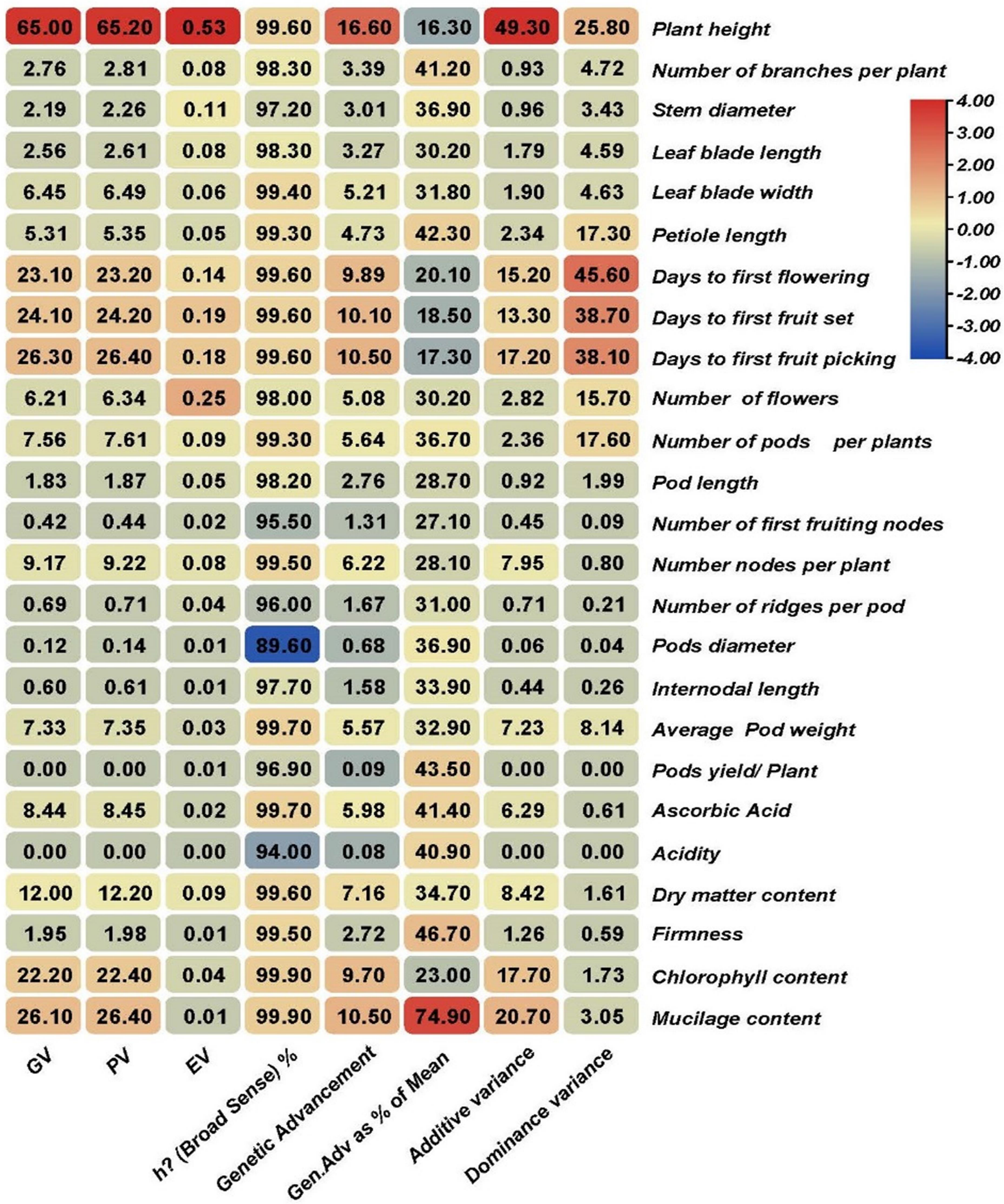

Fig. 4.3 Heat map of Genetic parameters

4.6 Heterosis and Heterobeltiosis4.6.1 Growth Parameters

4.6.1.1 Plant height (%)

The data presented in the table 4.7(a) shows that the maximum and significant heterobeltiosis for plant height recorded in environment 1 in hybrid L2×T1 (10.25) followed by hybrid L4×T1 & L5×T1 (10.23) each and L7×T1 (10.11) respectively whereas in environment 2, it was noted for hybrid L5×T1 (11.51) followed by hybrid L8×T1 (11.24) and hybrid L4×T1 (11.16) showed maximum heterobeltiosis. The maximum and significant standard heterosis for both environments was noted in hybridL15×T1 (1.90 and 1.35). The average of both years *i.e.*, pooled the data exhibited that significant and maximum heterobeltiosis was noted for hybrid L5×T1 (10.86) followed by hybrids L4×T1 (10.69), L7×T1 (10.66) respectively, while for standard heterosis it was recorded in hybrid L15 ×T1 (1.63) respectively.

4.6.1.2 Number of branches per plant (%)

The number of branches per plant recorded maximum and significant heterobeltiosis for environment 1 and 2 in hybrid L1×T3 (75.49 and 67.75) followed by hybrid L11×T3 (72.66 and 62.39) & L4×T4 (66.09 and 57.66) while standard heterosis was recorded for hybrid L6×T2 (21.47) followed by L5×T4 (19.37) & L15×T1 (18.88) in environment 1 whereas for environment 2, hybrid L11×T2 (20.07) followed by L5×T4 (19.14) recorded significant and maximum standard heterosis. The pooled data expresspositive and significant heterobeltiosis for hybrid L1×T3 (71.77) followed by L4×T4 (61.93) while standard heterosis was recorded in hybrid L6×T2 (19.51) followed by hybrid L5×T4 (19.26) respectively.

4.6.1.3 Stem diameter (%)

The data presented in the table 4.7 (b) shows that the maximum and significant heterobeltiosis for stem diameter was recorded in environment 1 for hybrid L9×T1 (64.49) followed by hybrid L3×T3 (42.19) in environment 2 it was recorded for hybrid L9×T1 (87.69) followed by L8×T4 (51.45). The standard heterosis recorded maximum and significant for stem diameter in environment 1 for hybrid L4×T4 (105.90) followed by hybrid L5×T1 (97.26) while in environment 2 it was noted in hybrid L8×T4 (128.29) followed by L4×T4 (118.86) and hybrid L9×T1 (109.63) respectively. The average of both years *i.e.*, pooled data that heterobeltiosis was recorded significant and maximum for hybrid L9×T1 (76.34) followed by hybrid L1×T1 (41.96) while for standard heterosis the values were recorded in a hybrid L4×T4 (112.03) followed by

L8×T4 (111.59) and L9×T1 (98.24) respectively.

4.6.1.4 Leaf blade length (%)

The data for leaf blade length for heterobeltiosis for environment 1 and 2 stated that maximum and significant values was noted for hybrid L11×T4 (66.01 & 72.86) followed by L11×T2 (62.70 & 72.20) and hybrid L11×T3 (52.67 & 52.33) respectively. The same pattern was observed for standard heterosis for both environments in hybrid L11×T3 (10.84 & 7.09) followed by hybrid L11×T4 (10.77 & 7.72) and hybrid L11×T2 (8.56 & 5.91) respectively. The pooled data recorded that the maximum and significant heterobeltiosis was recorded in hybrid L11×T4 (69.14) followed by hybrid L11×T2 (66.92) & L11×T3 (52.51) while standard heterosis was noted maximum and significant in hybrid L11×T4 (9.35) followed by L11×T3 (9.10) and hybrid L11 ×T2 (7.33) respectively.

4.6.1.5 Leaf blade width (%)

The data presented for leaf blade width in the table 4.7(c) express that the significant and positive heterobeltiosis was noted for hybrid L11×T2 (51.57 & 50.26) followed by hybrid L6×T2 (46.05 & 52.07) for both environment 1 and 2 respectively. For standard heterosis, in environment 1 significant and maximum values were noted for hybrid L15×T3 (17.70) followed by hybrid L12×T3 (12.32) while in environment 2 it was recorded for hybrid L15×T4 (12.77) and L12×T4 (7.31). In case of pooled data forheterobeltiosis noted that significant and maximum values were recorded in hybrid L11×T2 (50.94) followed by hybrid L6×T2 (48.92) & standard heterosis recorded for hybrid L15×T4 (15.25) followed by hybrid L12×T4 (9.83) respectively.

4.6.1.6 Petiole length (%)

The data observed for petiole length showed the significant and maximum heterobeltiosis in both environments along with pooled for hybrids L3×T3 (80.36, 76.48 & 78.47) followed by hybrid L11×T3 (77.16, 70.51 & 73.91) and hybrid L8×T1 (50.30, 52.83 &51.51) respectively. The standard heterosis following the same pattern for both environment and pooled data and noted maximum and significant values for hybrid L15×T4 (29.20, 27.31& 28.27) followed by hybrid L15×T2 (27.72, 25.8 & 26.77) respectively.

4.6.1.7 Days to first flowering (%)

For earliness traits, such as days to first flowering mainly focus on negative and significant data. The data extracted from the table 4.7(d) that showed the significant and maximum negative values for heterobeltiosis recorded for hybrid L1×T1 (-28.50 & -27.41) followed by hybrid L1×T3 (-25.21 &-23.01) in environment 1 and 2 respectively. The earliness trend for standard heterosis in environment 1 was recorded for hybrid L11×T4 (-3.92) followed by L5×T1 and L5×T2 (-3.81) each while for environment 2, it was noted by hybrid L10×T4 (-0.44) followed by hybrid L11×T1 (- 0.42) and hybrid L11×T2 (-0.37) respectively. The average of the both year, data revealed that for heterobeltiosis, the maximum negative and significant values were noted for hybrid L1×T1 (-27.94) followed by hybrid L1×T3 (-24.09) and L11×T2 (- 22.32) whereas for standard heterosis it was noted for hybrids L11×T2 (-2.04) followed by L11×T 4 (-1.92) and L11×T1 (-1.88) respectively.

4.6.1.8 Days to first fruit set (%)

The data observed for days to first fruit set in both the environments and pooled for heterobeltiosis was recorded in hybrid L1×T1 (-25.10, -24.09 & -24.58) followed by hybrid L1×T3 (-23.85, -22.63 & -23.22) along with that in environment 1 hybrid L10×T2 (-21.39) and hybrid L1×T4 (-20.48) also recorded significant and negative results while in environment 2 except the best hybrid L7×T4 (-20.31) proved its superiority in early fruit setting. In case of standard heterosis, in environment 1 the maximum negative and significant data was recorded for hybrid L11×T4 (-3.93) followed by L11×T3 (-3.79), L11×T2 (-3.60) and L11×T1 (-3.26) while in environment 2 it was recorded by hybrid L11×T1 (-0.19) respectively. In case of pooled data for standard heterosis, hybrid L11×T4 (-1.81) followed by L11×T1 (-1.69) and L11×T3 (-1.61) recorded significant and negative data for early fruit setting.

4.6.1.9 Days to first fruit picking (%)

Early picking results in early harvest and better economic returns. The expression of hybrids depend upon its significancy and negative impact for selection for this trait. The data presented for days to first fruit picking in the table 4.7(e) showed in both environments and pooled heterobeltiosis was recorded maximum and negative significant in hybrid L1×T1 (-23.79, -22.51 & -23.14) followed by hybrid L1×T3 (- 20.80, -19.59&-20.18) and hybrid L1×T4 (-19.03, -

17.77 & -18.39) respectively. In case of standard heterosis, in environment 1 maximum negative significant data was recorded for hybrid L2×T2 (-4.11) followed by hybrid L5×T1 (-3.55 & L5×T2 (-3.52) while in environment 2 it was recorded in hybrid L11×T3 (-0.27) and hybrid L11×T4 (-0.15) respectively. The pooled data for standard heterosis was recorded for hybrid L2×T2 (-2.09) followed by hybrid L4×T2 (-1.77) & L11×T4 (-1.72) respectively.

4.6.2 Yield Parameters

4.6.2.1 Number of flowers per plant (%)

The information gathered from the table 4.7 (e) showed that the heterobeltiosis for number of flowers per plant in the environment 1 recorded significant and maximum in hybrid L9×T2 (43.11) followed by hybrid L5×T4 (42.49) and L11×T2 (40.51) while in environment 2 it was recorded for hybrid L2×T2 (48.97) followed by L11×T2 (46.21) and L9×T2 (36.73) respectively. The standard heterosis for number of flower express that in environment 1 significant and maximum data was recorded for hybrid L4×T1 (43.78) followed by L3×T4 (41.98) while in environment 2 it was recorded in hybrid L3×T4 (28.23) followed by L4×T2 (26.59) and L4×T1 (25.04) respectively. The average of the both years revealed that the maximum and significant heterobeltiosis wasrecorded for hybrid L11×T2 (50.02) followed by L9×T2 (45.78) and L2×T2 (42.48) while standard heterosis was noted significant and positive for L3×T4 (34.88) followedby L6×T1 (34.28) and L4×T1 (34.10) respectively.

4.6.2.1 Number of pods per plant (%)

The data presented in the table 4.7(f) for number of pods per plant that for both environment 1 and 2 along with pooled data, heterobeltiosis recorded significant and maximum for hybrid L6×T2 (43.41, 63.98 & 53.61) followed by hybrid L6×T1 (32.48, 46.41 & 38.28) and hybrid L5×T2 (37.75, 35.23 and 36.06) respectively. In case of standard heterosis, it was noted that, it follows the same pattern for both environments and for pooled, significant and positive data was recorded for hybrid L2×T3 (32.52, 28.71 & 30.62) followed by hybrid L15×T4 (29.27, 24.85 & 27.07) and L2×T1 (28.44, 22.77 & 25.61) respectively.

4.6.2.2 Pod length (%)

The data presented for pod length revealed that, heterobeltiosis was recorded significant and positive in environment 1 for hybrid L9×T3 (40.37) followed by L9×T4 (39.40) and L10×T1

(34.81) while in environment 2 it was noted for hybrid L9×T4 (48.43) followed by L9×T3 (47.97) and L4×T3 (38.28) respectively. Pod length in case of standard heterosis revealed that significant and positive data was recorded in both environment and pooled for hybrid L5×T3 (40.37, 33.16 & 36.95) followed by hybrid L5×T1 (40.06, 33.38 & 36.90) and L4×T3 (27.98, 34.34 & 30.99) respectively. The

heterobeltiosis for pooled was recorded, significant and maximum for hybrid L9×T3 (43.32) followed by L9×T4 (41.14) and L4×T3 (35.01) respectively.

4.6.2.3 Number of first fruiting Node (%)

The data presented for number of first fruiting nodes in the table 4.7 (g) revealed that in environment 1, 2 and pooled data showed significant and maximum values for heterobeltiosis in hybrid L8×T4 (20.38, 25.41 & 22.65) followed by hybrid L6×T1 (14.96, 28.38 & 20.81) except this hybrid L10×T4 (16.94) perform better in environment 1 whereas hybrid L9×T4 (25.71)and L6×T4 (19.76) perform significant and positive in environment 2. In case of standard heterosis the same pattern was followed in both the environments and pooled for hybrids L12 × T3 (44.39, 36.61 & 40.64) followed by hybrid, L3×T3 (40.36, 32.28 & 36.46) and hybrid L2×T3 (34.47, 25.97 & 30.37) respectively.

4.6.2.4 Number of nodes per plant (%)

In case of number of nodes per plant, the data revealed that for heterobeltiosis in both the environments along with average of both years showed significant and maximum values for hybrid L2×T4 (30.12, 33.16 & 32.99) followed by hybrid L3×T4 (27.98, 28.13 & 28.11) and hybrid L2×T2 (26.08, 23.15 & 25.82) respectively. The same pattern was observed for standard heterosis in both environment and pooled data for hybrids L11×T1 (33.31, 36.05 & 33.59) followed by hybrid L14×T1 (31.45, 34.37& 32.02) and L11 ×T3 (21.78, 29.05 & 25.01) respectively.

4.6.2.5 Number of ridges per pod (%)

The information for number of ridges per pod extracted from the table 4.7 (h) for heterobeltiosis revealed that in environment 1 the maximum and significant values are recorded for hybrid

L3×T3 (15.90) followed by hybrid L1×T2 (15.28) and hybrid L8×T1 (13.61) while in environment 2 it was noted for hybrid L1×T2 (27.19) followedby a hybrid L3×T3 (22.26) and L8×T1 (14.36) respectively. In case of standard heterosis in environment 1 maximum and significant data was recorded for hybrid L3×T3 (15.90) while in environment 2 it was noted for hybrid L3×T3 (25.92) followedby L3×T2 (17.84) and L8×T3 (11.86) respectively. In case of an average of both years, it was noted heterobeltiosis was maximum and significant for hybrid L1×T2 (20.64) followed by L3×T3 (18.86) and L8×T1 (13.96) while in standard heterosis, it was observed for hybrid L3×T3 (20.49) followed by hybrid L3×T2 (13.10) respectively.

4.6.2.6 Pod diameter (%)

The data observed for heterobeltiosis for pod diameter revealed that in environment 1 it was maximum and significant for hybrid L15×T1 (40.72) followed by hybrid L8×T2 (33.13) & L1×T4 (32.54) while in environment 2 it was found for hybrid L8×T2 (55.30) followed by hybrid L7×T1 (42.42) and hybrid L8×T1 (34.68) respectively. Standard heterosis was recorded significant and maximum in environment 1 for hybrid L8×T1 (54.12) followed by hybrid L14×T4 (48.03) and L15×T2 (42.47) while in environment 2 it was noted for hybridL8×T2 (39.46) followed by hybrid L15×T1 (33.84). The pooled data recorded significant and positive heterobeltiosis for hybrid L8×T2 (44.21)followed by hybrid L14×T4 (40.75) and L15×T2 (29.57) whereas for standard heterosis it was noted for hybrid L14×T4 (37.75) followed by hybrid L8×T2 (36.60) and hybridL15×T2 (25.34) respectively.

4.6.2.7 Internodal length (%)

It is observed from the data given in the table 4.7 (i) revealed that the Internodal length showed themaximum and significant heterobeltiosis in environment1 for hybrid L7×T4 (19.66) followed by hybrid L6×T4 (13.59) while in environment 2 it was noted for hybrid L11×T1 (46.23) followed by a hybrid L12×T3 (26.25) and L10×T3 (24.29) respectively. Standard heterosis for internodal length recorded positive and significant in environment 1 for hybrid L7×T4 (25.47) followed by hybrid L13×T4 (23.20) while in environment 2 it was noted for hybrid L7×T4 (19.38) and hybrid L13×T4 (17.03). In case of pooled data, the maximum heterobeltiosis was recorded for hybrid L11×T1 (52.66) followed by hybrid L12×T3 (23.86)and L10×T3 (22.39) while standard heterosis was recorded significant and maximum for hybrid L7×T4 (22.44) followed by hybrid L13×T4 (20.13) and L15×T4 (16.17) respectively.

4.6.2.8 Average pod weight (%)

The data observed for average pod weight showed significant and positive heterobeltiosis in both environments along with pooled for hybrid L10×T3 (22.39, 24.60 & 23.45) followed by hybrid L11×T4 (21.15, 22.94 & 22.00) and hybrid L6×T3 (18.58, 22.50 & 20.43) respectively. In case of standard heterosis, the same pattern was observed for environment 1, 2 and pooled data. The data revealed that it was maximum and significant for hybrid L14×T1 (58.25, 65.44 & 61.66) followed by hybrid L9×T1 (56.93, 63.98 & 60.27) and hybrid L14×T2 (47.17, 53.17 & 50.02) respectively.

4.6.2.9 Pod yield/Plant (%)

It is observed from the data in the given table 4.7 (j) for the pod yield per plant showed for heterobeltiosis in both environments and average of both years revealed significant and maximum values in hybrid L15×T3 (28.13, 31.15 & 29.60) followed by hybrid L13×T4 (22.58, 22.95 & 23.77) and hybrid L5×T4 (22.03, 18.03 & 20.00) respectively. Standard heterosis for pod yield per plant noted the same pattern for both environment and pooled the data for hybrid L7×T3 (44.44, 45.90 & 45.16) followed by hybrid L2×T3 (42.86, 42.62 & 42.74) and hybrid L7×T2 (39.68, 44.26 & 41.94) respectively.

4.6.4 Biochemical Parameters

4.6.4.1 Ascorbic acid content (%)

The data presented in the table 4.7 (j) for ascorbic acid content showed the heterobeltiosis were maximum and significant data for both environments and pooled was noted for hybrid L12×T1 (30.44, 30.39 & 30.42) followed by hybrid L5×T4 (23.99, 26.08 & 24.98) and hybrid L12×T4 (22.85, 22.61 & 22.73) respectively. The same pattern was observed for standard heterosis in both environments and pooled data for hybrids L12×T1 (100.81, 113.77 & 106.87) followed by hybrid L12×T4 (89.12, 101.03 & 94.68) and hybrid L9×T4 (84.1, 94.97 & 89.21) respectively.

4.6.4.2 Acidity (%)

The information gathered from the table 4.7(k) that acidity showed significant and maximum heterobeltiosis in environment 1 for hybrid L12×T3 (20.97) followed by L5×T4 (20.51) & L15×T4 (20.48) while in environment 2 it was noted for hybrid L2×T1 (37.84) followed by

L6×T3 (25.93) & L15×T4 (17.81) respectively. Standard heterosis revealed significant and maximum values for hybrid L15×T4 in both environment and pooled (23.85, 26.47 & 25.76). The pooled data for heterobeltiosis express significant and maximum values for hybrid L15×T4 (19.23) followed by L6×T3 (16.39) and L7×T4 (15.86) respectively.

4.6.4.3 Dry matter content (%)

The data presented for dry matter showed maximum and significant heterobeltiosis in the environment 1 for hybrid L14×T4 (17.45) followed by L12×T2 (16.82) and L4×T4(16.68) while in environment 2 it was noted for hybrid L6×T1 (23.43) followed by L14×T4 (20.74) and L12×T2 (19.10) respectively. The heterobeltiosis in pooled of each year was recorded significant and maximum for hybrid L14×T4 (19.00) followed by L4×T4 (18.04) and L6×T1 (16.40) respectively. Standard heterosis for both environment and pooled recorded positive and significant for hybrid L5×T1 (12.53, 13.02 & 12.77) followed by L8×T1 (9.02, 9.06 & 9.04) and hybrid L15×T1 (7.49, 7.63 & 7.56) respectively.

4.6.4.4 Firmness (%)

The data presented for firmness from the table 4.7(l) revealed that in both environment and pooled data heterobeltiosis found maximum and significant for hybrid L14×T4 (21.81, 27.77 &24.50) followed by hybrid L2×T4 (18.75, 22.61 & 20.54) and hybrid L1×T4 (18.81,21.30 & 19.97) respectively. The same pattern was expressed in case of standard heterosis in both environments and pooled for hybrids L6×T4 (39.15, 45.08 & 41.91) followed by hybrid L5×T2 (39.31, 43.96 & 41.48) and hybrid L5×T4 (37.26, 42.91 & 39.89) respectively.

4.6.4.5 Chlorophyll content (%)

The Chlorophyll content showed significant and maximum heterobeltiosis in both the environment 1 & 2 and pooled in hybrid L8×T4 (11.56, 11.04 & 11.30) followed by L4×T3 (10.22, 11.02 & 10.61) and hybrid L7×T1 (8.33, 9.26 & 8.79) respectively. Incase of standard heterosis, the same pattern was recorded for hybrid L7×T1 (67.92, 75.75 & 71.69) followed by hybrid L7×T3 (63.45, 70.91 & 67.04) and hybrid L7×T4 (60.83, 68.09 & 64.33) respectively.

4.6.4.6 Mucilage content (%)

The information gathered from the table 4.7 (m) showed the significant and maximum mucilage content was recorded for heterobeltiosis in environment 1 for hybrids L15×T2 (14.31) followed by L14×T1 (10.84), L11×T1 (10.31) while in environment 2 it was noted for hybrid L15×T2 (13.99) followed by L14×T1 (1 1.11) & L11×T1 (10.42) respectively. Standard heterosis showed significant and positive data in environment 1 for hybrid L15×T2 (11.34) followed by hybrid L15×T1(8.18) while in environment 2 it was noted for hybrid L15×T2 (12.18) followed by hybrid L15×T1 (7.87) respectively. The average of the both years recorded significant and maximum heterobeltiosis for hybrid L15×T2 (14.15) followed by L14×T1 (10.97) and L11×T1 (10.36) while standard heterosis noted for hybrid L15×T2 (11.85) followed by L15×T1 (8.03) and L15×T3 (1.30) respectively.

Table 4.7 (a) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two Environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Plant height						Number of branches per plant					
Hybrids	HB (%)		SH (%)		Pooled		HB(%)		SH(%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	10.02 **	10.46 **	-14.91**	-17.44**	10.24**	-16.18**	-17.78**	-35.06**	-17.20**	-30.45**	-26.42**	-23.62**
L1×T2	5.25 **	4.76 **	-14.79	-16.47	5.01**	-15.63	22.57	7.47	-4.86	-16.62	15.25	-10.56
L1×T3	-1.95 *	-2.95 **	-18.25	-20.17	-2.45**	-19.21	75.49 **	67.75 **	12.90 **	5.95 **	71.77**	9.53**
L1×T4	-7.44 **	-7.51 **	-21.29**	-22.84**	-7.47**	-22.07**	24.70 **	1.22	-11.92**	-25.87**	13.11**	-18.68**
L2×T1	10.25 **	10.50 **	-14.73**	-17.42**	10.37**	-16.07**	14.51	9.89	15.31 **	17.70 **	12.2	16.47**
L2×T2	7.17	6.15	-13.23**	-15.35**	6.67	-14.29**	17.03 **	-6.23 *	-9.16	-27.25	5.76	-17.93
L2×T3	-1.84	-2.91	-18.16**	-20.13**	-2.37	-19.15**	37.55 **	35.20 **	-11.50**	-14.61**	36.42**	-13.01**
L2×T4	-7.13	-8.07	-21.03	-23.31	-7.6	-22.17	34.75 **	17.61 **	-4.83	-13.87	26.29**	-9.21
L3×T1	9.37 **	10.28 **	-15.41**	-17.57**	9.82**	-16.49**	-9.31 *	-21.38	-8.67 *	-15.80**	-15.34	-12.13**
L3×T2	7.57 **	6.18 **	-12.91**	-15.34**	6.88**	-14.13**	40.54 **	39.39 **	9.09 *	8.14 **	39.98**	8.63**
L3×T3	-1.47	-1.75	-17.85**	-19.18**	-1.61	-18.52**	36.90 **	22.42 **	-11.92	-22.68	29.95**	-17.14
L3×T4	-7.36	-8.36	-21.23	-23.55	-7.86	-22.39	24.50 **	15.94 **	-12.06**	-15.09**	20.28**	-13.53**
L4×T1	10.23 **	11.16 **	-14.74**	-16.92**	10.69**	-15.83**	-5.14	-18.85	-4.48	-13.09**	-11.99	-8.65**
L4×T2	-5.90 **	-11.16**	-23.82	-29.16	-8.52**	-26.5	9.32	-7.38	-15.14	-28.14	1.23	-21.44
L4×T3	-1.62	-2.67	-17.98**	-19.93**	-2.14	-18.96**	46.41 **	54.56 **	-5.8	-2.38	50.32**	-4.14
L4×T4	-6.88 **	-7.92 **	-20.81	-23.18	-7.39**	-22	66.09 **	57.66 **	17.31 **	15.46 **	61.93**	16.41**
L5×T1	10.23 **	11.51 **	-14.74**	-16.66**	10.86**	-15.70**	-5.31	-21.28	-4.65	-15.69**	-13.3	-10
L5×T2	1.48	0.25	-17.85**	-20.06**	0.87	-18.96**	11.15 *	11.03	-9.06 *	-10.56**	11.09	-9.78
L5×T3	-1.8	-2.65	-18.13**	-19.92**	-2.22	-19.02**	11.54 *	3.55	-8.74 *	-16.58**	7.70*	-12.54**
L5×T4	-8.08 **	-8.11 **	-21.84	-23.35	-8.10**	-22.59	45.90 **	47.90 **	19.37 **	19.14 **	46.86**	19.26**

L6×T1	5.31 **	5.66 **	-15.62**	-17.23**	5.48**	-16.43**	18.44 **	5.55 **	19.27 **	13.05 **	11.99**	16.25**
L6×T2	1.69	0.55 **	-17.67**	-19.82**	1.12*	-18.75**	56.49 **	51.37 **	21.47 **	17.43 **	54.01**	19.51**
L6×T3	-1.55	-2.31	-17.92**	-19.63**	-1.93	-18.78**	59.44 **	54.70 **	19.30 **	14.39 **	57.16*	16.92**
L6×T4	-4.92 **	-4.08 **	-19.15**	-19.98**	-4.50**	-19.57**	17.62 **	14.63	-11.99**	-15.24**	16.18	-13.57**
L7×T1	10.11 **	10.59 **	-14.84**	-16.87**	10.66**	-15.85**	-18.20**	-20.86**	-15.91 **	-15.24**	-18.68**	-15.59**
L7×T2	6.5	5.4	-13.78**	-15.96**	5.95	-14.87**	-11.46**	-16.04**	-8.99	-14.2	-13.68**	-11.51
L7×T3	-1.77	-2.64	-18.10**	-19.91**	-2.2	-19.00**	-11.29**	-7.97 **	-8.81	-5.95	-9.69**	-7.42
L7×T4	-7.24	-8.14	-21.12	-23.37	-7.69	-22.25	-6.67	-6.58	-4.06	-4.54 *	-6.63	-4.29
L8×T1	9.10 **	11.24 **	-15.62**	-16.86**	10.15**	-16.24**	-3.09	-12.77	-2.41	-6.58 **	-7.93	-4.43
L8×T2	6.53 **	6.67 **	-13.76**	-14.94**	6.60**	-14.35**	-12.39**	-22.80**	-15.45	-26.99	-17.38**	-21.05
L8×T3	-1.22	-2.62	-17.64**	-19.89**	-1.92	-18.77**	-6.2	-10.3	-9.48 *	-15.17**	-8.16	-12.23**
L8×T4	-7.19	-7.87	-21.08	-23.14	-7.53	-22.11	16.78 **	18.71 **	12.69 **	12.27 **	17.70**	12.49**
L9×T1	8.71 **	9.12 **	-15.53**	-16.96**	8.91**	-16.24**	9.51 *	9.2	10.28 *	16.95 **	9.36	13.51**
L9×T2	6.31 **	6.22 **	-13.93**	-15.30**	6.26**	-14.62**	29.91 **	19.60 **	0.84	-7.21	24.91**	-3.06
L9×T3	-1.63	-1.94	-17.98**	-19.33**	-1.78	-18.66**	56.90 **	47.85 **	0.94	-6.62 **	52.56**	-2.72
L9×T4	-6.2	-6.72	-20.24	-22.18	-6.46	-21.21	63.42 **	60.00 **	15.42 **	17.17 **	61.73**	16.27**
L10×T1	0.15	0.89 **	-15.60**	-17.29**	0.52	-16.45**	-10.49	-13.22	-9.86 *	-7.06 **	-11.86	-8.50**
L10×T2	2.32	3.57	-13.78**	-15.09**	2.94	-14.44**	-6.22	-5.34	-22.48	-23.57	-5.8	-23.01
L10×T3	1.39	1.84 **	-14.57**	-16.23	1.78	-15.4	5.75	6.35 **	-12.59**	-14.13**	6.04	-13.33**
L10×T4	0.04	-0.2	-14.93**	-16.74**	-0.08	-15.84**	18.78 **	18.09 **	-1.82	-4.65 *	18.45**	-3.19
L11×T1	0.08	-0.29	-14.54 *	-16.06**	-0.1	-15.30**	14.44 **	3.37	15.24 **	10.71 *	8.90**	13.05**
L11×T2	1.18	0.61 **	-13.60**	-15.30**	0.9	-14.45**	43.65 **	54.77 **	11.50 **	20.07 **	49.04**	15.66**
L11×T3	0.54	0.21	-14.14**	-15.64**	0.37	-14.89**	72.66 **	62.39 **	11.08 *	2.57	67.73**	6.95*
L11×T4	0.72	0.70 **	-13.99**	-15.22**	0.71	-14.61**	53.32 **	57.51 **	8.29	15.35 **	55.39**	11.71**
L12×T1	4.48 **	5.08 **	-15.57**	-16.5**	4.78**	-16.06**	2.08	-1.49	2.8	5.50 **	0.3	4.11

L12×T2	6.68 **	6.13 **	-13.63**	-15.38**	6.41**	-14.50**	-10.99 *	-13.01**	-12.24**	-14.28**	-11.97**	-13.23**
L12×T3	-1.37	-2.72 **	-17.76**	-19.98	-2.04	-18.87**	-19.50**	-18.75	-20.63	-19.93**	-19.14	-20.29**
L12×T4	-3.57 **	-3.73 **	-18.00**	-19.69	-3.65	-18.84**	-6.38	-8.45 **	-7.69	-9.78 **	-7.38**	-8.70**
L13×T1	1.53	1.93 **	-11.60**	-13.36**	1.73**	-12.48**	-13.54**	-20.76**	-12.94**	-15.13**	-17.15**	-14.00**
L13×T2	1.69	1.72 **	-11.46**	-13.54**	1.71**	-12.50**	8.97	4.38	-10.84 *	-13.23**	6.73*	-12.00**
L13×T3	1.46	3.87 **	-11.67**	-11.71**	2.65**	-11.69**	-1.71	-3.53	-19.58	-19.81	-2.6	-19.69
L13×T4	1.66	2.56 **	-11.49**	-12.83**	2.10**	-12.16**	1.71	-5.95 **	-16.78**	-21.82**	-2.03	-19.23**
L14×T1	1.69	2.46 **	-13.72**	-15.14**	2.07**	-14.43**	-11.46	-16.21	-10.84 *	-10.26**	-13.83	-10.56**
L14×T2	1.63	2.26 **	-13.78**	-15.30**	1.94**	-14.54**	8.11	5.08 *	-16.08**	-18.48**	6.64*	-17.24**
L14×T3	1.52	1.74 **	-13.87**	-15.74**	1.63**	-14.81**	3.65	1.34	-30.42	-29.48	2.51	-29.96
L14×T4	-5.85	-8.2	-19.94**	-23.41**	-7.01	-21.68**	10.4	9.95 **	-22.03**	-19.48**	10.18**	-20.79**
L15×T1	1.90 *	1.35 **	1.90 *	1.35 **	1.63**	1.63**	18.06 **	7.74 **	18.88 **	15.39 **	12.90**	17.19**
L15×T2	0.48	0.19	0.48	0.19	0.34	0.34	-12.59**	-12.30**	-12.59**	-12.30**	-12.45**	-12.45**
L15×T3	1.54	0.61	1.54	1.002*	0.77	0.77	-12.94**	-15.43**	-12.94**	-15.43**	-14.14**	-14.14**
L15×T4	0.74	-0.61 **	0.74	-0.61 **	0.07	0.07	-11.19 *	-14.46**	-11.19 *	-14.46**	-12.77**	-12.77**
S.E. ±	0.98	0.17	0.94	0.13	0.49	0.5	0.41	0.16	0.36	0.07	0.22	0.32
CD (0.05)	1.94	0.34	1.46	0.37	1.05	1.37	0.82	0.33	0.96	0.15	0.47	0.97

Table 4.7 (b) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two Environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Stem diameter						Leaf blade length					
Hybrids	HB (%)		SH (%)		Pooled		HB(%)		SH(%)		Pooled	
	E1	E2	E1	E2	HB(%)	SH (%)	E1	E2	E1	E2	HB(%)	SH(%)
L1×T1	39.82 **	45.81**	52.32 **	62.75 **	41.96**	57.26**	-6.65	-10.77	-22.36	-30.8	-8.49	-26.28
L1×T2	14.20 *	27.28**	52.86 **	80.61 **	24.27**	65.99**	10.19 **	12.45 **	-22.46	-29.1	11.18**	-25.54
L1×T3	9.21	-3.63	42.07 **	34.00 **	31.63**	38.25**	29.14 **	23.01 **	-6.24	-13.52	26.34**	-9.62
L1×T4	16.4	17.14	76.82 **	76.56 **	16.87**	76.70**	14.01 **	11.66 **	-19.77**	-29.60**	12.98**	24.33**
L2×T1	27.63	23.66	39.03	40.9	24.48	39.92	12.51 **	11.21 **	-6.42 *	-13.76**	11.93**	-9.83**
L2×T2	29.07	15.72	72.77 **	64.21 **	16.3	68.72**	14.75 **	17.17 **	-19.93	-27.78	15.80**	-23.58
L2×T3	16.95 *	5.87 *	52.15 **	47.21 **	26.29**	49.81**	4.92	-0.97	-23.82**	30.38**	2.23	-26.87**
L2×T4	2.9	7.18 **	56.32	61.55	39.29**	58.79	7.21	9.48 **	-25.19	-31.78	8.72**	-28.25
L3×T1	27.01 **	20.34**	67.58 **	66.60 **	34.92**	67.12**	-4.24	-12.50**	-20.36**	-32.14**	-7.93**	25.83**
L3×T2	18.25 **	6.64 **	58.28 **	51.33 **	15.57**	54.99**	38.31 **	35.09 **	-6.26 *	-13.76**	36.86**	-9.75**
L3×T3	42.19 **	32.43**	87.60 **	84.13 **	13.03**	85.96**	6.99	-4.03 *	-22.32**	-32.54**	1.96	-27.06**
L3×T4	12.12	6.7	70.32 **	60.82 **	-1.51**	65.83**	16.87	10.98	-20.79**	-29.15**	14.22	-24.67**
L4×T1	17.73	9.88	57.87 **	57.97 **	5.63	57.91**	4.03	-0.03	-13.48**	--2.48**	2.21	-17.66**
L4×T2	27.87 **	13.76**	71.45	63.55	6.54**	67.71	46.53 **	38.93 **	-5.19	-13.5	43.07**	-9.05
L4×T3	39.38 **	39.21**	86.89 **	100.13**	39.33**	93.15**	16.62 **	13.93 **	-15.33	-19.91	15.40**	-17.45
L4×T4	35.54 **	45.20**	105.90**	118.86**	40.38**	112.03**	36.92 **	41.68 **	-8.7	-11.71	39.05**	-10.1
L5×T1	19.32 **	6.40 **	97.26 **	95.35 **	12.65**	96.36**	-0.99	-2.1	-17.65**	24.08**	-1.48	20.64**

L5×T2	-3.17	-20.65	60.07 **	45.68 **	-7.83	53.27**	6.08	0.88	-15.74**	-24.42**	3.74	-19.77**
L5×T3	5.19	-7.05	73.90 **	70.65 **	-2.59	72.36**	-2.58	-5.47 **	-22.61**	-29.18**	-3.88	-25.66**
L5×T4	5.34	-10.81	74.14 **	63.75 **	7.32	69.22**	23.51 **	21.21 **	-1.89	-9.19**	22.47**	-5.28**
L6×T1	42.03**	41.46**	69.96 **	71.51 **	41.20**	70.70**	-2.85	1.69	-19.2	-21.14	-0.82	-20.1
L6×T2	37.09 **	27.19**	83.49 **	80.48 **	23.21**	82.07**	17.99	-4.08	-22.32	-39.47	7.97	-30.28
L6×T3	31.42 **	11.32**	70.98 **	54.78 **	20.84**	63.32**	6.9	-0.97	-22.39**	-30.38**	3.31	-26.10**
L6×T4	2.43	2.51	55.6	54.52	2.25	55.09	26.81 **	22.85 **	-15.44**	-22.48**	25.73**	-18.71**
L7×T1	36.45	27.8	85.40 **	83.13 **	21.94	84.33**	4.27	-2.27	-13.28**	-24.21**	1.35	-18.36**
L7×T2	20.13	2.64	63.23 **	47.08 **	8.27	55.59**	17.08	10.57	-13.05	-23.35	14.17	-17.83
L7×T3	27.41 **	31.7**	73.12 **	88.84 **	21.71**	80.56**	22.36 **	17.30 **	-9.13 **	-17.54**	20.83**	-13.04**
L7×T4	14.04 *	26.78**	73.24 **	91.10 **	21.24**	81.69**	24.93 **	12.95 **	-7.22 **	-21.69**	19.57**	-13.94**
L8×T1	25.16 **	3.29 **	67.82 **	69.46 **	24.73**	68.59**	5.91	8.43	-11.91	-15.91	7.04	-13.77
L8×T2	37.16 **	24.94**	83.91 **	77.29 **	27.46**	80.78**	11.88 **	11.97 **	-27.08	-29.49	11.92**	-28.2
L8×T3	26.09 **	16.67**	69.07 **	62.22 **	20.81**	65.83**	7.75 *	-2.32	-21.77	-31.33	3.15	-26.21
L8×T4	29.42 **	51.45**	96.60 **	128.29**	38.43**	111.59**	41.46 **	38.78 **	-5.67 *	12.61**	40.92**	-8.89**
L9×T1	64.49 **	87.69**	88.02 **	109.63**	76.34*	98.24**	9.78 **	10.87 **	-8.70 **	14.02**	10.26**	11.17**
L9×T2	27.74	15.26	70.98 **	63.55 **	23.27	67.46**	-6.46	-9.35	-24.5	-32.25**	-7.75	-28.1
L9×T3	42.88 **	21.44**	85.88 **	6886 **	32.36**	77.83**	-1.55	-8.68 **	-20.54**	31.75**	-4.73*	- 25.75**
L9×T4	-13.10 *	-15.81**	32	26.89	19.22**	29.59	20.91 **	14.86 **	-2.41	-14.15	18.22**	-7.87
L10×T1	8.01	9.16 **	68.83 **	86.79 **	7.70**	77.32**	-1.12	-7.11	-17.76	-27.97	-3.8	-22.5
L10×T2	3.77	-10.17**	62.22 **	53.72 **	-4.07**	58.20**	19.32	7.7	-8.86 **	-22.87**	14.11	-15.37**
L10×T3	20.02 **	6.67 **	87.60 **	82.54 **	16.32**	85.21**	16.25 **	16.57 **	-11.20**	6.52**	16.40**	-13.67**
L10×T4	2.13	-5.24	59.65 **	62.15 **	-3.09	60.84**	16.55	11.92	-10.98**	-19.85**	14.47	-15.10**
L11×T1	39.71 **	29.20**	54.53 **	43.36 **	34.33**	49.25**	28.45 **	29.97 **	6.83	0.79	29.13**	4.02
L11×T2	29.83 **	16.75**	73.78 **	65.67 **	25.59 **	69.94**	62.70 **	72.20 **	8.56 **	5.91 **	66.92**	7.33**

L11×T3	37.98 **	37.87**	79.50 **	91.70 **	37.56**	85.27**	52.67 **	52.33 **	10.84 **	7.09 **	52.51**	9.10**
L11×T4	10.47	2.78	67.82 **	54.91 **	8.69**	61.71**	66.01 **	72.86 **	10.77 **	7.72 **	69.14**	9.35**
L12×T1	-18.31	-26.37	36.35 **	35.52 **	-23.59	35.96**	8.98 **	18.08 **	-9.36 **	-8.43**	13.05**	-8.93**
L12×T2	-9.32	-14.43**	51.37 **	57.50 **	-8.78**	54.27**	-8.77	-12.74	-29.4	-38.47	-10.52	-33.61
L12×T3	-11.46	-15.3	47.79 **	55.91 **	-15.83	51.63**	3.88	13.63 **	-19.61**	-19.88**	8.19**	-19.73**
L12×T4	12.46 *	1.01	87.72 **	85.92 **	7.26**	86.87**	0.94	5.03	-21.89	-25.95	2.75	-23.77
L13×T1	-11.93	-12.03	-4.05	-2.39	-3.27	-3.27	-9.64 **	-11.28**	-24.85**	-31.20 **	-10.37**	7.80**
L13×T2	-14.07	-17.03	15.02	17.73 **	-15.99	16.30**	-7.07	-5.05 *	-33.27**	-40.23**	-6.20*	-36.50**
L13×T3	-5.18	-6.83	23.36 *	29.55 **	-8.25	26.29**	5.71	1.87	-23.25**	-28.39**	3.96	-25.64**
L13×T4	-10.55	-5.07 *	35.88 **	43.09 **	5.70 **	39.29**	11.96	17.73	-19.61**	-25.89**	14.45	-22.53**
L14×T1	13.33	23.07**	31.70 **	38.51 **	-5.92**	34.92**	7.89	14.29	-10.27**	1.37**	10.75	-10.78**
L14×T2	6.41	5.05 *	42.43 **	49.07 **	17.72**	45.57**	-7.90 *	-9.71 **	-27.81**	-33.11**	-8.72**	-30.27**
L14×T3	-16.17	-15.52	9.06	17.46 **	5.79	13.03*	2.85	3.19	-19.38**	-23.56**	3	-21.32**
L14×T4	-10.55	-6.17**	35.88 **	41.43 **	-16.12**	38.51**	-10.52	-12.87	-29.86**	-35.45**	-11.58	-32.46**
L15×T1	11.6	17.3	21.57*	30.15 **	-5.99	25.63**	12.96 **	17.54 **	12.96 **	17.54**	15.09**	15.09**
L15×T2	-5.16	-9.64	26.94 **	28.22 **	15.96	27.54**	-17.33**	-21.32**	-17.33**	-21.32**	-19.19**	-19.19**
L15×T3	7.19	3.01	39.45 **	43.23 **	5.91**	41.24**	1.34	-1.47	1.34	-1.47	0.04	0.04
L15×T4	-4.67	-1.23	44.82 **	48.87 **	-3.71	46.73**	-9.13	-13.37	-9.13	-13.37	-11.1	-11.1
S.E. ±	0.51	0.16	0.43	0.12	0.27	0.23	0.38	0.16	0.3	0.13	0.21	0.23
CD (0.05)	1.01	0.32	1.00	0.38	0.57	0.58	0.77	0.32	0.96	0.34	0.44	0.57

Table 4.7 (c) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two Environments *viz*., Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Leaf blade width						Petiole length					
Hybrids	HB (%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	15.59**	11.12 **	-19.86**	-11.05**	13.43**	-6.67**	-11.2	-16.07	-30.21	-38.8	-13.52	-34.46
L1×T2	6.71 **	7.85 **	-7.51	-26.47	7.25**	-23.15	4.65	3.49	-14.83	-21.01	4.1	-17.88
L1×T3	4.06	-0.87	0.49	-15.8	1.66	-11.63	31.60 **	23.80 **	-14.43	-21.29	27.79**	-17.82
L1×T4	5.82 **	3.71 **	-9.58	-6.71	4.80**	-3.09	9.10 **	7.13 **	17.59 **	17.47 **	8.12**	17.53**
L2×T1	7.03 **	3.35 **	-3.07	-17.27	5.26**	-13.4	20.87 **	19.38 **	-4.99	-12.95	20.16**	-8.93
L2×T2	22.53 **	29.09 **	-13.14	-4.79	25.67**	-3.92	-9.34 **	-16.73	-26.22	-36.45	-12.88	-31.27
L2×T3	-2.27	-2.93	-18.17	-17.55	-2.59	-15.33	36.42 **	28.96 **	-11.29	-18	32.77**	-14.61
L2×T4	-13.83	-19.36	-5.35	-27.46	-16.5	-22.79	-20.6	-24.47	-14.43	-17.18	-22.53	-15.79
L3×T1	12.05 **	9.55 **	-4.06	-12.31	10.84	-8.81**	-8.14	-7.49	-27.8	-32.55	-7.83	-30.15
L3×T2	25.65 **	25.01 **	1.17	-10.51	25.34**	-7.26	5.12	5.21	-14.45	-19.70**	5.16	-17.05
L3×T3	13.82 **	11.66 **	-14.67	-5.16	12.77**	-1.97	80.36 **	76.48 **	17.29 **	12.21 **	78.47**	14.77**
L3×T4	-10.15	-14.02	-4.08	-22.66	-12.02	-18.64**	-21.25	-27.86	-15.13	-20.9	-24.55	-17.98
L4×T1	13.55 **	13.50 **	-6.41	-9.15	13.53**	-6.6	5.84	9.78 **	-16.81	-19.95	7.71**	-18.36
L4×T2	16.21 **	8.31 **	-2.63	-17.15	12.39**	-11.74	10.57 **	10.01 **	-10.01	-16.03	10.31**	-12.99
L4×T3	9.55 **	6.17 **	-9.13	-9.82	7.91**	-6.2	36.88 **	36.79 **	-10.99	-13.03	36.84**	-12
L4×T4	-4.31	-9.44	-11.48	-18.54	-6.79	-13.8	-16.97	-21.96	-10.51**	-14.44	-19.46**	-12.45**
L5×T1	4.79	2.38	-1.06	-18.05	3.62	-14.74	6.49	6.07	-9.46	-13.57	6.29	-11.49
L5×T2	24.25 **	24.32 **	-23.35**	-7.31 **	24.28**	-4.17**	-17.5	-17.25	-29.85	-32.57	-17.38	-31.2
L5×T3	-13.76	-19.92	-7.53	-31.98	-16.75	-27.64	4.54	0.66	-11.11	-17.98	2.67	-14.51
L5×T4	-2.62	-7.07	-19.76	-16.4	-4.77	-11.94**	-12.10**	-18.41**	-5.27 *	-10.54**	-15.25**	-7.88**

L6×T1	-5.01	-8.78	2.79	-26.98	-6.83	-23.35**	24.35 **	25.43 **	-2.26	-8.54 **	24.87**	-5.36**
L6×T2	46.05 **	52.07 **	-36.64**	-1.55	48.92**	0.63	45.35 **	45.03 **	18.29 **	10.70 **	45.19**	14.53**
L6×T3	-28.72	-31.95	-2.39	-42.2	-30.29	-39.41	36.03 **	23.52 **	-11.54**	-21.47**	29.92**	-16.45**
L6×T4	2.79	-0.27	3.12	-10.29**	1.31	-6.31	-11.15	-19.67	-4.24	-11.93	-15.4	-8.04
L7×T1	22.07 **	17.27 **	-20.00**	-6.13 **	19.75**	-1.47	32.25 **	25.04 **	19.14 **	10.41 **	28.72**	14.83**
L7×T2	10.60 **	9.77 **	-7.61 **	-27.97**	10.21**	-23.96**	6.07	0.23	-4.44	-11.49	3.21	-7.9
L7×T3	3.94	-2.52	-4.88	-17.2	0.81	-12.38	8.33 **	6.22 **	-2.41	-6.21 **	7.29**	-4.29**
L7×T4	0.17	-1.3	-32.11	-11.21	-0.54	-8.02	-11.38	-19.04	-4.49	-11.23	-15.2	-7.82
L8×T1	-19.64	-28.22	-43.54	-42.54	-23.78	-37.29	50.30 **	52.83 **	18.14 **	11.44 **	51.51**	14.83**
L8×T2	-4.03	-13.02	-4.06	-51.05	-8.4	-47.27	-4.13	-7.26	-21.98	-29.21	-5.63	-25.55
L8×T3	7.94 **	2.95 *	-9.58	-12.56	5.52**	-8.28	17.65 **	22.39 **	-9.88 **	-12.64**	19.91**	-11.25**
L8×T4	-4.79	-5.71	3.03	-15.19	-5.24	-12.3	-11.89	-18.06	-5.04	-10.16	-14.97	-7.57
L9×T1	21.97 **	15.71 **	-3.92	-7.38	18.94**	-2.14	38.57 **	30.94 **	17.89 **	11.16 **	34.80**	14.56**
L9×T2	25.72 **	23.77 **	1.32	-11.28	24.78**	-7.58	-17.34	-25.86	-29.68	-37.06	-21.55	-33.33
L9×T3	14.00 **	9.83 **	-10.19	-6.71	11.98**	-2.67	35.62 **	28.01 **	15.38 **	8.67 **	31.86**	12.06**
L9×T4	-5.43	-9.84	-11.67	-18.89	-7.56	-14.51**	-32.26	-41.38	-26.99	-35.73	-36.81	-31.31
L10×T1	0.9	-0.44	-4.60 *	-19.32**	0.26	-15.47**	-3.03	0.87	-12.52	-14.03	-1.16	-13.27
L10×T2	8.98 **	8.37 **	3.05	-12.18**	8.69**	-8.37**	-24.64	-22.48	-32.01	-33.93	-23.6	-32.96
L10×T3	15.94 **	11.21 **	2.82	-5.54 **	13.64**	-1.22	27.70 **	29.55 **	15.20 **	10.41 **	28.59**	12.83**
L10×T4	8.28 **	2.14	4.36 *	-8.12 **	5.31**	-2.61	-32.1	-40.44	-26.82	-34.7	-36.26	-30.72
L11×T1	23.54 **	26.08 **	5.14 **	0.92	24.76**	2.65*	8.43 **	11.54 **	-14.78	-18.67	9.91**	-16.7
L11×T2	51.57 **	50.26 **	4.41 *	-2.65 **	50.94**	1.27	9.62 **	12.74 **	-10.79	-13.95**	11.11	-12.35
L11×T3	17.47 **	18.09 **	5.96	0.3	17.77**	2.37	77.16 **	70.51 **	15.20 **	8.41 **	73.91**	11.85**
L11×T4	11.58 **	13.62 **	-3.87	2.21	12.57**	4.1	-19.02**	-22.01	-12.72	-14.49	-20.51	-13.6
L12×T1	13.80 **	10.59 **	-35.62	-11.48	12.25**	-7.65	9.65 **	2.51	-8.18	-10.9	6.05	-9.52
L12×T2	-8.79	-9.18	1.95	-41.27	-8.97	-38.42**	6.62 *	-0.47	-10.71**	-13.49**	3.05	-12.09**

L12×T3	14.70 **	13.97 **	12.32 **	-3.20 **	14.35**	-0.61	-2.22	-9.18 **	-18.11**	-21.06**	-5.72**	-19.57**
L12×T4	18.28 **	19.30 **	-7.82 **	7.31 **	18.77**	9.83**	-11.17**	-15.09	-4.26	-6.9	-13.13	-5.57
L13×T1	9.12 **	8.56 **	-23.77**	-13.10**	8.85**	-10.45**	-9.70 **	-7.03	-29.03	-32.21	-8.43	-30.6
L13×T2	-4.95	-5.3	0.82	-29.26	-5.12	-26.5	-18.06**	-16.94	-33.32	-36.6	-17.52	-34.94
L13×T3	13.43 **	12.62 **	-3.61	-4.34 **	13.04**	-1.75	8.76 *	6.21 *	-29.28	-32.47	7.51**	-30.86
L13×T4	1.5	1.35	-5.54	-8.83	1.43	-6.2	-17.92	-21.87	-11.54	-14.34	-19.89	-12.92
L14×T1	5.26	4.97	-27.48	-10.79	5.12**	-8.15	3.77	7.81 **	-18.44**	-21.39**	5.69**	-19.90**
L14×T2	-19.18	-21.19	4.18	-33.02	-20.15	-30.23	-17.39	-16.2	-32.76	-36.03	-16.82	-34.38
L14×T3	16.1	16.56	3.96	-0.94	16.32	1.64	1.47	-3.55	-34.02**	-37.32**	-0.9	-35.65**
L14×T4	9.47 **	9.87 **	-3.75 *	-1.17	9.66**	1.41	-1.79	-5.66	5.85	3.44	-3.72	4.65
L15×T1	-3.75	-8.97	-14.32	-8.97	-6.34	-6.34**	14.53 **	12.31 **	14.53 **	12.31 **	13.43**	13.43**
L15×T2	-14.32	-19.69	9.97	-19.69	-16.99	-16.99**	27.72 **	25.80 **	27.72 **	25.80 **	26.77**	26.77**
L15×T3	9.97 **	4.93 **	17.70 **	4.93 **	7.46**	7.46**	-12.22**	-15.03**	-12.22**	-15.03**	-13.61**	-13.61**
L15×T4	17.70 **	12.77 **	-19.86**	12.77 **	15.25**	15.25**	19.88 **	16.12 **	29.20 **	27.31 **	18.00**	28.27**
S.E. ±	0.35	0.18	0.31	0.23	0.2	0.24	0.31	0.2	0.38	0.25	0.18	0.14
CD (0.05)	0.7	0.37	0.77	0.86	0.42	0.41	0.63	0.39	0.78	0.45	0.39	0.4

Table 4.7 (d) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two Environments *viz*., Rainy 2022 (E1) and Summer 2023 (E2) and in pooled over the environment

Traits	Days to first flowering						Days to first fruit set					
Hybrids	HB (%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	-28.50**	-27.41**	-0.78	2.18	-27.94**	0.72	-25.10**	-24.09**	-0.65	1.96	-24.58**	0.68
L1×T2	-12.66**	-11.47**	21.19 **	24.62 **	-12.05**	22.93**	-11.30**	-9.83 **	17.65 **	21.12 **	-10.54**	19.42**
L1×T3	-25.21**	-23.01**	3.78	8.37	-24.09**	6.11	-23.85**	-22.63**	1.01	3.92	-23.22**	2.5
L1×T4	-21.80**	-19.11**	8.51 **	13.86	-20.43**	11.23**	-20.48**	-19.28**	5.48 **	8.43 **	-19.86**	6.99**
L2×T1	-8.04	-4.81	3.36	8.1	-6.39	5.77	-7.03 **	-5.25 **	1.37	4.02	-6.11**	2.72
L2×T2	-21.01**	-19.51**	-0.81	1.89 **	-20.25**	0.56	-18.96**	-16.01**	-2.08	2.77	-17.44**	0.4
L2×T3	-3.23 **	-0.66	8.78 **	12.82 **	-1.92**	10.82**	-4.24	-1.64	4.41	7.98	-2.9	6.23
L2×T4	4.44	5.48	19.82 **	23.20 **	4.97	21.53**	1.84	4.5	15.28 **	19.44 **	3.2	17.40**
L3×T1	-20.43	-19.8	-0.7	2.17	-20.11	0.76	-17.98	-15.98	-1.46	2.73 **	-16.95**	0.68
L3×T2	-4.66	-3.61	19.73 **	22.78 **	-3.84	21.28**	-16.93	-14.64	0.38	4.44 **	-15.75**	2.46
L3×T3	-20.46**	-18.13**	-0.73	4.29	-19.27**	1.81	-9.44	-7.64	8.80 **	12.93 **	-8.51	10.91**
L3×T4	-16.43**	-15.06**	4.29	8.2	-15.73**	6.27	-7.72 **	-6.14 **	10.87 **	14.77 **	-6.90**	12.86**
L4×T1	-4.33	-2.99	13.47 **	17.75 **	-3.64	15.64**	-14.33**	-13.27**	-1.84	2.09	-13.78**	0.17
L4×T2	-7.62 **	-4.81 **	16.02 **	20.51 **	-6.19**	18.29**	-16.72**	-14.89**	0.63	4.13	-15.78**	2.42**
L4×T3	-16.92**	-16.39**	-1.46	1.48	-16.65**	0.03	-13.68**	-12.94**	-1.09	2.48 **	-13.30**	0.73
L4×T4	-12.65**	-11.26**	3.6	7.71	-11.94**	5.69	-14.51**	-12.93**	-2.04 **	2.49 **	-13.69**	0.27
L5×T1	-10.73**	-5.79 **	-3.81 **	1.57 **	-8.22**	-1.08	-6.53	-5.68	-1.99 **	2.79 **	-5.18	0.45
L5×T2	-23.41**	-20.88**	-3.81 **	0.16	-22.12**	-1.80**	-18.85**	-16.27**	-1.94 *	2.44 **	-17.53**	0.3
L5×T3	-5.1	-1.98	-1.43	1.94	-3.44	0.28	9.39	6.07	13.19 **	15.59 **	8	14.42**
L5×T4	-0.56	0.68	14.09 **	17.59 **	0.07	15.86**	-11.31**	-8.93 **	0.4	4.09	-10.09**	2.28
L6×T1	-12.37**	-7.71 **	3.94	8.34	-10.02**	6.17	1.14	3.03	17.99 **	19.83 **	2.1	18.93**

L6×T2	-2.48	-1.48	22.47 **	24.73 **	-1.97	23.61**	-11.90**	-9.37 **	6.46 **	10.88 **	-10.60**	8.72**
L6×T3	-6.5	-1.61	10.90 **	15.51 **	-4.03	13.24**	-8.53	-4.64	6.72 **	10.90 **	-6.55	8.85**
L6×T4	-16.9	-13.37	-1.43	1.70 **	-15.12**	0.15	-16.00**	-11.83**	-2	2.55	-13.87**	0.32
L7×T1	-17.92**	-17.51**	5.62 **	9.40 **	-17.71**	7.54**	-13.00**	-14.05**	6.94 **	10.02 **	-13.55**	8.51**
L7×T2	-18.02**	-17.78**	5.49 **	9.04 **	-17.90**	7.29**	-13.31**	-13.84**	6.56 **	10.28 **	-13.59**	8.46**
L7×T3	-4.78	-6.08	22.53**	24.56 **	-5.45	23.56**	-4.49	-6.11	17.40 **	20.19 **	-5.33	18.82**
L7×T4	-22.96**	-22.30**	-0.86	3.04	-22.62**	1.12	-20.14**	-20.31**	-1.83 *	2.01 **	-20.23**	0.13
L8×T1	-1.33	0.23	12.43 **	15.38 **	-0.54	13.93**	-2.61 **	-2.38 **	8.89 **	12.05 **	-2.49**	10.50**
L8×T2	-21.49**	-18.88**	-1.4	2.69	-20.16**	0.67	-10.1	-7.49	8.63 **	13.18 **	-8.76	10.95**
L8×T3	-9.47	-8.1	3.16	5.79	-8.77	4.5	-11.81**	-11.42**	-1.4	1.67 **	-11.61**	0.17
L8×T4	-1.3	-0.94	13.23 **	15.70 **	-1.12	14.48**	-11.21	-8.64	0.5	4.86	-9.69	2.73
L9×T1	-10.49**	-9.41 **	-1.47	1.79 **	-9.94**	0.19	-1.94 **	-0.05	8.95	12.47	-0.97	10.75**
L9×T2	-9.90 **	-8.50 **	13.16 **	15.84 **	-9.18**	14.51**	-18.32**	-16.52**	-1.31	2.14 **	-17.40**	0.45
L9×T3	-6.29	-5.08	3.16 **	6.66 **	-5.67	4.93	-1.37 *	-0.3	9.59	12.19	-0.82	10.92**
L9×T4	-14.14**	-12.35**	-1.5	2.37 **	-13.23**	0.47	-11.34	-7.96	0.35	5.19	-9.61	2.83
L10×T1	-2.54	-1.11	22.39 **	24.52 **	-1.82	23.47**	-6.5	-4.67	16.87 **	20.19 **	-5.56	18.57**
L10×T2	-14.20**	-11.93**	7.74 **	11.50 **	-13.04**	9.65**	-21.39**	-18.75**	-1.74 *	2.43 **	-20.04**	0.39
L10×T3	-13.60**	-11.45**	8.50 **	11.50 **	-12.51**	10.03**	-13.26**	-11.33**	8.43 **	11.79 **	-12.27**	10.15**
L10×T4	-22.86**	-20.93**	-3.13 **	-0.44**	-21.88**	-1.77**	-13.14**	-10.78**	8.58 **	12.48 **	-11.93**	10.57**
L11×T1	-18.53**	-17.10**	-3.37 **	-0.42**	-17.80**	-1.88**	-18.54**	-16.71 *	-3.26 **	-0.19**	-17.60**	-1.69**
L11×T2	-23.37**	-21.30**	-3.77 **	-0.37**	-22.32**	-2.04**	-20.22**	-17.38**	-3.60 **	1.09 **	-18.76**	-1.21**
L11×T3	-18.54**	-16.74**	-3.39 **	0.02	-17.62**	-1.66**	-18.98**	-16.15**	-3.79 **	0.48	-17.53**	-1.61**
L11×T4	18.99 **	-16.73**	-3.92 **	0.03	-17.84**	-1.92**	-19.10**	-16.36**	-3.93 **	0.23	-17.70**	-1.81**
L12×T1	-6.14	-7.03	21.51 **	23.02 **	-6.59	22.28**	-1.59	-2.48	26.42 **	27.54 **	-2.05	27.00**
L12×T2	5.73	4.26	36.88 **	37.96 **	4.98	37.42**	1.76	1.6	30.74 **	32.88 **	1.68	31.83**
L12×T3	-8.1	-8.89	18.97 **	20.55 **	-8.51	19.77**	-4.39	-4.82	22.83 **	24.48 **	-4.61	23.67**

L12×T4	-1.85	-2.95	27.06 **	28.42 **	-2.41	27.75**	-1.03	-1.96	27.15 **	28.22 **	-1.51	27.70**
L13×T1	-3.35	-4.32	28.87 **	30.17 **	-3.85	29.53**	-7.81	-8.76	21.65 **	22.40 **	-8.3	22.03**
L13×T2	3.7	2.39	38.27 **	39.31 **	3.03	38.80**	2.23	1.64	34.89 **	36.34 **	1.93	35.63**
L13×T3	-10.13**	-10.78**	19.83 **	21.39 **	-10.46**	20.62**	-11.45**	-11.69**	16.83 **	18.47 **	-11.57**	17.67**
L13×T4	-5.02	-5.91	26.64 **	28.01 **	-5.48	27.34**	-0.02	-0.61	31.92 **	33.32 **	-0.32	32.64**
L14×T1	0.86	1.29 **	13.36 **	15.11 **	1.07*	14.25**	-3.52	-3.16	8.53 **	11.05 **	-3.34	9.82**
L14×T2	-5.54	-5.04	18.62 **	20.21 **	-5.29	19.43**	-7.36 **	-7.28 **	11.94 **	13.44 **	-7.32**	12.70**
L14×T3	-4.96	-4.3	6.83	8.75	-4.62	7.81	-3.33	-3.05	8.75 **	11.18 **	-3.19	9.99**
L14×T4	1.83	1.43	16.83 **	18.47 **	1.63	17.66**	3.72 **	3.46 **	17.41 **	18.65 **	3.77**	18.04**
L15×T1	-4.55	-2.72	2.84 **	4.88 **	-3.62	3.88**	-1.16	-0.52	3.65	5.31	-0.83*	4.49
L15×T2	-8.75	-8.13	14.60 **	16.30 **	-8.43	15.46**	-6.06 **	-5.33 **	13.51 **	15.83 **	-5.69**	14.69**
L15×T3	0.37	2.34	4.26	6.26	1.37	5.28	-0.28	1.72	3.18	5.57	0.74	4.4
L15×T4	-3.54	-3.7	10.67 **	12.48 **	-3.62	11.59**	-3.09	-2.66	9.70 **	11.25 **	-2.87	10.49**
S.E. ±	0.41	0.18	0.21	0.17	0.22	0.23	0.36	0.17	0.33	0.11	0.24	0.13
CD (0.05)	0.82	0.36	0.46	0.46	0.48	0.46	0.715	0.34	0.97	0.33	0.57	0.42

Table 4.7 (e) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two Environments *viz*., Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Days to first fruit picking						Number of flowers per plant					
Hybrids	HB (%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	-23.79**	-22.51**	-3.47	-0.5	-23.14**	-1.96	4.83	-3.94	17.61	2.87	0.4	10
L1×T2	-10.65**	-9.83 **	13.18 **	15.78 **	-10.23**	14.50**	10.94 **	2.43 *	19.77 **	5.29 **	6.65**	12.30**
L1×T3	-20.80**	-19.59**	0.32	3.26	-20.18**	1.81	11.57 **	6.09 **	20.45 **	9.06 **	8.81**	14.57**
L1×T4	-19.03**	-17.77**	2.56	5.6	-18.39**	4.1	-2.53	-11.42	5.23	-8.94	-7.01	-2.09
L2×T1	-5.34	-2.91	0.4	3.78	-4.1	2.11	3.7	-3.26	16.34 **	3.61 **	0.19	9.77**
L2×T2	-17.59**	-14.98**	-4.11 **	-0.14	-16.26**	-2.09**	36.76 **	48.97 **	10.01 **	-1.21	42.48**	4.22**
L2×T3	-3.71	-1.32	2.13	5.47	-2.49	3.83	-9.02	-10.54	-7.56	-19.39	-9.76	-13.67
L2×T4	1.39	3.03	11.22 **	14.46 **	2.23	12.87**	12.72 **	-3.09 **	12.15 **	-4.80 **	4.61**	3.40*
L3×T1	-8.88 **	-6.41 **	-3.36	0.05	-7.62	-1.63	-0.66	-10.13	11.45 **	-3.75	-5.44	3.60*
L3×T2	-13.65	-11.33	0.48	4.15 **	-12.47**	2.34	8.32 **	12.98 **	14.65 **	4.26 **	10.56**	9.29**
L3×T3	0.39	2.29 **	6.47 **	9.35 **	1.36**	7.93**	5.84 *	3.54 **	12.02 **	-4.44 **	4.73**	3.52*
L3×T4	-1.74 **	-0.33	7.79 **	10.72 **	-1.02**	9.28**	34.14 **	30.53 **	41.98 **	28.23 **	36.46**	34.88**
L4×T1	-16.13	-15.3	-2.92 **	0.06	-15.71**	-1.4	7.81 **	3.11 **	43.78 **	25.04 **	5.49**	34.10**
L4×T2	-16.88**	-15.62**	-3.28 **	-0.31	-16.02**	-1.77**	6.43 **	4.38 **	41.93 **	26.59 **	5.42**	34.01**
L4×T3	-16.52	-15.01	-3.37 **	0.41	-15.74**	-1.45	-17.35	-20.27	10.22	-3.31	-18.79	3.24
L4×T4	-16.2	-15.04	-3	0.38	-15.6	-1.29	-10.29	-14.32	19.64	3.91	-12.27	11.52
L5×T1	-13.03**	-12.41**	-3.55 **	-0.07	-12.71**	-1.78**	-7.38 **	-16.20**	3.92	-10.25**	-11.83**	-3.40*
L5×T2	-17.08**	-14.10**	-3.52 **	0.90 **	-15.56**	-1.27**	22.56 **	20.75 **	16.74 **	1.86	21.68**	9.06**
L5×T3	0.1	-0.11	11.02 **	13.96 **	-0.01	12.51**	16.96 **	14.65 **	18.84 **	3.31 **	15.84**	10.82**
L5×T4	-9.43 **	-8.54 **	0.45	4.34 **	-8.97**	2.43**	42.49 **	27.77 **	41.77 **	25.52 **	34.94**	33.37**
L6×T1	8.53 **	9.38 **	13.14 **	15.40 **	8.96**	14.28**	26.34 **	18.84 **	41.74 **	27.28 **	22.56**	34.28**

L6×T2	-8.91 **	-7.35 **	6.00 **	8.83 **	-8.11**	7.44**	-3.78	-11.88	3.87	-10.63	-7.84	-3.61
L6×T3	4.34	4.8	5.61 **	8.52 **	4.58	7.09	-13.53	-21.79	-6.65	-20.68	-17.67	-13.89
L6×T4	-11.67**	-9.82 **	-3.11 **	0.18	-10.73**	-1.44	2.1	-3.38	10.22	-2	-0.65	3.91
L7×T1	-7.48 **	-4.06 **	5.98 **	9.15 **	-5.75**	7.59**	-20.02	-21.56	10.06	-4.16	-20.77	2.71
L7×T2	-8.57	-6.93	6.39 **	9.33 **	-7.73	7.88**	-37.60**	-35.57**	-14.14**	-21.27**	-36.61**	-17.82**
L7×T3	-1.25 *	1.72 **	13.11 **	15.72 **	0.25	14.44**	-13.85	-11.75	18.54	7.83	-12.82	13.01*
L7×T4	-15.59**	-11.73**	-3.32	0.42	-13.64**	-1.42	-14.48**	-17.25**	17.68 **	1.11	-15.83**	9.12**
L8×T1	-11.63**	-12.69**	6.04 **	9.17 **	-12.18**	7.63**	3.53	-4.37	16.15	2.42	-0.46	9.06
L8×T2	-11.98**	-12.96**	5.62 **	8.84 **	-12.49**	7.26**	21.93 **	24.67 **	5.82 *	-1.92	23.28**	1.82
L8×T3	-18.86**	-19.82**	-2.63	0.26	-19.36**	-1.16	7.69 **	9.77 **	9.42 **	-1.09	8.70**	3.99**
L8×T4	-15.86**	-16.50**	0.96	4.42	-16.19**	2.72	17.00 **	6.03 **	16.41 **	4.16 **	11.37**	10.08**
L9×T1	-3.45	-3.11	6.50 **	9.07 **	-3.27	7.81**	-5.53	-14.7	5.99	-8.64	-10.16	-1.57
L9×T2	-16.75**	-14.91**	-3.13 **	-0.05	-15.81**	-1.57**	43.11 **	36.73 **	12.09 **	1.41	45.78**	6.57**
L9×T3	-3.92	-3.46	5.98 **	8.68 **	-3.68	7.35**	9.92 **	4.88 **	11.69 **	-5.49 **	7.47**	2.82*
L9×T4	-9.07 **	-7.85 **	0.3	3.73 **	-8.44**	2.04**	19.34 **	7.57 **	18.73 **	5.67 **	13.30**	11.99**
L10×T1	9.97 **	8.02 **	20.63 **	19.28 **	8.97**	19.95**	-5.87	-15.98	5.61	-10.01	-10.97	-2.46
L10×T2	-16.36**	-14.53**	-2.67 **	0.39	-15.43**	-1.12**	7.63	1.11	16.19	2.91	4.36	9.34
L10×T3	-3.35	-1.36	6.02 **	8.93 **	-2.33	7.50**	2.14	-11.75**	10.27 **	-10.17**	-4.83**	-0.29
L10×T4	-1.65	-0.24	7.88 **	10.82 **	-0.93	9.38**	-12.22	-22.46	-5.23	-21.07	-17.35	-13.41
L11×T1	-16.57	-15.13	-2.92 **	0.54	-15.83**	-1.16	5.98	-5.15	18.9	1.59	0.36	9.96**
L11×T2	-16.64	-15.06	-3.00 **	0.63 *	-15.83**	-1.16	40.51 **	46.21 **	10.06 **	-1.27	50.02**	4.21**
L11×T3	-16.64	-15.82	-2.99 **	-0.27	-16.22**	-1.61	2.5	1.41	4.15	-8.62	1.97	-2.45
L11×T4	-16.94**	-15.72**	-3.35 **	-0.15	-16.31**	-1.72**	11.13	-2.28	10.56	-4	4.25	3.04
L12×T1	-7.09 **	-7.02 **	16.00 **	17.41 **	-7.05**	16.72**	-2.08	-7.16 **	9.86 **	-0.57	-4.64**	4.47**
L12×T2	3.24	2.88	28.90 **	29.91 **	3.06	29.41**	-6.71	-9.04	-11.13	-18.58	-7.88	-14.98
L12×T3	-2.82	-2.93	21.33 **	22.58 **	-2.87	21.97**	22.08 **	23.98 **	24.05 **	11.72 **	23.01**	17.68**
L12×T4	-2.71	-2.82	21.47 **	22.71 **	-2.77	22.10**	18.77 **	8.70 **	18.16 **	6.78 **	13.60**	12.29**

L13×T1	-0.68	-1.77	27.01 **	28.08 **	-1.24	27.56**	5.04	-1.46	17.85	5.53	1.76	11.49
L13×T2	3.86	2.55	32.81 **	33.70 **	3.18	33.26**	-9.68 **	-5.10 **	-15.88**	-23.71**	-7.49**	-19.92**
L13×T3	-7.66 **	-8.41 **	18.08 **	19.42 **	-8.04**	18.76**	6.52 **	8.05 **	8.23 **	-2.64 *	7.27**	2.62
L13×T4	-4.18 **	-5.10 **	22.53 **	23.74 **	-4.65**	23.14**	18.02 **	7.85 **	17.42 **	5.95 **	12.80**	11.50**
L14×T1	1.8	2.33	12.90 **	14.41 **	2.07	13.67**	-3.79	-8.07 **	7.94 **	-1.55	-5.95**	3.04*
L14×T2	-0.25	0.01	16.07 **	17.48 **	-0.11	16.79**	19.54	22.31	-1.31	-12.27	20.87	-6.97
L14×T3	5.90 **	6.28 **	17.45 **	18.82 **	6.09**	18.15**	6.88 **	9.68 **	8.59 **	-1.17	8.24**	3.55*
L14×T4	7.03 **	7.36 **	18.70 **	20.03 **	7.20**	19.38**	16.72 **	5.11 **	16.13 **	3.25 **	10.76**	9.48**
L15×T1	5.64	5.88	10.12 **	11.71 **	5.76	10.93**	21.51 **	15.36 **	36.33 **	23.55 **	18.41**	29.73**
L15×T2	-1.4	-1.09	14.74 **	16.19 **	-1.24	15.48**	-4.06	-14.08	-4.06	-14.08	-9.23	-9.23
L15×T3	10.47 **	11.54 **	11.81 **	13.35 **	11.01**	12.59**	19.33 **	9.48 **	21.25 **	9.48 **	15.17**	15.17**
L15×T4	2.19	2.29	12.10 **	13.63 **	2.24	12.88**	33.72 **	19.87 **	33.72 **	19.87 **	26.57**	26.57**
S.E. ±	0.38	0.17	0.13	0.11	0.21	0.24	0.38	0.17	0.13	0.24	0.21	0.24
CD (0.05)	0.76	0.34	0.46	0.33	0.45	0.5	0.76	0.34	0.36	0.57	0.44	0.58

Table 4.7 (f) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two Environments *viz.*, Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Number of pods per plants						Pod length					
Hybrids	HB (%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	12.68 **	18.33 **	13.39 **	6.66 **	10.00**	10.03**	6.09	4.34	-4.63	-13.97	7.28	-9.06
L1×T2	14.78 **	19.96 **	15.51 **	8.13 **	12.30**	11.83**	9.67	17.96	11.98	6.28	17.83	9.28
L1×T3	11.64 **	14.08 **	12.34 **	2.83 *	14.57**	7.60**	17.72	18.98	2.61	-1.9	18.53	0.47
L1×T4	21.51 **	17.53 **	26.65 **	22.53 **	-2.09	24.60**	18.14 **	37.49 **	13.18 **	13.36 **	32.11**	13.27**
L2×T1	8.95 **	1.84 *	28.44 **	22.77 **	9.77**	25.61**	27.40 **	13.85 **	15.72 **	12.64 **	15.76**	14.26**
L2×T2	8.68 **	0.69	28.11 **	21.39 **	4.22**	24.76**	17.50 **	10.04 **	15.17 **	8.87 **	13.66**	12.18**
L2×T3	12.41 **	6.76 **	32.52 **	28.71 **	-13.67**	30.62**	16.94 **	12.74 **	15.89 **	11.53 **	15.33**	13.83**
L2×T4	-12.43	-14.47	3.23	3.11	3.4	3.17	17.67 **	26.66 **	22.86 **	25.31 **	25.66**	24.03**
L3×T1	13.87 **	11.32 **	6.72 **	1.05	3.60*	3.89**	24.75 **	21.42 **	26.16 **	19.34 **	18.95**	22.92**
L3×T2	7.21	4.85	0.48	-4.82	9.29	-2.16	16.93 **	22.89 **	29.45 **	20.78 **	21.29**	25.34**
L3×T3	24.74 **	21.34 **	17.32 **	10.15 **	3.52*	13.74**	19.98 **	29.36 **	30.66 **	27.14 **	24.82**	28.99**
L3×T4	15.23 **	10.68 **	20.11 **	15.38 **	34.88**	17.75	21.09	3.87	13.18	2.09	4.44	7.92
L4×T1	11.58 **	11.67 **	22.07 **	15.54 **	34.10**	18.81**	4.9	15.95	16.75	12.64	18.33	14.8
L4×T2	11.18 **	10.34 **	21.64 **	14.16 **	34.01**	17.91**	20.47 **	7.72 **	11.16 **	4.64 *	11.39**	8.07**
L4×T3	0.38	-1.8	9.81	1.6	3.24	5.72**	14.70 **	38.28 **	27.98 **	34.34 **	35.01**	30.99**
L4×T4	-8.35	-7.34	0.26	-3.4	11.52	-1.56	32.06 **	29.11 **	28.97 **	25.43 **	31.20**	27.29**
L5×T1	7.72	13.69	-2.33	-11.37	-3.4	-6.84	33.09 **	15.23 **	40.06 **	33.38 **	17.27**	36.90**
L5×T2	37.75 **	35.23 **	8.88 **	5.41 **	36.06**	7.15**	19.09 **	11.71 **	25.95 **	29.31 **	9.26**	27.55**
L5×T3	1.65	1.05	-4.41	-11.51	10.82	-7.95	7.09 *	15.03 **	40.37 **	33.16 **	17.32**	36.95**

L5×T4	10.73 **	11.65 **	15.42 **	16.39 **	33.37**	15.91**	19.35 **	-0.43	16.34 **	15.26 **	-0.77	15.83**
L6×T1	32.48 **	46.41 **	20.11 **	13.46 **	38.28**	16.79	-1.08	11.17	19.77	19.3	10.77	19.55
L6×T2	43.41 **	63.98 **	15.57 **	8.85 **	53.61**	12.22**	10.41 **	4.79 **	19.77 **	12.45 **	7.76**	16.30**
L6×T3	16.30 **	16.12 **	9.38 **	1.69	-13.89**	5.54**	10.41 **	1.81	16.92 **	9.25 **	4.97*	13.29**
L6×T4	16.84 **	11.10 **	21.79 **	15.82 **	3.91**	18.81**	7.78 *	-15.86**	-3.78	-9.71 **	-13.45**	-6.59**
L7×T1	15.30 **	10.54 **	22.44 **	16.11 **	2.71	19.28	-11.3	-6.29	4.36	-9.9	0.28	-2.4
L7×T2	14.13 **	10.49 **	21.20 **	16.06 **	-17.82**	18.64	6.07	-6.49	-7.31	-10.09	-6.12	-8.63
L7×T3	-14.93	-24.77	-9.66	-20.97	13.01	-15.3	-5.79	2.85	-1.2	-1.1	1.56	-1.16
L7×T4	-19.53	-23.72	-14.55	-19.88	9.12	-17.21	0.42	1.98	-2.85	-1.94	0.26	-2.42
L8×T1	-12.64	-11.15	-11.25	-18.1	9.06	-14.67	-1.26	-13.07	-6.21	-4.57	-14.03	-5.43
L8×T2	18.01 **	23.94 **	19.89 **	14.25 **	1.82	17.07**	-14.89**	3.78 *	18.40 **	13.93 **	5.71*	16.28**
L8×T3	19.94 **	24.94 **	21.85 **	15.17 **	3.99**	18.52**	7.45	-21.71	-14.9	-14.05	-22.27	-14.49
L8×T4	21.26 **	18.23 **	26.39 **	23.25 **	10.08**	24.83	-22.77	-6.93	-1.03	2.17	-8.65	0.49
L9×T1	14.65 **	12.60 **	28.20 **	22.40 **	-1.57	25.31	-10.19	21.98	-4.05	0.57	14.9	-1.86
L9×T2	-8.76	-12.6	2.03	-5	6.57	-1.48	8.92 *	32.83 **	19.26 **	19.68 **	28.80**	19.46**
L9×T3	2.15	-1.45	14.22 **	7.12 **	2.82*	10.68**	40.37 **	47.97 **	22.79 **	22.00 **	43.32**	22.42**
L9×T4	-12.62**	-12.80**	-2.29	-5.22 **	11.99**	-3.75*	39.40 **	48.43 **	19.77 **	22.38 **	41.14**	21.01**
L10×T1	-9.50 **	-4.95 **	-17.95**	-26.34**	-2.46	-7.41**	34.81 **	27.08 **	21.52 **	20.40 **	27.46**	20.99**
L10×T2	33.88 **	37.37 **	0.24	-3.57 **	9.34**	35.56**	27.80 **	9.16 **	-3.71	3.43	5.00*	-0.32
L10×T3	18.18 **	24.02 **	11.15 **	8.61 **	-0.29	20.99**	1.23	-4.66	-1.17	-9.67	-0.13	-5.2
L10×T4	-31.03	-33.4	-28.11	-30.57	-13.41	-29.34	3.94	19.93	6.73	13.63	15.88	10
L11×T1	7.26 **	6.56 **	13.78 **	10.72 **	9.96**	12.25**	12.24 **	7.97 **	16.75 **	13.40 **	8.39**	15.16**
L11×T2	2.57	0.51	8.81 **	4.43 **	4.21**	6.62**	8.76	10.62	17.03	16.18	9.77	16.62
L11×T3	2.82	-2.95 **	9.07 **	0.83	-2.45	4.96**	9.02 *	0.11	15.55 **	5.14 **	4.11	10.61**
L11×T4	0.88	-2.48 *	7.02 **	1.67	3.04*	4.35**	7.64 *	6.05 **	19.98 **	11.38 **	9.09**	15.90**
L12×T1	6.89 **	6.88 **	20.39 **	18.87 **	4.47**	19.63**	11.77	-1.95	-13.49	-15.84 *	-2.15	-14.60**
L12×T2	-28.58	-29.02	-19.56	-21.06	-14.98	-20.31	-2.33	-3.72	-11.50**	-13.25**	-5.47*	-12.33**

L12×T3	-6.86	-5.42	4.91	5.19	17.68	5.05	-6.96	-5.68 *	-19.33**	-19.03**	-7.40*	-19.19**
L12×T4	9.26 **	9.02 **	23.05 **	21.26 **	12.29**	22.16**	-8.91 *	5.54 *	-7.24	-9.40 **	5.11	-8.27**
L13×T1	-15.59	-6.39	-23.47	-27.46	11.49	-25.46	4.4	-10.49**	-1.17	-6.09 **	-8.51**	-3.5
L13×T2	-8.5	-2.97	-36.12	-36.91	-19.92	-36.51	-6.74	8.71 **	11.88 **	14.05 **	7.05**	12.91**
L13×T3	-5.77	-4.58	-11.38	-16.44	2.62	-13.9	5.57	-25.98**	-14.07**	-22.34**	-22.25**	-18.00**
L13×T4	-1.51	-3.32 **	2.66	0.79	11.50**	1.73	-18.92**	-8.35 **	-2.27	-3.84 *	-8.04**	-3.01
L14×T1	-6.21	7.47	-14.96	-16.72	3.04	-15.84	-7.77 *	1.53	-7.35	-9.14 **	3.67	-8.19**
L14×T2	-8.90 *	-7.35 **	-40.85**	-41.95**	-6.97**	-41.40**	5.64	10.52 **	-0.72	-0.42	7.20**	-0.58
L14×T3	-1.21	2.43	-7.09 **	-10.30**	3.55*	-8.69**	4.37	-19.18**	-21.73**	-27.67**	-14.80**	-24.55**
L14×T4	-6.55 **	-7.04 **	-2.6	-3.09 **	9.48**	-2.84*	-10.76 *	8.85 **	-3.33	-2.59	9.56**	-2.98
L15×T1	14.29 **	8.26 **	14.29 **	8.26 **	29.73**	11.28**	8.81 *	-10.28**	-1.48	-10.28**	-5.65*	-5.65*
L15×T2	-7.04	-6.75	-7.04	-6.75	-9.23	-6.9	-1.48	3.62	1	3.62	2.24	2.24
L15×T3	11.19 **	11.79 **	11.19 **	11.79 **	15.17**	11.49**	1	-12.14	-13.56	-12.14	-12.89	-12.89
L15×T4	24.02 **	19.76 **	29.27 **	24.85 **	26.57**	27.07**	-13.56	-3.16	2.54	-3.16	-0.16	-0.16
S.E. ±	0.36	0.16	0.13	0.35	0.24	0.29	0.37	0.16	0.13	0.15	0.2	0.25
CD (0.05)	0.71	0.33	0.42	1.47	0.42	0.42	0.74	0.33	0.35	0.79	0.43	0.96

Table 4.7 (g) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two Environments *viz*., Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Number of first fruiting node						Number of nodes per plant					
Hybrids	HB (%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	-6.46	0.66	0.96	-9.98	-3.36	-4.32	-11.88 **	-15.36 **	-13.56**	2.30 **	-14.67**	11.86**
L1×T2	-7.01	-14.72	-9.23	-20.91	-10.63	-14.87**	13.42 **	13.21 **	13.32**	-5.09 **	13.29**	-5.09**
L1×T3	-17.2	-19.48	12.31	2.2	-18.26	7.43	-6.64	-6.8	-6.71	-6.8	-11.99	-6.71
L1×T4	1.8	5.44	-3.42	-14.67	3.41	-8.85	3.72	-3.12	0.41	-14.56	1.78	-13.99
L2×T1	9.19 **	18.01 **	17.85 **	8.14 *	14.30**	13.17**	5.88 **	3.72 **	4.84**	25.37 **	-0.32	23.54**
L2×T2	-3.38	-1.98	1.78	-9.10 *	-2.22	-3.47	26.08 **	23.15 **	-5.82**	6.85 **	25.82**	6.14**
L2×T3	-0.86	-0.75	34.47 **	25.97 **	-0.81	30.37**	15.58 **	3.85 **	3.66**	18.22 **	11.7***	16.82**
L2×T4	-8.57 *	-7.21	-3.69	-14.97 **	-7.96*	-9.13**	30.12 **	33.16 **	-2.99**	10.25 **	32.99**	9.33**
L3×T1	2.88	5.26	22.37 **	12.99 **	3.97	17.84**	-1.74	-4.44	-3.04	15.50 **	-2.43	14.26**
L3×T2	-11.04	-11.28	5.81	-4.77	-11.15	0.71	13.94 **	-4.69	-3.14	-4.59	-2.55	-4.62
L3×T3	3.48	4.22	40.36 **	32.28 **	3.82	36.46**	2.24 **	3.06 **	2.67**	3.17 **	5.89**	2.67**
L3×T4	-13.05	-13.67	3.42	-7.34	-13.34	-1.77	27.98 **	28.13 **	9.11**	8.24 **	28.11**	7.45**
L4×T1	-4.25	3.53	3.35	-7.41	-0.86	-1.84	-1.73	-4.46	-3.04	15.49	-5.05	14.26
L4×T2	-7.01	-14.72 **	-9.23 *	-20.91 **	-10.63**	-14.87**	13.19 **	5.45 **	2.47**	-5.29 **	4.59**	-5.29**
L4×T3	-25.97 **	-29.54 **	0.41	-10.56 **	-27.63**	-4.88	11.80 **	13.94 **	12.81**	13.94 **	0.02	12.81**
L4×T4	1.51	4.6	-3.69	-14.97 **	3.09	-9.13**	20.27 **	12.44 *	8.87**	0.99	11.66**	0.63
L5×T1	-5.89	1.39	1.57	-9.32 *	-2.72	-3.68	2.2	-0.25	1.02	20.58	-1.91	19.05
L5×T2	-10.58 **	-18.75 **	-12.72 **	-24.65 **	-14.42**	-18.48**	1.65	-4.82	-5.01	-16.18	-1.09	-15.52
L5×T3	-4.64	-5.09	29.34 **	20.47 **	-4.85*	25.06**	1.55 *	2.39 **	1.94**	2.39 **	-1.38*	1.94**

L5×T4	5.7	10.34 *	0.27	-10.71**	7.75*	-5.03	14.45 **	8.33 **	7.37**	-4.46 **	7.58**	-4.51**
L6×T1	14.96 **	28.38 **	24.08 **	14.82 **	20.81**	19.61**	-1.14	-3.83	-2.43	16.25 **	3.31	14.98**
L6×T2	3.03	4.11	7.05	-3.45	7.06*	1.98	-2.65	-2.43	-2.55	1.69	-6.73	1.29
L6×T3	-6.20 *	-6.88 *	27.22 **	18.20 **	-6.52**	22.87**	5.32 **	6.52 **	5.89**	11.03 **	-1.78*	10.06**
L6×T4	3.36	19.76 **	7.39 *	-3.08	11.84**	2.34	-3.49	-3.37	-3.44	0.71	-6.6	0.37
L7×T1	2.72	3.39	10.88 **	0.66	7.01*	5.95*	-12.96	-16.52	-14.67	0.91	-3.9	0.55
L7×T2	10.65 **	0.23	8.00 *	-2.42	7.30*	2.97	1.95 *	0.36	1.2	-15.87	8.27	-15.24
L7×T3	-16.19 **	-18.32 **	13.68 **	3.67	-17.18**	8.85**	1.18	1.99 *	1.56*	1.99 *	5.03**	1.56*
L7×T4	12.33 **	-1.36	6.57	-3.96	5.75	1.49	4.23 **	-2.58 **	0.94	-14.08 **	4.52**	-13.54**
L8×T1	-3.17	4.92	4.51	-6.16	0.36	-0.64	-8.34	-11.54	-9.88	6.93	2.47	6.2
L8×T2	4.34	-1.9	1.85	-9.02 *	1.41	-3.4	7.51 **	6.59 **	7.07**	-10.64 **	-1.87**	-10.32**
L8×T3	-1.11	-1.04	34.13 **	25.61 **	-1.08	30.02**	-1.03	-0.51	-0.79	-0.51	5.45	-0.79
L8×T4	20.38 **	25.41 **	15.94 **	6.09	22.65**	11.19**	3.12 **	-3.76 **	-0.21	-15.12 **	1.03	-14.52**
L9×T1	1.08	10.42 *	9.10 *	-1.25	5.15	4.11	-3.67	-6.53	-5.05	12.98	11.45	11.9
L9×T2	0.51	4.27	7.18	-3.3	7.21*	2.12	4.69 **	3.96 **	4.59**	-12.85 **	-8.69**	-12.39**
L9×T3	-3.93	-4.28	30.30 **	21.50 **	-4.09	26.05**	-0.28	0.35	0.02	0.35	3.81	0.02
L9×T4	6.61	25.71 **	13.68 **	3.67	14.61**	8.85**	13.70 **	8.50 **	11.66**	-4.31 **	-11.43**	-4.36**
L10×T1	-3.17	-5.26	4.51	-6.16	0.36	-0.64	-0.64	-3.26 **	-1.91**	16.93 **	-1.94**	15.60**
L10×T2	-0.35	-13.11 **	-2.74	-13.94 **	-4.91	-8.14**	-4.05	2.48	-1.09	-5.62	7.37	-5.59
L10×T3	-2.67	-2.83	32.01 **	23.33 **	-2.75	27.82**	-1.59	-1.14	-1.38	-1.14	-2.43	-1.38
L10×T4	16.94 **	1.7	10.94 **	0.73	9.75**	6.02*	3.87 **	12.05 **	7.58**	3.18 **	-2.55**	2.68**
L11×T1	-6.21	0.98	1.23	-9.68 *	-3.07	-4.04	2.21 **	4.54 **	33.31**	36.05 **	5.89**	33.59**
L11×T2	2.71	0.24	3.69	-7.04	3.42	-1.49	-7.32	-6.06	-6.73**	22.25 **	-3.44	20.61**
L11×T3	-2.77	-2.95	31.87 **	23.18 **	-2.85	27.68**	-2.62 **	-0.84	21.78**	29.05 **	-14.67**	25.01**
L11×T4	0.2	11.51 *	1.16	-9.76 *	8.80*	-4.11	-7.2	-5.94	-6.60**	22.42 **	1.2	20.78**
L12×T1	4.93	11.19 **	23.73 **	14.45 **	7.74**	19.26**	-2.62 **	-5.42 **	-3.97**	14.33 **	1.56*	13.17**
L12×T2	-5.86	-2.07	11.01 **	0.81	-4.16	6.09*	7.51 **	9.13 **	8.27**	0.25	0.94	-0.07

L12×T3	6.45 *	7.63 *	44.39 **	36.61 **	7.00**	40.64**	4.46 **	5.67 **	5.03**	5.67 **	-9.88**	5.03**
L12×T4	-12.01 **	-9.62 *	3.76	-6.97	-10.94**	-1.42	3.98 **	5.13 **	4.52**	-3.43 **	7.07**	-3.53**
L13×T1	9.24 **	11.15 **	26.13 **	17.02 **	10.12**	21.73**	3.60 **	1.26	2.47**	22.40 **	-0.79	20.76**
L13×T2	-4.98	-5.57	9.71 **	-0.59	-5.25*	4.74	-2.22	-1.48	-1.87	-7.03	-0.21	-6.92
L13×T3	-11.35 **	-12.77 **	20.25 **	10.71 **	-12.01**	15.65**	4.86 **	6.12 **	5.45**	6.12 **	-5.05**	5.45**
L13×T4	-2.43	-2.58	12.65 **	2.57	-2.5	7.79*	0.49	1.63	1.03	-4.10 **	0.059	-4.17**
L14×T1	-6.59	0.49	0.82	-10.12 *	-3.5	-4.46	10.71 **	11.17 **	31.45**	34.37 **	11.66**	32.02**
L14×T2	-11.77 **	-20.09 **	-13.89 **	-25.90 **	-15.68**	-19.68**	-8.49 **	-8.92	-8.69	9.00	-1.91	8.15
L14×T3	-25.11 **	-28.55 **	1.57	-9.32 *	-26.72**	-3.68	3.42 **	4.24 **	3.81**	24.76 **	-1.09	22.97**
L14×T4	0.36	3.63	-4.79	-16.14 **	1.81	-10.27**	-11.08	-11.8	-11.43**	5.55 **	-1.38	4.92**
L15×T1	8.11 *	6.9	16.69 **	6.9	11.96**	11.96**	15.65 **	14.65 **	15.16**	46.41 **	7.58**	43.34**
L15×T2	9.23 *	-1.1	9.23 *	-1.1	4.25	4.25	-10.59 **	-13.50 **	-11.99**	10.46 **	3.31**	9.53**
L15×T3	-7.46	-8.32	25.51 **	16.36 **	-7.86	21.10**	2.71 **	0.78	1.78**	28.70 **	-6.73**	26.68**
L15×T4	0.55	-10.42 **	0.55	-10.42 **	-4.74	-4.74	0.69	-1.40 *	-0.32	25.92 **	-1.78**	24.07**
S.E. ±	0.17	0.13	0.1	0.09	0.12	0.26	0.17	0.13	0.24	0.46	0.12	0.25
CD (0.05)	0.35	0.43	0.35	0.24	0.35	0.54	0.341	0.34	0.681	1.08	0.36	0.52

Table 4.7 (h) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two Environments *viz*., Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Number of ridges per pod						Pod diameter					
Hybrids	HB (%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	-1.89	0.97	-15.90 **	-11.86 **	-0.57	-14.05	7.33	16.57	3.94	0.5	12.85	6.54
L1×T2	15.28 **	27.19 **	-1.19	5.65	20.64**	1.94	-6.15	2.46	2.15	-7.99	-2.18	-2.18
L1×T3	-12	-7.17	-12	-7.17	-9.79	-9.79	-8.8	-7.17	29.21 **	-9.69	-8.02	-3.93
L1×T4	-11.72 **	-5.85	-24.33 **	-21.80 **	-9.08**	-23.17**	32.54 **	34.32 **	-7.35	15.82	33.40**	22.34**
L2×T1	-12.78 **	-11.64 **	-25.24 **	-22.87 **	-12.25**	-24.15**	-11.93	-3.64	11.11	-18.88 *	-8.13	-13.26
L2×T2	8.07 *	0.14	-22.81 **	-20.05 **	4.22	-21.54**	0.32	10.04	3.41	-1.19	4.8	4.8
L2×T3	-5.19	0.9	-5.19	0.9	-2.4	-2.4	-7.68	-5.94	-23.12 *	-8.5	-6.85	-2.71
L2×T4	2.87	7.9	-26.52 **	-24.39 **	5.14	-25.55**	-6.13	-4.65	-7.35	-33.67 **	-5.43	-28.53**
L3×T1	-13.86	-12.06	-13.86	-9.43	-13.02	-11.83	-11.93	-3.43	-6.27	-18.71 *	-8.04	-13.18
L3×T2	9.10 **	14.42 **	9.10 **	17.84 **	11.57**	13.10**	-15.37	-8.33	-6.99	-17.69 *	-12.13	-12.13
L3×T3	15.90 **	22.26 **	15.90 **	25.92 **	18.86**	20.49**	-16.96 *	-16.08	-7.17	-18.37 *	-16.54*	-12.83
L3×T4	-11.24	-9.05	-11.24	-6.32	-10.22	-8.99	5.07	22.82	9.14	-18.54 *	12.91	-13
L4×T1	-7.78	-5.82	-20.95	-17.79	-6.87	-19.5	3.75	14.95	-5.73	-3.23	8.87	2.79
L4×T2	-9.33	-18.25	-35.24	-34.73	-13.66	-35	-14.89	-7.77	-1.43	-17.18	-11.61	-11.61
L4×T3	-15.24	-11.01 **	-15.24 **	-11.01 **	-13.30**	-13.30**	-12	-10.84	-15.77	-13.27	-11.45	-7.5
L4×T4	5.07	5.87	-24.95 **	-22.59 **	5.44*	-23.87**	7.06	-8.33	-12.9	-27.04 **	-0.88	-21.55**
L5×T1	-14.33	-13.58	-26.57	-24.56	-13.99	-25.65	-17.21	-9.7	-7.53	-23.98 **	-13.77	-18.59**
L5×T2	10.00 **	2.12	-21.43 **	-18.46 **	6.18*	-20.07**	-16.50 *	-9.66	-12.54	-18.88 *	-13.35	-13.35
L5×T3	-15.29	-11.07	-15.29	-11.07	-13.36	-13.36**	-21.92 **	-21.50 *	-19.00 *	-23.64 **	-21.72**	-18.24*
L5×T4	9.27 **	9.72 *	-21.95 **	-19.09 **	9.48**	-20.64**	-6.61	-9.05	8.78	-29.93 **	-7.79	-24.61**
L6×T1	-16.39	-15.85	-28.33	-26.54	-16.14	-27.51	3.41	6.57	6.27	-3.4	8.6	2.53

L6×T2	-7.6	-16.48	-34	-33.31	-11.91	-33.69	-4.05	3.94	9.14	-5.78	0.09	0.09
L6×T3	-12.33 **	-7.57 **	-12.33 **	-7.57 **	-10.15**	-10.15**	-2.56	-0.35	-15.59	-3.06	-1.5	2.88
L6×T4	3.6	8.70 *	-26.00 **	-23.83 **	5.91*	-25.01**	-9.07	-18.95	33.33 **	-26.53 **	-14.08	-21.20**
L7×T1	7	9.19	-8.29	-2.77	8.02	-5.76	26.75 **	42.42 **	17.2	19.90 *	33.92**	26.44**
L7×T2	-2.78	-1.97	-16.67 **	-12.70 **	-2.4	-14.85**	5.83	16.48	19.89 *	4.59	10.73	10.73
L7×T3	1.76	9.09 **	1.76	9.09 **	5.11*	5.11*	7.04	9.97	20.25 *	6.97	8.44	13.26
L7×T4	-7.5	-7.42	-20.71	-17.56	-7.46	-19.27	18.13 *	33.90 **	32.26 **	7.48	25.29**	13.70*
L8×T1	13.61 **	14.36 **	-2.62	3.9	13.96**	0.36	14.24	34.68 **	54.12 **	18.88 *	23.35**	25.39**
L8×T2	-7.72	-9.57	-20.9	-17.84	-8.59	-19.5	33.13 **	55.30 **	33.51 **	39.46 **	44.21**	36.60**
L8×T3	4.1	11.86 **	4.1	11.86 **	7.65**	7.65**	15.33	23.08 *	8.06	19.73 *	0.17	1.83
L8×T4	1.78	1.18	-12.76 **	-8.07 **	1.5	-10.62**	-6.66	8.67	-13.26	-4.08	-14.14	-18.94**
L9×T1	-10.39 **	-8.86 **	-23.19 **	-20.44 **	-9.68**	-21.93**	-17.55 *	-10.1	17.74	-24.32 **	11.17	11.17
L9×T2	-7.8	-16.62	-34.14	-33.43	-12.08	-33.82	6.31	16.86	-20.61 *	4.93	-29.24**	-26.09**
L9×T3	-4.95 *	1.19	-4.95 *	1.19	-2.14	-2.14	-29.12 **	-29.37 **	-11.11	-31.29 **	14	-16.84*
L9×T4	3.73	8.60 *	-25.90 **	-23.72 **	5.94*	-24.90**	7.13	22.52	15.41	-22.28 *	6.3	8.99
L10×T1	-14.94	-14.17	-27.1	-25.07	-14.58	-26.17	-0.77	15.02	20.97 *	2.89	11.57	14.40*
L10×T2	0.67	-7.78	-28.1	-26.37	-3.43	-27.31**	4.01	20.45 *	25.45 **	8.16	13.70*	18.76**
L10×T3	-10.29 **	-5.14	-10.29 **	-5.14	-7.93**	-7.93**	7.86	15.56	17.74	12.41	8.51	11.26
L10×T4	4.4	9.14 *	-25.43 **	-23.15 **	6.55*	-24.39**	1.23	17.49	-12.01	5.1	-12.85	-17.71*
L11×T1	13.44 **	10.60 **	-2.76	3.67	12.08**	0.18	-16.35	-8.69	-20.43 *	-23.13 **	-25.92**	-25.92**
L11×T2	0.78	-3.07	-13.62 **	-9.15 **	-1.07	-11.57**	-28.16 **	-23.30 *	12.9	-31.12 **	1.84	6.37
L11×T3	1.1	8.24 **	1.1	8.24 **	4.37*	4.37*	0.8	2.97	-11.47	0.17	4.86	-17.19*
L11×T4	-6.28	-10.66	-19.67	-16.26	-8.38	-18.11	5.11	4.6	11.11	-22.62 *	10.91	4.71
L12×T1	7.17 *	9.82 **	-8.14 **	-2.71	8.40**	-5.66**	5.62	17.17	-10.75	-1.36	-16.49*	-16.49*
L12×T2	-19.06	-20.14	-30.62	-29.25	-19.56	-29.99	-19.42 *	-13.07	13.62	-21.94 *	2.67	7.24
L12×T3	2.14	9.60 **	2.14	9.60 **	5.55**	5.55**	1.44	4.02	-7.35	1.19	15.43	-13.18
L12×T4	-10.11 **	-9.88 **	-22.95 **	-20.16 **	-10.00**	-21.67**	0.39	37.75 *	10.22	-18.71 *	-5.92	3.93

L13×T1	-1.62	-0.8	-1.62	5.08	-1.23	1.45	-0.16	-11.38	28.49 **	-2.04	10.19	21.73**
L13×T2	-15	-15.78	-15	-10.78	-15.37	-13.07	16.02	4.31	25.63 **	15.31	7.66	18.94**
L13×T3	3.71	5.17	3.71	11.41 **	4.40*	7.23**	12.16	1.85	20.97 *	12.59	3.4	14.22*
L13×T4	-7.43 **	-7.30 **	-7.43 **	-1.81	-7.37**	-4.86*	9.58	-2.46	7.53	7.82	7.3	1.31
L14×T1	-16.39	-15.85	-28.33 **	-26.54 **	-16.14	-27.51**	2.21	13.33	-0.72	-4.59	-6.72	-6.72
L14×T2	-2.4	-10.96 **	-30.29 **	-28.91 **	-6.55*	-29.66**	-10.36	-2.46	-21.68 *	-12.41	-30.33**	-27.23**
L14×T3	-14.38 **	-9.99 **	-14.38 **	-9.99 **	-12.37**	-12.37**	-30.08 **	-30.59 **	-23.84 *	-32.48 **	-3.23	-29.32**
L14×T4	9.80 **	16.28 **	-21.57 **	-18.52 **	12.73**	-20.18**	-4.71	-1.53	48.03 **	-34.52 **	40.75**	37.75**
L15×T1	-19.72 **	-19.73 **	-31.19 **	-29.93 **	-19.73**	-30.61**	40.72 **	33.84 **	33.69 **	33.84 **	26.79**	26.79**
L15×T2	-3.33	-11.88	-30.95	-29.64	-7.48	-30.35	20.71 *	20.24 *	42.47 **	20.24 *	29.57**	25.34**
L15×T3	-12.10 **	-7.34 *	-12.10 **	-7.34 *	-9.92**	-9.92**	27.20 **	28.57 **	-3.58	28.57 **	-9.51	-9.51
L15×T4	-11.20 **	-15.57 **	-36.57 **	-36.31 **	-13.26**	-36.45**	-3.58	-15.14	3.94	-15.14	0.17	1.83
S.E. ±	0.16	0.16	0.35	0.13	0.11	0.25	0.17	0.17	0.17	0.17	0.12	0.12
CD (0.05)	0.33	0.33	0.95	0.35	0.43	0.57	0.33	0.33	0.33	0.38	0.25	0.25

Table 4.7 (i) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two Environments *viz*., Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Internodal length						Average pod weight					
Hybrids	HB(%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	-5.75	1.71	-21.5	-28.02	-2.34	-24.75	-12.46	-11.5	16.97 **	19.72 **	-12	18.28**
L1×T2	-11.44	-10.72	-12.11	-18.49	-11.09	-15.28	13.81 **	12.05 **	20.96 **	24.14 **	12.96**	22.47**
L1×T3	11.68 **	13.92 **	-4.16	-10.55 **	12.75**	-7.34**	3.55 **	4.72 **	3.73 **	5.04 **	4.10**	4.35**
L1×T4	-10.82	-10.04	-6.49	-12.9	-10.45	-9.68	-7.18	-7.16	-7.02	-6.87	-7.17	-6.95
L2×T1	-2.83	-0.94	-32.98	-39.52	-1.95	-36.23	-7.43	-6	23.69 **	27.16 **	-6.75	25.34**
L2×T2	-14.55	-14.13	-15.2	-21.6	-14.35	-18.39	13.20 **	11.40 **	20.31 **	23.41 **	12.33**	21.78**
L2×T3	-13.37	-13.59	-25.66	-32.15	-13.48	-28.89	8.63 **	14.58 **	3.95 **	5.28 **	11.40**	4.58**
L2×T4	-6.92	-5.71	-2.4	-8.7	-6.34	-5.54	11.35 **	17.72 **	6.55 **	8.17 **	14.31**	7.31**
L3×T1	5.55	12.77 **	-18.41 **	-24.84 **	8.88*	-21.61**	11.13 **	14.31 **	48.49 **	54.63 **	12.65**	51.41**
L3×T2	-12.39	-11.76	-13.05	-19.44	-12.09	-16.23	3.11	4.19	24.86 **	28.46 **	3.63	26.57**
L3×T3	-5.14	-4.53	-18.6	-25.03	-4.85	-21.8	-7.84	-7.73	11.60 **	13.76 **	-7.79	12.62**
L3×T4	5.59	7.94 *	10.72 **	4.51	6.71**	7.63**	-9.88	-9.95	9.13 **	11.02 **	-9.92	10.03**
L4×T1	3.36	3.12	-28.31 **	-34.82 **	3.25	-31.55**	-6.86	-5.38	24.45 **	28.00 **	-6.15	26.14**
L4×T2	-12.9	-12.32	-13.56	-19.95	-12.62	-16.74	15.94 **	15.67 **	24.58 **	28.15 **	16.47**	26.27**
L4×T3	-4.63	-3.96	-18.16 **	-24.59 **	-4.31	-21.36**	10.31 **	14.59 **	18.53 **	21.45 **	12.33**	19.92**
L4×T4	-10.76	-9.91	-6.43	-12.77	-10.35	-9.59	-6.05	-3.78	0.95	1.97	-4.98	1.44
L5×T1	1.92	4.37	-29.70 **	-36.28 **	3.07	-32.97**	9.80 **	12.85 **	46.72 **	52.67 **	11.26**	49.54**
L5×T2	-15.12	-14.75	-15.76	-22.17	-14.95	-18.96	10.33 **	5.65 **	22.07 **	25.36 **	8.02**	23.63**
L5×T3	-2.42	-1.62	-16.27	-22.74	-2.04	-19.49	-6.52	-11.8	3.43 **	4.66 **	-9.12	4.01**
L5×T4	13.95 **	-13.39 **	-9.77 **	-16.14 **	-13.68**	-12.94**	-7.58 **	-12.85 **	2.25 *	3.41 **	-10.17**	2.80**
L6×T1	4.77	12.95 **	-16.96 **	-23.51 **	8.52*	-20.22**	-7.58	-6.16	23.50 **	26.95 **	-6.9	25.13**

L6×T2	-5.65	-4.38	-6.37	-12.71	-5.05	-9.53	6.24 **	4.01 **	12.92 **	15.23 **	5.16**	14.01**
L6×T3	9.11	11.17	-6.37	-12.71	10.09	-9.53	18.58 **	22.50 **	19.25 **	22.24 **	20.43**	20.67**
L6×T4	13.59 **	16.60 **	19.10 **	12.90 **	15.03**	16.01**	11.02 **	14.06 **	11.64 **	13.81 **	12.45**	12.67**
L7×T1	-0.66	-3.09	-5.74	-12.20 **	-1.84	-8.96**	11.49 **	14.70 **	48.97 **	55.16 **	13.02**	51.91**
L7×T2	7.18	9.67	6.37	0.13	8.37	3.26	2.08 *	-3.23 **	17.88 **	20.73 **	-0.54	19.23**
L7×T3	4.25	2.24	-1.07	-7.37 *	3.28	-4.21	-0.77	-6.16	14.59 **	17.07 **	-3.43	15.77**
L7×T4	19.66 **	23.29 **	25.47 **	19.38 **	21.40**	22.44**	-7.11	-12.69	7.26 **	8.93 **	-9.87	8.06**
L8×T1	-11.27	-12.17	-21.56	-28.02	-11.7	-24.78	13.45 **	16.85 **	51.59 **	58.07 **	15.07**	54.67**
L8×T2	4.07	6.26	3.28	-2.99	5.11*	0.16	16.47 **	15.25 **	26.04 **	29.76 **	15.88**	27.80**
L8×T3	2.57	2.87	-9.33 **	-15.69 **	2.71	-12.50**	-11.54	-14.57	-4.27	-3.82	-13.01	-4.06
L8×T4	-0.78	0.92	4.04	-2.29	0.03	0.89	10.48 **	8.87 **	19.55 **	22.57 **	9.70**	20.99**
L9×T1	-9.51	-9.03	-14.25	-20.65	-9.28	-17.44	17.44 **	21.21 **	56.93 **	63.98 **	19.24**	60.27**
L9×T2	5.78	8.14	4.98	-1.27	6.91**	1.87	7.69 **	14.25 **	36.83 **	41.71 **	10.77**	39.15**
L9×T3	-5.75	5.9	-1.32	-7.62 *	4.97	-4.46	-5.87	-1.14	19.60 **	22.62 **	-3.65	21.03**
L9×T4	-11.44	10.96	13.68 **	7.43	9.63**	10.57	-21.91	-19.34	-0.78	0.05	-20.71	-0.39
L10×T1	11.68 **	0.71	-12.48 **	-18.87 **	-0.04	-15.66	3.28	5.72	38	43.01	4.44	40.38
L10×T2	-10.82	-17.88	-18.54	-25.03	-17.9	-21.77	9.48 **	7.46 **	16.37 **	19.04 **	8.50**	17.64**
L10×T3	-2.83	24.29 **	6.37 *	0.13	22.39**	3.26	22.39 **	24.60 **	22.87 **	26.25 **	23.45**	24.47**
L10×T4	-14.55 **	-4.72	-1.45	-7.75 *	-5.40*	-4.59	5.98 **	6.59 **	6.39 **	8.00 **	6.27**	7.16**
L11×T1	-13.37 **	46.23 **	8.51 **	2.29	52.66**	5.41	-20.81	-20.65	5.81	7.35	-20.73	6.54
L11×T2	-6.92 *	-31.38 **	-30.83 **	-37.36 **	-30.82**	-34.08	10.71	8.76 **	17.67 **	20.49 **	9.76**	19.00**
L11×T3	5.55	18.93	-0.25	-6.61	17.52	-3.42	10.05 **	12.22 **	1.86	2.98 *	11.07**	2.39*
L11×T4	-12.39	-28.02	-23.83	-30.3	-27.67	-27.06	21.15 **	22.94 **	-2.90 *	-2.31	22.00**	-2.62**
L12×T1	-5.14	13.98 **	-1.01	-7.31 *	12.23**	-4.15	-5.08	-3.43	26.84 **	30.64 **	-4.29	28.64**
L12×T2	5.59	14.06 **	10.40 **	4.13	12.59**	7.28**	8.14 **	6.03 **	14.94 **	17.46 **	7.11**	16.13**
L12×T3	3.36	26.25 **	8.89 **	2.67	23.86**	5.79*	8.29 **	8.10 **	9.02 **	10.90 **	8.20**	9.91**
L12×T4	-12.9	8.14	10.91	4.7	6.9	7.82**	-6.76 **	-8.26 **	-6.13 **	-5.88 **	-7.48**	-6.02**

L13×T1	-4.63	1.56	-6.75 *	-13.21 **	0.49	-9.97	-29.79	-30.46	-6.18	-5.93	-30.11	-6.06
L13×T2	-10.76	16.28	12.36	6.16	14.68	9.27**	5.28 **	2.99 **	11.90 **	14.10 **	4.17**	12.94**
L13×T3	1.92	12.86 **	2.77	-3.56	11.20**	-0.38	5.06 **	6.65 **	-2.75	-2.14	5.81**	-2.46
L13×T4	-15.12 **	20.87 **	23.20 **	17.03 **	19.11**	20.13**	6.31 **	7.92 **	-14.85 **	-15.54 **	7.06**	-15.18**
L14×T1	-2.42	14.22	-18.98	-25.48	11.58	-22.22	13.04 **	15.90 **	58.25 **	65.44 **	14.41**	61.66**
L14×T2	13.95 **	-9.32 **	-10.84 **	-17.22 **	-9.76**	-14.02**	5.13 **	7.30 **	47.17 **	53.17 **	6.17**	50.02**
L14×T3	4.77	13.03	-4.92	-11.25	11.86	-8.07	-0.14	1.58	39.80 **	45.00 **	0.69	42.27**
L14×T4	-5.65	-8.27	-4.85	-11.18	-8.79	-8.01	-6.44	-5.27	30.98 **	35.23 **	-5.88	33.00**
L15×T1	9.11 *	-8.64 **	-2.33	-8.64 **	-5.47*	-5.47	-11.65	-10.62	18.06 **	20.92 **	-11.16	19.41**
L15×T2	13.59 **	0.95	7.19 *	0.95	4.08	4.08	17.64 **	16.13 **	25.04 **	28.65 **	16.91**	26.75**
L15×T3	-0.66	-20.9	-14.5	-20.9	-17.69	-17.69	3.99 **	5.31 **	3.99 **	5.31 **	4.61**	4.61**
L15×T4	7.18 *	13.09 **	19.23 **	13.09 **	15.19**	16.17**	12.07 **	14.29 **	12.07 **	14.29 **	13.13**	13.13**
S.E. ±	0.16	0.16	0.24	0.36	0.11	0.16	0.17	0.13	0.25	0.33	0.12	0.16
CD (0.05)	0.30	0.32	0.79	0.97	0.24	0.47	0.34	0.39	0.58	0.89	0.25	0.31

Table 4.7 (j) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Pods yield/Plant						Ascorbic Acid content					
Hybrids	HB (%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	-6.45 *	-8.20 **	-7.94 **	-8.20 **	-7.32**	-8.06**	-3.64	-4.7	38.42 **	42.20 **	-4.14	40.19**
L1×T2	-2.45	-3.82	-1.59	-1.55	-2.93	-1.57	4.83 **	7.17 **	13.46 **	13.24 **	5.95**	13.36**
L1×T3	6.35 *	6.56 *	6.35 *	6.56 *	6.45**	6.45**	-4.59	-4.23	1.86	1.19	-4.42	1.55
L1×T4	3.23	3.28	1.59	3.28	3.25	2.42	18.32 **	19.27 **	28.00 **	30.32 **	18.77**	29.09**
L2×T1	-1.28	-3.8	22.22 **	24.59 **	-2.55	23.39**	4.38 **	4.17 **	49.94 **	55.45 **	4.28**	52.51**
L2×T2	7.69 **	6.33 **	33.33 **	37.70 **	7.01**	35.48**	17.16 **	22.36 **	26.81 **	29.16 **	19.55**	27.91**
L2×T3	15.38 **	10.13 **	42.86 **	42.62 **	12.74**	42.74**	3.53 *	7.57 **	10.77 **	10.96 **	5.38**	10.86**
L2×T4	6.41 **	5.06 *	31.75 **	36.07 **	5.73**	33.87**	16.12 **	17.33 **	25.62 **	28.20 **	16.69**	26.83**
L3×T1	-4.11	1.45	11.11 **	14.75 **	-1.41	12.90**	-9.56	-11.27	29.92 **	32.41 **	-10.37	31.08**
L3×T2	12.33 **	14.49 **	30.16 **	29.51 **	13.38**	29.84**	-7.16	-6.08	0.49	-0.86	-6.66	-0.14
L3×T3	10.96 **	15.94 **	28.57 **	31.15 **	13.38**	29.84**	11.75 **	14.31 **	2.12	0.99	13.73**	1.59
L3×T4	8.22 **	11.59 **	25.40 **	26.23 **	9.86**	25.81**	3.22	2.76	11.67	12.28	3	11.95
L4×T1	-5.26 *	1.41	14.29 **	18.03 **	-2.04	16.13**	12.30 **	13.07 **	61.32 **	68.72 **	12.67**	64.78**
L4×T2	-3.95	-3.64 **	15.87 **	16.39 **	-2.04	16.13**	-2.56	-2.26	32.79 **	35.78 **	-2.42	34.19**
L4×T3	6.58 **	12.68 **	28.57 **	31.15 **	9.52**	29.84**	-5.88 **	-5.55 **	28.26 **	31.21 **	-5.72**	29.64**
L4×T4	5.26 *	9.86 **	26.98 **	27.87 **	7.48**	27.42**	8.39 **	10.41 **	47.71 **	53.39 **	9.34**	50.36**
L5×T1	-18.18**	-15.38 **	-28.57**	-27.87 **	-16.82**	-28.23**	5.58 **	6.01 **	51.65 **	58.19 **	5.78**	54.71**
L5×T2	10.91**	15.09 **	-3.17	-3.64 **	14.02**	-1.61	13.64 **	13.96 **	32.50 **	35.95 **	13.79**	34.11**
L5×T3	7.94**	11.48 **	7.94**	11.48 **	9.68**	9.68**	-4.23	-5.38	11.67 **	12.88 **	-4.78	12.23**

L5×T4	22.03 **	18.03 **	14.29 **	18.03 **	20.00**	16.13**	23.99 **	26.08 **	44.57 **	50.41 **	24.98**	47.30**
L6×T1	-8.89 *	-6.98	-34.92 **	-34.43 **	-7.95**	-34.68**	-11.98 **	-13.60 **	26.44 **	28.93 **	-12.75**	27.60**
L6×T2	13.21 **	13.21 **	-4.76	-1.64	13.21**	-3.23	7.59 **	11.45 **	16.45 **	17.64 **	9.37**	17.01**
L6×T3	-1.59	-2.93	-1.59	-1.55	-0.81	-0.81	10.87 **	9.42 **	2.99 *	2.68	10.19**	2.85*
L6×T4	5.08	1.64	-1.59	1.64	3.33	3.25	5.18 **	5.51 **	13.78 **	15.29 **	5.34**	14.49**
L7×T1	-9.20 **	-9.41 **	25.40 **	26.23 **	-9.30**	25.81**	12.61 **	13.60 **	61.75 **	69.51 **	13.08**	65.38**
L7×T2	1.15	3.53	39.68 **	44.26 **	2.33	41.94**	3.96 **	7.79 **	48.69 **	54.42 **	5.75**	51.37**
L7×T3	4.60 *	4.71 *	44.44 **	45.90 **	4.65**	45.16**	-7.3	-4.76	32.59 **	36.44 **	-6.11	34.39**
L7×T4	2.12	2.35	38.10 **	42.62 **	1.16	40.32**	4.30 **	8.66 **	49.19 **	55.68 **	6.34**	52.22**
L8×T1	-14.81 **	-21.05 **	-26.98 **	-26.23 **	-18.02**	-26.61**	13.70 **	14.60 **	63.32 **	71.00 **	14.13**	66.91**
L8×T2	12.96 **	3.51	-3.17	-3.28	8.11**	-3.23	15.53 **	19.12 **	46.84 **	52.40 **	17.21**	49.44**
L8×T3	9.52 **	11.48 **	9.52 **	11.48 **	10.48**	10.48**	-9.02	-8.38	15.64 **	17.21 **	-8.72	16.38**
L8×T4	11.86 **	4.92	4.76	4.92	8.33**	4.84*	6.23 **	8.98 **	35.03 **	39.42 **	7.52**	37.08**
L9×T1	-8.16 *	-6.38	-28.57 **	-27.87 **	-7.29**	-28.23**	12.48 **	17.18 **	83.81 **	94.17 **	14.69**	88.65**
L9×T2	7.55 *	5.66	-9.52 **	-8.20 **	6.60**	-8.87**	11.83 **	16.50 **	82.73 **	93.05 **	14.03**	87.55**
L9×T3	-6.35 *	-4.92	-6.35 *	-4.92	-5.65**	-5.65**	-1.03	2.16 *	61.72 **	69.28 **	0.47	65.25**
L9×T4	10.17 **	3.28	3.17	3.28	6.67**	3.23	12.70 **	17.66 **	84.16 **	94.97 **	15.03**	89.21**
L10×T1	-5.45	-3.77	-17.46 **	-16.39 **	-4.63	-16.94**	-13.05	-15.04	24.90 **	26.78 **	-14	25.78**
L10×T2	5.45	7.55 *	-7.94 **	-6.56 *	6.48**	-7.26**	3.52	7.90 **	13.61 **	13.90 **	5.57	13.75**
L10×T3	1.59	4.92	1.59	4.92	3.23	3.23	2.59	7.19 **	12.59 **	13.04 **	4.69**	12.80**
L10×T4	22.03 **	16.39 **	14.29 **	16.39 **	19.17**	15.32**	15.73 **	19.15 **	27.02 **	30.19 **	18.22**	28.50**
L11×T1	9.52 *	7.14	-26.98 **	-26.23 **	8.33**	-26.61**	11.74	12.31 **	60.50 **	67.59 **	12.01**	63.82**
L11×T2	5.66	5.66	-11.11 **	-8.20 **	5.66*	-9.68**	-10.19	-8.97	21.71 **	23.24 **	-9.62	22.42**
L11×T3	-3.17	-3.28	-3.17	-3.28	-3.23	-3.23	3.43 **	6.80 **	40.16 **	44.59 **	5.00**	42.23**
L11×T4	-13.56 **	-18.03 **	-19.05 **	-18.03 **	-15.83**	-18.55**	9.51 **	14.11 **	48.40 **	54.49 **	11.66**	51.24**
L12×T1	-20.41 **	-24.49 **	-38.10 **	-39.34 **	-22.45**	-38.71**	30.44 **	30.39 **	100.81**	113.77**	30.42**	106.87**
L12×T2	5.66	3.77	-11.11 **	-9.84 **	4.72	-10.48**	19.66 **	18.72 **	84.21 **	94.64 **	19.20**	89.08**

L12×T3	4.76	8.20 **	4.76	8.20 **	6.45**	6.45**	9.78 **	8.44 **	69.01 **	77.79 **	9.13**	73.11**
L12×T4	-1.55	-4.92	-6.35 *	-4.92	-2.5	-5.65**	22.85 **	22.61 **	89.12 **	101.03**	22.73**	94.68**
L13×T1	-9.68 **	-8.33 **	-11.11 **	-9.84 **	-9.02**	-10.48**	8.71 **	9.67 **	57.14 **	63.65 **	9.53**	60.18**
L13×T2	17.74 **	20.00 **	15.87 **	18.03 **	18.85**	16.94**	-5.5	-3.2	36.59 **	40.22 **	-4.42	38.29**
L13×T3	17.46 **	21.31 **	17.46 **	21.31 **	19.35**	19.35**	-22.08	-22.01	12.62 **	12.98 **	-22.05	12.79**
L13×T4	22.58 **	22.95 **	20.63 **	22.95 **	23.77**	21.77**	3.89 **	8.11 **	50.17 **	56.60 **	5.87**	53.18**
L14×T1	-7.55 *	-3.92	-22.22 **	-19.67 **	-5.77*	-20.97**	5.45 **	5.55 **	51.48 **	57.50 **	5.50**	54.29**
L14×T2	1.89	3.28	-14.29 **	-14.75 **	2.16	-14.52**	0.65	3.37 **	35.35 **	39.09 **	1.92*	37.10**
L14×T3	-6.35 *	-3.28	-6.35 *	-3.28	-4.84*	-4.84*	-15.47	-14.78	13.67 **	14.66 **	-15.15	14.13**
L14×T4	8.47 **	4.92	1.59	4.92	6.67**	3.23	11.46 **	16.21 **	49.88 **	56.37 **	13.68**	52.91**
L15×T1	9.38 **	14.75 **	11.11 **	14.75 **	12.00**	12.90**	-8.16	-9.07	31.92	35.68	-8.6	33.68
L15×T2	15.63 **	21.31 **	17.46 **	21.31 **	18.40**	19.35**	4.45 **	7.68 **	13.06 **	13.67 **	5.94**	13.34**
L15×T3	28.13 **	31.15 **	30.16 **	31.15 **	29.60**	30.65**	1.42	0.89	1.42	0.89	1.18	1.18
L15×T4	17.19 **	21.31 **	19.05 **	21.31 **	19.20**	20.16**	8.58 **	9.63 **	17.47 **	19.79 **	9.08**	18.56**
S.E. ±	0.004	0.036	0.35	0.36	0.24	0.065	0.17	0.13	0.25	0.58	0.12	0.25
CD (0.05)	0.011	0.23	0.89	1.08	0.63	0.043	0.33	0.39	0.83	1.32	0.38	0.53

Table 4.7 (k) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two *iz.*, Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Acidity						Dry matter content					
Hybrids	HB (%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	-10.71	-2.27	-39.76	-41.1	-7	-40.38	0.12	-0.81	-16.62	-18.48 **	-0.32	-17.52
L1×T2	-21.43	-52.08	-46.99	-68.49	-33.66	-57.05	0.27	3.19 **	-24.89	-27.52	1.63*	-26.16
L1×T3	14.52	7.41	-14.46 *	-20.55 **	11.21	-17.31**	-7.65	-5.14	-30.82	-33.36	-6.47	-32.05
L1×T4	-21.33 **	-45.71 **	-28.92 **	-47.95 **	-33.10**	-37.82**	2.2	5.68	-23.44	-25.77	3.83	-24.57
L2×T1	-7.41	37.84 **	-39.76 **	-30.14 **	10.99	-35.26**	-1.95	-3	-18.35	-20.29	-2.46	-19.29
L2×T2	1.85	-2.08	-33.73 **	-35.62 **	0.99	-34.62**	1.55	-1.57	-26.84	-29.32	0.05	-28.04
L2×T3	-25.18	-11.11	-25.30 **	-34.25 **	-25.17	-29.49**	-12.02	-16.05	-36.62 **	-39.72 **	-13.97**	-38.12**
L2×T4	-9.33	-15.71	-18.07	-19.18	-12.4	-18.59	-0.35	-3.38	-28.22	-30.62	-1.81	-29.38
L3×T1	-2.13	20	-44.58 **	-42.47 **	7.32	-43.59**	9.47 **	7.80 **	-8.84 **	-10.21 **	9.17**	-9.50**
L3×T2	9.43	2.08	-30.12 **	-32.88 **	5.94	-31.41**	4.03 **	1.14	-14.15 **	-15.76 **	2.63**	-14.93**
L3×T3	-4.84	-9.26	-28.92	-32.88	-6.9	-30.77**	-0.23	-3.37	-17.66	-19.51	-1.76	-18.56
L3×T4	-12	-8.57	-20.48 **	-12.33 *	-10.34*	-16.67**	2.54 **	-0.24	-15.38 **	-16.91 **	1.19	-16.12**
L4×T1	3.57	7.41	-30.12	-20.55	5.45	-25.64**	-5.15	-6.32	-21.02	-23.01	-5.7	-21.98
L4×T2	-3.57	-25.93 **	-34.94 **	-45.21 **	-14.55*	-39.74**	6.41 **	2.87 **	-27.87 **	-30.50 **	7.37**	-29.14**
L4×T3	12.65	16.67 *	-5.30 **	-13.70 **	7.76	-19.87**	6.48 **	-2.19 *	-31.30 **	-33.92 **	2.19**	-32.57**
L4×T4	-6.67	-17.14 **	-15.66 *	-20.55 **	-11.72*	-17.95**	16.68 **	14.19 **	-20.94 **	-22.85 **	18.04**	-21.86**
L5×T1	-2.56	2.82	-8.43	-6.43	0.34	-4.49	1.18 *	4.59 **	12.53 **	13.02 **	2.80**	12.77**
L5×T2	-5.13	-26.76 **	-10.84	-28.77 **	-15.44**	-19.23**	-4.78	-2.11	5.9	5.78	-3.51	5.84
L5×T3	1.28	14.08 **	-4.82	10.96 *	7.38	2.56	-31.05	-30.72	-23.31	-25.14	-30.9	-24.2
L5×T4	20.51 **	5.63	13.25 *	2.74	13.42**	8.33	-7.65	-4.99	2.72	2.66	-6.38	2.69
L6×T1	-5.88	1.85	-22.89 **	-24.66 **	-2.46	-23.72**	10.53 **	23.43 **	2.54 **	2.14 **	16.40**	2.35**

L6×T2	20.44	5.56	-18.07 **	-21.92 **	2.46	-19.87	-3.83	6.29	-10.78	-12.04	0.78	-11.39
L6×T3	8.82	25.93 **	-10.84	-6.85	16.39**	-8.97	-11.16	-2.28	-17.57	-19.13	-7.12	-18.33
L6×T4	12	12.86 *	1.2	8.22	12.41*	4.49	-1.12	9.88	-8.27	-9.07	3.89	-8.66
L7×T1	-5.26	-2.94	-13.25 *	-9.59	-4.17	-11.54	6.68	6.63	-11.16	-12.37	6.66	-11.75
L7×T2	-1.32	-22.06 **	-9.64	-27.40 **	-11.11*	-17.95	7.8	10.44	-23.3	-25.41	9.04	-24.32
L7×T3	7.89	-0.53	-1.2	-6.85	4.17	-3.85	-1.36	0.38	-29.82 **	-32.21 **	-0.54	-30.97**
L7×T4	15.79 *	14.29 **	6.02	9.59	15.86**	7.69	14.31 **	18.19 **	-18.67 **	-20.18 **	16.14**	-19.40**
L8×T1	-7.04	-21.21 **	-20.48 **	-28.77 **	-13.87**	-24.36**	9.63 **	9.61 **	9.02 **	9.06 **	9.62**	9.04**
L8×T2	5.63	-13.64 *	-9.64	-21.92 **	-3.65	-15.38**	-8.3	-9.45	-8.81	-9.9	-8.85	-9.34
L8×T3	1.41	16.67 **	-13.25 *	5.48	8.76	-4.49	-16.54 **	-18.07 **	-17.00 **	-18.48 **	-17.28**	-17.72**
L8×T4	9.33	4.29	-1.2	-8.32	6.9	-0.64	4.99 **	4.95 **	4.41 **	4.42 **	4.97**	4.41**
L9×T1	3.92	13.95	-36.14	-32.88	8.51	-34.62**	0.99	0.23	-15.90 **	-17.63 **	0.63	-16.74**
L9×T2	11.32	4.17	-28.9	-31.51	7.92	-30.13	-1.75	-2.73	-25.3	-27.62	-2.22	-26.42
L9×T3	11.29	1.85	-16.87	-24.66	6.9	-20.51**	-14.06	-16.06	-34.65	-37.54	-15.02	-36.05
L9×T4	-8	-18.57 **	-16.87	-21.92 **	-13.10**	-19.23**	4.64 **	4.41 **	-20.43 **	-22.31 **	4.53**	-21.34**
L10×T1	14.89	8.11	-34.94	-45.21	11.9	-39.74**	7.69 **	4.57 **	-3.99 **	-4.99 **	6.17**	-4.47**
L10×T2	5.66	-18.75	-32.53	-46.58	-5.94	-39.1	-0.3	-3.81	-11.11	-12.6	-2.01	-11.83
L10×T3	3.23	-7.41	-22.89 **	-31.51 **	-1.72	-26.92	-11.64	-15.55	-21.22	-23.27	-13.55	-22.21
L10×T4	-2.67	7.14	-12.05	2.74	2.07	-5.13	14.17 **	11.81 **	1.79 **	1.59 *	13.02**	1.69**
L11×T1	7.27	-2.04	-28.92 **	-34.25 **	2.88	-31.41**	-10.31	-12	-25.31	-27.68	-11.12	-26.45
L11×T2	-3.64	-4.08	-36.14 **	-35.62 **	-3.85	-35.90**	9.29 **	4.00 **	-25.92 **	-28.37 **	7.06**	-27.10**
L11×T3	4.84	-3.7	-21.69 **	-28.77 **	0.86	-25.00**	-10.2	-16.91	-39.52	-42.77	-13.48	-41.09
L11×T4	-4	4.29	-13.25 *	0.37	-9.54	-7.05	13.14 **	8.47 **	-23.34 **	-25.29 **	11.20**	-24.28**
L12×T1	6.67	-5.17	-22.89 **	-24.66 **	0.85	-23.72**	3.98 **	3.56 **	-13.41 **	-14.89 **	3.78**	-14.13**
L12×T2	3.33	-22.41 **	-25.30 **	-38.36 **	-9.32	-31.41**	16.82 **	19.10 **	-11.78 **	-13.24 **	17.90**	-12.49**
L12×T3	20.97 *	5.17	-9.64	-16.44 **	15.25*	-12.82**	10.22 **	12.08 **	-16.76 **	-18.35 **	11.11**	-17.53**
L12×T4	6.67	7.14	-3.61	-4.11	3.45	-3.85	-4.19	-3.7	-27.64	-29.85	-3.96	-28.71

L13×T1	8.51	18.92	-38.55 **	-39.73 **	13.1	-39.10**	-5.37	-6.7	-21.19	-23.33	-6.01	-22.22
L13×T2	-1.89	-4.17	-37.35 **	-36.99 **	-2.97	-37.18**	2.70 **	3.92 **	-26.67 **	-29.17 **	3.28**	-27.88**
L13×T3	-3.23	-14.81 *	-27.71 **	-36.99 **	-8.62	-32.05**	-4.71	-4.32	-31.96 **	-34.78 **	-4.53	-33.33**
L13×T4	-2.67	7.14	-12.05	2.74	2.07	-5.13	-7.27 **	-6.71 **	-33.79 **	-36.41 **	-7.01**	-35.06**
L14×T1	-4.29	-19.05 **	-19.28 **	-30.14 **	-11.28*	-24.36**	-6.15 **	-7.39 **	-21.84 **	-23.89 **	-6.74**	-22.83**
L14×T2	-4.29	-15.87 **	-19.28 **	-27.40 **	-9.77	-23.08**	8.92 **	11.25 **	-26.17 **	-28.52 **	10.70**	-27.31**
L14×T3	10	-3.17	-7.23	-16.44 **	3.76	-11.54*	-5.08 **	-5.57 **	-36.41 **	-39.33 **	-5.31**	-37.82**
L14×T4	17.33 *	5.71	6.02	1.37	11.72*	3.85	17.45 **	20.74 **	-20.42 **	-22.09 **	19.00**	-21.23**
L15×T1	-8.43	-6.85	-8.43	-6.85	-7.69	-7.69	7.49 **	7.63 **	7.49 **	7.63 **	7.56**	7.56**
L15×T2	-22.89	-23.29	-22.89	-23.29	-23.08	-23.08	2.22 **	1.80 **	2.22 **	1.80 **	2.02**	2.02**
L15×T3	2.41	-9.59	2.41	-9.59	-3.21	-5.28	-7.61	-8.49	-7.61	-8.49	-8.03	-8.03
L15×T4	20.48 **	17.81 **	23.85 **	26.47 **	19.23**	25.76**	5.68 **	5.94 **	5.68 **	5.94 **	5.80**	5.80**
S.E. ±	0.01	0.01	0.03	0.01	0.01	0.01	0.16	0.16	0.18	0.36	0.11	0.25
CD (0.05)	0.03	0.02	0.06	0.03	0.03	0.02	0.33	0.33	0.42	0.89	0.42	0.73

Table 4.7 (l) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two environments *viz.*, Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Firmness						Chlorophyll content					
Hybrids	HB (%)		SH (%)		Pooled		HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	1.34	1.2	10.26 **	9.72 **	1.27	10.01**	-2.86 **	-4.07 **	33.11 **	38.22 **	-3.46**	35.57**
L1×T2	9.48 **	9.71 **	19.11 **	18.95 **	9.59**	19.04**	6.19 **	6.57 **	12.56 **	16.06 **	6.38**	14.24**
L1×T3	3.62	5.03	12.74 **	13.87 **	4.28	13.27**	-1.7	-1.41	30.04 **	34.91 **	-1.56	32.38**
L1×T4	18.81 **	21.30 **	29.27 **	31.52 **	19.97**	30.31**	4.68 **	3.92 **	23.27 **	27.61 **	4.30**	25.36**
L2×T1	9.86 **	11.53 **	21.49 **	22.79 **	10.64**	22.09**	-1.01	-2.17	35.65 **	40.95 **	-1.58	38.20**
L2×T2	6.25	7.54	17.49 **	18.39 **	6.85	17.91**	5.46 **	3.13 **	13.42 **	16.99 **	4.31**	15.13**
L2×T3	4.25	5.4	15.28 **	16.04 **	4.78*	15.63**	5.71 **	6.32 **	39.85 **	45.47 **	6.01**	42.55**
L2×T4	18.75 **	22.61 **	31.32 **	34.98 **	20.54**	33.03**	10.13 **	9.57 **	29.69 **	34.54 **	9.85**	32.03**
L3×T1	17.43	25.62	24.08 **	25.39 **	19.57	24.69**	-3.42	-4.64	32.35 **	37.39 **	-4.02	34.77**
L3×T2	-4.48	-4.64	18.52 **	19.57 **	-4.56	19.01**	3.96 **	4.15 **	13.51 **	17.09 **	4.05**	15.24**
L3×T3	-4.09	-4.2	19.01 **	20.12 **	-4.14	19.53**	6.11 **	6.73 **	40.38 **	46.04 **	6.41**	43.10**
L3×T4	5.96 **	7.80 **	31.48 **	35.17 **	6.82**	33.20**	4.21 **	3.44 **	22.72 **	27.02 **	3.83**	24.79**
L4×T1	3.23	4	19.22 **	20.74 **	3.59	19.93**	8.38 **	7.45 **	48.51 **	54.82 **	7.92**	51.55**
L4×T2	4.53	4.85	20.73 **	21.73 **	4.68*	21.20**	-2.45	-1.68	24.58 **	29.02 **	-2.08	26.71**
L4×T3	4.11	5.33	20.25 **	22.29 **	4.68*	21.20**	10.22 **	11.02 **	45.82 **	51.91 **	10.61**	48.75**
L4×T4	10.57 **	12.69 **	27.70 **	30.84 **	11.56**	29.16**	6.03 **	7.22 **	35.41 **	40.69 **	6.61**	37.95**
L5×T1	-1.95	-2.3	30.24 **	34.30 **	-2.12	32.13**	2.93 **	1.87 **	41.05 **	46.77 **	2.41**	43.81**
L5×T2	4.88 *	4.73 *	39.31 **	43.96 **	4.81**	41.48**	6.63 **	4.50 **	18.19 **	22.14 **	5.58**	20.09**
L5×T3	-8.01	-8.6	22.19 **	25.63 **	-8.29	23.80**	-2.68	-2.42	28.76 **	33.52 **	-2.55	31.05**
L5×T4	3.33	3.96	37.26 **	42.91 **	3.63*	39.89**	5.35 **	4.62 **	24.07 **	28.47 **	4.99**	26.18**
L6×T1	-4.67	-5.31	34.40 **	38.14 **	-4.97	36.14**	-4.98	-6.24	30.21 **	35.09 **	-5.6	32.56**

L6×T2	-2.41	-2.67	37.58 **	41.98 **	-2.54	39.63**	1.57 **	1.59 **	16.76 **	20.59 **	1.58**	18.60**
L6×T3	-10.11	-10.7	26.73 **	30.28 **	-10.39	28.38**	-4.02	-3.82	26.98	31.61	-3.92	29.21
L6×T4	-1.3	-0.55	39.15 **	45.08 **	-0.95	41.91**	8.19 **	7.56 **	27.41 **	32.07 **	7.88**	29.65**
L7×T1	-4.27	-5.03	23.54 **	26.25 **	-4.63	24.81**	8.33 **	9.26 **	67.92 **	75.75 **	8.79**	71.69**
L7×T2	2.13	1.82	31.80 **	35.36 **	1.98	33.46**	-4.19 **	-3.76 **	48.51 **	54.82 **	-3.98**	51.55**
L7×T3	-3.68	-4.1	24.30 **	27.49 **	-3.88*	25.79**	5.44 **	6.25 **	63.45 **	70.91 **	5.84**	67.04**
L7×T4	5.56 **	6.61 **	36.23 **	41.73 **	6.06**	38.79**	3.76 **	4.50 **	60.83 **	68.09 **	4.12**	64.33**
L8×T1	0.51	0.14	27.11 **	29.78 **	0.34	28.35**	-4.11	-5.34	31.41 **	36.38 **	-4.72	33.80**
L8×T2	0.38	0.29	26.94 **	29.97 **	0.34	28.35**	-2.86	-3.13	13.81 **	17.42 **	-2.99	15.55**
L8×T3	-3.84	-3.87	21.60 **	24.58 **	-3.86	22.99**	5.82 **	6.43 **	40.00 **	45.64 **	6.12**	42.71**
L8×T4	4.74 *	5.88 *	32.45 **	37.21 **	5.28**	34.67**	11.56 **	11.04 **	31.38 **	36.35 **	11.30**	33.77**
L9×T1	5.75 *	6.89 *	23.16 **	24.89 **	6.28**	23.97**	-3.76	-4.98	31.89 **	36.90 **	-4.36	34.30**
L9×T2	6.03	7.37	23.49 **	25.45 **	6.65	24.40**	4.93 **	6.30 **	18.52 **	22.49 **	5.59**	20.43**
L9×T3	-0.23	0.53	16.20 **	17.46 **	0.12	16.79**	-5.34	-5.19	25.23 **	29.72 **	-5.27	27.40**
L9×T4	13.63 **	16.53 **	32.34 **	36.16 **	14.99**	34.12**	4.14 **	3.37 **	22.64 **	26.93 **	3.76**	24.71**
L10×T1	-24.38	-27.36	-4.86	-7.62	-25.78	-6.14	-2.39	-3.58	33.76	38.92	-2.98	36.24
L10×T2	-29.79	-33.5	-11.66	-15.42	-31.52	-13.41	6.86 **	7.26 **	23.98 **	28.37 **	7.05**	26.09**
L10×T3	-39.87	-44.5	-24.35	-29.41	-42.04	-26.75	4.45 **	5.00 **	38.18 **	43.68 **	4.72**	40.83**
L10×T4	-28.28	-30.33	-9.77	-11.39	-29.24	-10.53	7.28	6.61	26.33	30.91	6.95	28.53
L11×T1	2.09	2.8	-18.41	-22.79	2.41	-20.45	5.04 **	4.04 **	43.95 **	49.89 **	4.55**	46.81**
L11×T2	5.74	7.01	-15.5	-19.63	6.31*	-17.42	-3.71	-3.43	18.33 **	22.30 **	-3.57	20.24**
L11×T3	-12.09	-14.01	-29.75	-35.42	-12.96	-32.39	5.12	5.7	39.07	44.64	5.41	41.75
L11×T4	3.24	5.94	-17.49	-20.43	4.46	-18.86	3.30 **	3.89 **	26.94 **	31.56 **	3.58**	29.16**
L12×T1	0.49	0.58	-10.91 **	-13.81 **	0.53	-12.26**	7.38 **	7.00 **	47.91 **	54.16 **	7.46**	50.92**
L12×T2	-7.8	-9.68	-18.25	-22.6	-8.66	-20.28**	-5.16	-5.45	30.63 **	35.54 **	-5.3	32.99**
L12×T3	-4.81	-5.06	-15.60 **	-18.64 **	-4.92	-17.02**	5.25 **	5.33 **	44.97 **	51.00 **	5.29**	47.87**
L12×T4	-3.11	-2.38	-14.09 **	-16.35 **	-2.78	-15.14**	1.87 **	1.83 **	40.32 **	45.98 **	1.85**	43.04**

L13×T1	-2.5	-2.56	-7.40 **	-10.34 **	-2.53	-8.77**	5.44 **	4.44 **	44.48 **	50.47 **	4.94**	47.37**
L13×T2	-17.45	-20.26	-21.6	-26.63	-18.74	-23.94	-6.21	-6.3	21.63 **	25.85 **	-6.26	23.67**
L13×T3	-5.69	-6.12	-10.42 **	-13.62 **	-5.89*	-11.91**	5.99 **	6.61 **	40.22 **	45.87 **	6.29**	42.94**
L13×T4	-2.79	-1.08	-7.67 **	-8.98 **	-2	-8.28**	1.24 **	1.45 **	31.30 **	36.26 **	1.34**	33.69**
L14×T1	-2.66	-3.75	-25.05 **	-30.03 **	-3.15	-27.37**	5.07 **	4.06 **	43.98 **	49.92 **	4.57**	46.84**
L14×T2	8.77 *	10.14 *	-16.25 **	-19.94 **	9.38**	-17.97**	-0.52	-2.14	24.12 **	28.52 **	-1.32	26.24**
L14×T3	-2.52	-2.81	-24.95	-29.35	-2.65	-27.00**	4.25 **	4.81 **	37.92 **	43.41 **	4.52**	40.56**
L14×T4	21.81 **	27.77 **	-6.21 *	-7.12 *	24.50**	-6.63	3.82	2.31	29.53	34.36	3.07	31.86
L15×T1	-11.61 **	-13.68 **	-11.61 **	-13.68 **	-12.58**	-12.58	-20.7	-22.35	8.67	11.87	-21.52	10.21
L15×T2	-15.71 **	-19.32 **	-15.71 **	-19.32 **	-17.39**	-17.39**	7.82 **	10.95 **	7.82 **	10.95 **	9.33**	9.33**
L15×T3	-6.97 *	-8.36 **	-6.97 *	-8.36 **	-7.61**	-7.61**	-10.77	-10.85	18.05	21.98	-10.81	19.95
L15×T4	-37.15	-41.86	-37.15	-41.86	-39.34	-39.34	-6.65	-7.78 **	9.93	13.23	-7.21	11.52
S.E. ±	0.16	0.13	0.18	0.1	0.11	0.25	0.15	0.15	0.26	0.14	0.11	0.34
CD (0.05)	0.33	0.4	0.46	0.31	0.43	0.63	0.36	0.33	0.46	0.47	0.25	0.79

Table 4.7 (m) Estimation of Heterobeltiosis (HB) and Standard Heterosis(SH) for different traits in okra under two environments *viz*., Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Traits	Mucilage Content					
Hybrids	HB (%)		SH (%)		Pooled	
	E1	E2	E1	E2	HB (%)	SH (%)
L1×T1	-6.58	-7.69	-46.3	-48.6	-7.12	-47.43
L1×T2	-13.78	-14.73	-31.01	-33.04	-14.24	-32.01
L1×T3	-8.59	-10.07	-37.56	-39.33	-9.31	-38.43
L1×T4	-16.3	-17.96	-49.42	-51.82	-17.1	-50.6
L2×T1	7.12 **	6.95 **	-38.42 **	-40.45 **	7.04**	-39.42**
L2×T2	-9.86	-10.27	-27.87	-29.54	-10.06	-28.7
L2×T3	-14.18 **	-16.13 **	-41.38 **	-43.42 **	-15.13**	-42.39**
L2×T4	5.31 **	5.34 **	-36.36 **	-38.14 **	5.33**	-37.24**
L3×T1	-9.69	-11.06	-48.08 **	-50.48 **	-10.35	-49.27**
L3×T2	-19.24	-20.11	-35.38	-37.27	-19.66	-36.31
L3×T3	-18.09	-20.27	-44.05 **	-46.21	-19.16**	-45.12**
L3×T4	-25.39 **	-27.20 **	-54.91 **	-57.25 **	-26.27**	-56.06**
L4×T1	-9.21 **	-10.21 **	-47.81 **	-50.01 **	-9.69**	-48.89**
L4×T2	-19.39 **	-20.38 **	-35.50 **	-37.48 **	-19.87**	-36.48**
L4×T3	-30.96 **	-33.46 **	-52.84 **	-55.11 **	-32.18**	-53.96**
L4×T4	-12.04 **	-13.05 **	-46.85 **	-48.94 **	-12.53**	-47.88**
L5×T1	-40.39	-43.04	-65.73	-68.28	-41.67	-66.99
L5×T2	-42.18 **	-44.06 **	-53.74 **	-56.08 **	-43.10**	-54.89**
L5×T3	-36.39 **	-38.78 **	-56.55 **	-58.70 **	-37.56**	-57.61**
L5×T4	-38.73 **	-40.95 **	-62.98 **	-65.32 **	-39.81**	-64.13**
L6×T1	7.14 **	7.18 **	-38.41 **	-40.32 **	7.16**	-39.35**
L6×T2	-10.06 **	-10.34 **	-28.04 **	-29.59 **	-10.20**	-28.80**
L6×T3	-7.35 **	-8.66 **	-36.71 **	-38.38 **	-7.99**	-37.53**
L6×T4	-3.74 **	-3.85 **	-41.83 **	-43.54 **	-3.80**	-42.67**
L7×T1	-15.94 **	-17.16 **	-51.68 **	-53.88 **	-16.53**	-52.76**
L7×T2	-13.12 **	-13.55 **	-30.48 **	-32.12 **	-13.33**	-31.29**
L7×T3	-36.73	-39.31	-56.78	-59.06	-38.00	-57.91
L7×T4	-31.87 **	-33.68 **	-58.83 **	-61.05 **	-32.75**	-59.93**
L8×T1	6.15 **	6.12 **	-38.98 **	-40.91 **	6.13**	-39.93**
L8×T2	-8.91 **	-9.07 **	-27.11 **	-28.60 **	-8.99**	-27.85**
L8×T3	-4.40 **	-5.53 **	-34.70 **	-36.27 **	-4.95**	-35.47**
L8×T4	-2.40 *	-2.50 *	-41.02 **	-42.74 **	-2.44**	-41.87**
L9×T1	-41.26	-44.44	-66.23	-69.07	-42.8	-67.63
L9×T2	-34.84 **	-36.45 **	-47.86 **	-50.10 **	-35.62**	-48.96**
L9×T3	-55.32	-58.93	-69.48	-72.3	-57.09	-70.87

L9×T4	-54.51	-58.08	-72.51	-75.38	-56.25	-73.93
L10×T1	-23.17 **	-25.34 **	-55.84 **	-58.43 **	-24.22**	-57.11**
L10×T2	-31.48 **	-33.07 **	-45.18 **	-47.45 **	-32.26**	-46.29**
L10×T3	-28.55 **	-31.12 **	-51.19 **	-53.53 **	-29.80**	-52.34**
L10×T4	-26.21 **	-27.81 **	-55.41 **	-57.61 **	-26.99**	-56.49**
L11×T1	10.31 **	10.42 **	-36.59 **	-38.52 **	10.36**	-37.54**
L11×T2	-9.89 **	-10.35 **	-27.90 **	-29.61 **	-10.12**	-28.74**
L11×T3	-20.91 **	-23.09 **	-45.97 **	-48.12 **	-21.97**	-47.03**
L11×T4	-16.77 **	-17.87 **	-49.71 **	-51.77	-17.31**	-50.72**
L12×T1	-37.26	-40.06	-63.94	-66.62 **	-38.62**	-65.26**
L12×T2	-35.83	-37.54	-48.66	-50.96	-36.67	-49.79
L12×T3	-37.85	-40.59	-57.55 **	-59.92 **	-39.19**	-58.72**
L12×T4	-42.02	-44.57	-64.96	-67.45	-43.26	-66.19**
L13×T1	1.93	1.43	-41.41	-43.52	1.69	-42.45**
L13×T2	-10.39 **	-10.88 **	-28.30 **	-30.02 **	-10.63**	-29.15**
L13×T3	-19.08 **	-21.30 **	-44.73 **	-46.91 **	-20.16**	-45.80**
L13×T4	-30.04 **	-31.87 **	-57.72 **	-59.99 **	-30.92**	-58.84**
L14×T1	10.84 **	11.11 **	-36.29 **	-38.14 **	10.97**	-37.20**
L14×T2	-15.77 **	-16.38 **	-32.61 **	-34.34 **	-16.07**	-33.46**
L14×T3	-20.78 **	-22.78 **	-45.89 **	-47.91 **	-21.76**	-46.88**
L14×T4	-14.85 **	-15.70 **	-48.55 **	-50.50 **	-15.27**	-49.51**
L15×T1	8.18 **	7.87 **	8.18 **	7.87 **	8.03**	8.03**
L15×T2	14.31 **	13.99 **	.11.34**	12.18**	14.15**	11.85**
L15×T3	1.55 *	1.04	1.55 *	1.04	1.30*	1.30*
L15×T4	-0.76	-1.11	-0.76	-1.11	-0.93	-0.93
S.E. ±	0.17	0.2	0.17	0.23	0.12	0.26
CD (0.05)	0.35	0.75	0.47	0.57	0.43	0.67

4.7 Gene Action

The data presented in the table 4.8 revealed distinctive patterns in additive gene action for various plant traits especially plant height, number of first fruiting node, number of nodes per plant, number of ridges per pod, pod diameter, internodal length, ascorbic acid content, dry matter content, firmness, chlorophyll content, and mucilage content exhibited an additive gene action both within individual environments as well as pooled together. On the other hand, traits such as number of branches, stem diameter, leaf blade width, leaf blade length, petiole length, days to first flowering, days to first fruit set, days to first fruit picking, number of flowers per plant, number of pods per plant, pod length, averagepod weight, and pod yield per plant (kg) displayed a non-additive gene action in both individual environments and when aggregated.

Interestingly, for one specific trait, acidity, non-additive gene action was observed in one environment, whereas in environment 2 and when pooled, it demonstrated an additive gene action may be due to the season.

Table 4.8 Gene Action of different traits in okra

Genotypes	Particulars	$\sigma^2 A$	$\sigma^2 D$	$\sigma^2 A/\sigma^2 D$	Gene action
Plant height (cm)	**E1**	46.7	20.1	2.32	Additive gene action
	E2	51.8	31.4	1.64	
	Pooled	49.3	25.8	1.91	
Number of branches per plant	**E1**	0.89	3.86	0.23	Non- Additive geneaction
	E2	0.98	5.57	0.17	
	Pooled	0.93	4.72	0.19	
Stem diameter(cm)	**E1**	1.08	2.55	0.42	Non- Additive geneaction
	E2	0.85	4.32	0.19	
	Pooled	0.96	3.43	0.27	
Leaf blade length (cm)	**E1**	1.74	4.42	0.39	Non- Additive geneaction
	E2	1.83	4.76	0.38	
	Pooled	1.79	4.59	0.38	
Leaf blade width (cm)	**E1**	1.92	4.48	0.42	Non- Additive geneaction
	E2	1.87	4.78	0.39	
	Pooled	1.9	4.63	0.41	
Petiole length (cm)	**E1**	2.36	17.2	0.13	Non- Additive geneaction
	E2	2.32	17.4	0.13	
	Pooled	2.34	17.3	0.13	
Days to first flowering	**E1**	15.9	45.4	0.35	Non- Additive geneaction
	E2	14.5	45.8	0.32	
	Pooled	15.2	45.6	0.33	
Days to first fruit set	**E1**	14	38.5	0.36	Non- Additive gene action
	E2	12.7	38.9	0.32	
	Pooled	13.3	38.7	0.34	
Days to first fruit picking	**E1**	18.4	39.6	0.46	Non- Additive geneaction
	E2	16	36.5	0.43	
	Pooled	17.2	38.1	0.45	
Number of flowers per plant	**E1**	3.2	15.1	0.21	Non- Additive geneaction
	E2	2.44	16.3	0.14	
	Pooled	2.82	15.7	0.17	
Number of pods perplants	**E1**	1.68	16.4	0.1	Non- Additive geneaction
	E2	3.05	18.9	0.16	
	Pooled	2.36	17.6	0.13	
	E1	0.7	0.75	0.93	

Pod length (cm)	**E2**	1.15	3.23	0.35	Non- Additive geneaction
	Pooled	0.92	1.99	0.46	
Number of first fruiting node	**E1**	0.49	0.11	4.45	Additive gene action
	E2	0.42	0.06	7	
	Pooled	0.45	0.09	5	
Number nodes per plant	**E1**	7.78	0.89	8.74	Additive gene action
	E2	8.11	0.71	11.42	
	Pooled	7.95	0.8	9.93	
Number of ridges perpod	**E1**	0.64	0.2	3.2	Additive gene action
	E2	0.78	0.23	3.39	
	Pooled	0.71	0.21	3.38	
Pods diameter (cm)	**E1**	0.051	0.036	1.72	Additive gene action
	E2	0.062	0.043	1.44	
	Pooled	0.057	0.039	1.46	
Internodal length (cm)	**E1**	0.38	0.24	1.58	Additive gene action
	E2	0.51	0.28	1.82	
	Pooled	0.44	0.26	1.69	
Average Pod weight (g)	**E1**	7.89	8.24	0.95	Non additive gene
	E2	6.57	8.03	0.81	
	Pooled	7.23	8.14	0.88	
Pods yield/ Plant (Kg)	**E1**	0.0014	0.0023	0.6	Non- Additive geneaction
	E2	0.0017	0.0034	0.5	
	Pooled	0.0016	0.0029	0.55	
Ascorbic Acid (mg/100g)	**E1**	6.3	0.61	10.32	Additive gene action
	E2	6.28	0.62	10.12	
	Pooled	6.29	0.61	10.31	
Acidity (%)	**E1**	0.0015	0.003	0.5	Non-additive gene action
	E2	0.0036	0.002	1.8	Additive gene action
	Pooled	0.0026	0.0025	1.04	
Dry matter content (%)	**E1**	8.43	1.71	4.92	Additive gene action
	E2	8.42	1.52	5.53	
	Pooled	8.42	1.61	5.22	

Firmness (kg/ cm2)	**E1**	0.83	0.64	1.29	Additive gene action
	E2	1.68	0.55	3.05	
	Pooled	1.26	0.59	2.13	
Chlorophyll content (SPAD unit)	**E1**	17.4	1.8	9.66	Additive gene action
	E2	18	1.65	10.9	
	Pooled	17.7	1.73	10.23	
Mucilage content (%)	**E1**	13.9	1.22	11.39	Additive gene action
	E2	27.5	4.88	5.6	
	Pooled	20.7	3.05	6.78	

CHAPTER 5

DISCUSSION

This chapter comprises of the data obtained from experimental findings which scientifically examined and efforts were made to explore the facts behind it. The experimental findings of present investigation entitled **"Assessment of heterosis and combining ability studies on yield and quality parameters in Okra [*Abelmoschus esculentus* (L.) Moench]"** are described in the previous chapter. The favorable outcome in breeding depends on the choice of elite parental lines or testers for hybridization along with the knowledge on nature and magnitude of genetic advances and combining ability of the both. These genetic parameters assist in fixing the expedient breeding method for further improvements. Among the various plant breeding designs, line × tester design has been most often used to for the nature and magnitude of genetic advances through the estimates of general and specific combing ability, variances and their effects, gene action heterobeltiosis and heterosis. In these facts, the present study was designed to probe the extent for 25 important quantitative and qualitative traits. The prime aspects of the findings of present study is discussed in under following rubric.

5.1 Analysis of variance

5.2 Mean performance

5.3 General and specific combining ability

5.4 Genetic advance

5.5 Heterobeltiosis and Standard Heterosis

5.6 Gene action

5.1. Analysis of variance.

The result obtained in present experiment revealed that there is significant differences present among hybrids, parents, parent × hybrid, treatment × environment, parent × environment, hybrid × environment and parent × hybrid × environment for all the 25 traits studied. The significant differences for variability denotes the chances of better selection and utilization of parental lines and tester for growth, quality and yield enhancement. The morphological expression of hybrid for any characters is the result of interaction between parental lines, tester and the expression of gene in particular environment.

In present study, the analysis of variance indicated the significant differences among the parental lines, testers, and hybrids for all traits studied *viz*., plant height, number of branches per plant, stem diameter, leaf blade length and width, petiole length, days to first flowering, days to first fruit set, days to first fruit peaking, number of flowers per plant, number of pods per plant, pod length, number of first fruiting node, number of nodes per plant, number of ridges per pod, pod diameter, internodal length, average pod weight, pod yield per plant, acidity, ascorbic acid content, dry matter content, firmness and mucilage content. The similar results were reported by Jagan *et al.* (2013), Ramya and Kumar (2010), Javia *et al.* (2009), Shoba and Mariappan (2007), Nichal *et al*. (2006), Singh *et al*. (2004), Singh and Singh (2003), Dhankhar and Dhankhar (2001), Thippeswamy (2001), , Singh *et al*. (2006), Kumar and Pathania (2011) and Akotkar *et al*. (2011).

5.2. Mean Performance

The mean performance is the morphological expression of parental lines, testers and hybrids were recorded . The performance of hybrids along with parental lines and testers vary significantly different, depending upon various factors such as environment and expression of genes. In present study the mean performance mainly for growth, quality and yield attributes on which we can simplify the hybrids for which they can be utilize either for quality or yield basis even also some hybrid can be used for pass on specific trait for improvements of quality like ascorbic acid content, mucilage content, early floweringand picking of fruits, etc.

The result obtained from the study clearly indicated that the role of environment on most of characters was influenced and it is mainly due to the gene trigger under different environmental conditions in which the experiment was conducted. The data showed that parental lines and testers like L15, L12, L13, L14 and Kashi Pragati and Arka Anamika expressed among parental lines and tester in mean performance of hybrids one of the parents is involved which found superior among parental lines. The similar research was put forwarded by Patel and Patel (2016), Pathak and Prabhat (2014), Nagesh*et al.* (2014), Medagam *et al*. (2012), Khatik *et al*. (2012), Amutha *et al.* (2007), Desai *et al.* (2007), Mamidwar, and Nandan Mehta (2006), Nichal *et al.* (2000) and Ahlawat (2004).

5.3. Morphological Characterization

According to consumer's preference, attractive fruit colour, smooth texture, disease and insect-pests free fruits are the most desirable attributes in okra. Consumers always prefer green todark green and smooth textured fruits. These observations often provide a pre-estimated idea about other quality traits. There was no effect of environmental factors on the parents and their crosses. There is sufficient amount of variation is presence on traits on parents and also reflecting in the crosses and this happen due to the traits governs by the major gene (Reddy *et al*. 2023).

5.4. General and specific combining ability

General and specific combining ability is the concept of plant breeding and genetics use toevaluate the rendition and prospective of a different parental line while creating hybrids. General combining ability is an average genetic capability of a parent which bestow to theperformance of its progeny for the specific trait. It is the inherent, genetic quality of a particular line or tester, which is consistent across different hybrid combinations. Parent with the high GCA have alleles (Additive genes) that persistently contribute positively towards the trait of interest and respective of specific combination with another parent. Parental lines or tester with the high GCA is generally a good contributor to the desired traits.

The specific combining ability assess the particular interaction between parental line and tester when they are crossed. It estimate the synergetic effect that result when the line and tester with a different GCA are combined. SCA measures the divergence from expected outcome based completely on the GCA of the parents.

In the present experiment, the parental lines and a tester having good GCA for growth, yield and quality attributes indicate they are individually contributing in a positive way towards all traits studied. The crosses made up of such superior parental lines and testers results into exceptionally high yield as compared to other crosses. This is due to their specific combination and non-additive gene action which results in higher SCA. In the study, we found that GCA measures the inheritance and genetic quality of parental lines and tester for specific traits whereas SCA assess the interaction or compatibility between parental line and tester in respective hybrids. The above facts were supported by Rajani *et al.* (2021), Bhalekar *et al.* (2014), Reddy *et al.*, (2013) Kumar *et al.* (2012), Sharma and Singh (2012), Hadiya *et al.* (2018), Obiadalla-Ali *et al.* (2013), Nagesh *et al.* (2014), Kumar *et al.* (2014), Raghuvanshi *et al.* (2011), Dabhi *et al.* (2010), Singh and Kumar (2010), Mehta *et al.* (2007a), Pal and Hossain (2000), Sood and Kalia (2001), Sushmita and Das (2005), Rajendra *et al.* (2005), Dahake and Bangar (2006), Weerasekara *et al.* (2008), Srivastava *et al.* (2008), Wammanda *et al.* (2010), Ramya and Kumar (2010), Singh and Sanwal (2010), Adiger *et al.* (2013), Patel (2013), Paul (2013), Katagi *et al.* (2015) and Joshi *et al.* (2015).

5.5. Genetic Advance

Phenotypic and genotypic variance relates with quantitative genetics to evaluate the source of variation in traits within population. This variance used to compute contributions of genetic and environmental factors in expression of traits under studied. In present study, all traits recorded higher phenotypic variance than genotypic variance which signify the influence of both genetic and environmental factors on trait expression. The theory is supported by the study of Karadi & Hanchinamani *et al.*, (2021), Javiya *et al.* (2020), Prakash *et al.* (2002), Das *et al.* (2013), Jagan *et al.* (2013), Srivastava *et al.* (2013), Senthilkumar(2011).

Broad sense heritability is the proportion of total phenotypic variance in trait within population due to additive variance. In present study, traits such as plant height, number of first fruiting node, number of nodes per plant, number of ridges per pod, pod diameter, Internodal length, chlorophyll content, acidity percentage, ascorbic acid, dry matter content, firmness and mucilage content indicate high broad sense heritability (close to 1) indicated that the phenotypic variation had more contributions of genetic factors then while in traits number of branches per plant, stem diameter, leaf blade length, leaf blade width, petiole length, days to first flowering, days to first fruit set, days to first fruit picking, number of flowers per plant, number of pods per plant, pod length, average pod weight, pod yield per plant possess broad sense heritability above 80% indicates role of environmental factor along with genetic factors in our expression of traits. Broad sense heritability provide the suitable reason behind higher phenotypic variance for all 25 traits and proportion of more genetic factors involved in expression of a particular character then environmental factors. This finding in broad sense heritability helps in predicting the potential of genetic involvement and use in development of superior hybrids even in further line development for trait specific breeding. This study is conformity to the finding of Devi *et al*. (2020), Abinaya *et al*. (2020), Kumar *et al*. (2013), Paul *et al*. (2017), Lyngdoh *et al*. (2013), Olayiwola and Ariyo (2013), Hamedand Hafiz (2012), Dabhi *et al*. (2010), Jindal *et al*. (2008), Obiadalla-Ali *et al*. (2013) and Sundhari *et al*. (1992).

Genetic advancement, along with additive and dominance variance pointed towards expression of more additive genes than non-additive genes is clear from the experimental findings. The broad sense heritability clears the view of saturation of more additive genesfor expression of different traits than non-additive genes. Genes responsible for expressionof particular trait are carried from parental lines, testers, and also interaction between themsignify the role of additive gene along with dominance and epistasis influenced by environment for different planting season. Parental genes contribute for expression of characters like plant height, number of branches per plant, stem diameter, leaf blade lengthand width, petiole length, days to first flowering, days to first fruit set, days to first fruit picking, number of flowers per plant, number of pods per plant, pod length, number of node per plant, number of ridges per pod, pod diameter, internodal length, chlorophyll content, pod yield per plant, acidity, ascorbic acid, dry matter content, firmness and mucilage content while contribution of tester genes inherit for numberof first fruiting node and average pod weight. The epistasis is noted for number of flowers per plant, petiole length, leaf blade width, number of branches per plant and number of pods per plant. This epistasis can be used for further line improvement on the basis of identification whether it is recessive epistasis or dominant epistasis. The similar findings we are proposed by Mudhalvan & Senthilkumar (2021), Nanthakumar *et al*., (2021), Vekariya *et al.* (2020), Abinaya *et al*. (2020), Verma & Sood (2015), Kumar *et al*., (2013), Aulakh *et al.*(2012), Medagam *et al.* (2012), Jindal *et al.* (2009), Jindal *etal.* (2008), Jai prakashnarayan *et al.*(2008), Adiger *et al*. (2013), Reddy *et al.*(2012) and Raghuvanshi *et al*.(2011).

5.6. Heterobeltiosis and Standard Heterosis

Heterobeltiosis is one of the best ways for any breeder to find out the potential of hybrid to deliver the best for growth, yield or other desirable characteristics as compared to parental lines or testers. Heterosis is characterized by the improve performance on expression of various traits in the hybrid. Hybrid vigor results from combination of different alleles from two different parent lines cross with tester. Diversity present in parental lines or a tester can lead to the expression desirable dominant alleles, which contribute to improve and boost up the trait.

In present study, the superior hybrids are results from all the components such as phenotypical, genotypic and environmental variance, combining ability effect, broad sense heritability and contribution of genes from parental lines and tester along with their interaction leads to get best of expression in every character to reach out heterosis and heterobeltiosis. The degree of heterosis vary depending upon the genetic makeup of parental lines or a tester along with specific genetic and environmental interaction. The similar findings were bring forward by Suganthi *et al.* (2020), Tiwari *et al*. (2015), Kumar *et al*. (2013), Kishor *et al*. (2013),Akhtar *et al*. (2010), Patel *et al*. (2010), Kumar and Sreeparvathy (2010), Manivannan *et al*. (2007), Yadav *et al*., (2007), Dahake *et al*. (2007), Tripathi *et al*. (2004), Vermani *et al*. (2006), Chauhan and Singh (2002), Rani *et al*. (2002), Singh *et al*. (2002),Rewale *et al.* (2003), Fonseca and Paterson (1968), Borgaonkar *et al*. (2005), Poshiya and Vashi (1995), Kachhadia *et al*. (2011), and Vachhani *et al*. (2011).

5.7 Gene action

Gene action refers to the way genes are expressed in a population. In the context of additive gene action, expression is linked to homozygosity, while non-additive gene action is associated with heterozygosity. Consequently, non-additive gene action is most prominent in cross-pollinated crops, hybrids, synthetics, and composite varieties. The ratio of σ2 A/σ2 D serves as an indicator, with a ratio less than one indicating non-additive gene action and a ratio greater than one reflecting additive gene behavior. Several plant characteristics, including plant height, number of first fruiting node, number of nodes per plant, number of ridges per pod, pod diameter, internodal length, ascorbic acid content, dry matter content, firmness, chlorophyll content, and mucilage content, exhibit additive gene action in both environmental and pooled settings. Conversely, traits such as number of branches, stem diameter, leaf blade width, leaf blade length, petiole length, days to first flowering, days to first fruit set, days to first fruit picking, number of flowers per plant, number of pods per plant, pod length, average pod weight, and pod yield per plant showed non-additive gene action in both environments and when pooled. However, acidity displays non-additive gene action in one environment and additive gene action in the otherenvironment and when pooled. When the significance value equals one, both additive and non-additive gene impacts are equally distributed in the expression of a specific trait. Similar findings were reported by Duenk *et al*. (2020), Devi *et al*. (2020), Kumar *et al*. (2014).

CHAPTER 6

SUMMARY AND CONCLUSION

The present investigation entitled **"Assessment of heterosis and combining Ability studies on yield and quality parameters in Okra [*Abelmoschus esculentus* (L.) Moench]"** was conducted at research farm, Lovely Professional University during year 2021-2022 under two environments mainly E1 (Rainy season) and E2 (Summer season). The experimental material comprised of 15 okra parental lines and 4 testers. These parental lines and tester were crossed in Line × Tester mating design to produce 60 F_1 hybrids. All the genotypes, 15 parental lines and 4 testers along with 60 F_1 hybrids were evaluated in a randomized complete block design with three replications.

The silent features of the finding are abridged as follows:

6.1 Mean Performance

- In case of parental lines and testers for growth parameters line, L15, L12 and L13 expressed its superiority along with tester Kashi Kranti followed by Kashi Pragati and Arka Anamika whereas for yield attributes, parental line L7, L15, L4 along with tester Kashi Kranti proved the important role in outcome of best results. Line L15, L5 and L12 noted for improvising the quality parameters.
- The mean performance the crosses for growth, yield and quality attributes revealed that hybrids comprising of one of the superior parental lines or testers be the part of results in the best performing hybrids. This trend is observed for all the traits studied.
- The highest mean performance for plant height was observed for the lines L15 and L13 as well as in hybrid L7 × T4 and L15 × T2.
- Number of branches per plant was maximum among the lines and testers was observed in L7 and Kashi Pragati (T1) as well as in hybrids L6 × T2 and L5 × T4.
- The highest stem diameter was observed in L12 and Punjab Suhawani (C1) as well as in hybrid L4 × T4 and L5 × T1.
- The highest leaf blade length and width was observed for the lines and testers was L15 and Kashi Pragati (T1) and L15 and Arka Anamika (T4) respectively as well as

in hybrids L15×T1 and L11×T4 and L15×T4 and L12×T4 respectively.

- The highest petiole length was observed in L15 and Arka Anamika (T4) as well as in hybrids L15×T4 and L15×T2.

- The highest days to first flowering, fruit set and fruit picking was observed in L15 and Kashi Kranti (T3) in each as well as in hybrids L11×T4 and L11×T2, L11×T4 and L11×T3 and L2×T2 and L1×T1 respectively.

- The highest number of flowers per plant among the lines and testers was observed in L7, L4 and Kashi Pragati (T4) as well as in hybrids L3×T4 and L4×T

- The highest number of pods per plants, pod length and number of first fruiting node was observed among the lines and testers L2 and L12, L5 and Kashi Kranti (T3), L14 and Arka Anamika (T4) respectively as well as in hybrids L2×T3 and L15×T4, L5×T3 and L5×T1 and L14×T2 and L5×T2 respectively.

- Highest mean performance for number of nodes per plant, number of ridges per pod and pods diameter among the lines and testers was observed L11 and L15, L13 and L5 and L10 and Kashi Kranti (T3) respectively whereas in hybrids L15×T1 and L11×T1, L3×T3 and L3×T2 and L8×T2 and L15×T1 respectively.

- Highest mean performances for internodal length, average pod weight and pods yield/plant was observed in Arka Anamika (T4) and L15, L14 and Kashi Pragati (T1) and L7 and L4 respectively and for hybrids L7×T4 and L13×T4, L14×T1 and L9×T1 and L7×T3 and L2×T3 respectively.

- Mean performance for biochemical parameters *viz*., ascorbic acid content, dry matter content, firmness, chlorophyll content and mucilage content was highest among the genotypes were observed in L15 and L5, L5 and L15, L6 and L5, L7 and L12 and L15 and Kashi Lalima (T2) respectively and for hybrids L12×T1 and L12×T4, L15×T4 and L5×T4, L5×T2 and L6×T4, L7×T1 and L7×T3 and L15×T2 and L15×T1 respectively.

6.2 General Combining Ability & Specific Combining Ability

- For general combining ability for growth parameters, parental line L15, L13, L11 represent the best performing lines along with testers, Kashi Pragati (T1) and Arka Anamika (T4) while for yield attributes parental lines, L7, L2, and L15 along with testers, Arka Anamika (T4), Kashi Pragati (T1) and Kashi Kranti (T3) revealed as the best. In case of quality parameters L15, L12, L5 comes up with the best result along with testers Kashi Pragati (T1),and Arka Anamika (T4).
- In specific combining ability, the parental lines and testers which proves it's best for general combining ability expressed as one of the male or female parent in the best performing hybrids such as parental line L7 perform best in general combining ability also carried for hybrid L7×T3 and L7×T4 as a male parent.
- The best parental lines in general combining ability plant height, number of branches per plant, stem diameter, leaf blade length, leaf blade width and petiole length L15, L13 and Kashi Pragati (T1), L6, L13 and Kashi Pragati (T1), L4 and Arka Anamika (T4), L11, L15 and Kashi Pragati (T1), L15 and Arka Anamika (T4) and Arka Anamika (T4) and L15 respectively.
- The best parental lines for general combining ability for days to first flowering, first fruit set and first fruit picking was observed in L15 and Arka Anamika (T4), L11 and Kashi Pragati (T1) and L4, L11 and Kashi Kranti (T3) respectively.
- The best parental lines for number of flowers per plant, number of pods per plants, pod length, number of first fruiting node, pod length, number of first fruiting nodes and number of ridges per pod was observed in L15 ,L4 and Arka Anamika (T4), L2, L1 and Arka Anamika (T4), L5 and Kashi Lalima (T2), Kashi Kranti, L3 and L12, L11, L14 and Kashi Pragati and L13, L5 and Kashi Kranti and L13, L5 and Kashi Kranti respectively.
- The best parental lines for pods diameter, internodal length, average pod weight and pods yield/plant was observed in L8, L15 and Kashi Lalima, Arka Anamika and L13, L14 and Kashi Pragati and L7, L2 and Kashi Kranti respectively
- The best parental lines in general combining ability for biochemical parameters *viz*., ascorbic acid content, acidity, dry matter content, firmness, chlorophyll content and mucilage content was observed in L9, L12 and Kashi Pragati, L15, L5 and Arka Anamika,

L5, L15 and Kashi Pragati, L6, L5 and Arka Anamika, L7, L12 Kashi Kranti and L15 and Kashi Lalima respectively.

- ❖ The best hybrids in specific combining ability for plant height, number of branches per plant, stem diameter, leaf blade length, leaf blade width and petiole length was observed in L4 ×T1 and L11×T4, L1×T3 and L15×T1, L9×T1 and L5×T1, L3×T2 and L15×T1, L6×T2 and L5×T2 and L10×T3 and L1×T4 respectively.
- ❖ The best hybrids in specific combining ability for days to first flowering, first fruit set, first fruit picking L8×T2 and L2×T2 and L10×T2 and L13×T3 and L10×T2 and L7×T4 respectively.
- ❖ The best hybrids in specific combining ability for pods diameter, internodal length, average pod weight and pods yield/plant was observed L2×T3 and L8×T2, L11×T1 and L10×T3, L10×T1 and L9×T1and L7×T4 and L2×T3 respectively.

❖ The best hybrid in specific combining ability for biochemical parameters *viz*., ascorbic acid content, acidity, dry matter content, firmness, chlorophyll content and mucilage content was observed L10×T4 and L7×T4, L1×T3 and L15×T4, L12×T3 and L10×T4, L15×T3 and L10×T1, L12×T3 and L10×T4, L15×T4 and L3×T3, L7×T2 and L2×T4 respectively.

6.3 Genetic Variance

- ❖ Phenotypical variance is noted greater than genotypical variance in all traits, except acidity percentage understudied.
- ❖ The maximum broad sense heritability more than 95% is recorded in most of the traits except pod diameter and acidity percentage
- ❖ Genetic advancement is recorded, highest for pod yield, plant height, days to first flowering, fruit set & fruit picking and also for mucilage content while genetic advancement as a per cent of mean is recorded highest for traits, mucilage content and firmness respectively.
- ❖ The magnitude of additive variance, is greater than dominant variance is recorded for traits, plant height, number of first fruiting node, node per plant, number of ridges per pod, pod diameter , Internodal length, chlorophyll content, acidity percentage, ascorbic acid, dry matter content, firmness and mucilage content while dominant variance greater over additive variance is noticed for traits number of branches per plant, stem diameter, leaf blade length, leaf blade width, petiole length, days to first

flowering, days to first fruit set, days to first fruit picking, number of flowers per plant, number of pods per plant, pod length, average weight of pod, pod yield per plant.

- ❖ Highest contribution for expression of traits by parental lines is recorded for plant height, number of branches per plant, stem diameter, leaf blade length and width, petiolelength, days to first flowering, days to first fruit set, days to first fruit picking, number of flowers per plant, number of pods per plant, pod length, node per plant, number of ridges per pod ,pod diameter, internodal length, chlorophyll content, dry weight of pod, pod yield per plant, acidity percentage, ascorbic acid, dry matter content, firmness and mucilage content while contribution of tester more than parental lines is noted in trait number of first fruiting node and average weight of pod.
- ❖ The interaction of parental lines and tester for contribution in traits recorded maximumin number of flowers per plant, petiole length, leaf blade width, number of branches per plant andnumber of pods per plant.

6.4 Heterosis and Heterobeltiosis

- ❖ The best hybrids perform among 60 F1 hybrids revealed that the combination made up of best parental lines and testers scrutiny in general combining ability continued to convey the best expression of trait in specific combiningability and the same for heterosis and heterobeltiosis.
- ❖ The best hybrids in heterosis and heterobelitosis in plant height L15×T1 and L4×T1and L2×T1, L4×T1 and L5×T1 respectively for number of branches per plant L6×T2, L5×T4 and L15×T1 and L1×T3 and L11×T3 respectively , for stem diameter L4×T4 and L5×T1 and L9×T1 and L3×T3 respectively, for leaf blade length and width L11×T2 and for petiole length it was found L15×T4 and L15×T2 and L3×T3 and L11×T3 respectively.
- ❖ The best hybrids in heterosis and heterobeltiosis for days to first flowering L11×T4 and L5×T1 and L1×T1 and L1×T3 respectively, for days to first fruit set L11×T4 and L11×T3 and L1×T3 and L10×T2 respectively, for days to first fruit picking L2×T2, L5×T1 and L5×T2 and L1×T1 and L1×T3 respectively .
- ❖ The best hybrids in heterosis and heterobeltiosis for number of flowers per plant L4×T1, L4×T2 and L3×T4 and L9×T2, L5×T4 and L11×T2 respectively for number of pods per plants was L2×T3, L2×T1 and L15×T4 and L6×T2 and L6×T1 respectively, for pod length L5×T3, L5×T1 and L4×T3 and L9×T3, L9×T4 and

L10×T1 respectively.

- ❖ The best hybrids in heterosis and heterobeltiosis for number of first fruiting node L12×T3 and L3×T3 and L8×T4 and L6×T1 respectively, for number of nodes per plant L11×T1 and L14×T1 and L2×T4 and L3×T4 respectively, for Number of ridges per pod L3×T3 and L1×T2 and L3×T3 and L1×T1 respectively.
- ❖ The best hybrids in heterosis and heterobeltiosis for pods diameter L8×T1, L14×T4 and L15×T2 and L15×T1 and L8×T2 respectively, for internodal length L7×T4 and L13×T4 and L7×T4, L11×T1 and L6×T4 respectively for average pod weight L14×T1 and L9×T1 and L10×T3 and L11×T4 respectively for pods yield/plant L7×T3, L2×T3 and L7×T2 and L15×T3, L13×T4 and L5×T4 respectively.
- ❖ The best hybrids in heterosis and heterobeltiosis for ascorbic acid content L12×T1 and L12×T4 and L12×T1 and L5×T4 respectively for acidity L15×T4 and L12×T3, L5×T4 and L15×T4 respectively dry matter content L5×T1, L8×T1 and L15×T1 and L14×T4, L12×T2 and L4×T4 respectively for firmness L6×T4 and L5×T2 and L14×T4 and L2×T4 for chlorophyll content L7×T1 and L7×T3 and L8×T4 and L4×T3 respectively mucilage content L15×T2 and L15×T1 and L15×T2, L14×T1 and L11×T1 respectively.

Conclusion

- Among the 25 traits study showed significant effect for wide range of variation including individual and interactions of parents, hybrids and environmentsas discussed in an Anova table. The phenotypical interpretation of parental line and testers counterparts with hybrids performance.
- The correlation between general combining ability and specific combining ability is clearly established as the superior parental lines and testers which perform best for general combining ability are also involved as one of the parents for hybrids noted best in specific combining ability.
- In study of genetic advance, it is clear that role of environment influences most of the traits, higher percentage of broad sense heritability showed ability of parents (Line and Testers) to carry the trait to hybrid. Higher broad senseheritability amalgamate with genetic advance and genetic advance as percentage of mean is

observed for most of growth, yield and quality parameters. The magnitude of additive variance is greater than dominant variance in most of the traits under studied also saturation of gene in hybrids for characters is more from parental lines than tester. They effect of epistasis is recorded for number of flowers per plant, petiole length, leaf blade width, number of branches per plant and numberof pods per plant.

- Synopsis of heterosis and heterobeltiosis indicate the relevance between general and specific combining ability along with genetic advance of parental line and tester contribute hybrid make over. Trait specific expression of gene is noted for every character which is utilize for hybrid development and also for further breeding programs.
- Keeping in view the findings of this experiment, some parental lines and testers like L7, L15, L12 & L13 and Kashi Kranti, Kashi Pragati, Arka Anamika were found promising based on their performance. Hence, these can be utilized in okra line development and other breeding programs.

CHAPTER 7

REFFERENCES

Abinaya, S., Saravanan, K. R., Thangavel, P., Madhubala, R., & Pushpanathan, K. R. (2020). Studies of Heterosis and Combining Ability Analysis in Okra (*Abelmoschus esculentus* Moench.). *Plant Archives*, 20(1), 1340-1342.

Adetunji, I. A., & Chheda, H. R. (1989). Seed yield stability of okra as influenced by planting date. Plant breeding, 103(3), 212-215

Adiger, S., Shanthakumar, G. and Salimath, P.M. (2013). Selection of parents based on combining ability studies in okra [*Ablemoschus esculentus* (L.) Moench]. *Karnataka Journal Agriculture Science*, 26(1): 6-9.

Ahlawat, T.R. (2004). Line × tester analysis for combining ability, heterosis and gene action in okra [*Abelmoschus esculentus* (L.) Moench]. Ph.D., Thesis, Submitted to Anand Agricultural University, Anand.

Ahmed, N.; Hakim, M.A. and Gandroo, M.Y. (1999). Exploitation of hybrid vigour in okra. *Indian Journal Horticulture*. 56 (3): 247-251.

Akhtar, M., Singh, J. N., Shahi, J. P., & Srivastava, K. (2010). Exploitation of heterosis for yield and its attributing traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Environment and Ecology*, 28(2B), 1243-1246.

Akinyele, B.O. and Taye, T. (2007). Effect of Variation in Soil Texture on the Vegetative and Pod Characteristics of Okra (*Abelmoschus esculentus* (L.) Moench. *International Journal of Agricultural Research*, 2(2): 165-169.

Akotkar, P. K., De, D. K. and Dubey, U. K. (2014). Genetic studies on fruit yield and yield attributes of okra [*Abelmoschus esculentus* (L). Moench.] *Electronic Journal of Plant Breeding,* 5(1), 38-44.

Akotkar, P.K.; De, D.K. and Dubey, U. (2014). Genetic studies on fruit yield and yield attributes of okra [*Abelmoschus esculentus* (L.) Moench]. *Electronic Journal Plant Breeding*. 5 (1): 38-44.

Akotkar, P.K.; De, D.K. and Ghoshdastidar, K.K. (2011). Stability analysis for fruit yield and component characters in okra [*Abelmoschus esculentus* (L.) Moench]. In: National Seminar on Contemporary Approaches to Crop Improvement. Abstract. 62: 196.

Allard, R.W. and Bradshaw, A.D. (1964). Implications of genotype environmental interactions in applied plant breeding. *Crop Science.* 4: 503-508.

Amutha, R.; Venkatesan, M.; Senthil, K.N. and Thangavel, P. (2007). Hybrid vigour and inbreeding depression in bhindi [*Abelmoschus esculentus* (L.) Moench]. *Agriculture Science Digest*. 27 (2): 131-133.

Anonymous (2009). Guidelines for the conduct of tests for distinctness, uniformity and stability of okra [*Abelmoschus esculentus* (L.) Moench.]

Anonymous (2011). Series of Crop Specific Biology Documents, Biology of *Abelmoschus esculentus* L. (Okra). Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. pp. 3- 4.

Anonymous (2020). National Horticulture Database. www.nhb.gov.in

Anonymous (2021). FAOSTAT, Value of agriculture production. https://www.fao.org/faostat/en/#data/QVretrieved on 20 August 2023.

Ariyo, O. J., & Ayo-Vaughan, M. A. (2000). Analysis of genotype× environment interaction of okra [*Abelmoschus esculentus* (L) Moench]. *Journal of Genetics & Breeding*, 54(1), 35-40.

Ariyo, O.J. (1990). Effectiveness and relative discriminatory abilities of techniques measuring genotype × environment interaction and stability in okra [*Abelmoschus esculentus* (L.) Moench]. *Euphytica*. 47 (2): 99-105.

Arora, M., Kiran, B., Rani, S., Rani, A., Kaur, B. and Mittal, N., 2008. Heavy metal accumulation in vegetables irrigated with water from different sources. *Food chemistry*, *111*(4), pp.811-815

Aulakh, P.S.; Dhall, R.K. and Singh, J. (2012). Genetics of early and total yield in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Science*. 39 (2): 165-168.

Babel, Y.S. and Yadav, S. (1971). All about okra or bhindi for commercial grower. Farmer and Parliament. 6 (6): 11-12.

Babu, K.V.S.; Gopalkrishnan, P.K. and Peter, K.V. (1983). Phenotypic stability in okra. Indian Journal of Agriculture Science. 53 (4): 261-264.

Baker, R.S. (1969). Genotype × environment interactions in yield of wheat. *Canadian Journal of Plant Science.* 49: 743-751.

Bhalekar, M.N.; Patil, B.T.; Patil, S.G. and Shinde, K.G. (2014). Combining ability studies in okra (*Abelmoschus esculentus* L.). Abstracts of National Symposium on Precision Horticulture for Small and Marginal Farmers held from 24th to 27th June, 2014 at Indira Gandhi Krishi Vishwavidyalaya, Raipur. pp. 8-9.

Bhalekar, S.G.; Desai, U.T. and Nimbalkar, C.A. (2004). Heterosis studies in okra. *Journal of Maharashtra Agriculture University*. 29 (3): 360-362.

Borgaonkar, S.B.; Vaddoria, M.A.; Dhaduk, H.L. and Poshiya, V.K. (2005). Heterosis in okra [*Abelmoschus esculentus* (L.) Moench]. *Agriculture Science Digest*. 25 (4): 251- 253.

Breese, E.L. (1969). The measurement and significance of genotype environment interactions in grasses. *Heredity*. 24: 27-44

Chauhan, S. and Singh, Y. (2002). Heterosis studies in okra. Vegetable Science. 29 (2): 116-118.

Cockerham, C.C. (1961). Implication of genetic variances in a hybrid breeding programme. *Crop Science*. 1: 47-52.

Comstock, R.E. and Moll, R.H. (1963). Genotype-environment interactions. In: "Statistical Genetics and Plant Breeding" (Hanson, W.D. and Robinson, H.F. Eds.), NAS-NRC Publication 982. Washington, D.C. pp. 164-197.

Dabhi, K.H.; Vachhani, J.H.; Poshiya, V.K.; Jivani, L.L. and Chitaroda, J.D. (2010). Stability analysis in okra [*Abelmoschus esculentus* (L.) Moench]. *Research on Crops*. 11 (2): 391-396.

Dabhi, K.H.; Vachhani, J.H.; Poshiya, V.K.; Jivani, L.L. and Kachhadia, V.H. (2010a). Combining ability for fruit yield and its components over environments in okra [*Abelmoschus esculentus* (L.) Moench]. *Research on Crops*. 11 (2): 383-390.

Dabhi, K.H.; Vachhani, J.H.; Poshiya, V.K.; Jivani, L.L.; Vekariya, D.H. and Shekhati, H.G. (2009). Heterosis for fruit yield and its components over environments in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Agricultural Sciences*. 5 (2): 572-576.

Dahake, K.D. and Bangar, N.D. (2006). Combining ability analysis in okra. *Journal Maharashtra Agriculture University*. 31 (1): 39-41.

Dahake, K.D.; Bangar, N.D.; Lad, D.B. and Patil, H.E. (2007). Heterosis studies for fruit yield and its contributing characteristics in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Science*. Muzaffarnagar. 2 (2): 137-140.

Das, S.; Chattopadhyay, A.; Dutta, S.; Chattopadhyay, S. and Hazra, P. (2013). Breeding okra for higher productivity and yellow vein mosaic tolerance. *International Journal of Vegetable Science.* 19: 58-77.

Datta, P.C. and Naug, A. (1968). A few strains of [*Abelmoschus esculentus* (L.) Moench] their karyological in relation to phylogeny and organ development. *Beitrage zur Biologie der Pflanzen*. 45: 113-126.

Desai, D.T. (1990). Genetic analysis of some quantitative characters in okra [*Abelmoschus esculentus* (L.) Moench]. Ph.D. Thesis (Unpublished), M.P.K.V., Rahuri.

Desai, S.S.; Bendale, V.W.; Bhave, S.G. and Jadhav, B.B. (2007). Heterosis for yield and yield components in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal Maharashtra Agriculture University.* 32 (1): 41-44.

Devi, K. A., Kumar, P. S., Saravanan, K., Suganthi, S., Kamaraj, A., & Sabesan, T. (2020). Studies on gene action in bhendi (*Abelmoschus esculentus* L. Moench). *Plant Archives*, 20(1), 1717-1723.

Devi, K. A., Kumar, P. S., Saravanan, K., Suganthi, S., Kamaraj, A., & Sabesan, T. (2020). Studies on gene action in bhendi (*Abelmoschus esculentus* L. Moench). *Plant archives*, *20*(1), 1717-1723.

Dhankhar, B.S. and Dhankhar, S.K. (2001). Heterosis and combining ability studies for me economic characters in okra. *Haryana Journal of Horticulture Science*. 30 (3-4): 230-233.

Dudley, J.W. and Moll, R.H. (1969). Interaction and use of estimate of heritability and genetic advance in plant breeding. *Crop Science.* 9: 257-262.

Duenk, P., Bijma, P., Calus, M. P., Wientjes, Y. C., & van der Werf, J. H. (2020). The impact of non-additive effects on the genetic correlation between populations. *G3: Genes, Genomes, Genetics*, *10*(2), 783-795.

Finlay, K.W. and Wilkinson, G.N. (1963). Analysis of adaptation in plant breeding programme. *Australian Journal of Agricultural Research*. 14: 742-754.

Fisher, R.A. and MacKenzie, W.A. (1923). Studies in crop variation II. The manorial response of different potato varieties. *Journal of Agriculture Sciences*. 13: 311-320.

Fonseca, S. and Patterson, F. (1968). Hybrid vigour in a seven parent diallel cross in common winter wheat (*Triticum aestivum* L.). *Crop Sciences*. 8: 85-88.

Friedt, W., Snowdon, R., Ordon, F. and Ahlemeyer, J. (2007). Plant breeding: assessment of genetic diversity in crop plants and its exploitation in breeding. *Progress in Botany*, 68: 151- 178.

Giriraj, K. and Swamy, R.T. (1973). Note on simple crossing technique in okra. *Indian Journal of Agricultural Sciences*. 43: 1089.

Gopalan, C.; Rama Sastri, B.V. and Balasubramanian, S. (2007). Nutritive Value of Indian Foods. National Institute of Nutrition (NIN), ICMR.

Grafius, J.E. (1956). Components of yield in oats, a geometrical interpretation.
Agronomy Journal. 51: 515-554.

Hadiya, D. N., Mali, S. C., Gamit, A. M. and Sangani, J. L. (2018). Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Pharmacognosy and Phytochemistry*, 7(5), 2525-2528.

Hamed, H.H. and Hafiz, M.R. (2012). Selection of local okra (*Abelmoschus esculentus* L.) genotypes for stability under saline conditions. Bulletin of Faculty of Agriculture, Cairo University. 63 (2): 188-200.

Hosamani, R.M.; Ajjapalavara, P.S.; Basavarajeshwari C.; Smith, R.P. and Ukkand,
K.C. (2008). Heterosis for yield and yield components in okra. *Karnataka Journal of Agricultural Sciences*. 21 (3): 473-475.

Imbalkar, C.A.; Bajaj, V.H.; Deshmukh, V.D. and Baviskar, A.P. (2005). AMMI analysis for fruit yield trial of okra. *Journal of Indian Society of Agricultural Statistics*. 591 (1): 32-47.

Jackson, M.L. (1957). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India. pp. 327-350.

Jagan, K.; Reddy, K.R.; Sujatha, M.; Reddy, S.M. and Sravanthi, V. (2013a). Combining Ability Studies in Okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Innovative Research and Development.* 2 (8): 314-325.

Jagan, K.; Reddy, K.R.; Sujatha, M.; Sravanthi, V. and Reddy, M.S. (2013). Heterosis for yield and yield components in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Pharmacy and Biological Sciences.* 7 (4): 69-70.

Jaiprakashnarayan, R.P.; Prashanth, S.J.; Mulge, R. and Madalageri, M.B. (2008). Study on heterosis and combining ability for earliness and yield parameters in okra [*Abelmoschus esculentus* (L.) Moench]. *The Asian Journal of Horticulture*. 3 (1): 136-141.

Javia, R.M. (2014). Stability analysis for fruit yield and it's attributing characters in okra *[Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Sciences.* 9 (1): 35-39.

Javia, R.M.; Patel, N.B.; Vaddoria, M.A.; Mehta, D.R. and Chovatia, V.P. (2009). Combining ability analysis for fruit yield and its attributes in okra [*Abelmoschus esculentus* (L.) Moench]. *Crop Improvement*. 36 (1): 88-94.

Javiya, U. R., Mehta, D. R., Sapovadiya, M. H. and Pansuriya, D. J. (2020). Selection of parents and breeding methods based on combining ability and gene action for fruit yield and its contributing characters in okra (*Abelmoschus esculentus* L. Moench*). Journal of Pharmacognosy and Phytochemistry*, 9(5), 1936-1939.

Jensen, N.F. (1988). Plant breeding methodology. John Wiley and Sons, New York.

Jethava, B.A. (2014). Heterosis and combining ability in Okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis, Submitted to Navsari Agricultural University, Navsari.

Jindal, S.K.; Arora, D. and Ghai, T.R. (2009). Genotype × Environment interaction for fruit traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Crop Improvement*. 36 (1): 1-5.

Jindal, S.K.; Arora, D. and Ghai, T.R. (2010). Heterosis and combining ability for yield traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Research in Punjab Agricultural University.* 47 (1-2): 42-45.

Jindal, S.K; Arora, D. and Ghai, T.R. (2008). Stability analysis for earliness in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Research in Punjab Agricultural University*. 45 (3-4): 148-155.

Joshi, V. M., Saravaiya, S. N., Patel, C. R., Patel, A. I., Patel, R. K., & Patel, P. N. (2015). Combining ability studies in yield and quality of okra (*Abelmoschus esculentus* (L.) Moench). *Trends in Bioscience*, 8(10), 2517-2522.

Kachhadia, V. H., Vachhani, J. H., Jivani, L. L., Madaria, R. B. and Dangaria, C. J. (2011). Heterosis for fruit yield and yield components over environments in okra [*Abelmoshcus esculentus* (L.) Moench] *Research on Crops*., 12(2): 568-573.

Kang, M.S. (1994). Applied quantitative genetics. M. S. Kang Publisher, Baton Rouge, LA

Karadi, S. M., & Hanchinamani, C. N. (2021). Estimation of Heterosis in Okra [*Abelmoschus esculentus* (L.) Moench] for Fruit Yield and its Components Through Line× Tester Mating Design. *Bangladesh Journal of Botany*, 50(3), 531-540.

Katagi, A.; Tirakannanvar, S. and Jagadeesha, R.C. (2015). Combining ability through diallel analysis in okra [*Abelmoschus esculentus* (L.) Moench]. *Green Farming International Journal.* 6 (1): 26-29.

Kempthrone, O. (1957). An Introduction to Genetics Statistics. John Willey and Sons.
New York. pp. 453-471.

Khanpara, M.D.; Jivani, L.L.; Vachhani, J.H.; Kachhadia, V.H. and Madaria, R.B. (2009). Heterosis studies in okra. *International Journal of Agricultural Sciences*. 5 (2): 497-500.

Khanpara, M.D.; Jivani, L.L.; Vachhani, J.H.; Shekhat, H.G. and Mehta, D.R. (2009). Line × tester analysis for combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Agricultural Sciences*. 5 (2): 554-557.

Khatik, K.R.; Chaudhary, R. and Khatik, C.L. (2012). Heterosis studies in okra. *Annals of Horticulture.* 5 (2): 213-218.

Kishor, D.S.; Arya, K.; Duggi Shrishail; Magadum, S.; Raghavendra, N.R.; Venkateshwaralu, Challa and Reddy, P.S. (2013). Studies on heterosis for yield and yield contributing traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Molecular Plant Breeding*. 4 (35): 277-284.

Kishor, D.S.; Shrishail, D.K.; Arya, K. and Magadam, S. (2013a). Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Bioinfolet*. 10 (2): 490-494.

Koelreuter, J.G. (1766). Vorlacvfigen nachricht von. einigon de geschlechtter pflanzen betreffenden versuchen and beobachtum. *Genetics Leipzig*. p. 266.

Korla, B.N. and Rastogi, K.B. (1979). A note on phenotypic stability for fruit yield in bhindi. *Punjab Horticulture Journal*. 19 (3-4): 182-183.

Krishnamurthy, K.H. (1994). Okra "In Vegetable Health Series, Traditional Family Medicine".Published by Books for all, Ashok Vihar, Delhi. pp. 12-15.

Kumar, A., Baranwal, D. K., Aparna, J. and Srivastava, K. (2013). Combining Ability and heterosis for yield and its contributing characters in Okra [*Abelmoschus esculantus* (L.) Moench]. *Madras Agricultural Journal*, 100(1-3), 30-35.

Kumar, D.S.; Tony, D.E.; Kumar, A.P.; Kumar, K.A.; Rao, D.B.S. and Nadendla, R. (2013). A Review on: *Abelmoschus esculentus* (Okra). *International Research Journal on Pharmaceutical and Applied Sciences.* 3 (4): 129-132.

Kumar, N. (2006). Breeding of Horticultural crops. New Delhi: New India Publishing Agency, pp 173–7

Kumar, N. (2006). Breeding of Horticultural crops. New Delhi: New India Publishing Agency. pp.173-177.

Kumar, N. (2014). Heterosis and combining ability for yield and yield attributes in okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis, (Unpublished), Submitted to Navsari Agricultural University, Navsari.

Kumar, N. S. (2011). Heterosis in okra [*Abelmoschus esculentus* (L.) Moench]. *Plant Archives*, 11(2), 683-685.

Kumar, P.; Singh, V. and Dubey, R.K. (2012). Combining ability analysis in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Sciences*. 39 (2): 180-182.

Kumar, S. and Pathania, N.P. (2007). Heterosis and combining ability studies for shoot and fruit borer infestation (*Earias* spp.) in okra [*Abelmoschus esculentus* (L.) Moench]. *The Asian Journal of Horticulture*. 2 (1): 126-130.

Kumar, S. and Pathania, N.P. (2011ab). Combining ability and gene action studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Research in Punjab Agricultural University*. 48 (1-2): 43-47.

Kumar, S. and Reddy, M. T. (2016). Combining ability of inbred lines and half-diallel crosses for economic traits in okra (*Abelmoschus esculentus* (L.) Moench). *Jordan Journal of Agricultural Sciences*, 12(2).

Kumar, S.; Singh, A.K.; Das, R.; Datta, S. and Arya, K. (2014). Combining ability and its relationship with gene action in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal Crop and Weed*. 10 (1): 82-92.

Kumar, S.P. and Sreeparvathy, S. (2010). Studies on heterosis in okra [*Abelmoschus esculentus* (L.) Moench]. *Electronic Journal Plant Breeding*. 1 (6): 1431 -1433.

Kumar, S.P.; Srirama, P. and Kuruppiah, P. (2006). Studies on combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *Indian Journal of Horticulture*. 63 (2): 182-184.

Kumbhani, R. P., Godhani, P. R., & Fougat, R. S. (1993). Hybrid vigour in eight parent diallel cross in okra [*Abelmoschus esculentus* (L.) Moench]. *Gujarat Agricultural Universities Research Journa*l.18(2):13-18

Lamont, W. (1999) Okra a versatile vegetable crop. *Horticulture Technology*, 9: 179-184.

Lee, M. (1995). DNA markers and plant breeding programmes. Advances in Agronomy.
55: 265- 344.

Levin, D.A. and Kerster, H.W. (1970). Phenotypic dimorphism and population fitness in phlo×. *Evolution*. 24: 128-134.

Lewis, D. (1954). Genotype-environment interaction: A relationship between dominance, heterosis, phenotypic stability and variability. *Heredity*. 8: 333-356.

Lyngdoh, R.; Mulge, R. and Shadap, A. (2013a). Heterosis and combining ability studies in near homozygous lines of okra [*Abelmoschus esculentus* (L.) Moench] for growth parameters. *The Bioscan*. 8 (4): 1275-1279.

Lyngdoh, Y.A., Mulge, R. and Shadap, A. (2013). Heterosis and combining ability studies in near homozygous lines of okra [*Abelmoschus esculentus* (L.) Moench] for growth parameters. *The Bioscan*. 8(4):1275–279.

Mamidwar, S. R., and Nandan Mehta, N. M. (2006). Heterobeltiosis in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Sciences*. 1 (1): 127- 129.

Manivannan, M.I.; Rajangam, J. and Aruna, P. (2007). Heterosis for yield and yield governing traits in okra. *Asian Journal of Horticulture*. 2 (2): 96-103.

Martin, F.W. and Ruberte, R. (1978). Vegetables for the hot humid tropics. Part 2 Okra, *Abelmoschus esculentus*, Science and Education Administration, United States Department of Agriculture, (USDA) New Orleans. p. 22.

Mather, K. (1943). Polygenic inheritance and natural selection. *Biological Reviews*. 18: 32-64.

Mather, K. and Jinks, J.L. (1971). Biometrical genetics. Chapman and Hill Ltd., London. p. 382.

Medagam, T. R., Kadiyala, H. B., Mutyala, G. and Begum, H. (2012) Diallel analysis for yield and its components in okra (*Abelmoschus esculentus* (L.) Moench). *The Asian and Australasian Journal of Plant Science and Biotechnology*, 6(1), 53-61.

Medagam, T.R.; Kadiyala, H.; Mutyala, G. and Hameedunnisa, Begum (2012). Heterosis for yield and yield components in okra. *Chilean Journal of Agriculture Research*. 72 (3): 316-325.

Mehta, N.; Asati, B.S. and Mamidwar, S.R. (2007). Heterosis and gene action in okra..*Bangladesh Journal of Agriculture Research*. 32 (3): 421-432.

Mehta, Y.R.(1959). Vegetable growing in Uttar Pradesh Bureau of Agriculture Research 31:215-218.

Mudhalvan, S., & Senthilkumar, N. (2021). Combining ability, reciprocal effects and heterosis for fruit yield characters in okra [*Abelmoschus esculentus* (L.) Moench] *Journal of Pharmacognosy and Phytochemistry*, 10(1), 96-101.

Nagesh, G.C.; Mulge, R.; Rathod, V.; Basavaraj, L.B. and Mahaveer, S.M. (2014). Heterosis and combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench] for yield and quality parameters. *The Bioscan*. 9 (4): 1717-1723.

Nanthakumar, S., Kuralarasu, C., & Gopikrishnan, A. (2021). Heterosis and Combining Abilities Studies in Okra [*Abelmoschus esculentus* (L.) Moench]. *Current Journal of Applied Science and Technology*, 40(30): 25-33.

Naphade, P.V.; Potdukhe, N.R.; Parmar, J.N. and Sable, N.H. (2006). Line × Tester analysis for combining ability in okra. *Annals of Plant Physiology*. 20 (1): 91-94.

Nichal, S.S.; Datke, S.B.; Deshmukh, D.T. and Patil, N.P. (2000). Heterobeltiosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Annals of Plant Physiology*. 15 (1): 34-39.

Nichal, S.S.; Mehta, N. and Saxena, R.R. (2006). Study Of Heterosis Through Diallel Crosses of Okra [*Abelmoschus esculentus* (L.) Moench]. *Plant Archives*. 6 (1): 109-113.

Obi, S.U. (2009). Studies on heterosis in [*Abelmoschus esculentus* (L.) Moench] and *A. callei* (*A. Chev*) stevels cultivars during shorter day photoperiods in south eastern Nigeria. *Pakistan Journal of Biological Sciences*. 12 (21): 1388-1398.

Obiadalla-Ali.; Eldekashi, M.H. and Helaly, A.A. (2013). Combining ability and heterosis studies for yield and its components in some cultivars of okra. *American-Eurasian Journal of Agricultural and Environmental Sciences*. 13 (2): 162-167.

Olayiwola, M.O. and Ariyo, O.J. (2013). Relative discriminatory ability of GGE biplot and YSi in the analysis of genotype × Environment interaction in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Breeding and Genetics*. 7 (3): 146-158.

Padadalli, S., Satish, D., Babu, A. G., Chittapur, R., Prabhuling, G., & Peerjade, D. (2019). Studies on combining ability in okra [*Abelmoschus esculentus* (L.) Moench] through Line × Tester analysis for productivity and quality traits. *Journal of Pharmacognosy and Phytochemistry*, 8(4), 639-643.

Pal, A.K. and Hossain, M. (2000). Combining ability analysis for seed yield, its components and seed quality in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Interacademicia.* 4 (2): 216-223.

Panse, V.G. and Sukhatme, P.V. (1967). Statistical Methods for Agricultural Workers, Indian Council of Agricultural Research, New Delhi, India. pp. 152-161.

Patel, B.G. (2013). Genetic analysis of yield and yield attributing characters in Okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis (Unpublished), Submitted to Navsari Agricultural University, Navsari.

Patel, B.G. and Patel, A.I. (2016). Heterosis Studies in Okra [*Abelmoschus esculentus* (L.) Moench]. *Annals of Agricultural and Environment Sciences*. 1 (1): 15-20.

Patel, K. D., Barad, A. V., Savaliya, J. J., & Butani, A. M. (2010). A study on hybrid vigour and inbreeding depression in okra *Abelmoschus esculentus* (L.) Moench. *Asian Journal of Horticulture*, 5(2), 277-280.

Pathak, M. and Prabhat, K. (2014). Heterosis in okra [*Abelmoschus esculentus* (L.) Moench]. Abstract of national symposium on "Precision Horticulture for Small and Marginal Farmers" held at 24th to 27th June, 2014 at Indira Gandhi Krishi Vishwavidyalaya, Raipur.

Patil, S.S. (2013). Genetic analysis for yield and yield contributing traits in okra [*Abelmoschus esculentus* (L.) Moench] over environments. Ph.D. Thesis (Unpublished), Submitted to Navsari Agricultural University, Navsari.

Paul, T. (2013). Genetic architecture and fruit yield analysis in okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis (Unpublished), Submitted to Navsari Agricultural University, Navsari.

Paul, T., Desai, R. T. and Choudhary, R. (2017). Genetic architecture, combining ability and gene action study in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Current Microbiology and Applied Science,* 6(4), 851-858.

Perkins, J.M. and Jinks, J.L. (1968). Environmental and genotype-environmental components of variability. III. Multiple lines and crosses. *Heredity*. 23: 339-356.

Poshiya, V.K. and Shukla, P.T. (1986). Heterosis studies in okra [Abelmoschus esculentus (L.) Moench]. *Gujarat Agricultural Universities Research Journal*. 11 (2): 21-25.

Poshiya, V.K. and Vashi, P.S. (1995). Heterobeltiosis in relation to general and specific combining ability in okra. *Gujarat Agricultural Universities Research Journal*. 20 (2): 69-72.

Prakash, M.; Kumar, M.S.; Saravanan, K.; Kannan, K. and Ganesan, J. (2002). Line × tester analysis in okra. *Annals of Agricultural Research*. 23 (2): 233-237.

Purewal, S.S and Randhawa, G.S. (1947). Studies in *Hibiscus esculentus*, chromosome and pollination studies. *Indian Journal of Agricultural Sciences*. 17: 129-136.

Raghuvanshi, M., Singh, T.B., Singh, A.P., Singh, U., Singh, V.P. and Singh, B. (2011). Combining ability analysis in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Science*, 38(1): 26- 29.

Raghuvanshi, M.; Singh, T.B.; Singh, A.P.; Singh, U.; Singh, P. and Singh, B. (2011). Combining ability in okra. *Vegetable Sciences*. 38 (1): 26-29.

Rajani, A., Naidu, L. N., Reddy, R. V. S. K., Srikanth, D., Kumari, N. R., & Babu, D. R. (2021). Studies on combining ability for yield and quality attributing traits in okra [*Abelmoschus esculentus* (L.) Moench.]. *The pharma Innovation* 10(10):1398-1400.

Rajani, B.; Manju, P.; Manikantan Nair, P. and Saraswathy, P. (2001). Combining ability in okra *[Abelmoschus esculentus* (L.) Moench]. *Journal of Tropical Agriculture*. 39: 98- 101.

Rajendra, K.; Yadav, J.R.; Tripathi, P. and Tiwari, S.K. (2005). Evaluating genotypes for combining ability through diallel analysis in okra. *Indian Journal of Horticulture*. 62 (1): 88-90.

Rameshkumar, D., Gunasekar, R. and Sankar, R. (2017). Gene action studies for quantitative and qualitative traits in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Chemical Studies*, 5(5), 2309-2312.

Ramya, K. and Kumar, N. (2010). Heterosis and combining ability for fruit yield in okra. *Crop Improvement*. 37 (1): 41-45.

Ramya, K. and Senthilkumar, N. (2010). Genotype × environment interaction and screening saline tolerant genotypes in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Plant Sciences*. 5 (1): 198-202.

Ranganna, S. (1979). Chapter 5: Ascorbic acid, in: Manual of Analysis of fruit and vegetable Products (Ed.), Tata McGraw Hill Publishing Company, New Delhi. pp. 94-96.

Rani, M.; Arora, S.K. and Dhall, R.K. (2002). Heterobeltiosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Research, Punjab Agricultural University*. 39 (4): 491-498.

Reddy, M. A., Sridevi, O., Salimath, P. M. and Nadaf, H. L. (2013). Combining ability for yield and yield components through diallel analysis in okra [*Abelmoschus esculentu*s (L.) Moench]. *Journal of Agriculture and Veterinary Science*, 5, 1-6.

Reddy, M. T., Haribabu, K., Ganesh, M., Reddy, K. C., Begum, H., Subbararama Krishna Reddy, R., & Dilip Babu, J. (2012). Genetic analysis for yield and its components in okra [*Abelmoschus esculentus* (L.) Moench]. *Songklanakarin Journal of Science & Technology*, 34(2).

Reddy, R. S. (2013). Gene action and combining ability of yield and its components for late kharif season in okra [*Abelmoschus esculentus* (L.) Moench]. *Chilean journal of agricultural research*, 73(1), 9-16.

Reddy, T.M.; Babu, K.H.; Ganesh, M.; Hameedunnisa, Begam.; Dilipbabu, J. and Reddy, R.S.K. (2013). Gene action and combining ability of yield and its components for late kharif season in okra [*Abelmoschus esculentus* (L.) Moench]. *Chilean Journal of Agricultural Research*. 73 (1): 9-16.

Reddy, J.P., Anbanandan, V., Kumar, B.S. and Saravanan, K. (2023). Qualitative and Phenotyping Characterization among Okra [*Abelmoschus esculentus* (L.) Moench] Genotypes. *Indian Journal of Agricultural Research*. A-(5987) 1-9.

Rekhi, S.S. (1976). Grow bhindi for more profits. Seeds and Farms. 2 (2): 25-27.

Rewale, V.S.; Bendale, V.W.; Bhave, S.G.; Madav, R.R. and Jadhav, B.B. (2003). Heterosis for yield and yield components in okra. *Journal of Maharashtra Agricultural Universities*. 28 (3): 247-249.

Ryan, J. J., & Dupont, J. A. (1973). Identification and analysis of the major acids from fruit juices and wines. *Journal of Agricultural and Food Chemistry*, 21(1), 45-49.

Samuel, C.J.A.; Hill, J.; Breese, E.L. and Davis, A. (1970). Assessing and predicting environmental response in Lolium. Perreene *Journal of Agricultural Sciences*, Cambridge. 75: 1-9.

Senthilkumar, N. (2011). Stability of bhindi hybrids [*Abelmoschus esculentus* (L.) Moench] for fruit yield traits under saline environment. *Plant Archives*. 11 (2): 797-799.

Sharma, J.P. and Singh, A.K. (2012). Line × Tester analysis for combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Sciences*. 39 (2): 132-135.

Shobha, K. and Marriappan, S. (2007). Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench] for some important biometrical traits. *Acta Horticulturae*. 75 (2): 437- 438.

Shull, G. H. (1908). A new Mendelian ratio and several types of latency. *The American Naturalist*, 42(499), 433-451.

Shull, G.H. (1908). The composition of field of maize. Report American Breeders Association. 4: 296-301.

Shull, G.H. (1948). What is heterosis? Genetics. 33: 439-446.

Singh, B. and Kumar, V. 2010. Studies on combining ability analysis in okra. *Indian Journal of Horticulture*., 67(Special issue): 154-159.

Singh, B. and Sanwal, S.K. (2010). Heterosis, combining ability and gene action studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Sciences*. 37 (2): 187-189.

Singh, B. and Singh, S.P. (2003). Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Plant Archives*. 3 (1): 133-136.

Singh, B.; Singh, S.P.; Yadav, J.R. and Kumar, R. (2002). Heterobeltiosis and inbreeding depression in okra. *Plant Archives*. 2: 127-132.

Singh, B.; Singh. S.; Pal, A.K. and Rai, M. (2004). Heterosis for yield and yield components in okra [*Abelmoschus esculentus* (L.) Moench]. *Vegetable Sciences*. 31 (2): 168-171.

Singh, D.R.; Singh, P.K.; Syamal, M.M. and Gautam, S.S. (2009). Studies on combining ability in okra. *Indian Journal of Horticulture.* 66 (2): 277-280.

Singh, N., Singh, D. K., Sati, U. C., Rawat, M. and Pandey, P. (2017). Genetic analysis studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Indian Journal of Pure & Applied Biosciences*, 5(4), 361-367.

Singh, R.K. and Chaudhary, B.D. (1985). Biometrical Methods in Quantitative Genetic Analysis.Kalyani Publishers, New Delhi.

Singh, S.; Singh, B. and Pal, A.K. (2006). Line × Tester analysis of combining ability in okra. *Indian Journal of Horticulture*. 63 (4): 397-401.

Singh, S.P. (2011). Combining ability analysis for yield and yield contributing characters in okra. *Vegetable Sciences*. 38 (2): 212-214.

Sivakumar, S.; Ganesan, J. and Sivasubramanian, V. (1995). Combining ability analysis in bhindi.*South Indian Horticulture*. 43 (1-2): 21-24

Solankey, S.S. and Singh, A.K. (2010). Studies on combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *The Asian Journal of Horticulture*. 5 (1): 49-53.

Sood, S. and Kalia, P. (2001). Heterosis and combining ability studies for some quantitative traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Haryana Journal of Horticultural Sciences.* 30 (1-2): 92-94.

Sood, S. and Sharma, S.K. (2001). Heterosis and gene action for economic traits in okra. SABRAO. *Journal of Breeding and Genetics*. 33 (1): 41-46.

Sprague, G.F. and Tatum, L.A. (1942). General vs. specific combining ability in single crosses of corn. *Journal of American Society of Agronomy*. 34: 927-932.

Sprague, G.F.; Rusell, W.A.; Penny, L.H. and Hanson, W.D. (1962). Epistatic gene action and grain yield in maize. *Crop Sciences*. 21: 205-208.

Srivastava, K.; Aparna, J.; Singh, P.K. and Kumar, S. (2011). Stability performance of okra hybrids over environments. In: National Seminar on Contemporary Approaches to Crop Improvement. Abstract. 138. p. 244.

Srivastava, K.; Kumar, A.; Baranwal, D.K. and Aparna, Judy (2013). Combining Ability and Heterosis for yield and its contributing characters in okra [*Abelmoschus esculentus* (L.) Moench*]*. *Madras Agriculture Journal*. 100 (1-3): 30-35.

Srivastava, M.K.; Kumar, S. and Pal, A.K. (2008). Studies on combining ability in okra through diallel analysis. *Indian Journal of Horticulture*. 65 (1): 48-51.

Suganthi, S., Priya, R. S., Kamaraj, A., Satheeshkumar, P., & Bhuvaneswari, R. (2020). Combining ability studies in bhendi (*Abelmoschus esculentus* (L.) moench) through diallel analysis for yield and yield attributing characters. *Plant Archives*, 20(1), 3609-3613.

Sulikiri, G.S. and Swamy, R. (1972). Studies on floral biology and fruit formation in okra [*Abelmoschus esculentus* (L.) Moench] varieties. *Progressive Agriculture*. 4. p. 71.

Sundhari, S.S.; Irulappan, I.; Arumugam, R. and Sankar, S.J. (1992). Combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *South Indian Horticulture*. 40 (1): 21-27.

Sushmita, M. and Das, N.D. (2005). Combining ability studies in okra [*Abelmoschus esculentus. (*L.) Moench]. *Journal of Interacademicia*. 7 (4): 382-387.

Thimmaiah, S.R. (1999). Standard methods of biochemical analysis. Kalyani publishers, New Delhi. pp. 64-65.

Thippeswamy, S. (2001). Line × tester analysis for heterosis and combining ability using male sterility in okra [*Abelmoschus esculentus* (L.) Moench]. M.Sc. Thesis, U.A.S., Bangalore.

Tindall, H.D. (1983). Vegetables in the tropics. u: Macmillan Education Limited, London: AVI.

Tiwari, J.N.; Kumar, S.; Ahlawat, T.R.; Kumar, A. and Patel, N. (2015). Heterosis for yield and its components in okra [*Abelmoschus esculentus* (L.) Moench]. *Asian Journal of Horticulture*. 10 (2): 201-206.

Tripathi, P.; Yadav, J.R.; Tiwari, S.K. and Kumar, R. (2004). Useful heterosis and inbreeding depression for yield and it's components in okra. *Horticulture Journal*. 17 (3): 227- 233.

Vachhani, J. H., Shekhat, H. G., Kachhadia, V. H., Jivani, L. L., & Padhar, P. R. (2011). Heterosis and inbreeding depression in okra [*Abelmoschus esculentus* (L.) Moench]. *Research on Crops*, 12(2), 556-560.

Vekariya, R. D., Patel, A. I., Modha, K. G., Kapadiya, C. V., Mali, S. C. and Patel, A.A. (2020). Estimation of Heterosis, Gene Action and Combining Ability over Environments for Improvement of Fruit Yield and its Related Traits in Okra [Abelmoschus esculentus (L.) Moench]. International Journal Current Microbiology Applied Science, 9(9), 866-881.

Verma, A., & Sood, S. (2015). Gene action studies on yield and quality traits in okra (*Abelmoschus esculentus* (L.) Moench). *African Journal of agricultural research*, 10(43), 4006-4009.

Verma, M.M. and Gill, K.S. (1975). Genotype × Environment interactions. Its measurement and significance in Plant Breeding. P.A.U., Ludhiana, Teaching

Aid Bulletin. 1: 1-39.

Vermani, A., and Vidya Sagar, V. S. (2006). Implications of mean performance, heterosis and specific combining ability effects on performance of okra crosses. *Crop Research*, Hisar. 31 (2): 288-290.

Via, S. (1984). The quantitative genetics of polyphagy in an insect herbivore. I. Genotype- environment interaction in larval performance on different host plant species. *Evolution*. 38: 881-895.

Vijayaraghavan, C., & Warrier, V. A. (1946). Evolution of high yielding hybrid bhindi (*Hibiscus esculentus* L).In *Proceeding of the 33rd Indian Science Congress, Bangalore, India*. 163

Wammanda, D.T.; Kadams, A.M. and Jonah, P.M. (2010). Combining ability analysis and heterosis in a diallel cross of okra. *African Journal of Agricultural Research*. 5 (16): 2108-2115.

Weerasekara, D.; Jagadeesha, R.C.; Wali, M.C.; Salimath, P.M.; Hosamani, R.M. and Kalappanavar, I.K. (2008). Combining ability of yield and yield components in okra. *Indian Journal of Horticulture*. 65 (2): 236-238.

Wolak, M. E. (2013). *The quantitative genetics of sexual differences: new methodologies and an empirical investigation of se×-linked, se×-specific, non-additive, and epigenetic effects*. University of California, Riverside.

Woolfe, M. L., Chaplin, M. F. and Otchere, G. (1977). Studies on the mucilages extracted from okra fruits (*Hibiscus esculentus* L.) and baobab leaves (*Adansonia digitata* L.). *Journal of the Science of Food and Agriculture*, 28(6), 519-529.

Yadav, J.R.; Bhargava, L.; Kumar, S.; Mishra, G.; Yadav, A.; Parihar, N.S. and Singh, S.P. (2007). Useful heterosis for yield and its components in okra [*Abelmoschus* esculentus (L.) Moench]. Progressive Agriculture. 7 (1-2): 5-7.

Yadav, J.R.; Kumar, R.; Singh, B. and Srivastava, J.P. (2002.) Unmasking heterosis artifact in okra. *Progressive Agriculture*. 2 (1): 44-48.

Appendix

Table 1 Analysis of variance for the Randomized Complete Block Design for different traits in okra under two environments *viz.*,Rainy 2022 (E1) and Summer 2023(E2) and in pooled over the environment

Sr. No.	Source	Mean Sum of Squares								
		Replications			Genotypes			Error		
		2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
	Degree of freedom	2			79			156		312
1	Plant height (cm)	10.98**	0.31**	3.79**	190.81**	205.61**	606.19**	1.62	0.05	0.84
2	No. branches per Plant	7.48*	0.37*	2.27*	8.86*	8.22*	16.75*	0.25	0.04	0.15
3	Stem diameter (cm)	5.59	0.23	1.77	6.93	6.26	12.78	0.34	0.04	0.19
4	Leaf blade length (cm)	3.12	0.24	0.81	8.4	7.39	15.46	0.23	0.04	0.13
5	Leaf blade width (cm)	1.7	0.18	0.38	19.7	19.43	38.9	0.19	0.04	0.12
6	Petiole Length (cm)	1.34*	0.23*	0.26*	16.3*	15.88*	79.22**	0.15	0.05	0.1
7	Days to first flowering	13.84**	0.11**	8.18**	71.24**	68.71**	139.50**	0.47	0.06	0.27
8	Days to first fruit set	17.39**	0.46**	11.67**	74.6**	71.25**	145.32**	0.61	0.04	0.32
9	Days to first fruit picking	14.57**	0.26**	9.33**	82.65**	76.9**	159.02**	0.6	0.04	0.32
10	Number of flowers per plant	2.4**	0.33*	0.53**	18.65**	17.45**	35.51*	0.74	0.04	0.39
11	Number of pods per plants	10.02*	0.33*	3.35*	22.12*	22.06*	43.81*	0.29	0.04	0.17
12	Pod length (cm)	1.10**	0.37**	0.01**	6.127*	5.14**	11.01**	0.17	0.04	0.1
13	Number of first fruiting node	0.21*	0.33*	0.54**	1.334**	1.41**	2.68**	0.07	0.04	0.06
14	Number of nodes per plant	0.29*	0.40*	0.6*	27.48*	27.35**	54.72**	0.24	0.04	0.14
15	Number of ridges per pod	0.2	0.45	0.64	2.05*	2.05*	4.09*	0.03	0.04	0.03
16	Pod diameter (cm)	0.14*	0.29*	0.42*	0.34*	0.37*	0.70*	0.03	0.04	0.04
17	Internodal length (cm)	0.07**	0.16**	0.23*	1.71*	1.80**	3.50*	0.03	0.04	0.04
18	Average pod weight (g)	0.24**	0.51**	0.72**	22.27**	22.49**	44.68**	0.09	0.04	0.06
19	Chlorophyll content (SPAD unit)	0.74**	0.57*	1.311**	67.7**	67.48**	135.135*	0.12	0.043	0.08
20	Pods yield/Plant (Kg)	0.003**	0.005**	0.004**	0.005*	0.005**	0.01**	0.005	0.04	0.005
21	Acidity (%)	0.005*	0.02*	0.01*	0.004**	0.005*	0.01*	0.03	0.02	0.03
22	Ascorbic Acid content (mg/100)	0.015**	0.21**	0.17**	24.69*	24.73**	49.39**	0.05	0.04	0.04
23	Dry matter content (%)	0.50*	0.42*	0.92**	35.54*	34.85*	70.19**	0.3	0.04	0.17
24	Firmness (kg/cm^2)	0.35**	0.35**	0.71*	5.88**	5.92*	11.80*	0.04	0.04	0.04
25	Mucilage content (%)	0.13**	0.31**	0.42*	76.61*	78.13**	154.70*	0.06	0.048	0.05