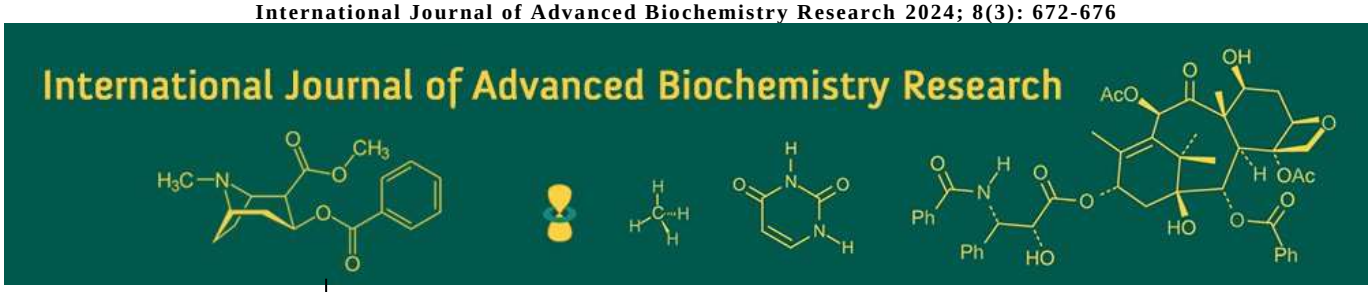

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Mohita Srivastava
Department of Horticulture, Lovely Professional University, Phagwara, Punjab, India

Vikanksha Thakur
Department of Horticulture, Lovely Professional University, Phagwara, Punjab, India

Jatinder Singh
Department of Horticulture, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
Mohita Srivastava
Department of Horticulture, Lovely Professional University, Phagwara, Punjab, India

Comparative studies of different okra genotypes under Punjab's Doaba region

Mohita Srivastava, Vikanksha Thakur and Jatinder Singh

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Abstract
The present investigation was carried out at the experimental farm, School of Agriculture, Lovely, Professional University, Jalandhar, Punjab, during 2021-22. Fifteen different germplasm L_1 to L_{15} were collected from NBPGR, New Delhi and sown during the second fortnight of March in Randomized block design (RBD) with three replications. To determine the nature and magnitude of variation among okra genotypes for different growth and yield-related characters, and to identify the potential genotypes with promising attributes under conditions of Punjab's Doaba region. The observations on different traits were recorded following the standard procedures. The genetic divergence among the 15 okra genotypes were evaluated for range, mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance as a percentage of mean. The genotypic and phenotypic coefficients of variation were enumerated to compute the existing variability in genotypes.
The genotype EC 169472 performed best in terms of the maximum average weight of the pod (21.5 g) as well as it had the highest plant height (122.8 cm). Genotype EC 169455 contained a maximum pod length (10.7 cm) and pod diameter (2.15 cm). A maximum number of branches per plant is found in genotype EC 169453 (9.80). The highest stem diameter is observed on genotype EC 169464 (9.34 mm). The traits responsible for earliness such as days to first flowering (43.0 days), days to first fruits set (48.0 days) and days to first fruit picking (55.0) were recorded for genotype EC 169472. It may be concluded that genotypes EC 169472, EC 169455, EC 169453, EC 169464 and EC 169472 performed best in terms of growth and yield traits.

Keywords: Okra, semi-arid, genotype, genetic advance, heritability, pod yield

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench] commonly known as lady finger or bhindi belongs to Malvaeceae family, a well-known fast-growing species known for its vegetable purpose throughout the globe (Guebebia *et al.,* 2023) [6]. Okra is cultivated throughout the tropics and sub-tropics regions with an average temperature range of 21-30 ^{0}C and is highly valued for its immature and edible green fruits mainly for vegetable purposes that may be raw or processed. Further, lower precipitation rates, lower relative humidity and high light in semi-arid regions favour higher productivity and yield (Ranga *et al.,* 2021) [11]. Okra being a versatile crop is not only used for supplementing nutritional requirements but also has several medicinal benefits such as ability to treat haemorrhoids, ulcers, dysentery and genitourinary problems and treat tubulointerstitial renal disease. Additionally, it is an excellent source of iodine, which helps cure uncomplicated goiter etc. Since, the mucilage present in fruit bears huge medicinal properties (Chavan *et al.,* 2019) [4]. It is grown commercially in India, Turkey, Iran, Western Africa and Yugoslavia. In India, okra is commercially grown in Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh and West Bengal. India ranks first in the world with 74.3 percent of total world production and had an average productivity of 12.1 mt/ha covering an area of 0.58 mha with annual production of 7.12 mt all over India (Venkataravanappa *et al.,* 2018) [16].
Genetic improvement of crops mainly depends on the amount of genetic variability present in the population and the germplasm serves as a valuable source of base population and provides scope for wide variability (Begna *et al.,* 2023) [2]. Further, the crop exhibits rich genetic diversity and scope for improvement for various horticultural traits. Heritability is the portion of phenotypic variance. The estimates of heritability help the plant breeder in

selection of elite genotypes from diverse genetic populations. Heritability indicates only the effectiveness with which selection of a genotype can be done based on phenotypic performance but it fails to indicate the expected genetic progress in one cycle of selection (Butoto *et al.,* 2022) [3]. Heritable variation can be effectively used with greater degree of accuracy when heritability is studied in conjunction with genetic advancement.

Genetic advance denotes the improvement in the mean genotypic values of selected families over base population and thus helps the breeder to select the progenies in the earlier generation itself (Kherwa *et al.,* 2020) [7]. An improvement in yield and quality of okra is normally achieved by selecting the genotypes with desirable character combinations existing in nature or by hybridization. The present study was carried out to determine and evaluate the most suitable okra genotype for higher yield and productivity under semi-arid conditions in Punjab.

Materials and Methods

Experimental Site

The experiment 'Growth and yield attributes associated with different okra germplasm in Punjab's semi-arid region' was carried out at the Vegetable Research Farm, Department of Horticulture, Lovely Professional University, Phagwara, (Punjab) during 2022-23. In the summer, temperatures crosses 40-45 degrees Celsius (even more) while in winter, they plummeted below 5- 10 degrees Celsius.

Experimental material and design: 15 different genotypes *viz*., IC 128021, IC128023, IC 128024, IC 128028, IC 128029, EC 169451, EC 169453, EC 169455, EC 169459, EC 169462, EC169463, EC 169464, EC 169467, EC 169470, and EC 169472, respectively were collected from NBPGR, New Delhi and sown during second fortnight of March and laid out in Randomized block design (RBD) with three replications. Two seeds were sown in a raised bed, with a gap of 60 cm row to row 30 cm plant to plant in a single row. Optimum seed germination and crop growth, development was carried out as per Punjab Agri. University (PAU) along with, plant protection measures.

Parameters studied

The observations were recorded on randomly chosen five plants in each genotype and replication. Above all, collected data was statically analyzed as per Panse and Suktame, (1954) [10]. To determine the best genotypes among the fifteen which was suitable for the semi-arid condition of Punjab. Plant height was recorded in cm from the ground level to the tip of the plant. The first flowering time (in days) was investigated from sowing day to onset of first flowering. Similarly, days to fruit set were figured up from the day of sowing until the first fruit appeared. Days to first fruit picking were counted in each replication from date of sowing to first picking. The total number of pods per plant per picking was recorded in grams. Pod length and diameter were noted with the help of Vernier calliper at the centre of the fruit in centimetres. Average weight of pod (g) was calculated by dividing the total fruit weight by total number of fruits harvested from all the picking, to get the average fruit weight in each replication and pod yield per plant (kg) was calculated by the total number of fruits from each plant over all the picking were recorded in grams and total to get fruit yield per plant.

Statistical analysis

Statistical analyses for mean, standard deviation and coefficient of variation was done as per the Panse and Sukhatme (1995) [10]. Genetic divergence among 15 okra genotypes were anaysed and. data was subjected to multivariate statistical analysis (PCA and HCA) using the R Statistical Software.

Results and Discussion

Coefficient of Variation

It was noted that the calculated coefficients of variation indicate that the extent of phenotypic coefficients of variation (PCV) exceeded that of genotypic coefficient of variation (GCV) across all traits, highlighting the significant influence of the environment. The phenotypic coefficient of variation for plant height was 10.1% whereas genetic variation was 9.97%. The number of branches per plant exhibits 28.2% phenotypic coefficient of variation over 27.9% genotypic coefficient of variation. Stem diameter of okra was noted with 20.8% PCV and 20.4% GCV. In case of earliness, days to first flowering and days to 1st fruit set shows 9.06% and 8.34% of phenotypic coefficient of variation and 8.93% and 8.03% genotypic coefficient of variation respectively. Days to first fruit picking in okra among all genotypes showed higher percentage of phenotypic coefficient of variation or genotypic coefficient of variation, the PCV 7.52% along with GCV 7.27% was recorded in close mode. The trait, number of flowers and number of pods per plant were correlated with each other in case off the GCV and PCV. The phenotypic coefficient of variation for number of flowers was 20.8% and number of pods per plant was 19.7% respectively (Table 1) (Fig1).

The GCV for number of flowers was recorded at 18.5% while number of pods per plant was 18.9%. The traits which signify yield and build attributes show a close counter for both variations. The phenotypic coefficient of variation for pod diameter was recorded 14.9% while genotypic coefficient of variation was 12.9%. The average weight of pod has 16.7% phenotypic coefficient of variation closely followed by genotypic coefficient of variation 16.5%. The important aspect for a breeder while studying genotypes is yield for particular crop. In the study, pod yield per plant was noted at 21.4% phenotypic coefficient of variation closely traded on by genetic variation at 21.2% (Table 1). The present findings were also supported by (Muluken *et al.,* 2016; Singh *et al.,* 2017; Lalunaik *et al.,* 2017) [9, 12, 8].

Heritability and Genetic advance

The highest heritability in broad sense was recorded for plant height, number of branches per plant, days to first flowering, average weight of pod and pod yield per plant (9.7%). The lowest broad sense heritability was noted for diameter of pod 0.75% following number of flowers 0.79% whereas, steam diameter (0.96%), days to first fruit set (0.92%), days to first fruit picking (0.93%), number of pods per plant (0.92%) and pod length (0.96%) length showed moderate heritability. The highest genetic advance estimated for pod yield per plant (84.6) following plant height (19.8). The lowest genetic advance was recorded in traits viz. diameter of pod (0.41) followed by trait pod length (2.20) and steam diameter (2.99). Number of branches per plant (4.00), days to first flowering (9.20), days to first fruit set (8.88), days to first fruit picking (9.01), number of flower (5.15), number of pod per plant (5.28) and average weight

of pod (5.53) indicate the moderate genetic advance (Table 1) (Fig 3 & 4).

Heritability presides over the similitude of progeny with their parents, whereas genetic advancement comes up with the knowledge about surmising genetic gain for particular traits after selection. It also connotes a way of selection to be applied for a trait during selection within diversity because it determines correlation between parents and their progeny, that's why it was widely used in settling the degree to which a trait that transmitted from parents to offspring. Heritability along with high genetic advancement impart good ambit for improvement in advanced generations. The genetic advance reveals that improvement can be made in a specific trait by applying certain amount of selection intensity. The genetic advance depends on the selection divergent, the genotypic coefficient of variation and the heritability ratio. Such values of high heritability and high genetic advance may be ascribed to the action of additive genes. Therefore, traits having high heritability coupled with genetic advancement would be effective in crop improvement through selection approaches. Similar findings were also submitted by Alam *et al.*, (2020) [1]; Faisal *et al.*, (2021) [5]; and Vani *et al.*, (2021) [15].

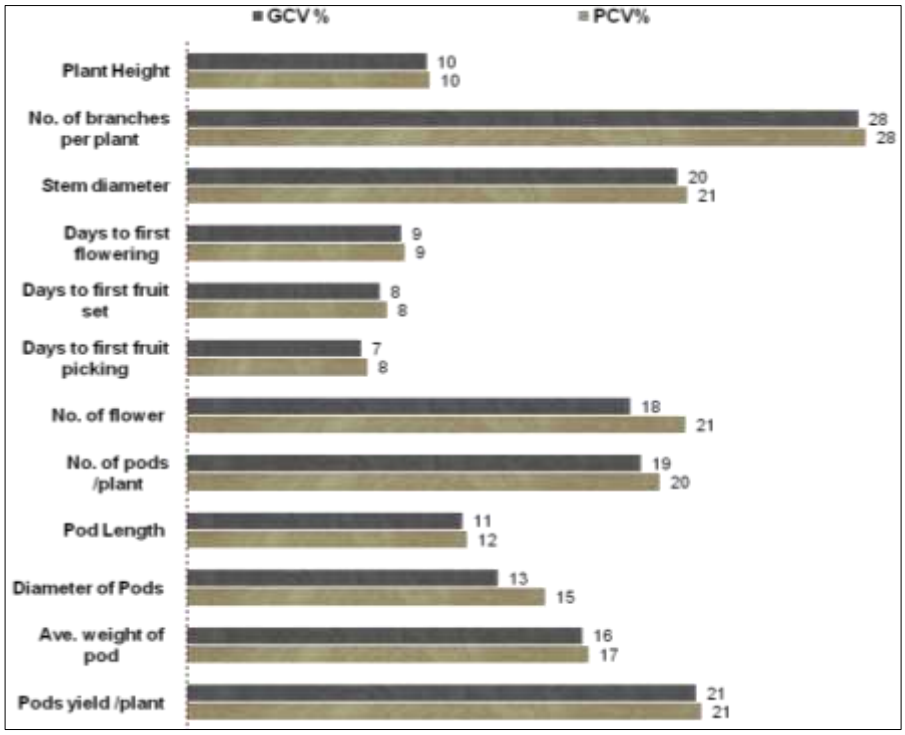

Fig 1: Phenotypic and genotypic coefficient of variation for different traits of okra

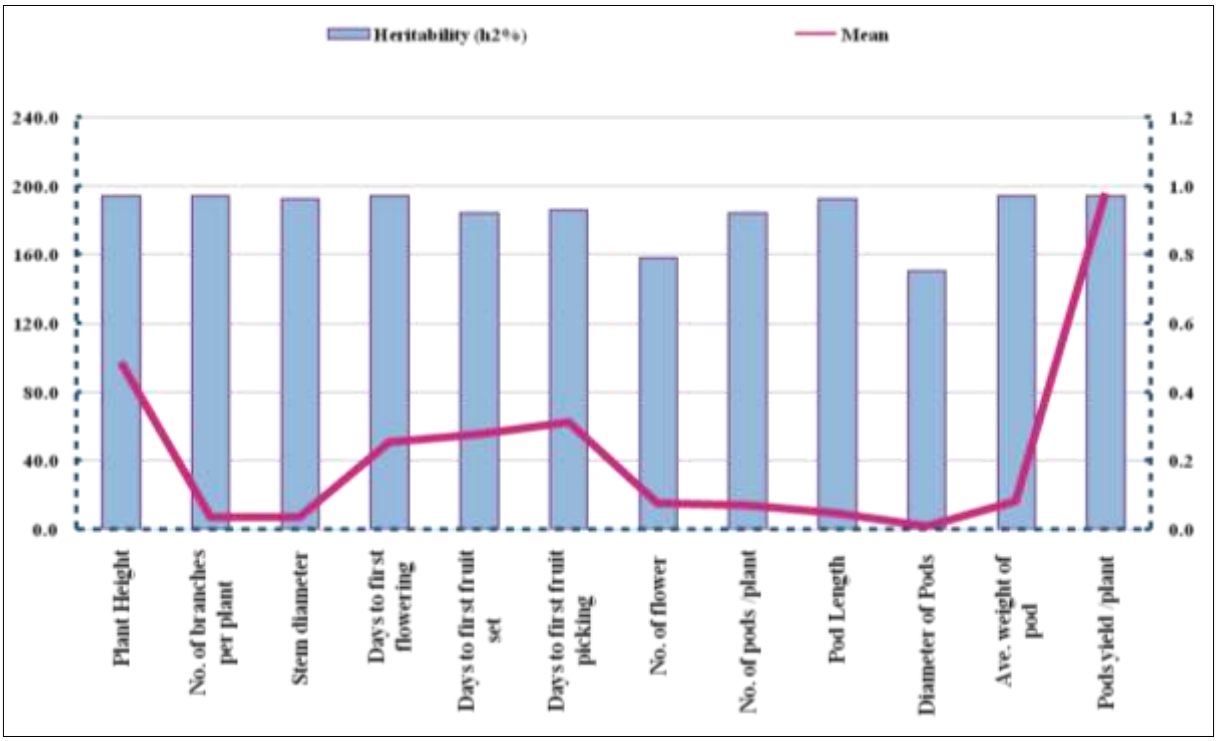

Fig 2: Mean and Heritability for different traits of okra

Genetic advance as percent of mean

Genetic gain (expressed as percent of general mean) was noted highest for the number of branches per plant 56.9%, pod yield per plant 43.2% and stem diameter 41.3%. The moderate genetic gain was recorded for number of flowers (33.8%), number of pod per plant (37.4%), pod length (23.2%), diameter of pod (23.2%) and average weight of pod (33.4%). The minimum genetic gain was found for plant height (20.3%), days to first flowering (18.1%), days to first fruit set (16.0%) and days to first fruit picking (14.5%). Based on mean performance among all genotypes under study, it was noted that maximum value was recorded for genotype EC 169472 expressed highest plant height (122.8 cm), number of branches per plant in genotype EC 169453 (9.80), stem diameter for genotype EC 169464 (9.34 mm). The traits responsible for earliness such as days to first flowering (43.0 days), days to first fruits set (48.0 days) and days to first fruit picking (55.0) were recorded for genotype EC 169472. flower wall found under genotype EC 169453 (21.7). IC 128023 possess maximum number of pods for a plant of 18.0. The maximum pod length (10.7 cm) and pod diameter (2.15 cm) were recorded for genotype EC 169455. Genotype EC 169472 maximum average weight of pod 21.5 g. whereas maximum pod per plant was recorded under genotype EC 169453 (292.3 g) (Table 1) (Fig 3). The variation present within different genotypes of okra understudied showed morphological variability and was also expressed in terms of genetic gain. The similar finding were recorded by Temam *et al.*, (2021) [14] and Sujata *et al.*, (2019) [13].

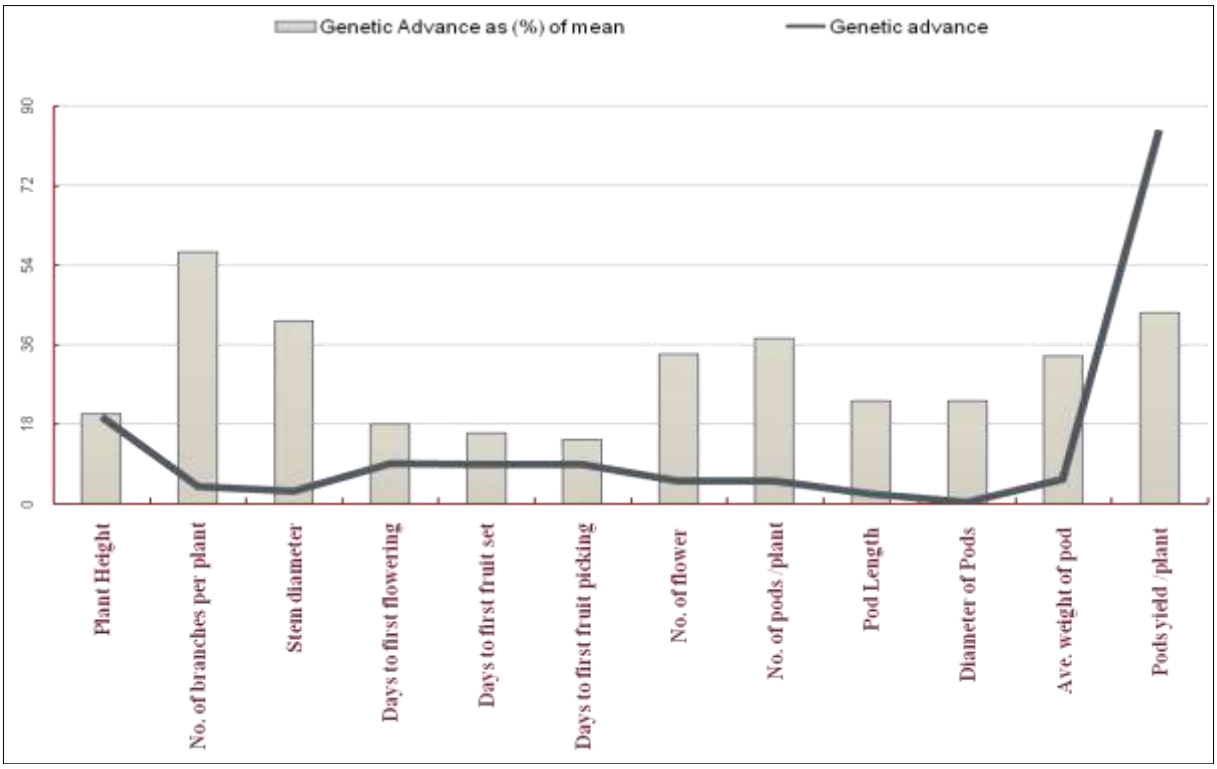

Fig 3: Genetic Advance and Genetic advance% (as of mean) for different traits of okra

Table 1: Growth parameter of 15 genotypes understudies

Genotype	Plant Height (cm)	No. of branches plant^{-1}	Stem diameter (cm)	Days to first flowering	Days to first fruit set	Days to first fruit picking	No. of flower	No. of pods plant^{-1}	Pod Length (cm)	Diameter of Pods (cm)	Average weight of pod (g)	Pods yield plant^{-1} (g)
IC 128021 (L1)	86.9	4.4	5.83	59.7	63.7	69.7	17	15.4	8.43	1.81	15.4	207.9
IC 128023 (L2)	87.9	4.27	5.94	48.3	52.3	58.3	12.7	18	9.56	1.52	14.7	259.7
IC 128024 (L3)	89.8	4.33	7.38	53.7	57.7	63.7	16.7	14.3	10.48	1.64	18.6	244.8
IC 128028 (L4)	78.6	3.83	7.5	51	55	61	21	16.7	9.41	1.46	16.5	253.9
IC 128029 (L5)	88.1	7.8	9.25	43.7	49.3	55.7	15	12.1	11.42	1.61	17	181.2
EC 169451 (L6)	98.4	7.13	6.69	51	56	63	17	12.3	10.53	1.73	15.5	151.4
EC 169453 (L7)	94.2	9.8	7.6	55.3	59	66	21.7	16.2	9.55	1.89	17.8	292.3
EC 169455 (L8)	86.6	9.2	7.5	49	53.7	60.7	13.7	15.5	10.7	2.15	16.6	180.2
EC 169459 (L9)	95.4	5.27	6.39	47.3	53.3	60.3	11.3	17.1	8.55	1.54	19.5	164.4
EC 169462 (L10)	103.5	7.88	8.74	54	60	67	17	11.4	9.23	2.16	15.4	184.5
EC 169463 (L11)	104.9	5.47	6.19	51	57	64	11	16.2	10.42	1.57	12.3	141.5
EC 169464 (L12)	99.3	9.4	9.34	55.7	61.7	68.7	15	17.2	8.6	1.72	20.2	163.6
EC 169467 (L13)	106.9	7.8	4.71	57.3	63.3	70.3	14.7	10.7	10.29	2.05	15.5	206.5
EC 169470 (L14)	104.2	6.4	6.5	48.3	54	61	13	9.9	8.52	1.49	11.6	175.5
EC 169472 (L15)	122.8	9.53	5.59	43	48	55	15.8	15.3	9.71	1.86	21.5	213.2
Mean	97.5	7.05	7.26	50.7	55.7	62.2	15.27	14.11	9.52	1.77	16.6	196
CD 5%	2.4	0.47	0.48	1.27	2.04	1.98	2.4	1.26	0.34	0.21	0.78	9.92

Range	77.8-124.8	3.60-10.0	4.26-11.2	42.0-60.0	47.0-64.0	54.0-71.0	10.0-22.0	8.64-18.5	7.14-11.6	1.24-2.19	11.5-21.8	120.1-294.0
GCV %	9.97	27.9	20.4	8.93	8.03	7.27	18.5	18.9	11.5	12.9	16.5	21.2
PCV%	10.1	28.2	20.8	9.06	8.34	7.52	20.8	19.7	11.7	14.9	16.7	21.4
Heritability (h2%)	0.97	0.97	0.96	0.97	0.92	0.93	0.79	0.92	0.96	0.75	0.97	0.97
Genetic advance	19.8	4	2.99	9.2	8.88	9.01	5.15	5.28	2.2	0.41	5.53	84.6
Genetic Advance as (%) of mean	20.3	56.9	41.3	18.1	16	14.5	33.8	37.4	23.2	23.2	33.4	43.2

Conclusion

All the genotypes showed variability in the economic traits as it is perceivable from the estimates of coefficients of variation, heritability, genetic advance and genetic advance as percent of mean. The phenotypic coefficient of variation was higher than the genetic coefficient of variation revealing the role of environment on expression of genes in different genotypes. The range of large variability for economically important characters will provide the breeder with a good scope for genetic improvement in okra. The genetic advance recorded for each trait should be considered in breeding to ensure the success and improvement of economic traits.

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Authors' contribution

MS: Conceptualization of research and Execution of field/lab experiments; VT: Data collection, analysis of data and interpretation; JS: Preparation of the manuscript and supervised it.

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Research content: The manuscript's study is distinctive because it hasn't been published anywhere else.

Ethical approval: Not applicable

Conflict of interest: There is no conflict of interest among authors.

Data availability–Ph.D. work

Consent to publish: Publication of the manuscript in the Journal of Environmental Biology is approved by all authors.

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