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Genetic Component Estimation for Fruit Yield and Attributing Traits of Okra in Mid-Hills of Himachal- Pradesh, India

Harish, B. M [a*], Desh Raj Chaudhary [a], Sonia Sood [a], Gopal Katna [b] and Sandeep Manuja [c]

[a] Department of Vegetable Science and Floriculture, Choudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya – Palampur, Himachal Pradesh, Pin. 176 061, India.
[b] Department of Genetics and Plant Breeding, Choudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya – Palampur, Himachal Pradesh, Pin. 176 061, India.
[c] Department of Agronomy, Choudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya – Palampur, Himachal Pradesh, Pin. 176 061, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

With the aim to elucidate the components of genetic variation which will be of major importance in selection of parental genotypes and planning an appropriated hybridization programme for okra improvement. The present study was carried out at Department of Vegetable Science and Floriculture, CSKHPKV, Palampur, Himachal Pradesh, involving the 45 F_1 hybrids developed

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**Corresponding author: E-mail: harshareddy886153@gmail.com;*

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through diallel matting excluding reciprocals consisting of 10 diverse okra genotypes as parents. The elucidation of different genetic components and ratios were done upon 11 different traits that included, growth, earliness, yield and quality traits of okra. It was noticed that all the traits studied were influenced mainly by non-additive gene actions and the expression of the traits were found to be genetically controlled by over-dominance effects. The narrow sense heritability for most of the traits was found to be very low that supported the findings of the component estimation. Hence, it is concluded that the hybridization followed by selection will be of great help in improvement of these traits in okra under mid-hill regions of Himachal Pradesh.

Keywords: Additive; non-additive; over-dominance; okra; heritability; genetic variance.

1. INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is an economically important vegetable crop widely cultivated in tropical and sub-tropical regions of the world. It belongs to the family *Malvaceae*, having a somatic chromosome number of cultivated species 2n = 58-138 under order *Malvales* and is considered as an amphidiploid. The diverse agro-climatic conditions prevailing in the country offer enough scope for year-round cultivation of okra and production can even be planned as per the consumers' requirement and market driven demand but the cultivation of this important vegetable in Himachal Pradesh region is hindered for considerable extent due to climatic factors, but in some patches of the state okra is grown in low and mid hills during spring-summer and rainy seasons, whereby it occupies an area of 3,314 hectares with an annual production of 60,949 tons which ensures the scope of breeding the high yielding and superior quality fruity producing hybrids for these regions (Amiteye et al. 2019).

Major constraint for realizing the full yield potential of the crop is the lack of availability of high yielding varieties and hybrids suitable for cultivation under hilly regions of the country (Anonymous, 1984). Of late, hybrids are being preferred over the open pollinated varieties on account of their higher yield potential, uniformity, early maturity, wider adaptability and quality (Jindal et al. 2009). Manifestation of heterosis for fruit yield and its attributing traits in okra have been reported from the various quarters and large number of high yielding varieties and hybrids have been developed and made available to the growers, yet they did not gain much popularity amongst the farmers of temperate regions of the country. Collectively all these factors have restricted the popularity of okra hybrids amongst the farming community of hills (Yadav and Singh, 2024).

The exploitation of heterosis for wider adoptability is largely dependent on the screening and identification of gene actions based on genetic components of variation pertaining to yield and quality traits in diverse genotypes. Sufficient genetic information of gene actions governing inheritance of yield and quality traits will aid in the successful planning and execution of the breeding programme (Griffing, 1956). Of the various mating designs, the diallel mating design developed by Jinks and Hayman, (1953) and Hayman, (1954) has been extensively used to estimate genetic components and ratios to understand the nature of gene actions. Hence, the present study to elucidate the components and ratios of genetic variances seems very much needed in okra crop improvement specially in mid-hills of Himachal Pradesh and other similar agro-climatic regions of the world.

2. MATERIALS AND METHADOLOGY

The present study to elucidate the various components of genetic variation and ratio of these components to infer the gene action and some important aspects of genes that control expression of the traits was carried out in experimental farm of Department of Vegetable Science and Floriculture, CSKHPKV, Palampur, Himachal Pradesh situated at an elevation of about 1300 m above mean sea level with 32.1° North latitude and 76.5° East longitude, representing mid hill zone of the country where the mean temperature during the trail ranged from 26- 30℃. The experimental material of 45 F_1 hybrids developed through half diallel mating of ten diverse genotypes viz., Kashi Lalima, Kashi Pragati, Kashi Kranti, Arka Abhay, Arka Anamika, Sherley Special, VRO_6, PO-13, Parmil-11 and Palam Komal. The parents and F_1 were sown in a spacing of 60 x 60 cm^2 in three replications. Genotypes were evaluated in the present study for 11 traits viz., node at which first flower appear, days to 50% flowering, days to first harvest, fruit length (cm), fruit diameter (cm), number of fruits per plant, average fruit weight (g), mucilage content (per cent), dry matter content (per cent), ascorbic acid content (mg/100g) and fruit yield per plant (g).

Allt the morphological and yield parameters were recorded by standard scale of measurement using appropriate instruments (scale for fruit length, vernier callipers for fruit diameter, weighing balance for average fruit weight and fruit yield per plant). The quality parameters were estimated by following the standard laboratory procedures for estimation viz., dry matter by the protocol suggested by Association of Official Analytical Chemists (AOAC, 1984), mucilage content by Woolfe et al. (1977) and ascorbic acid content by following the protocol suggested by Sadasivam and Theymoli (1987). The various components of genetic variation and their significance were computed through the statical procedures suggested by Hayman (1954), with these components other ratios of the components were calculated.

3. RESULTS AND DISCUSSION

From the results depicted in Table 1. it is observed that all the parameters in the present investigation were controlled by the non-additive gene action as the additive components (D) were noticed to be positive and non-significant for every trait studied except for number of fruits per plant, average fruit weight, mucilage content, ascorbic acid content and dry matter where the (D) additive components were positive and significant. However, the positive and significant non-additive components (H_1 and H_2) for all the traits were recorded to be comparatively of greater magnitudes, this inferred the need of incorporating the hybridization programme in development of these traits in progeny generation (Vachhani and Shekhat, 2008 and Makdoomi et al. 2019). The estimates of mean F_r over arrays (F) were observed to be significant and positive for the traits fruit diameter, number of fruits per plant, average fruit weight, ascorbic acid content and fruit yield per plant while positive and significant for the traits node at which 1st flowering appears, fruit length mucilage content and dry matter that indicated the influence of the dominant genes for the inheritance of these traits over the generations. Meanwhile, the F values were observed in the negative magnitudes for the traits, days to 50% flowering and days to first picking that disclosed the impact of recessive genes in the expression of these earliness parameters, these deviation in involvement of either recessive or dominant genes for different traits demands the separate selection of the parents for individual trait improvement as opined by Mudhalvan and Kumar, 2020, Maurya et al. 2022 and Abdelkader et al. 2024. The environmental component for all the traits was notice to be comparatively negligible magnitude compared to other components of variation, which inferred the absence of environmental effects in expression of the traits.

The ratios of various components studied for all the traits in the present study are described in Table 1. All the traits studied in the present investigation were declared to be influenced by the over-dominance gene effects as every trait exhibited the mean degree of dominance ($H_1/D^{1/2}$) greater than unity inferring the existence of more than one gene or gene groups to control the expression of dominance, which was further supported by the ratio of h^2/H_2. From the table it was identified that the proportion of negative and positive alleles in the parent were symmetrically distributed for the traits nodes at which first flower appear, days to first harvest, fruit length and fruit diameter as the ratio of $H_2/4H_1$ of these traits were approaching the expected value 0.25. Whereas, this estimate was recorded deviating from 0.25 for remaining traits viz., days to 50% flowering, number of fruits per plant, average fruit weight, mucilage content, ascorbic acid content, dry matter and fruit yield per plant, that confirmed the asymmetrical distribution of negative and positive alleles in the parents for this traits, similar finding were also reported by Maurya et al. (2022), Adedoyin et al. (2024) and Harsiddhi and Mehta, (2024) that supported the present findings. The influence of dominant genes for the inheritance of traits as suggested by F values were assisted by the ratio of K_D/K_r for all the traits except days to 50% flowering and days to first picking for which the ratio of K_D/K_r were less than unity declaring the major effect of recessive gene controlling the genetic expression of these traits these were further advocated by the low narrow sense heritability percentage exhibited by most of the traits except days to 50% flowering, days to first picking and mucilage content which were estimated from medium to low narrow sense heritability, this prominent role of recessive genes on the expression of earliness parameters demands the involvement of special hybridization techniques followed by recurrent selection for their improvement (Abdelkader et al. 2024, Adedoyin et al. 2024, Harsiddhi and Mehta, 2024 and Yadhav and Singh, 2024).

Table 1. Estimates of genetic parameters and genetic ratios for fruit yield and quality traits in okra

Traits	Additive effect (D)	Dominance effect (H_1)	H_2	Mean F_r over arrays (F)	Environment component (E)	$H_1/D^{1/2}$	h^2/H_2	H2/4 H_1	K_D/K_r	h^2 $_{ns}$ (%)
Node at which first flower appears	0.22±0.33	2.79*±0.71	2.48*±0.60	0.35±0.77	0.11±0.10	3.55	0.03	0.22	1.58	10.90
Days to 50 % flowering	21.07±4.56	44.00*±9.71	34.24*±8.25	-0.65±10.53	0.61±1.37	1.44	0.45	0.19	0.97	63.20
Days to first picking	22.62±5.24	33.57*±11.17	28.19*±9.49	-5.56±12.11	0.95±1.58	1.21	0.14	0.21	0.81	67.00
Fruit length (cm)	1.21±1.44	11.16*±3.06	10.59*±2.60	1.00±3.32	0.07±0.43	3.03	0.12	0.23	1.21	12.60
Fruit diameter (cm)	0.08±0.01	0.26*±0.02	0.24*±0.02	0.07*±0.02	0.01±0.00	1.82	0.12	0.23	1.70	14.50
Number of fruits per plant	12.61*±5.44	59.48*±11.59	42.08*±9.85	18.80*±12.56	0.33±1.64	2.17	0.47	0.17	2.04	34.00
Average fruit weight (g)	4.44*±2.03	25.24*±4.32	21.04*±3.67	8.20*±4.69	0.04±0.61	2.38	0.19	0.20	2.26	4.00
Mucilage content (%)	0.38*±0.04	0.50*±0.10	0.34*±0.08	0.06±0.10	0.01±0.01	1.13	0.07	0.17	1.16	71.10
Ascorbic acid content (mg/100g)	19.81*±3.95	36.14*±8.42	26.77*±7.15	24.40*±9.13	0.01±1.19	1.35	1.18	0.18	2.67	26.30
Dry matter (%)	2.55*±1.64	8.35*±3.49	6.18*±2.97	3.96±9.79	0.01±0.49	1.81	0.07	0.18	2.50	19.50
Fruit yield per plant (g)	3421.95*±737.07	9797.25*±1568.93	6594.18*±1333.42	5442.25*±1700.65	40.31±98.23	1.69	0.86	0.16	2.77	25.90

***Significant at 5% probability level**
[a] *H_2: Dominance including symmetry/asymmetry of genes*
[b] *$H_1/D^{1/2}$: Mean degree of dominance*
[c] *$H2/4H_1$: Proportion of positive and negative alleles in parents*
[d] *K_D/K_r: Proportion of dominant and recessive alleles in parents*
[e] *h^2 $_{ns}$ (%): Narrow sense heritability percentage*
[f] *h^2/H_2: Number of gene groups controlling the trait to exhibit dominance*

4. CONCLUSION

From the present investigation all the traits were found to exhibit the non-additive gene actions for their expression hence, crossing would be of greater impact and it is clear that the overdominance gene effects were of prominent role in controlling the genetic expression of earliness, yield and quality parameters of okra that demands the incorporating of hybridization programme in okra improvement. Further, the traits studied were found to be influenced by both dominant and recessive genes which were helpful in concluding that recurrent selection may be of immense importance in sorting the traits especial that determines the earliness in okra. Summarily, from all the findings it is evidenced that the hybridization followed by selection would be fruitful in improvement of yield and quality traits of okra. The finding of the present study could be further confirmed by repeated trials in the region that could be of high practical utility in hybrid development of okra.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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