Diallel Analysis to Investigate the Nature of Gene Action in Okra [*Abelmoschus esculentus* (L.) Moench]

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Authors' contributions

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

Original Research Article

ABSTRACT

A diallel scheme excluding reciprocal was adopted in okra to generate 45 F_1 hybrids in *Rabi* season 2020 and the hybrids along with 10 parents were evaluated using a randomized complete block design (RCBD) in *Kharif* 2020. The additive components (D) of genetic variance was found to be highly significant for days to first flowering, days to 50% flowering, node at first flower appear, number of branches per plant and plant height (cm) at harvesting. The estimates of dominant components $\hat{H}_1$, $\hat{H}_2$ and $\hat{h}^2$ were evaluated. $\hat{H}_1$ and $\hat{H}_2$ were highly significant for all the characters.

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Dominance components ($\hat{h}^2$) were found in few characters *viz.* days to first flowering, number of fruit per plant, fruit weight, fruit length, fruit diameter, 100 seed weight, fruit yield per plant and fruit yield quintal per hectare suggested the role of dominance components for these traits. Near about fifty percent traits was showed significant value in environment component. The average degree of dominance was more than one for all the characters showed over dominance.

ABBREVIATIONS

$\hat{D}$	: *Additive effect;*
$\hat{H}_1$	: *Dominance effect*
$\hat{H}_2$	: *Dominance including asymmetry of +/- effect of genes;*
$\hat{F}$	: *Mean Fr Over arrays;*
$\hat{E}$	: *Environmental component;*
$(\hat{H}_1/\hat{D})^{1/2}$	: *Mean degree of dominance;*
$\hat{H}_2/4\hat{H}_1$	: *Proportion of gene with +/- effects in parents;*
$(4\hat{D}\,\hat{H}_1)^{1/2} + \hat{F}/(4\hat{D}\,\hat{H}_1)^{1/2} - \hat{F}$	: *Proportion of dominant and recessive genes in parents;*
$\hat{h}^2/\hat{H}_2$	: *Number of genes groups;*
R	: *Correlation coefficient.*

1. INTRODUCTION

"Okra (*Abelmoschus esculentus* L. (Moench) is an economically important vegetable crop grown in the tropical and sub-tropical parts of the world. This crop is suitable for cultivation as a garden crop as well as in large commercial farms. It is one of the most widely known and utilized species of the family Malvaceae" [1]. "Okra/lady's finger is a powerhouse of valuable nutrients. Due to its high soluble fiber content in the form of gum and pectin, it helps to lower serum cholesterol and the risk of heart diseases" [2]. "Okra mucilage has medicinal applications when used as a plasma replacement or blood volume expander" [3]. "Okra has several potential health beneficial effects for some of the important human diseases like cardiovascular diseases, type 2 diabetes, digestive diseases and some cancers" [4]. "In India, okra is cultivated in Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pradesh, Karnataka and Assam" [5]. "A good knowledge of the nature and inheritance of economically important quantitative traits will help to develop a more pragmatic breeding prgramme. Diallel analysis is a useful tool for getting a quick overview of the gene action involved in the inheritance of various quantitative traits. Several hybrids have been released by public as well as private sectors for its commercial cultivation. The area under F_1 hybrids is growing fast, which has helped to enhance the production and productivity of this crop. Different researchers" [6], Verma & Sood [7] and Bhatt et al. [8] have investigated the nature of gene action on several biometric traits in okra. However, the mode of action of genes differs from germplasm to germplasm. Consequently, the study was conducted to elucidate the nature and extent of gene action involved in the inheritance of fruit yield and their constituents.

2. MATERIALS AND METHODS

The investigation on gene action involved in inheritance of yield and yield attributing traits in okra was carried out at the Vegetable Research Farm, Department of Vegetable Science, Banda University of Agriculture and Technology, Banda, Uttar Pradesh. The experimental farm is situated on 24º 53'-25º 55' N latitudes and 80º 07'-81º 34' E longitudes. Experiment was done during *rabi* season by providing good agronomic practices to keep the crop in good condition. The material for experimentation comprised of 10 distinct genotypes and 45 F_1 hybrids developed through diallel cross design excluding receprocal. The observations were recorded on randomly selected five plants in each replication of F_1s and their parents. The selected plants were tagged and properly labeled before flowering for taking observations, *viz.* Days to first flowering, Days to 50% flowering, Plant height (cm), Number of branches per plant, Node at which first flower Appear, Internodal length (cm), Number of nodes per plant, Number of fruits per plant, Fruit yield per plant (g), Fruit yield (q ha^{-1}), Fruit length (cm), Fruit diameter (cm), Fruit weight (g), Days to edible fruit maturity, Number of seeds per fruit,

Seed weight per fruit, 100-Seed weight and Seed yield per plant. "Genetic parameter *viz.,* Additive effect, Dominance effect, Dominance including asymmetry of +/- effect of genes and Environmental component and the standard ratios of these genetic parameters were worked out by component of variance methods, using second degree statistics and error mean square" [9].

3. RESULTS AND DISCUSSION

The findings on the additive genetic effects were positive and significant for characters *viz.* days to first flowering, days to 50% flowering, node at which first flower appear, number of branches per plant and plant height (cm) at harvesting indicating high transmissibility in the progeny.

Therefore, it was conformed that direct selection in okra for such traits will be useful which is agreement with the findings of Devi et al. [10], Verma and Sood [7], Bhatt et al. [8] and Kumar et al. (2014). Among all the characters the F value (mean for over arrays) observed were significant only for days to 50% flowering, node at which first flower appear and plant height (cm) at harvesting implying that dominant alleles were preponderance for these traits in the parents. The estimates of components of variation due to dominance (H_1) and proportion of dominance due to positive and negative genes (H_2) showed the importance of non-additive gene effects than additive gene effects in controlling the expression of all eighteen characters i.e. days to first flowering, days to 50% flowering, node at first flower appear, edible fruit maturity, node number/plant, internodal length, plant height, number of fruits per plant, fruit weight, fruit length, fruit diameter, number of seeds per fruit, seed weight per fruit, 100-Seed weight, seed yield per plant, fruit yield per plant and fruit yield quintal per hectare these characters magnitude of dominance effect is more compare to the additive component, hence selection may be practiced in the segregating population and also intermating of selected plants in segregating population or recurrent selection may be practiced to improve the yield (Table 2).

"The estimated mean degree of dominance $(H_1/D)^{1/2}$ estimate was more than one for all traits, indicating repulsive phase linkage or over dominance. Which is in accordance with the reports" of Vachhani and Shekhat [11], Solankey et al. [12] and Mrinmoy et al. [13].

The proportion of total dominant to recessive alleles $[(4\hat{D}\hat{H}_1)^{1/2} + \hat{F}/ (4\hat{D}\hat{H}_1)^{1/2} -\hat{F}]$ pooled over all the parents also indicated unequal frequency of dominant and recessive genes with more number of dominant genes in all the traits except for internodal length (cm), fruit yield per plant and fruit yield quintal per hectare have predominance of recessive alleles. So it can be assumed that the parents used were carrying more of recessive than dominant alleles for the above traits.

"The proportion of genes with positive and negative effects in the parent is less than 0.25 for all eighteen characters indicates positive and negative alleles at the loci exhibiting dominance were not in equal proportions of the parents of interest". Similar results were obtained by Vachhani & Shekhat [11], Ramesh et al. [14] and Paul et al., [15]. If the proportion was equal to 0.25 it indicates that the positive and negative alleles at the loci are in equal proportion in the parents. The knowledge of number of gene groups responsible for a particular character is important for genetic progress through selection. The ratio of number of gene group was low for most of the characters under study excluding number of branches per plant, fruit length (cm) and seed yield per plant indicating that a few genes or group of genes generally controlled the inheritance of particular traits.

"The estimates of sum of dominance effect over all loci (h_2) were positive and significant for days to first flower, number of fruits per plant, fruit weight (g), fruit length (cm), fruit diameter, 100-seed weight, fruit yield per plant and fruit yield quintal per hectare". Similar results were obtained by Hamada et al., [16], Devi et al. [10] and Vekariya et al. [17]. Consequently, both additive and non-additive genetic components were important in fruit yield and inheritance of those components, with non-additive genetic effects predominant. Accordingly, it is suggested that improvement of fruit yield and its characteristics in okra can be achieved by breeding methods such as selective diallel mating followed by selection in the advanced generation. The positive correlation coefficient (r) between parental order of dominance (Wr + Vr) and parental measurement (Yr) were positive for all the characters indicated that the excess for recessive gene for these traits in the parental population. For the rest characters including days to edible fruit maturity, number of nodes per plant, fruit diameter (cm), number of seed per fruit and seed weight per fruit were negative

Table 1. Estimate of components of variation and their related statistics in 10 x 10 diallel crosses for Days to First Flowering, Days to 50% Flowering, Node at first flower appear, Days to Edible Fruit Maturity, Number of Node/Plant, Internodal length (cm), Number of Branches/ Plant, Plant height (cm) at Harvesting and No. of fruit / plant of okra

Components of variation and related statistics	Days to First Flowering	Days to 50% Flowering	Node at first flower appear	Days to Edible Fruit Maturity	Number of Node/Plant	Internodal length (cm)	Number of Branches/ plant	Plant height (cm) at harvesting	No. of fruit / plant
$\hat{D}$	3.45* ± 1.27	6.85* ± 1.29	0.89* ± 0.16	1.65 ± 3.94	1.41 ± 1.96	0.14 ± 0.18	0.12* ± 0.03	229.97* ± 49.63	1.96 ± 2.47
$\hat{H}_1$	14.54* ± 2.7	15.43* ± 2.74	2.52* ± 0.35	21.17* ± 8.39	25.4* ± 4.18	1.64* ± 0.38	0.53* ± 0.07	1002.58* ± 105.65	45.15* ± 5.25
$\hat{H}_2$	11.6* ± 2.29	10.06* ± 2.33	1.47* ± 0.3	18.2* ± 7.13	23.95* ± 3.55	1.48* ± 0.33	0.51* ± 0.06	867.72* ± 89.79	41.19* ± 4.47
$\hat{F}$	4.76 ± 2.93	10.94* ± 2.97	1.74* ± 0.38	4.15 ± 9.09	1.17 ± 4.53	-0.15 ± 0.42	0.04 ± 0.08	287.79* ± 114.52	2.08 ± 5.69
$\hat{h}^2$	3.54* ± 1.54	1.77 ± 1.56	0.07 ± 0.2	2 ± 4.77	1.6 ± 2.38	0.07 ± 0.22	-0.01 ± 0.04	59.31 ± 60.1	10.07* ± 2.99
$\hat{E}$	2.04* ± 0.38	1.23* ± 0.39	0.08 ± 0.05	4.36* ± 1.19	1.52* ± 0.59	0.1 ± 0.05	0.03* ± 0.01	9.28 ± 14.96	1.95* ± 0.74
$(\hat{H}_1/\hat{D})^{1/2}$	2.05	1.5	1.68	3.58	4.25	3.44	2.14	2.09	4.8
$\hat{H}_2/4\hat{H}_1$	0.2	0.16	0.15	0.22	0.24	0.23	0.24	0.22	0.23
$(4\hat{D}\,\hat{H}_1)^{1/2} + \hat{F}/(4\hat{D}\,\hat{H}_1)^{1/2} - \hat{F}$	2.01	3.27	3.76	2.08	1.22	0.72	1.18	1.86	1.25
$\hat{h}^2/\hat{H}_2$	0.31	0.18	0.05	0.11	0.07	0.04	-0.01	0.07	0.25
R	0.52	0.67	0.3	-0.28	-0.07	0.22	0.71	0.68	0.29
t^2	0.74	4.53	0.02	6.54	5.65	4.46	0.14	0.42	0.05

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively

Table 2. Estimate of components of variation and their related statistics in 10 x 10 diallel crosses for Fruit Weight (g), Fruit Length (cm), Fruit diameter (cm), No. of Seeds per fruit, Seed Weight Per Fruit, 100-Seed Weight, Seed Yield Per Plant (g), Fruit yield per plant (g) and Fruit yield quintal per hectare of okra

Components of variation and related statistics	Fruit Weight (g)	Fruit Length (cm)	Fruit diameter (cm)	No. of Seeds per fruit	Seed Weight Per Fruit	100-Seed Weight	Seed Yield Per Plant (g)	Fruit yield per plant (g)	Fruit yield quintal per hectare
$\hat{D}$	3.56 ± 5.55	0.23 ± 0.14	0.01 ± 0.01	2.97 ± 10.54	0.1 ± 0.11	0.09 ± 0.19	16.54 ± 32.42	610.44 ± 369.97	188.4 ± 114.19
$\hat{H}_1$	68.73* ± 11.82	1.55* ± 0.3	0.08* ± 0.01	92.63* ± 22.43	1.29* ± 0.24	2.97* ± 0.4	253.64* ± 69.02	6133.55* ± 787.51	1893.03* ± 243.06
$\hat{H}_2$	60.18* ± 10.05	1.28* ± 0.25	0.06* ± 0.01	83.06* ± 19.06	1.04* ± 0.2	2.39* ± 0.34	219.22* ± 58.66	5642.27* ± 669.3	1741.41* ± 206.57
$\hat{F}$	8.36 ± 12.81	0.28 ± 0.32	0.02 ± 0.02	3.3 ± 24.31	0.17 ± 0.25	0.38 ± 0.43	21.74 ± 74.81	-298.87 ± 853.63	-92.24 ± 263.46
$\hat{h}^2$	38.32* ± 6.72	2.94* ± 0.17	0.03* ± 0.01	22.02 ± 12.76	0.15 ± 0.13	1.43* ± 0.23	-5.83 ± 39.26	5093.82* ± 448	1572.14* ± 138.27
$\hat{E}$	1.38 ± 1.67	0.3* ± 0.04	0.01* ± 0	4.09 ± 3.18	0.06 ± 0.03	0.09 ± 0.06	21.39* ± 9.78	124.39 ± 111.55	38.39 ± 34.43
$(\hat{H}_1/\hat{D})^{1/2}$	4.39	2.58	3.1	5.58	3.66	5.61	3.92	3.17	3.17
$\hat{H}_2/4\hat{H}_1$	0.22	0.21	0.2	0.22	0.2	0.2	0.22	0.23	0.23
$(4\hat{D}\hat{H}_1)^{1/2} + \hat{F}/(4\hat{D}\hat{H}_1)^{1/2} - \hat{F}$	1.73	1.62	2.38	1.22	1.66	2.11	1.4	0.86	0.86
$\hat{h}^2/\hat{H}_2$	0.64	2.3	0.5	0.27	0.14	0.6	-0.03	0.9	0.9
R	0.15	0.57	-0.01	-0.01	-0.38	0.42	0.26	0.62	0.62
t^2	4.53	0.79	0.12	12.77	1.18	22.25	3.76	1.70	1.70

*, ** *Significant at 5 per cent and 1 per cent probability levels, respectively.*

which indicated preponderance of dominant gene in the parents. The value of t^2 was significant for all the eighteen characters which indicated the validity of the hypothesis of assumption of diallel cross analysis.

It was suggested that the heterosis breeding might be advantageous for improvement of yield and its component traits in okra. The findings are similar to that of Ayesha et al. [18] and Devi et al. [10].

4. CONCLUSION

Form this study it is concluded that both the additive and non-additive conflicts were initiate to be prime in genetic control of all eighteen quantitative and associated characters in okra. The adoption of a population improvement technique, like diallel selective mating or mass selection with simultaneous random mating, can allow in the release of new varieties of okra with higher yields.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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