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Studies on genetic variability, heritability, and genetic advance for selection of genotypes in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract
The present investigation was carried out at the Horticulture Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during summer season 2021. Analysis of variance revealed significant variability among the genotypes of okra for all characters studied. The PCV were higher than the GCV for all the characters indicating important role of environment. The PCV and GCV were higher for number of primary branches per plant. While moderate PCV and GCV was seen, plant height, internodes length, number of nodes per plant, number of fruits per plant, fruit length, number of seeds per fruit, weight of 100 seed, fruit yield per plant. Whereas PCV and GCV was found low days to 50 per cent flowering, days to first flowering and fruit diameter. The highest value of broad sense of heritability was recorded for all the traits. The highest genetic advance as per cent of mean was recorded plant height, number of primary branches per plant, internodes length, number of nodes per plant, number of fruits per plant, fruit length, number of seeds per fruit, weight of 100 seed and fruit yield per plant. While moderate GAM was recorded days to 50 per cent flowering, days to first flowering fruit diameter. Number of primary branches per plant recorded high GCV and PCV, high heritability along with high genetic advance as a per cent of the mean (GAM) indicates the governance of additive gene on trait expression while high heritability and low GAM elucidated the non-additive gene action governing the trait.

Keywords: Okra, genetic variability, heritability and genetic advance

Introduction
Okra (*Abelmoschus esculentus* L. Moench) is a Malvaceae family member of the Malvales order with a somatic chromosomal number of 2n=130 and an amphi-diploid of A. tuberculatus with 2n=58. Okra is a native of tropical and sub-tropical Africa (Gavint *et al*., 2018) [5]. According to Zeven and Zhukovsky (1975) [21], it came from a Hindustani centre of origin. The green tender fruits of okra are good source of carbohydrate, protein, vitamin, calcium, potassium and various minerals. It contains 88 ml water, 10.4 g dry matter, 2.1 g protein, 0.2 g fat, 1.7 g fibre, 8 g carbohydrate, 3100 calories energy, 0.1 mg (86 iu) carotene, 0.07 mg thiamine, 0.08 mg riboflavin, 18 mg ascorbic acid, 0.08 mg niacin, 70-90 mg calcium and 59 mg phosphorus (Agbowuro *et al.* 2019, Rambabu *et al*. 2019, Thamburaj and Singh, 2018) [1, 14, 20]. India is a major producing country in the world. In India, it was cultivated on an area of 0.52 million hectare with annual production of 6.35 million tonnes w and productivity of 12.21 t ha^{-1} and in Uttar Pradesh area 1.31 million hectare, production 29.16 million tonnes and productivity 22.25 t ha^{-1} (Anonymous, 2021) [3]. It's a versatile vegetable since its fresh leaves, buds, blossoms, pods, stems, and seeds may be used in a variety of ways. Fruits eaten as vegetables are used in salads, soups, either fresh, dried, fried, or boiled (Ndunguru & Rajabu, 2004) [12]. Plant breeding's fundamental objective is to increase the economic value of all crop traits. The amount of genetic variation in the base population determines crop improvement. A study of genetic variability using appropriate metrics such as genotypic and phenotypic coefficients of variation, heritability, and genetic advance is required to start an efficient breeding programme (Mishra *et al.*, 2015) [11]. The purpose of present study is to analyse the variability of significant yield and yield contributing characteristics.

Material and Methods
The present study was carried out at Horticulture Research Centre, Department of Horticulture,

Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during the summer season of 2020-21. The research work includes of 20 genotypes received from the ICAR- Indian Institute of Vegetable Research, Varanasi. The 20 parents and 75 F_1s sown in randomized block design with three replications. Twelve observations were recorded on five randomly selected plants in each replication for the morphological traits *viz*., Plant height (cm), days to 50 per cent flowering, Days to first flowering, Number of primary branches per plant, Internodes length (cm), Number of nodes per plant, Number of fruits per plant, Fruit length (cm), Fruit diameter (cm), Number of seeds per fruit, Weight of 100 seed (g) and Fruit yield per plant (g). The statistical analysis for experimental design was given by Panse and Sukhatme (1967) [13]. Genotypic coefficient of variation and phenotypic coefficient of variation were evaluated by the method suggested by Burton and Davane (1953) [4]. Heritability in broad sense and narrow sense was categorized as suggested by Hason *et al.* (1956) [6]. The estimate of genetic advance and genetic advance per cent mean was proposed by Johnson *et al.* (1955) [8].

Result and Discussion

The analysis of variance revealed a significant variance (Table-1) among the genotypes for all traits *viz*., plant height (390.87), days to 50 per cent flowering (35.11), days to first flowering (34.22), Number of primary branches per plant (1.62), Internodes length (2.77), Number of nodes per plant (35.15), Number of fruits per plant (37.94), Fruit length (19.10), Fruit diameter (0.59), Number of seeds per fruit (180.78), Weight of 100 seed (2.63) and Fruit yield per plant (47.52.19) indicated that presence of wide spectrum of variability among the genotypes.

Table 1: Analysis of variance for twelve characters in okra genotypes

Source of variation	df	Plant height (cm)	Days to 50% flowering	Days to first flowering	Number of primary branches per plant	Internodes length (cm)	Number of nodes per plant
Replication	2	0.79	0.51	0.57	0.15	0.02	0.14
Treatment	94	390.87**	35.11**	34.22**	1.62**	2.77**	35.15**
Error	188	2.10	0.34	0.48	0.05	0.01	0.25
Total	284	130.77	11.85	11.65	0.57	0.93	11.80

Source of variation	df	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Number of seeds per fruit	Weight of 100 seed (g)	Fruit yield per plant (g)
Replication	2	0.31	0.83	0.15	0.79	0.14	2.24
Treatment	94	37.94**	19.10**	0.59**	180.78**	2.63**	4752.19**
Error	188	0.25	0.12	0.04	2.09	0.02	27.62
Total	284	12.73	6.41	0.18	61.22	0.87	1591.18

Table 2: Estimation of genetic variability, heritability and genetic advance for different characters under study in okra

Parameters	Mean	Min	Max	GCV (%)	PCV (%)	Heritability (%)	GA	GA% mean	GA mean 1%
Plant height (cm)	106.37	81.82	129.50	10.70	10.79	98.40	23.26	21.87	28.03
Days to 50% flowering	42.79	34.00	51.67	7.96	8.08	97.12	6.91	16.16	20.71
Days to first flowering	39.28	30.67	47.53	8.54	8.72	95.91	6.77	17.22	22.07
Number of primary branches per plant	3.07	1.60	5.07	23.55	24.59	91.68	1.43	46.45	59.52
Internodes Length (cm)	5.06	3.12	7.19	18.98	19.09	98.86	1.97	38.87	49.82
Number of nodes per plant	21.61	15.47	30.80	15.78	15.95	97.93	6.95	32.18	41.24
Number of fruits per plant	18.70	11.20	28.87	18.96	19.15	98.04	7.23	38.67	49.56
Fruit length (cm)	15.86	8.62	22.17	15.86	16.01	98.10	5.13	32.36	41.47
Fruit diameter (cm)	1.68	1.39	2.04	8.08	8.17	97.92	0.28	16.48	21.12
Number of seeds per fruit	63.10	39.00	84.53	12.23	12.44	96.62	15.63	24.77	31.74
Weight of 100 seed (g)	6.65	4.11	8.24	14.08	14.09	99.86	1.93	28.99	37.15
Fruit yield per plant (g)	204.08	129.00	318.80	19.45	19.62	98.28	81.04	39.71	50.89

The results with regard to mean, range, Genetic variability parameters like genotypic coefficient of variation and phenotypic coefficient of variation, heritability, genetic advance and genetic advance as per cent mean for all twelve characters are mentioned in Table-2. The details of these variability parameters are presented below.

Plant height ranged from ranged from 81.82 cm to 129.50 cm with a mean value 106.37 cm and the value of GCV (10.70%) and PCV (10.79%) was moderate. In case of days to 50% flowering, the value ranged from 34.00 days to 51.67 days with a mean value 42.79 days and the value of GCV (7.96%) and PCV (8.08%) was found to be low. Across all genotypes, days to first flowering ranged from 30.67 days to 47.53 days with an average value 39.28 days and the value of GCV (8.54%) and PCV (8.72%) was observed low. The number of primary branches per plant varied from 1.60 to 5.07 with a mean value 3.07 and high value of GCV (23.55%) and PCV (24.59%). Considering every genotype, internodes length ranged from 3.12 cm to 7.19 cm with a mean value 5.06 cm and the value of GCV (18.98%) and PCV (19.09%) was exhibited moderate. In case of number of nodes per plant ranged from 15.47 to 30.80 with a mean value 21.61 with moderate value of GCV (15.78%) and PCV (15.95%). The number of fruits per plant across the genotype was from 11.20 to 28.87 with an average value 18.70 and the value of GCV (18.96%) and PCV (19.15%) was reported moderate. Across all genotypes, fruit length (cm) ranged from 8.62 cm to 22.17 cm with a mean value 15.86 cm and value of GCV (15.86%) and PCV (16.01%) was noted moderate. Across all genotypes, fruit diameter (cm) varied from 1.39 cm to 2.04 cm with a mean value 1.68 cm and the value of GCV (8.08%) and PCV (8.17%) was observed low. The number of seeds per fruit

across the genotype was from 39.00 to 84.53 with a mean value 63.10 and the value of GCV (12.23%) and PCV (12.44%) was observed moderate. In case of weight of 100 seed varied from 4.11 g to 8.24 g with a mean value 6.65 g with the value of GCV (14.08%) and PCV (14.09%) was reported moderate. Fruit yield per plant ranged from 129.00 g to 318.80 g with an average value 204.08 g and the value of GCV (19.45%) and PCV (19.62%) was recorded high.

Plant height showed very high heritability (98.40%) coupled with high genetic advance (23.26). Days to 50% flowering had very high heritability (97.12%) accompanied with low genetic advance (6.91). Days to first flowering observed very high heritability (95.91%) along with low genetic advance (6.77). For Number of primary branches per plant showed very high heritability (91.68%) coupled with low genetic advance (1.43). For internodes length registered very high heritability (98.86%) accompanied with low genetic advance (1.97). The number of nodes per plant had high heritability (97.93%) coupled with low genetic advance (6.95). For Number of fruits per plant observed very high heritability (98.04%) coupled with low genetic advance (7.23). Fruit length (cm) had very high heritability (98.10%) along with low genetic advance (5.13). Fruit diameter (cm) showed high heritability (97.92%) accompanied with low genetic advance (0.28). Number of seeds per fruit had very high heritability (96.62%) accompanied with moderate genetic advance (15.63). Weight of 100 seed (g) recorded high heritability (99.86%) along with low genetic advance (1.93). Fruit yield per plant had very high heritability (98.28%) accompanied with very high genetic advance (81.04).

Highest genetic advance as per cent mean was observed in trait plant height (21.87%), number of primary branches per plant (46.45%), internodes length (38.87%), number of nodes per plant (32.18%), number of fruits per plant (38.67%), fruit length (32.36%), number of seeds per fruit (24.77%), weight of 100 seed (28.99%) and fruit yield per plant (39.71%). Whereas moderate was reported in days to 50 per cent flowering (16.16%), days to first flowering (17.22%) and fruit diameter (16.48%). All the findings are in association with Agbowuro *et al.* (2019) [1], Alam *et al.* (2020) [2], Jibung *et al.* (2021) [7], Kumar *et al.* (2020) [9], Kumar *et al.* (2021) [10], Rambabu *et al.* (2019) [14], Ranga *et al.* (2021) [15], Samim *et al.* (2018) [16], Sravanthi (2017) [17], Sravanthi *et al.* (2021) [18], Srivarsha *et al.* (2022) [19].

Conclusion

Analysis of variance revealed significant differences for all the genotypes for all the characters. The values of PCV were of higher magnitude than GCV for all the characters indicating influence of environment over the genotype. High to very high heritability (broad sense) was observed for all the traits. Plant height, number of primary branches per plant, internodes length, number of nodes per plant, number of fruits per plant, fruit length, number of seeds per fruit, weight of 100 seed and fruit yield per plant having high heritability and high genetic advance as a per cent of the mean could be exercised for improvement through simple direct selection.

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