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Genetic variability studies in okra [*Abelmoschus esculentus* (L.) Moench] for yield and yield contributing traits

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Abstract
An experiment was undertaken at experimental field, Department of Vegetable Science, College of Horticulture, Bagalkot with the aim to study the genetic variability among forty-eight genotypes of okra. The experiment was laid out in randomized complete block design (RCBD) with two replications during late-*rabi* season 2019. The analysis of variance revealed that the genotypes differed significantly (p=0.05) for all the parameters studied. High values of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), and high estimates of heritability coupled with greater genetic advance were recorded for the traits like number of leaves per plant at 60 and 90 DAS, number of branches per plant at 60 and 90 DAS, pod diameter, average pod weight, total yield per plant, total yield per plot and total yield per hectare, indicating the existence of wider genetic variability for these traits in the germplasm under study. There is an ample scope for improving these traits through direct selection on the basis of phenotypic characters which will lead to high pod yield in okra.

Keywords: Okra, GCV, PCV, heritability, genetic advance

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench] is commonly known as bhendi or lady's finger in India. It is a fast growing annual, which has captured prominent position among the vegetables for its nutrition and deliciousness. It is native of Tropical Africa and grown for its tender pods in tropics, sub-tropics and warmer seasons of the temperate areas in the world. India is the largest producer of okra in the world and it has great potential as foreign exchange earner and accounts for about 60% of the export of fresh vegetables from India to the Middle East and European countries (Singh *et al.*, 2014) [1]. Okra is specially valued for its tender, delicious green fruits which are cooked, canned and consumed in various forms in different parts of the country.

The progress of any breeding programme depends on the information regarding genetic variability present in a population. The genetic variability is determined with the help of certain genetic parameters *viz.*, genotypic coefficient of variation (GCV), phenotypic coefficient of variability (PCV), heritability in broadsense (h^2) and genetic advance (GA) estimates. Genotypic coefficient variability and phenotypic coefficient of variability were used to assess the extent of variation between two different contrasting characters. The knowledge of heritability helps the plant breeder in pre-assessing the results of selection for a particular character. However, for predicting the effect of selection, heritability estimates along with genetic advance are more useful than the heritability estimates alone. Keeping these things in view, the study was planned to assess genetic variability parameters in okra to select superior genotypes for further crop improvement programme.

Materials and Methods
Forty-eight genotypes of okra collected from different sources *viz.*, NBPGR New Delhi, IIVR Varanasi, IIHR Bengaluru, KAU Kerala and Advanta Seeds were used for the present investigation. The okra genotypes were evaluated for yield and yield contributing traits in the field of Vegetable Science unit of College of Horticulture, Bagalkot (Karnataka), India. The experiment was laid out in randomized complete block design (RCBD) with two replications during late-*rabi* season 2019. Each treatment or a genotype in each replication was represented by one row each accommodating 20 plants at a row to row spacing of 60cm and 30cm from

plant to plant. Five plants were randomly selected for each genotype from each replication and evaluated for different quantitative characters and the replicated mean values of various characters were subjected to statistical analysis. Analysis of variance was carried out in order to partition the total variation showed by different characters under the study into its components *viz*., replication, treatments and error. Genotypic and phenotypic coefficients of variation were estimated according to Burton and Devane (1953) [2] and heritability estimates as per Falconer (1981) [3] and genetic advance estimates according to Johanson *et al.* (1995) [4].

Results and Discussion

Crop improvement depends on the extent of genetic variability present in the gene pool. The present study revealed that, variance due to treatments was significant (at p=0.05) for all the characters studied (Table 1), thus indicating the existence of genetic variation among the genotypes. The existence of genetic variability among the genotypes for the character to be improved is the most basic requirement for the successful selection. The mean performance of the genotypes revealed a wide range of variability for all the traits studied. These results are in consonance with the findings of Prakash and Pitchaimuthu (2010) [5], Kerure *et al.* (2017) [6], Thulasiram *et al.* (2017) [7], Patra *et al.* (2018) [8], Kumar *et al.* (2019) [9], Singh *et al.* (2020) [10] and Ranga *et al.* (2021) [11].

The components of genetic parameters of variation for yield and its attributes exhibited a wide range of variability for the parameters studied (Table 2). The values of phenotypic coefficient of variation (PCV) were of higher in magnitude than that of genotypic coefficient of variation (GCV) for all the characters indicating that the environment played an important role in influencing the expression of the traits.

The relative values of genotypic and phenotypic coefficient of variation gives an idea about the magnitude of variability present in a population. The results obtained from the statistical analysis revealed high, medium and low estimates of genotypic and phenotypic coefficient of variation among the genotypes for different characters studied (Table 2). High values of GCV and PCV were noticed for number of leaves per plant at 90 DAS (21.51%, 22.90%), pod diameter (22.16%, 22.72%), average pod weight (24.57%, 25.81%), total yield per plant (24.79%, 26.45%), number of branches per plant at 60 DAS (25.09%, 26.28%), number of branches per plant at 90 DAS (25.14%, 26.31%), total yield per plot (28.05%, 29.55%), total yield per hectare (28.05%, 29.54%) and number of leaves per plant at 60 DAS (32.60%, 33.97%). Sufficient variability existed in the material under the study, which could be exploited either through selection or hybridization. These results are in agreement with the findings of Ahamed *et al.* (2015) [12] and Al-Juboori (2021) [13] for number of leaves per plant, Bello and Aminu (2017) [14], Verma *et al.* (2018) [15] and Melaku *et al.* (2020) [16] for number of branches per plant, Prakash and Pitchaimuthu (2010) [5], Rambabu *et al.* (2019) [17] and Walling *et al*. (2020) [18] for average pod weight, Verma *et al.* (2018) [15] and Ashraf *et al.* (2020) [19] for total yield per plant and, Melaku *et al.* (2020) [16] for total yield per plot and total yield per hectare.

Moderate estimates of GCV and PCV were observed for plant height at 90 DAS (10.99%, 12.96%), number of pods per plant (14.54%, 16.86%), number of nodes on main stem at 60 DAS (14.65%, 15.78%), pod length (16.53%, 18.11%), plant height at 60 DAS (16.68%, 18.24%), internodal length at 60 DAS (17.72%, 18.77%) and internodal length at 90 DAS (17.39%, 18.78%). These results obtained from the studies carried out in okra are in accordance with Thulasiram *et al.* (2017) [7] and Alam *et al.* (2020) [20] for number of pods per plant and number of nodes on main stem, Thulasiram *et al.* (2017) [7], Alam *et al.* (2020) [20] and Ranga *et al.* (2021) [11] for plant height and internodal length and, Ahamed *et al.* (2015) [12] and Kerure *et al.* (2017) [6] for pod length.

Low GCV and PCV were observed for days to 50 per cent flowering (1.70%, 2.73%) and days to first flowering (2.50%, 3.92%). These results were parallel to the results of Nikitha *et al.* (2016) [21] and Kerure *et al.* (2017) [6] for days to first flowering and Kumar *et al.* (2019) [9] and Singh *et al.* (2020) [10] for days to 50 per cent flowering. However, low GCV coupled with moderate PCV was recorded for number of nodes on main stem at 90 DAS (8.79%, 11.54%) and number of seeds per pod (9.26%, 10.65%). Similar results were found by Kumar *et al.* (2019) [9] for number of nodes on main stem, Makhdoomi *et al.* (2018) [22] and Rambabu *et al.* (2019) [17] for number of seeds per pod.

The coefficient of variation indicates only the extent of variability present in different characters. However, for the prediction of response to selection, heritability estimates are useful. Heritability estimates in broad sense alone do not act as true indicators of effective selection for the trait, since their scope is restricted by their interaction with the environment (Johanson *et al*., 1955) [4]. Hence heritability values considered along with the predicted genetic gain increase the reality of the parameters as a tool in selection programme.

High heritability coupled with high genetic advance was recorded for number of pods per plant (74.38%, 25.84%), pod length (83.37%, 31.10%), plant height at 60 DAS (83.55%, 31.40%), internodal length at 90 DAS (85.80%, 33.19%), number of nodes on main stem at 60 DAS (86.23%, 28.02%), total yield per plant (87.87%, 47.87%), number of leaves per plant at 90 DAS (88.23%, 41.61%), internodal length at 60 DAS (89.21%, 34.47%), total yield per plot (90.10%, 54.85%), total yield per hectare (90.12%, 54.85%), average pod weight (90.61%, 48.18%), number of branches per plant at 90 DAS (91.31%, 49.49%), number of branches per plant at 60 DAS (91.39%, 49.36%), number of leaves per plant at 60 DAS (92.08%, 64.43%) and pod diameter (95.08%, 44.50%). This indicating the effectiveness of selection for these traits. These results are in agreement with the findings of Prakash and Pitchaimuthu (2010) [5], Bello and Aminu (2017) [14], Kerure *et al.* (2017) [6], Thulasiram *et al.* (2017) [7], Rambabu *et al.* (2019) [17], Alam *et al.* (2020) [20], Ashraf *et al.* (2020) [19], Melaku *et al.* (2020) [16], Singh *et al.* (2020) [10] and Ranga *et al.* (2021) [11].

High heritability coupled with moderate genetic advance was observed for plant height at 90 DAS (71.94%, 19.20%) and number of seeds per pod (75.62%, 16.58%). These results are in agreement with the earlier findings of Nikitha *et al.* (2016) [21], Makhdoomi *et al.* (2018) [22], Patra *et al.* (2018) [8] and Ashraf *et al.* (2020) [19] for plant height, and Rambabu *et al.* (2019) [17] and Walling *et al.* (2020) [18] for number of seeds per pod.

Moderate estimates of heritability and genetic advance were observed for number of nodes on main stem at 90 DAS (58.09%, 13.81%). However, moderate estimates of heritability and low genetic advance was observed days to 50 per cent flowering (38.83%, 2.18%), days to first flowering

(40.46%, 3.27%). Similar observations were recorded by Sharma *et al.* (2016) [23] for number of nodes on main stem, Kerure *et al.* (2017) [6] for days to 50 per cent flowering and Melaku *et al.* (2020) [16] for days to first flowering.

The traits like number of leaves per plant at 60 and 90 DAS, number of branches per plant at 60 and 90 DAS, pod diameter, average pod weight, total yield per plant, total yield per plot and total yield per hectare expressed higher values of GCV and heritability estimates supplemented with greater genetic gains. This is the indicative of additive gene effect regulating the inheritance of such traits therefore these characters reflect greater selective value and offers ample scope for selection.

Table 1: Analysis of variance for growth, earliness and yield characters in okra

Sl. No.	Characters	Mean sum of squares		
		Replication	Treatment	Error
		(1)	(47)	(47)
1	Plant height at 60DAS (cm)	3.05	190.62**	31.36
2	Plant height at 90DAS (cm)	0.50	245.30**	68.82
3	Number of leaves per plant at 60DAS	22.03	84.27**	6.68
4	Number of leaves per plant at 90DAS	12.69	79.75**	9.38
5	Number of branches per plant at 60DAS	0.23	0.72**	0.06
6	Number of branches per plant at 90DAS	0.10	1.13**	0.10
7	Number of nodes on main stem at 60DAS	0.10	4.24**	0.58
8	Number of nodes on main stem at 90DAS	5.18	3.69**	1.55
9	Internodal length at 60DAS (cm)	0.62	1.89**	0.21
10	Internodal length at 90DAS (cm)	0.83	2.99**	0.42
11	Days to first flowering	12.04	5.68*	3.38
12	Days to 50% flowering	1.76	3.92*	2.40
13	Pod length (cm)	2.29	8.89**	1.48
14	Pod diameter (mm)	2.51	31.96**	1.57
15	Average pod weight (g)	1.31	40.16**	3.77
16	Number of pods per plant	6.72	20.13**	5.16
17	Total yield per plant (g)	11022.09	25304.07**	3070.49
18	Total yield per plot (kg)	0.37	9.01**	0.89
19	Total yield per hectare (t)	1.83	44.48**	4.40
20	Number of seeds per pod	4.55	45.49**	11.09

*Significant @ 5% level of significance **Significant @ 1% level of significance

Table 2: Estimates of mean, range, genotypic coefficient of variance (GCV), phenotypic coefficient of variance (PCV), heritability (h^2), genetic advancement (GA) and genetic advancement as% mean (GAM) for pod yield and its component characters in okra

Characters	Mean	Range	GCV (%)	PCV (%)	h^2 in broad sense (%)	GA	GA as% of Mean
Plant height at 60DAS (cm)	53.51	36.50 - 74.67	16.68	18.24	83.55	16.80	31.40
Plant height at 90DAS (cm)	85.47	60.97 - 104.78	10.99	12.96	71.94	16.41	19.20
Number of leaves per plant at 60DAS	19.11	8.62 - 36.62	32.6	33.97	92.08	12.31	64.43
Number of leaves per plant at 90DAS	27.58	17.17 - 44.40	21.51	22.90	88.23	11.48	41.61
Number of branches per plant at 60DAS	2.28	1.17 - 3.80	25.09	26.28	91.39	1.13	49.36
Number of branches per plant at 90DAS	2.86	1.46 - 4.76	25.14	26.31	91.31	1.41	49.49
Number of nodes on main stem at 60DAS	9.23	6.50 - 12.17	14.65	15.78	86.23	2.59	28.02
Number of nodes on main stem at 90DAS	11.78	9.00 – 15.30	8.79	11.54	58.09	1.63	13.81
Internodal length at 60DAS (cm)	5.18	3.38 - 7.62	17.72	18.77	89.21	1.79	34.47
Internodal length at 90DAS (cm)	6.51	4.25 - 9.58	17.39	18.78	85.80	2.16	33.19
Days to first flowering	42.98	40.00 - 46.00	2.50	3.92	40.46	1.40	3.27
Days to 50% flowering	51.39	49.00 - 54.00	1.70	2.73	38.83	1.12	2.18
Pod length (cm)	11.64	8.70 - 17.40	16.53	18.11	83.37	3.62	31.10
Pod diameter (mm)	17.59	10.86 - 32.47	22.16	22.72	95.08	7.83	44.50
Average pod weight (g)	17.36	8.54 - 30.85	24.57	25.81	90.61	8.36	48.18
Number of pods per plant	18.81	12.75 - 26.95	14.54	16.86	74.38	4.86	25.84
Total yield per plant (g)	425.31	239.18 - 726.40	24.79	26.45	87.87	203.60	47.87
Total yield per plot (kg)	7.18	3.50 - 12.96	28.05	29.55	90.10	3.94	54.85
Total yield per hectare (t)	15.96	7.77 - 28.80	28.05	29.54	90.12	8.76	54.85
Number of seeds per pod	44.80	36.40 - 56.10	9.257	10.65	75.62	7.43	16.58

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