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GENETIC VARIABILITY STUDIES IN OKRA [*ABELMOSCHUS ESCULENTUS* (L.) MOENCH

SANGANAMONI MALLESH*, REVANAPPA, S. SHIVASHANKAR, B. PRABHAKAR AND VITTAL MANGI
Department of Vegetable Science,
College of horticulture, University of Horticultural Sciences, Bagalkot, Karnataka - 587104, INDIA
e-mail: mallesh.horticulture@gmail.com

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***Corresponding author**

ABSTRACT
Fifty two okra accessions were assessed to determine their genetic variability, heritability and genetic advance from twenty six parameters. The genotypic and phenotypic coefficient of variability were high for plant height at 90 days after sowing, number of nodes per plant, number of fruits per plant, rind thickness, crude fibre content, vitamin C content, seed yield per fruit and number of seeds per fruit (24.03% and 25.85%, 22.14% and 27.19%, 25.00% and 27.64%, 25.43% and 26.45%, 36.92% and 37.25%, 27.16% and 27.48%, 24.62% and 29.48% and 27.20% and 31.07% respectively) indicating maximum amount of variability present in the genotypes for these characters which would be amenable for further selection. High heritability coupled with high genetic advance over mean was observed for plant height at 45 and 90 days after sowing, number of leaves at 90 days after sowing, first flowering node, number of nodes per plant, number of fruits per plant, fruit yield per plant, average fruit weight, fruit length, fruit diameter, fruit yield per hectare, rind thickness, number of ridges on fruit surface, crude fibre content, vitamin C content, seed yield per fruit and number of seeds per fruit (71.29% and 34.00%, 86.44% and 46.03%, 72.56% and 31.61%, 91.51% and 41.19%, 66.35% and 37.16%, 81.84% and 46.60%, 74.03% and 30.86%, 72.49% and 28.44%, 91.61% and 33.75%, 88.30% and 30.83%, 74.05% and 30.86%, 92.46% and 50.37%, 96.98% and 35.95%, 98.23% and 75.38%, 97.64% and 55.29%, 76.63% and 49.05% and 69.80% and 42.38% respectively) indicates predominance additive gene action. Thus, there is ample scope for improving these characters through direct selection.

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] also known as lady's finger and bhendi is an important spring - summer and rainy season vegetable crop cultivated in tropical and sub-tropical parts of the world. Looking to the potentials of okra its improvement is inevitable. So, before taking up any breeding programme, a thorough knowledge is required regarding the nature and magnitude of genetic variability, heritability and genetic advance over mean. The key for any success of any breeding program lies in the availability of genetic variability for desired traits (Heller, 1996).

The phenotypic expression of the plant is mainly controlled by genetic makeup of plant and its interaction with environment. It is necessary to partition the observed phenotypic variability into its heritable and non heritable components with suitable parameters (Robinson *et al*., 1949). Yield is a complex character and is a function of large number of characters, their interaction and is also influenced to a great extent by environment. Therefore, selection for yield alone is not effective and it is imperative to depend on traits which are highly heritable and contribute greatly for yield (Johanson et al., 1955).

This study was conducted by keeping objective to improve the productivity, by generating information about the nature and magnitude of genetic variability, which is quite necessary to select and plane effective breeding programme.

MATERIALS AND METHODS

The current study on genetic variability studies in okra were undertaken during the year 2014 in *kharif* season at experimental site Department of Vegetable Science, College of Horticulture, Bagalkot, Karnataka. The experimental site falls under agro-climatic zone-3 (northern dry zone) of region-2 of Karnataka situated at 16º46' North latitude, 74º59' East longitude and at an altitude of 533.00 meters above the mean sea level. It has the benefit of both South-West and North-East monsoons. The temperature ranges from 14ºC to 30ºC and relative humidity from 60.00 to 87.00 per cent with a rainfall of 338 mm during the experimental period.

The fifty two genotypes (Table 1) were evaluated through a field experiment conducted in randomized block design with two replications, ridges and furrows were opened at a distance of 60 cm apart. Two to three seeds per hill were dibbled at a distance of 30 cm in a row. For recording observations, five plants in each experimental plot were chosen at randomly as per NBPGR minimal descriptors from five competitive plants from each replication on twenty six parameters.

The mean values of the data collected were used for analysis of variance (ANOVA) for RBD was estimated (Panse and Sukhtame 1989) (Table 2 and 3). With a view to understand the extent to which the observed mean, range, genotypic variance (GV), phenotypic variance (PV), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability (h^2 bs), genetic advance and

genetic advance as per cent over mean (GAM) were worked out for 26 plant traits (Burton 1953; Johanson *et al.,* 1955; Weber and Moorthy, 1952) (Table 4 and 5).

RESULTS AND DISCUSSION

The analysis of variance showed that the genotypes under study differed significantly among themselves for all the twenty six characters (Table 2 and 3). The mean, range, genotypic (GCV) and phenotypic (PCV) coefficients of variation, heritability and genetic advance as per cent of mean for all the characters are presented in Table 4 and 5. The magnitude of PCV was higher than that of GCV for all the traits revealing little influence of the environment in the expression of these traits (Janaki *et al*. 2015). The high ratio of GCV and PCV indicate that some of the characters were influenced by the environment. The GCV and PCV were high for plant height at 90 days after sowing (24.03% and 25.85% respectively), number of fruits per plant (25.00% and 27.64% respectively), rind thickness(25.43% and 26.45% respectively), seed yield per fruit (27.20% and 31.07% respectively), number of seeds per fruit (24.64% and 29.48% respectively), crude fibre content (36.92% and 37.25% respectively) and vitamin C content (27.16% and 27.48% respectively) which indicating maximum amount of variability present in the genotypes for these characters which would be amenable for further selection and characters like days to first flowering (7.05% and 8.80% respectively), days to first fruit set (6.91% and 8.74% respectively), days to first harvest (6.78% and 8.81% respectively) and number of days to dry fruit harvest (5.10% and 9.55% respectively) indicating the existence of limited variability in the genotypes evaluated for the traits showing low genetic variability in the genotypes stock studied. This necessitates need for generation of new variability for these characters. Similar observations have been reported by Dhankar and Dhankar (2002); Mehta *et al*. (2006); Prakash and Pitchaimuthu (2010); Pradip *et al*. (2010) and Nwangburuka *et al*. (2012).

High heritability (>60 %) coupled with high genetic advance (>20 %) as per cent of mean was observed for plant height both at 45 (71.29% and 34.00% respectively) and 90 (86.44% and 46.03% respectively) days after sowing, number of leaves per plant at 90 days after sowing (72.56% and 31.61% respectively), first flowering node (91.51% and 41.19% respectively), number of nodes per plant (66.35% and 37.16% respectively), number of fruits per plant (81.84% and 46.60% respectively), fruit yield per plant (74.03% and 30.86% respectively), average fruit weight (72.49% and 28.44% respectively), fruit length (91.61% and 33.75% respectively), fruit diameter (88.30% and 30.83% respectively), fruit yield per hectare (74.05% and 30.86% respectively), rind thickness (92.46% and 50.37% respectively), number of ridges on fruit surface (96.98% and 35.95% respectively), crude fibre content (98.23% and 75.38% respectively), vitamin C content (97.64% and 55.29% respectively), number of seeds per fruit (69.80% and 42.38% respectively) and seed yield per fruit (76.63% and 49.05% respectively) indicating predominance of additive genetic component in governing of these traits and improvement of these traits through simple selection would be rewarding. Similar results were noticed in earlier studies by Vishalkumar *et al*. (2006); Sharma *et al*. (2007); Jindal *et al*. (2010); Adeoluwa and Kehinde (2011); Adiger *et al*. (2011); Das *et al*. (2012); Reddy *et al*. (2012) and Om Prakash Meena and Vijay Bahadur (2014).

Moderate heritability coupled with moderate genetic advance as per cent of mean was observed for internodal length both at 45 (41.28% and 19.54% respectively) and 90 (53.89% and 17.68% respectively) days after sowing and days to first harvest (59.21% and 10.75% respectively). This indicates the importance of additive effects for this trait and selection may be rewarding. These same results were also observed by Mehta *et al*. (2006); Sharma *et al*. (2007) and Osekita and Akinyele (2008).

Table 1: Details of okra genotypes with their sources

Sl. No.	Genotype	Sl. No.	Genotype	Sl. No.	Genotype
NBPGR-New Delhi		20.	IC 90231	39.	SB-8
1.	IC 15036	21.	IC 90264	40.	VRO-106
2.	IC 15537	22.	IC 90271	41.	D1-87-5
3.	IC 16262-A	23.	EC 693223	42.	VRO-103
4.	IC 18073-A	24	EC 693224	43.	VRO-13-178
5.	IC 18530	25	EC 693226	44.	BCO-1
6.	IC 22237	26	EC 693228	45.	003163
7.	IC 22237-A	27	EC 693229	46	Khashi Pragathi
8.	IC 23594	28	EC 693233	KRCCH, Arabhavi	
9.	IC 24137	29.	EC 693234	47.	J-76
10.	IC 24906-A	30.	EC 469409	48.	N-59
11.	IC 27826-A	IIVR, Varanasi, Utter Pradesh		49.	N-64
12.	IC 27875-A	31.	DKHYS-1402	COH, Bagalkot, Karnataka	
13.	IC 45893	32.	NO.315	50.	Melavanki Local
14.	IC 45980	33.	JBS-2	IIHR, Bengaluru, Karnataka	
15.	IC 45992-B	34.	VRO-104	51.	Arka Anamika
16.	IC 45995	35.	SB-2	Parbhani, Maharashtra	
17.	IC 48281	36.	BO-2	52.	Parbhani Kranthi
18.	IC 50418	37.	307-10-1		
19.	IC 90225	38.	HRB-55		

IC: Indigenous Collection; EC: Exotic Collection; NBPGR : National Bureau of Plant Genetic Resources, New Delhi.; IIVR : Indian Institute of Vegetable Research, Varanasi; IIHR : Indian Institute of Horticultural Research, Bangalore; BGKB: Bagalkot Bhendi; KRCCH : Kittur Rani Channamma College of Horticulture, Arabhavi.

Table 2: Analysis of variance (mean sum of square) for growth, earliness and yield parameters in okra genotypes

Sl.No.	Sources of variation/characters	Replication	Treatments (genotypes)	Error	CD (1 %)	CD(5 %)
	Degrees of freedom	1	51	51		
A	Growth parameters					
1	Plant height (cm)(45 DAS)	91.78	152.95**	25.62	13.54	10.16
2	Plant height (cm) (90 DAS)	768.40	2280.39**	165.85	34.45	25.85
3	Number of leaves (45 DAS)	23.84	23.96**	7.899	7.52	5.64
4	Number of leaves (90 DAS)	3.05	43.98**	6.99	7.07	5.30
5	Number of branches (45 DAS)	0.23	1.07**	0.29	1.45	1.09
6	Number of branches (90 DAS)	0.86	0.60**	0.27	1.39	1.04
7	Internodal length (cm) (45 DAS)	2.05	0.55**	0.23	1.28	0.96
8	Internodal length (cm) (90 DAS)	0.90	0.50**	0.15	1.04	0.78
B	Earliness and yield parameters					
9	Days to first flowering	0.24	22.47**	4.90	5.92	4.44
10	Days to first fruit set	0.34	23.06**	5.30	6.16	4.62
11	Days to first harvest	5.08	27.89**	7.14	7.15	5.36
12	First flowering node	4.32	3.81**	0.41	1.71	1.28
13	Number of nodes per plant	91.21	324.62**	65.67	21.68	16.26
14	Number of fruits per plant	17.15	55.37**	5.52	6.29	4.72
15	Fruit yield per plant (g)	354.42	8485.92**	1266.12	95.20	71.43
16	Average fruit weight (g)	6.82	20.00**	3.19	4.77	3.58
17	Fruit length (cm)	0.00098	10.01**	0.43	1.77	1.32
18	Fruit diameter (cm)	0.22	0.21**	0.01	0.31	0.23
19	Fruit yield per hectare (tonnes)	1.09	26.19**	3.90	5.28	3.96

** Significant @ 1 %; DAS: Days after sowing

Table 3: Analysis of variance (mean sum of square) for quality and seed parameters in okra genotypes.

Sl.No.	Sources of variation/characters	Replication	Treatments (genotypes)	Error	CD (1 %)	CD (5 %)
	Degrees of freedom	1	51	51		
A	Quality parameters					
1	Rind thickness (mm)	0.027	0.30**	0.01	0.29	0.21
2	Number of ridges on fruit surface	0.0077	2.015**	0.03	0.47	0.35
3	Crude fibre content (%)	1.62	67.82**	0.60	2.08	1.56
4	Vitamin C content (mg/100g)	0.0098	0.055**	0.00065	0.068	0.051
B	Seed parameters					
5	Seed yield per fruit (g)	0.19	3.37**	0.44	1.78	1.34
6	Number of seeds per fruit	29.29	610.40**	108.57	27.88	20.91
7	Number of days for dry fruit harvest	88.24	17.11*	9.52	8.28	6.19

* Significant @ 5 %; ** Significant @ 1 %;DAS: Days after sowing

Table 4: Estimates of mean, range, components of variance, heritability and genetic advance for growth and earlyness parameters in okra genotypes

Sl.No.	Characters	Mean ±S.Em	Range	GV	PV	GCV (%)	PCV (%)	h^2(%)	GA	GAM (%)
1	Plant height (cm) (45 DAS)	40.81 ± 3.54	26.80-57.55	63.65	89.29	19.54	23.15	71.29	13.87	34.00
2	Plant height (cm) (90 DAS)	135.27 ± 9.01	66.10-221.40	1057.26	1223.12	24.03	25.85	86.44	62.27	46.03
3	Number of leaves/plant (45DAS)	17.41 ± 1.96	12.10-25.80	8.03	15.93	16.27	22.92	50.42	4.16	23.80
4	Number of leaves/plant (90 DAS)	23.86 ± 1.85	16.60-41.00	18.49	25.48	11.07	18.01	72.56	7.54	31.61
5	Number of branches/plant (45 DAS)	3.68 ± 0.38	1.70-5.40	0.38	0.68	16.86	22.43	56.54	0.96	26.13
6	Number of branches/plant (90 DAS)	4.11 ± 0.36	2.90-5.80	0.16	0.44	9.95	16.12	38.07	0.52	12.64
7	Internodal length (cm) (45 DAS)	2.72 ± 0.33	1.56-3.95	0.16	0.39	14.76	22.97	41.28	0.53	19.54
8	Internodal length (cm) (90DAS)	3.60 ± 0.27	1.94-4.74	0.17	0.33	11.69	15.92	53.89	0.63	17.68
9	Days to first flowering	42.02 ± 1.55	37.50-56	8.78	13.69	7.05	8.80	64.16	4.89	11.63
10	Days to first fruit set	43.07 ± 1.61	38.5-57	8.87	14.18	6.91	8.74	62.59	4.85	11.27
11	Days to first harvest	47.49 ± 1.87	42.50-62.50	10.37	17.51	6.78	8.81	59.21	5.10	10.75
12	First flowering node	6.58 ± 0.44	3.50-11.90	1.709	2.11	19.81	22.07	91.51	2.64	41.19
13	Number of nodes per plant	51.37 ± 5.67	28.60-92.90	129.49	195.14	22.14	27.19	66.35	19.09	37.16

DAS- Days after sowing; PCV- Phenotypic co-efficient of variation; GV- Genotypic variance;h^2- Heritability (Broad sense); PV- Phenotypic variance; GA- Genetic advance; GCV- Genotypic co-efficient of variation; GAM- Genetic advance as per cent of mean

High heritability coupled with moderate genetic advance as per cent of mean was observed for days to first flowering (64.16% and 11.63% respectively) and days to first fruit set (62.59% and 11.27% respectively) indicating non-additive gene action. The high heritability was being exhibited due to favorable influence environment rather than genotype and selection for such traits may not be rewarding. These results were confirmative with results obtained by Singh *et al*. (2007).

Table 5: Estimates of mean, range, components of variance, heritability and genetic advances for yield, quality and seed parameters in okra genotypes

Sl.	Characters	Mean ± S.Em	Range	GV	PV	GCV(%)	PCV(%)	h^2(%)	GA	GAM(%)
1	Number of fruits per plant	19.96 ± 1.64	7.42-35.21	24.92	30.45	25.00	27.64	81.84	9.30	46.60
2	Fruit yield per plant (g)	345.06 ± 24.91	177.74-485.87	3609.89	4876.02	17.41	20.23	74.03	106.49	30.86
3	Average fruit weight (g)	17.88 ± 1.25	11.32-28.22	8.40	11.59	16.21	19.04	72.49	5.08	28.44
4	Fruit length (cm)	12.78 ± 0.46	8.46-17.98	4.78	5.22	17.11	17.88	91.61	4.31	33.75
5	Fruit diameter (cm)	2.00 ± 0.08	1.64-3.15	0.10	0.11	15.93	16.95	88.30	0.61	30.83
6	Fruit yield per hectare (tonnes)	19.17 ± 1.38	9.87-26.99	11.14	15.05	17.41	20.23	74.05	5.91	30.86
7	Rind thickness (mm)	1.50 ± 0.07	1.05-3.14	0.14	0.15	25.43	26.45	92.46	0.75	50.37
8	Number of ridges on fruit surface	5.62 ± 0.12	5.0-8.3	0.99	1.02	17.70	17.98	96.98	2.02	35.95
9	Crude fibre content (%)	15.70 ± 0.54	4.50-34.50	33.67	34.21	36.92	37.25	98.23	11.83	75.38
10	Vitamin C content (mg)	0.60 ± 0.017	0.39-1.12	0.0272	0.0278	27.16	27.48	97.64	0.33	55.29
11	Seed yield per fruit (g)	4.44 ± 0.46	2.08-9.18	1.46	1.90	27.20	31.07	76.63	2.18	49.05
12	Number of seeds per fruit	64.31 ± 7.29	17.06-115.35	250.91	359.48	24.62	29.48	69.80	27.26	42.38
13	Number of days for dry fruit harvest	38.18 ± 2.16	32.05-43.80	3.76	13.31	5.10	9.55	28.50	2.14	5.60

DAS- Days after sowing; PCV- Phenotypic co-efficient of variation; GV- Genotypic variance; h^2- Heritability (Broad sense);PV- Phenotypic variance; GA- Genetic advance; GCV- Genotypic co-efficient of variation;GAM- Genetic advance as per cent of mean

High genetic advance as per cent of mean coupled with moderate heritability was observed for number of leaves at 45 days after sowing (23.80% and 50.42% respectively) and number of branches per plant at 45 days after sowing (26.13% and 56.54% respectively) indicates the importance of additive effects for this trait and selection may be rewarding. These same results were also observed by Mehta *et al*. (2006) and Sharma *et al*. (2007).

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