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Nature and magnitude of genetic variability studies in okra (*Abelmoschus esculentus* (L.) Moench)

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Abstract
The present investigation, an attempt has been made to evaluate the genetic variability of yield contributing characters in sixty-five genotypes of okra collected from different parts of the country. Analysis of variance indicated significant differences among the genotypes for different morphological characters except number of leaves per plant 90 days after sowing. High genotypic and phenotypic coefficients of variation were noticed for fruit yield per plot, fruit yield per hectare and vitamin C content indicating maximum variability among the different genotypes. High estimates of heritability coupled with high genetic advance over mean obtained for plant height at 90 days after sowing, internodal length (cm) 60 DAS, fruit yield per plant (g), fruit yield per plot (kg), fruit yield per hectare (t) and vitamin C (mg/100g) indicating presence of additive gene effects which indicated the effectiveness of selection for these traits. Presence of high heritability coupled with low genetic advance over mean for days to first flowering and days to 50 per cent flowering that straight selection has limited scope for further improving these traits.

Keywords: Okra, heritability, genotypic coefficient of variation, phenotypic coefficient of variation. Genetic advance over mean

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench] also known as lady's finger which is an important spring - summer and rainy season vegetable cultivated in tropical and sub-tropical parts of the world. India is the largest producer of okra in the world with an annual production of 5.85 million tonnes from an area of 0.50 million hectare with a productivity of 11.53 tonnes per hectare (Anon., 2016) [3]. Exploitation of variability is of a great importance and prerequisite for the effective screening of superior genotypes. Magnitude and nature of genetic variability determined the progress of breeding for the economic characters and plays an important role in a crop in selecting the best genotypes for making rapid improvement in yield and other desirable characters, reported by Vavilov, N.I. 1926. Heritability is an index for calculating the relative influence of environment on expression of genotypes. It becomes very difficult to judge how much of the variability is heritable and how much is non heritable. Hence, it is essential to partition the overall variability into its heritable and non-heritable components with the help of genetic parameters like genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance. With the limited variability, the interested traits cannot possible to incorporate and the breeder will have to enrich the greater variability of genetic resources namely germplasm by hybridization, mutation, polyploidy breeding and also by several other breeding procedure (Kumaran *et al.*, 2000) [16]. Therefore, the present investigation was carried out to study the variability, heritability and genetic advance for twenty two quantitative traits in okra.

Material and Methods
The present study carried out at Kittur Rani Chennamma College of Horticulture, Arabhavi, and Karnataka during august 2016 with 65 genotypes. The genotypes were assessed in a field experiment under a randomized block design with two replications. 15 plants maintained in each treatment with spacing of 60 cm × 45cm between rows and plants, respectively. The data 90 DAS, number of were recorded on five randomly selected plants from each treatment for 22 Characters. Observations recorded on plant height (cm) at 45,60 and leaves per plant at 45,60 and 90 DAS, intermodal length (cm), number of branches per plant, number of nodes on main

stem, days to first flowering days to 50 per cent flowering, node at first flowering, fruit length (cm), fruit diameter(mm), average fruit weight (g), fruit yield per plant (g), fruit yield per plot (kg), fruit yield per hectare (t), number of ridges on fruit surface, number of seeds per fruit and vitamin C content (mg/100g). The mean values were subjected to statistical analysis (ANOVA) as suggested by Panse 1957. Phenotypic and genotypic co-efficient of variation (Burton and Dewane, 1953) [6], heritability and genetic advance as per cent mean (Johnson *et al.*, 1955) [14] were calculated.

Table 1: Analysis of variance (ANOVA) for growth, earliness, yield and quality parameters in okra (*Abelmoschus esculentus* (L). Moench)

Sl. No.	Source of variation / characters	Replication	Genotypes (Treatment)	Error	CD (5%)	CD (1%)
	Degrees of freedom	1	64	64		
A.	**Growth parameters**					
1.	Plant height (cm) 45 DAS	152.06	205.86**	57.10	15.09	20.06
2.	Plant height (cm) 60 DAS	58.22	798.58**	314.82	35.44	47.10
3.	Plant height (cm) 90 DAS	1255.50	805.51**	111.70	21.11	28.05
4.	Number of leaves per plant at 45 DAS	7.20	3.83**	1.66	2.57	3.4
5.	Number of leaves per plant 60 DAS	3.79	6.12**	3.22	3.58	4.76
6.	Number of leaves per plant 90 DAS	0.16	7.03NS	5.24	4.57	6.07
7.	Internodal length (cm) 60 DAS	0.73	3.24**	0.50	1.41	1.87
8.	Number of branches per plant	0.22	0.40**	0.17	0.84	1.11
9.	Number of nodes on main stem	50.05	2.19**	0.86	1.86	2.47
B.	**Earliness parameters**					
10.	Days to first flowering	1.50	8.36**	1.64	2.56	3.40
11.	Days to 50 per cent flowering	8.37	8.68**	2.33	3.04	4.05
12.	Node at first flowering	0.01	0.29*	0.06	0.50	0.66

Table 1: Contd...

Sl. No.	Source of variation / characters	Replication	Genotypes (Treatment)	Error	CD (5%)	CD (1%)
C.	**Yield parameters**					
13.	Fruit length (cm)	18.91	3.37**	1.25	2.23	2.97
14.	Fruit diameter (mm)	10.49	2.37**	1.18	2.17	2.88
15.	Average fruit weight (g)	34.01	14.56**	7.63	5.52	7.33
16.	Number of fruits per plant	1.86	4.47**	2.13	2.91	3.87
17.	Fruit yield per plant (g)	4692.00	4119.17**	1499.02	77.34	102.78
18.	Fruit yield per plot (kg)	1.45	0.37**	0.07	0.52	0.70
19.	Fruit yield per hectare (tonnes)	21.98	5.13**	1.02	2.02	2.69
D.	**Quality parameters**					
20.	Number of ridges on fruit surface	0.71	0.60**	0.11	0.68	0.90
21.	Number of seeds per fruit	1.12	131.30**	53.17	14.56	19.36
22.	Vitamin C (mg/100)	1.11	26.24**	0.21	0.92	1.23

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

Table 2: Estimates of mean, range, components of variance, heritability and genetic advance for growth, earliness, yield and quality parameters in okra (*Abelmoschus esculentus* (L.) Moench)

Sl. No.	Character	Range	Mean	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
A.	**Growth parameters**									
1.	Plant height (cm) at 45 DAS	30.40-83.50	60.36	74.37	131.48	14.28	18.99	56.57	13.36	22.13
2.	Plant height (cm) at 60 DAS	51.40-144.90	108.33	241.88	556.70	14.35	21.78	43.45	21.11	19.49
3.	Plant height (cm) at 90 DAS	83.55-166.70	125.50	346.90	458.61	14.84	17.06	75.64	33.37	26.58
4.	Number of leaves per plant at 45 DAS	9.10-15.10	11.58	1.08	2.74	8.98	14.31	39.40	1.34	11.61
5.	Number of leaves per plant at 60 DAS	11.50-20.90	15.75	1.45	4.67	7.64	13.72	31.08	1.38	8.78
6.	Number of leaves per plant at 90 DAS	17.20-26.20	21.11	0.89	6.13	4.48	11.73	14.59	0.74	3.52
7.	Internodal length (cm) 60 DAS	5.40-12.80	7.64	1.37	1.87	15.32	17.90	73.30	2.06	27.03
8.	Number of branches per plant	1.00-3.60	1.86	0.11	0.29	18.13	28.95	39.25	0.43	23.41
9.	Number of nodes on main stem	8.00-12.62	10.61	0.66	1.53	7.66	11.66	43.25	1.10	10.38
B.	**Earliness parameters**									
10.	Days to first flowering	38.50-47.50	42.44	3.35	5.00	4.31	5.27	67.07	3.09	7.28
11.	Days to 50 per cent flowering	43.00-54.00	45.63	4.04	6.71	4.41	5.68	60.22	3.21	7.04
12.	Node at first flowering	2.00-3.50	2.84	0.11	0.18	11.90	14.80	64.67	0.56	19.72

Table 2: contd.…..

Sl. No.	Character	Range	Mean	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
C.	**Yield parameters**									
13.	Fruit length (cm)	6.93-12.89	10.03	1.05	2.31	10.25	15.15	45.81	1.14	14.30
14.	Fruit diameter (mm)	12.80-17.92	15.62	0.59	1.77	4.94	8.53	33.59	0.92	5.90
15.	Average fruit weight (g)	8.10-18.40	12.91	3.46	11.09	14.40	25.78	31.19	2.14	16.57
16.	Number of fruits per plant	4.80-12.60	9.42	1.16	3.30	11.47	19.28	35.42	1.32	14.06
17.	Fruit yield per plant (g)	104.50-291.10	197.25	1310.07	2809.10	18.34	26.89	46.64	50.91	25.81

18.	Fruit yield per plot (kg)	0.90-3.55	1.79	0.15	0.22	21.62	26.16	68.32	0.66	36.82
19	Fruit yield per hectare (t)	3.33-13.14	6.64	2.05	3.08	21.58	26.43	66.66	2.41	36.29
D.	**Quality parameters**									
20.	Number of ridges on fruit surface	5.00-8.50	5.31	0.24	0.36	9.29	11.31	67.53	0.83	15.73
21.	Number of seeds per fruit	22.45-64.40	44.32	39.06	92.24	14.09	21.66	42.35	8.37	18.90
22.	Vitamin C (mg/100g)	8.41-26.21	13.50	13.01	13.23	26.70	26.92	98.37	7.37	54.56

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

Results and Discussion

Analysis of variance revealed the significant differences among the genotypes used in the present investigation for all the characters studied except number of leaves per plant at 90 DAS appears and rest of the traits indicated wide spectrum of variation among the genotypes presented in Table-1. A wide range of variation was recorded for all the characters suggesting presence of high genetic variability.

The extent of variability present in the okra genotypes was measured for various traits in terms of mean, range, phenotypic coefficient of variation (PCV), genetic coefficient of variation (GCV), heritability (broad sense), genetic advance and genetic advance as percent of mean are given in (Table-2). Among the twenty two traits showed a range of GCV for various characters varied from 4.31 (Days to first flowering) to 26.70 (vitamin C content). The GCV and PCV values were found to be very distant to each other for most of the characters suggesting the presence of large amount of variability.

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, Bendale *et al.* (2004) [5]; Mehta *et.al* (2006) [18] and Janaki *et al*. (2015) [12] in okra. 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 fruit yield per plot (21.62% and 26.16% respectively), fruit yield per hectare (21.58% and 26.43% respectively) and vitamin C content (26.70% and 26.92% 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 (4.31% and 5.27% respectively), days to fifty flowering (4.41% and 5.68% respectively) and fruit diameter (4.94% and 8.53% 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) [8]; Mehta *et al*. (2006) [18]; Bello *et al*. (2006) [4]; Qhereshi (2007); Sharma *et al*. (2007) [31]; Prakash and Pitchaimuthu (2010) [26]; Pradip *et al.* (2010) [25]; Jindal *et al.* (2010) [13]; Monpara and Chhaatrola (2010) [20]; Nwangburuka *et al.* (2012) [21]; Reddy *et al*. (2012) [29]; Ezhilrasi and Senthilkumar (2012) [9]; Das *et al*. (2012) [7]; Simon *et al.* (2013) [32]; Jagan *et al.* (2013) [11]; Kandasamy (2015) [15]; Mishra *et al.* (2015) [19] and Sanganamoni (2015) [30].

To determinate the amount of heritable variation estimates of GCV alone is not sufficient. Therefore heritable variation can be found out with the greater degree of accuracy when heritability is studied in conjuction with genetic advance. The value of heritability in broadsence for all characters ranged from 14.59% for number of leaves per plant at 90 DAS to 98.37% for vitamin C content. High heritability (>60 %) coupled with high genetic advance (>20 %) as per cent of mean was observed for plant height at 90 days after sowing (75.64% and 26.58% respectively), internodal length (73.30 %and 27.03%), fruit yield per plot (68.32% and 36.82%respectively), fruit yield per hectare (66.66% and 36.29% respectively) and vitamin C content (98.37% and 54.56% respectively). The high heritability indicated that the characters were less influenced by the environment and 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) [31]; Qhureshi (2007) [27]; Magar and Madrap (2009) Jindal *et al.* (2010) [13]; Adeoluwa and Kehinde (2011); Prakash and Pitchaimuthu (2010) [26]; Ramanjnappa *et al.* (2011) Adiger *et al.* (2011) [2]; Das *et al*. (2012) [7]; Reddy *et al*. (2012) [29]; Kandasamy (2015) [15]; Sanganamoni (2015) [30] and Phanikrishna *et al.* (2016) [24].

Moderate heritability (30-60 %) coupled with moderate genetic advance as per cent of mean (10-20%) was observed for plant height at 60 DAS (43.45% and 19.49 % respectively), number of leaves per plant at 45 DAS (39.40% and 11.61% respectively), number of nodes on main stem (43.25 %and 10.38% respectively), fruit length (45.81% and 14.30 %respectively), average fruit weight (31.19% and 16.57 % respectively), number of fruits per plant (35.42% and 14.06% respectively) and number of seeds per fruit (42.35% and 18.90% respectively). This indicates the characters are not heritable, influenced by environment and selection will not be effective for these traits. These same results were also observed by Gandhi *et al.* (2001); Mehta *et al*. (2006) [18]; Sharma *et al.* (2007) [31]; Osekita and Akinyele (2008) [22]; Monpara and Chhatrola (2010) [20]; Ezhilarasi and Senthilkumar (2012) [9]; Mishra *et al.* (2015) [19] and Phanikrishn *et al.* (2016) [24].

High genetic advance as per cent of mean (>20%) coupled with moderate heritability (30-60%) was observed for plant height at 45 DAS (22.13 % and 56.57 % respectively), number of branches per plant (23.41% and 39.25% respectively) and fruit yield per plant (25.81% and 46.64% respectively). This indicates the moderate heritability is being exhibited due to favorable influence of environment rather than genotypes where little progress would be achieved by applying direct selection pressure on these traits. The improvement in these traits would be more effective by simple selection. These results were confirmative with results obtained by Mehta *et al*. (2006) [18] and Sharma *et al.* (2007) [31]; Monpara and Chhtrola (2010) [20]; Ezhilarasi and Senthilkumar (2012) [9] and Phanikrishn *et al.* (2016) [24].

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