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Estimation of genotypic and phenotypic coefficient of variation, heritability and genetic advance in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract
The present investigation was carried out at Main Vegetable Research Station, Anand Agricultural University, Anand during *Kharif* 2017. The experimental material comprised of fifty diverse genotypes of okra collected from different eco-geographical area of the country. The genotypes were evaluated in Randomized Block Design (RBD) with three replications for fruit yield and yield attributing traits in okra. The analysis of variance revealed that mean sum of squares due to genotypes were found highly significant for all the traits under study indicated the existence of tremendous variability present in the experimental material for the characters. The high values of genotypic and phenotypic coefficients of variation were observed for number of branches per plant and chlorophyll content. The high heritability values coupled with high to moderate GCV and PCV as well as high genetic advance were exhibited by chlorophyll content, number of branches per plant, length of internodes, number of internodes on main stem, number of fruits per plant, plant height and fruit yield per plant suggested that preponderance of additive gene action. On the basis of *per se* performance, heritability and genetic advance as per cent of mean, the genotypes AOL-16-23, Parbhani Kranti, Arka Anamika, Kashi Vibhuti, AOL-10-22, Pusa Sawani, JOL-11-12, AOL-16-01 and AOL-16-03 can be used for development of pure line/ transgressive segregants, which would be effective for the improvement of these traits in okra.

Keywords: Okra, genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance

Introduction
Okra is polyploid, belongs to the family Malvaceae and often cross pollinated crop. There are significant variations (2n = 56 to 130) in the chromosome numbers of okra and at ploidy levels of different species in the genus *Abelmoschus*. The lowest number reported is 2n=56 for *Abelmoschus angulosus* (Ford, 1938) [9], whereas the highest chromosome number reported are close to 200 for *Abelmoschus manihot var. caillei* (Singh and Bhatnagar, 1975; Siemonsma, 1982) [18, 17]. Occurrence of outcrossing to an extent of 4-19 per cent with the maximum of 42.2 per cent is noticed with the insect assisted pollination. Tender green fruits are cooked in curry and soup, while crop has not adapted in India as leafy vegetable as in for East countries. According to Vavilov (1951) [20], it was probably domesticated in the Ethopian region but according to Murdock it is in West Africa.

Okra is known by many local names in different parts of the world. It is called lady's finger in England, Gumbo in U.S.A. and bhindi in India. Edible fresh and tender fruits contain 88 per cent moisture and large number of chemical components including vit. A 88 IU, B 63 IU and C 13 mg/100g. Immature okra fruit contain 3100 calorie energy, 1.8 g protein, 90 mg calcium and 1.0 mg iron (Aykroyd, 1941) [4]. Okra has Ayurvedic medicinal properties. Its leaves are used for preparing a medicament to reduce inflammation. It is an excellent source of Iodine for control of goitre (Chadha, 2001) [7].

In India, among fresh vegetables, 60 per cent share of export goes to okra. In India okra was grown in 501 thousand ha area with production of 5783 thousand MT and 11.54 tonnes productivity (Anonymous, 2017) [3]. In Gujarat, it was grown in 73.79 thousand ha area with production of 859.47 thousand MT during 2015-16 (Anonymous, 2016) [2].

A logical way to start any breeding programme is to survey the variation in the available material. Presence of genetic variability is unambiguously the most important prerequisite for

crop improvement programme. Selection is said to be effective in a population having large heritable variability. The genetic variability and its components are the genetic fractions of observed variability that provides measures of transmissibility of the variation and response to selection. The knowledge of pattern of inheritance of various characters are important consideration while determining the most appropriate breeding procedures applicable to any crop. The breeder's choice of the material for any improvement work consequently depends on the amount of genetic variability present. The phenotype is often not true indicator of its genotype. The phenotypic variability is the result of the effect of environment and genotype interaction.

Attempts have been made to determine the magnitude of heritable and non-heritable components and genetic parameters such as genotypic and phenotypic coefficient of variation, heritability and genetic advance as percentage of mean in some of the quantitative characters of okra.

Material and Methods

The experimental material for present study comprised 50 okra genotypes. The field experiment was conducted at Main Vegetable Research Station, Anand Agricultural University, Anand. The experiment materials were sown in Randomized Complete Block Design (RCBD) with three replications in field during *Kharif*- 2017. Each genotype was represented by single row of 4.5 m length with a spacing of 60 x 30 cm, inter and intra row, respectively. The data were recorded from five randomly selected plants from each entry in each replication for fruit yield per plant (g), plant height (cm), number of internodes on main stem, length of internodes (cm), number of branches per plant, days to first picking, number of fruits per plant, fruit length (cm), fruit girth (cm), fruit weight (g), chlorophyll content (mg/100g), moisture content (%) and mucilage (%). Whereas, days to 50 per cent flowering was recorded on plot basis. The mean of the data recorded were used for statistical analysis. The analysis of variance was calculated with the method suggested by Panse and Sukhatme, 1978 [15]. The genotypic and phenotypic coefficients of variation (GCV and PCV) were estimated as per Burton, 1952 [6], while classification of GCV and PCV were followed by Johnson *et al.*, (1955) [12], Heritability in the broad sense and genetic advance (GA), suggested by Allard, 1960 [1].

Results and Discussion

The analyses of variance revealed that mean square due to genotypes were found highly significant for all the traits under study. This is indicating that the existence of sufficient amount of genetic variability in the experimental materials thus, there may be a scope for improvement of these traits (Table 1). The estimates of genotypic and phenotypic variance were high for fruit yield per plant (723.55 and 1269.42) and plant height (132.30 and 171.73) (Table 3). The estimates of genotypic and phenotypic variances revealed that more contribution of genotypic variance to the total variance was observed for these traits.

A wide range of genotypic coefficient of variation varied from 1.93% for days to 50% flowering to 29.42% for number of branches per plant and phenotypic coefficient of variation varied from 2.68% for Days to first picking to 30.19% for number of branches per plant. High GCV and PCV were noted for number of branches per plant and chlorophyll content. The findings are in close harmony with the result of Goswami *et al.* (2012) [10], Jagan *et al.* (2013) [11], Chandra *et al.* (2014) [8] and, Bello and Aminu (2017) [5] for number of primary branches. The high values of GCV and PCV suggested greater genotypic variability among the genotypes and responsiveness of the attributes for making further improvement by selection. Days to 50% flowering, days to first picking, fruit length (cm), fruit girth (cm), moisture content (%) and mucilage (%) showed low genotypic coefficient of variation. Low GCV and PCV for days to 50% flowering, days to first picking and fruit girth was reported by Goswami *et al.* (2012) [10] and Jagan *et al.* (2013) [11]. Low GCV and PCV for days to 50% flowering and days to first picking were also reported by Chandra *et al.* (2014) [8].

The rest of the characters such as plant height, number of internodes on main stem, length of internodes, number of fruits per plant, fruit weight and fruit yield per plant exhibited moderate genotypic and phenotypic coefficient of variation. The findings are similar with Jagan *et al.* (2013) [11] for characters like plant height (cm), length of internodes (cm), number of fruits per plant, fruit weight and fruit yield per plant (g).

High estimates of heritability were obtained for characters *viz*., chlorophyll content (95.10%), number of branches per plant (95.00%), length of internodes (93.90%), number of internodes on main stem (84.10%), number of fruits per plant (79.00%), plant height (77.10%) and fruit lengh (62.70%). Higher values of heritability (broad sense) of these characters expressed that they were less influenced by the environmental factors. High heritability for plant height, fruit length and number of fruits per plant were in close harmony to those Kumar *et al.* (2016) [14] and, Bello and Aminu (2017) [5].

High heritability along with high genetic advance as percent of mean was observed for number of internodes on main stem, number of branches per plant, chlorophyll content (mg/100 gm), length of internodes, number of fruits per plant, plant height and fruit yield per plant, indicating the preponderance of additive gene action and hence simple selection would be more effective for improvement of these characters. The findings are in concordance with the reports of Goswami *et al.* (2012) [10] for number of internodes per plant, Jagan *et al.* (2013) [11] and Kandasamy (2015) [13] reported for number of branches per plant; Kumar *et al.* (2016) [14] reported similar results for fruit yield per plant, number of fruits per plant and plant height; Shrihari *et al.* (2016) [16] reported for number of branches, number of fruits per plant and internodal length; Singh *et al.* (2017) [19] observed similar results for plant height, number of fruits per plant and internodal length.

On the basis of above findings it can be concluded that on the basis of *per se* performance the genotypes AOL-16-23, Parbhani Kranti, Arka Anamika, Kashi Vibhuti, AOL-10-22, Pusa Sawani, JOL-11-12, AOL-16-01 and AOL-16-03 can be further tested and utilized in the future breeding programme for development of high yielding varieties/hybrids in okra.

Table 1: Analysis of variance (ANOVA) showing mean sum square for different characters in okra

Sr. No.	Source	Replications	Genotypes	Error
	d.f.	2	49	98
1	Days to 50% flowering	4.19	4.07**	1.84
2	Plant height	49.69	436.30**	39.34
3	Number of internodes on main stem	0.79	11.62**	0.69
4	Length of internodes	0.04	1.69**	0.04
5	No. of branches per plant	0.05	1.58**	0.03
6	Days to first picking	2.46	4.59**	0.88
7	Fruit length	3.45	6.34**	1.05
8	Fruit girth	0.12	0.22**	0.06
9	Fruit weight	7.30	10.41**	2.77
10	No. of fruits per plant	0.83	6.80**	0.55
11	Fruit yield per plant	1008.40	2716.84**	545.68
12	Chlorophyll content	0.55	10.61**	0.18
13	Moisture content	8.48	25.68**	9.29
14	Mucilage	4.50	10.97**	2.85
*, ** Significant at 0.05 and 0.01 level of probability, respectively.				

Table 2: Mean performance and range of genotypes for different characters in okra

	Days to 50% flowering	Plant height (cm)	Number of internodes on main stem	Length of internodes (cm)	Number of branches per plant	Days to first picking	Fruit length (cm)
Minimum	41.95 (AOL-16-06)	64.6 (Kashi Vibhuti)	8.33 (AOL-13-73)	4.24 (JF-108-02)	1.47 (Phule Utkarsh)	52 (Arka Anamika)	10.88 (AOL-16-22)
Maximum	47.05 (JDNOL-11-9)	135.00 (Parbhani Kranti)	15.33 (Parbhani Kranti)	7.04 (AOL-16-06)	3.67 (AOL-16-11)	57 (JDNOL-11-9)	15.88 (AOL-16-06)
Mean	0.78	91.58	11.88	5.65	2.45	54.16	13.60
S.Em. ±	2.20	3.62	0.48	0.11	0.095	0.54	0.59
C.D. at (5%)	2.20	10.13	1.34	0.31	0.27	1.52	1.65
C.V. (%)	3.05	6.85	6.97	3.34	6.75	1.74	7.52

	Fruit girth (cm)	Fruit weight (cm)	Number of fruits per plant	Fruit yield per plant (g)	Chlorophyll content (mg/100g)	Moisture content (%)	Mucilage (%)
Minimum	5.15 (AOL-16-22)	10.7 (AOL-13-112)	7.50 (AOL-13-144)	107.59 (AOL-13-144)	4.96 (Red one long)	72.34 (JDNOL-11-2)	20.9 (Kashi Vibhuti)
Maximum	6.40 (GO-2)	18.7 (Arka Anamika)	13.47 (AOL-16-11)	246.69 (AOL-16-23)	11.74 (AOL-16-13)	87.44 (Arka Anamika)	28.4 (Varsha Upahar)
Mean	5.92	15.58	11.21	186.54	8.72	78.06	25.04
S.Em. ±	0.14	0.96	0.43	13.49	0.24	1.76	0.97
C.D. at (5%)	0.40	2.69	1.20	37.74	0.69	4.93	2.73
C.V. (%)	4.21	10.69	6.63	12.52	4.87	3.91	6.74

Table 3: Variability parameters for different characters in okra.

Sr. No.	Character	σ^2g	σ^2p	GCV (%)	PCV (%)	H^2_b (%)	GA	GA (% of mean)
1.	Days to 50% flowering	0.74	2.59	1.93	3.61	28.60	0.95	2.13
2.	Plant height	132.30	171.73	12.56	14.31	77.10	20.8	22.71
3.	No. of internodes on main stem	3.64	4.33	16.06	17.51	84.10	3.61	30.38
4.	Length of internodes	0.55	0.59	13.13	13.55	93.90	1.48	26.19
5.	No. of branches per plant	0.52	0.55	29.42	30.19	95.00	1.45	59.23
6.	Days to first picking	1.24	2.11	2.06	2.68	59.20	1.77	3.27
7.	Fruit length	1.76	2.81	9.76	12.33	62.70	2.17	15.95
8.	Fruit girth	0.05	0.12	3.91	5.75	46.40	0.33	5.57
9.	Fruit weight	2.54	5.32	10.24	14.80	47.90	2.28	14.63
10.	No. of fruits per plant	2.08	2.63	12.88	14.48	79.00	2.64	23.56
11.	Fruit yield per plant	723.55	1269.42	14.42	19.10	57.00	41.85	22.43
12.	Chlorophyll content	3.48	3.66	21.40	21.94	95.10	3.75	43.03
13.	Moisture content	5.45	14.75	2.99	4.92	37.00	2.93	3.75
14.	Mucilage	2.71	5.55	6.57	9.41	48.70	2.37	9.46
Where, σ^2g = Genotypic variance, σ^2p = Phenotypic variance, GCV % = Genotypic coefficient of variation, PCV % = Phenotypic coefficient of variation, H^2_b = Broad sense heritability, GA = Genetic Advance and GA (% of mean) = Genetic advance expressed as per cent of mean.								

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