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Variability studies in Okra (*Abelmoschus esculentus* L. Moench)

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Abstract
Sixty genotypes of okra were evaluated in one location for two years at Chatha, Jammu during 2009-10 and 2010-11. The objective was to study the genetic variability between various economically important traits for the purpose of genetic improvement. The estimates of phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation for all the characters indicating the less environment influences. The results showed variation in all genotypes and characters. Characters such as seed yield per plant and number of fruits per plant showed high genotypic coefficient of variation, heritability and genetic advance which indicates that selection of these characters

Key words: Variability, Okra, Heritability, Genetic advance, genotypes

Introduction

Okra (Bhindi) **(*Abelmoschus esculentus* L. Moench)** is one of the most widely grown vegetable from tropical to sub-tropical parts of the world. The green, tender and immature fruits are consumed as vegetables. Besides this the mature fruits are used in paper industry and purifying cane juice in Gur making (Chauhan, 1972).The seeds of okra are consumed as substitute for coffee in many parts of Africa (NRC, 2006). It is good for people suffering from renal colic, leucorrhea and general weakness. Leaves of okra are used in Turkey for preparation of medicine to reduce inflammation (Mehta, 1959). It is a very nutritious vegetable, rich in vitamins, calcium, potassium and other mineral matters (Aykroyd, 1963). There is always high demand for a suitable variety with respect to yield and other quality parameters which is to be achieved by adopting proper breeding techniques for the recognition of the genotypes and quantitative assessment of population for the yield and its contributing characters. Any breeding programme depends upon the extent of genetic variability present in the population (Singh *et al*., 2002).improvement of any character depends on the magnitude of variability present in the population. The desirable variability provides valuable information regarding selection of diverse parents to be used in hybridization programme. Estimates of heritability can serve to identify the factors which can be used as indicators for high yield during selection. Keeping these things in view, the study was planned to assess genetic variability with heritability and genetic advance so as to select superior genotypes for the further improvement in crop.

Material and Methods

The experimental material for the present study consisted of sixty genotypes collected from SKUAST-J, Jammu. The genotypes were evaluated through in Randomized Block Design (RBD) with three replication under sub-tropical conditions of Jammu at experimental farm, Division of Vegetable Science and Floriculture,SKUAST-J, main campus, Chatha, Jammu (J&K). Each genotype was sown at spacing of 60 x45 cm in individual plot with three replication. All recommended package of practices was followed for raising a healthy crop. The observations were recorded as per NBPGR minimal descriptors from randomly selected five competitive plants in each plot and replication on twenty one parameters *viz.*, Sepal size (mm^2), Petal size($mm^{2)}$, Flower circumference (cm), Mature bud length (cm), Carpel length (cm), Pollen fertility count (%), pedicel length (cm), Fruit length at marketable stage (cm), Fruit width at marketable stage (cm), Number of ridges per fruit, Fruit length at mature stage (cm), Number of fruits per plant, Fresh fruit weight (g), Length of beak (cm), Dry fruit weight (g), Fruit colour, Number of seeds per fruit, Seed weight per fruit (g), Shelling percentage (%), 100 seed weight (g) and Seed yield per plant (g). The mean values were subjected to statical analysis (ANOVA) as suggested by Panse and Sukatme, (1967). Phenotypic and genotypic coefficient of variation (Burton and De-Vane, 1953), heritability and genetic advance (Allard, 1960).

Results And Discussion

The mean sum of square was significant for all the characters except for mature bud length and number of ridges per fruit during 2009-10 and 2010-11(Table 1.a., Table1.b., Table1.c.) while number of ridges per fruit and length of beak in pooled analysis, indicating the presence of substantial amount of variability in the material under study. It implies that this population of okra genotypes would respond positively to selection. Similar results were observed by earlier workers *viz.*, Shukla et al (1989), Chowdhary et al. (1991) and Chauhan and Singh, (2002), indicating large amount of variability in Okra. However, selection based on characters which shows no significant difference in their mean values will bring no progress.

The study indicates the presence of wide variability in the present genotypes of okra (Table 2.a.). Seed yield per plant showed a wide range (51.81g – 226.44 g), minimum and maximum seed yield was recorded in JBS-9 and MO-15 with general mean of 109.87 g followed by Petal size (50.53 – 139.16 $mm^{2)}$ with over all mean of 90.67 mm^2; Sepal size (48.49 – 103.54 mm^2 with over all general mean of 74.10 mm^2; Number of fruits per plant (17.67 - 51.40 mm^2) with over all general mean of 31.12 mm^2 ; Number of seed per fruit (37.40 – 69.73 mm^2) with general mean of 53.26 mm^2 and other characters also showed good range of variability in the year 2009-10. Seed yield per plant during the year 2010-11 was varied from 50.56 g in JBS – 9 to 232.35g in genotype 205-1-4 with overall general mean of 110.64 followed by petal size (53.33 – 122.33 mm^2) with general mean of 88.38 mm^2; Sepal size (48.13 – 95.27 mm^2) wit over all general mean of 71.51 $mm^{2;}$ Number of fruits per plant (177.33 – 61.00) with general mean of 31.44 and other characters also showed their part in variability. While in pooled analysis, seed yield per plant was varied from 51.19g in JBS – 9 to 228.20g in genotype 205-1-4 with over all mean of 110.26g followed by petal size (51.93 – 129.28 mm^2) with general mean of 89.53 mm^2; pollen fertility count (28.92 – 84.42%) with general mean of 39.44 %; sepal size (48.46 – 99.41 mm^2) with over all general mean of 72.81 mm^2 and other characters also showed their role in variability.

In general the phenotypic coefficient of variability were higher in magnitude than genotypic ones for all the characters under study (Table 2.a., Table 2.b., Table 2.c.), indicating that there is considerable effects of environment on their expression. In present investigation, the phenotypic and genotypic coefficient of variability were found to be high for seed yield per plant (37.26 % and 36.60 %) in the year 2009-10 (Table 2.a.), seed yield per plant (38.55 % and 37.47 %) and number of fruits per plant (31.10 % and 30.61 %) in the year 2010-11 (Table 2.b.), and seed yield per plant (37.32 % and 37.29 %) in pooled analysis (Table 2.c.). Moderate phenotypic and genotypic coefficient of variability wasobserved for number of fruits per plant (29.45 %and 28.99 %); petal size (23.87 % and 20.48 %) and fresh fruit weight (20.73 % and 20.34 % in the year 2009-10 (Table 2.a.), petal size (24.21 % and 15.21 %); sepal size (21.31 % and 11.43 %) and fresh fruit weight (21.08 % and 20.53 %) in 2010-11(Table 2.b.) and number of fruits per plant (29.12 % and 29.09 %); pollen fertility count (24.83 % and 19.99 %); fresh fruit weight (20.59 % and 20.56 %) and petal size (20.17 % and 19.84 %) in pooled analysis (Table 2.c.). For rest of the characters low phenotypic and genotypic coefficient of variability were observed in 2009-10, 2010-11 and pooled analysis respectively.

Burton, (1952) has suggested that GCV together with heritability estimates would give the best option expected for selection. In present investigation, heritability in broad sense varied from 4.1% (number of ridges per fruit) to 99.2 % (number of seeds per fruit) in 2009-10 (Table 2.a.), 3.5 % (number of ridges per fruit) to 97.6 % (fruit length at marketable stage) in 2010-11(Table 2.b.) and 5.5 % (number of ridges per fruit) to 99.9 % (pedicel length) in pooled analysis (Table 2.c.). It was found to be high for almost all the characters except for flower circumference, mature bud length and number of ridges per fruit in the year 2009-10, petal size, flower circumference, sepal size , mature bud length and number of ridges per fruit 2010-11 where as in pooled analysis number of ridges per fruit have low heritability. Similar results have been reported by Singh and Singh (2004), Bello *et al*. (2006) and Sharma *et al*. (2007).

The estimates of heritability along with genetic advance are more reliable than heritability alone for predicting the effects of selection, Johnson *et al*. (1955). These estimates were quite high for seed yield $plant^{-1}$ and number of fruits $plant^{-1}$ during the year 2009-10, 2010-2011 and pooled analysis, Suggesting that additive genes play role in the inheritance of these characters, therefore, these characters are amendable to selection and would produce desirable variety, whereas high heritability accomplished with moderate genetic advance were recorded for petal size, fresh fruit weight, dry fruit weight and seed weight $fruit^{-1}$ during 2009-10; fresh fruit weight, dry fruit weight and seed weight

fruit^{-1} in 2010-2011 and sepal size, petal size, length of beak, dry fruit weight and number of seeds fruit^{-1} in pooled analysis. The results are in agreement with the findings of Pal *et al.* (2009), Pradip *et al.* (2010), Dhall *et al*. (2000). Hence the improvement in the characters like seed yields plant^{-1} and numbers of fruits plant-1 are possible through simple selection.

Conclusion

From the results obtained it was concluded that genetic variation existed among the genotypes in all characters. The characters such as seed yield per plant, number of fruits per plant, petal size, fresh fruit weight and dry fruit weight showed high genotypic coefficient of variation, heritability and genetic advance, indicating that selection of these characters will show a positive response in crop improvement.

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Table 1a: Analysis of variance for various characters in okra (2009-10)

Sources of variation	df	(1) Sepal size (mm^2)	(2) Petal Size (mm^2)	(3) Flower Circumference (cm)	(4) Mature bud length (cm)	(5) Carpel length (cm)	(6) Pollen fertility count(%)	(7) Pedicel length (cm)	(8) Fruit length at marketable stage (cm)	(9) Fruit width at marketable stage(cm)
Replication	2	1659.00	1832.375	76.223	1.318	0.008	156.390	0.005	0.069	0.018
Genotype	59	497.432*	1158.343*	10.180*	0.142 NS	0.108*	103.965*	0.234*	8.757*	0.062*
Error	118	73.523	123.617	3.583	0.121	0.003	5.892	0.004	0.033	0.001

*Significant at 5% level ** Significant at 1% level

Table 1a: Analysis of variance for various characters in okra (2009-10)

Sources of variation	(10) No. of ridges per fruit	(11) Fruit length at mature stage (cm)	(12) Number of fruits per plant	(13) Fresh fruit weight (g)	(14) Length of beak (cm)	(15) Dry fruit weight (g)	(16) No. of seeds per fruit	(17) Seed weight per fruit (g)	(18) Shelling percentage (%)	(19) 100 seed weight (g)	(20) Seed yield per plant (g)
Replication	3.772	27.764	0.313	11.584	0.982	0.024	230.063	0.774	163.172	0.181	840.125
Genotype	0.821NS	19.293*	246. 82*	35.043*	0.522*	4.466*	172.477*	0.968*	96.156*	0.796*	4909.839*
Error	1.060	0.117	2.594	0.443	0.031	0.076	0.478	0.025	13.888	0.036	59.053

Table 1b: Analysis of variance for various characters in okra (2010-11)

Sources of variation	df	(1) Sepal size (mm^2)	(2) Petal Size (mm^2)	(3) Flower Circumference (cm)	(4) Mature bud length (cm)	(5) Carpel length (cm)	(6) Pollen fertility count (%)	(7) Pedicel length (cm)	(8) Fruit length at marketable stage (cm)	(9) Fruit width at marketable stage (cm)
Replication	2	3732.594	4131.000	69.143	1.237	0.002	35.375	0.000	0.040	0.019
Genotype	59	365.802	819.267	10.978	0.150	0.115	107.748	0.240	9.122	0.063
Error	118	165.429	277.156	4.245	0.145	0.009	9.529	0.005	0.073	0.002

Table 1b: Analysis of variance for various characters in okra (2010-11)

Sources of variation	(10) No. of ridges per fruit	(11) Fruit length at mature stage (cm)	(12) Number of fruits per plant	(13) Fresh fruit weight (g)	(14) Length of beak (cm)	(15) Dry fruit weight (g)	(16) No. of seeds per fruit	(17) Seed weight per fruit (g)	(18) Shelling percentage (%)	(19) 100 seed weight (g)	(20) Seed yield per plant (g)
Replication	6.450	35.309	0.273	8.303	0.327	0.046	237.250	1.025	288.406	0.304	1312.750
Genotype	0.822	13.909	280.974	36.843	0.261	4.333	175.499	0.941	106.132	0.972	5262.887
Error	0.908	0.290	2.985	0.650	0.038	0.160	3.748	0.047	24.306	0.535	100.253

Table 1c: Analysis of variance for various characters in okra (Pooled)

Sources of variation	df	(1) Sepal size (mm^2)	(2) Petal Size (mm^2)	(3) Flower Circumference (cm)	(4) Mature bud length (cm)	(5) Carpel length (cm)	(6) Pollen fertility count (%)	(7) Pedicel length (cm)	(8) Fruit length at marketable stage (cm)	(9) Fruit width at marketable stage (cm)
Replication	2	101.344	78.500	0.021	0.001	0.001	22.250	0.001	0.025	0.001
Genotype	59	414.194*	956.723*	10.488*	0.143*	0.111*	208.063*	0.237*	8.921*	0.062*
Error	118	5.806	10.696	0.030	0.001	0.001	39.801	0.001	0.006	0.001

Table 1c: Analysis of variance for various characters in okra (Pooled)

Sources of variation	(10) No. of ridges per fruit	(11) Fruit length at mature stage (cm)	(12) Number of fruits per plant	(13) Fresh fruit weight (g)	(14) Length of beak (cm)	(15) Dry fruit weight (g)	(16) No. of seeds per fruit	(17) Seed weight per fruit (g)	(18) Shelling percentage (%)	(19) 100 seed weight (g)	(20) Seed yield per plant (g)
Replication	1.372	0.012	0.102	0.736	0.866	0.020	0.734	0.001	2.063	0.006	9.125
Genotype	0.853 NS	14.741*	246.651	35.835*	0.355 NS	4.389*	173.668*	0.949*	99.723*	0.876*	50.73.667
Error	1.005	0.034	0.173	0.036	0.123	0.003	0.108	0.002	0.473	0.003	3.226

Table 2.a. Estimates of genetic variability parameters for various characters in okra genotypes (2009-10)

Characters	Mean ± SE	Range	Coefficient of variation (%)		Heritability % (Broad sense)	Genetic Advance	Genetic Advance as % age of mean
			PCV	GCV			
Sepal size (mm^2)	74.10 ± 7.00	48.79 - 103.54	19.78	16.04	65.8	19.86	26.80
Petal Size(mm^2)	90.67 ± 9.07	50.53 - 139.16	23.87	20.48	73.6	32.82	36.20
Flower circumference(cm)	15.25 ± 1.54	11.45 - 20.70	15.77	9.72	38.0	1.88	12.33
Mature bud length(cm)	3.45 ± 0.28	2.89 - 3.87	10.37	2.42	05.5	0.80	23.18
Carpel length(cm)	2.77 ± 0.004	2.39 - 3.10	7.01	6.75	92.5	0.37	13.35
Pollen fertility count (%)	48.43 ± 1.98	39.07 - 60.77	12.83	11.81	84.7	10.84	22.38
Pedicel length(cm)	2.13 ± 0.05	1.64 - 2.85	13.30	12.99	95.5	0.56	26.29
Fruit length at marketable stage(cm)	12.67 ± 0.14	9.29 - 17.77	13.54	13.46	98.9	3.49	27.55
Fruit width at marketable stage(cm)	1.75 ± 0.03	1.44 - 2.10	8.36	8.10	93.8	0.28	16.00
Number of ridges per fruit	5.22 ± 0.84	5.00 - 7.00	19.73	0.61	04.1	1.20	22.99
Fruit length at mature stage(cm)	17.23 ± 0.27	13.13 - 26.60	14.81	14.68	98.2	5.16	29.95
Number of fruits per plant	31.12 ± 1.31	17.67 - 51.40	29.45	28.99	96.9	18.30	58.82
Fresh fruit weight (g)	16.69 ± 0.54	8.07 - 25.87	20.73	20.34	96.3	6.87	41.16
Length of beak(cm)	3.29 ± 0.14	2.00 - 3.90	13.41	12.29	83.9	0.76	23.10
Dry fruit weight (g)	6.57 ± 0.22	4.13 - 11.13	18.88	18.40	95.1	2.43	36.99
Number of seeds per fruit	53.26 ± 0.57	37.40 - 69.73	14.28	14.22	99.2	15.53	29.16
Seed weight per fruit (g)	3.45 ± 0.13	2.40 - 5.00	16.82	16.18	92.6	1.11	31.99
Shelling percentage (%)	53.23 ± 3.04	39.82 - 68.16	12.08	9.84	66.4	8.79	16.51
100 seed weight (g)	5.99 ± 0.16	5.00 - 7.40	8.98	8.40	87.5	0.97	16.19
Seed yield per plant (g)	109.87 ± 6.27	51.81 - 226.44	37.26	36.60	96.5	81.36	74.05

Table 2.b. Estimates of genetic variability parameters for various characters in okra genotypes (2010-11)

Characters	Mean ± SE	Range	Coefficient of variation (%)		Heritability % (Broad sense)	Genetic Advance	Genetic Advance as % age of mean
			PCV	GCV			
Sepal size (mm^2)	71.51±10.50	48.13-95.27	21.31	11.43	28.9	9.03	12.62
Petal Size(mm^2)	88.38±13.59	53.33-122.33	24.21	15.21	39.5	17.40	19.69
Flower circumference(cm)	15.21±1.68	11.50-20.80	16.75	9.85	34.6	1.81	11.90
Mature bud length(cm)	3.45±0.31	2.87-3.92	11.10	1.27	06.5	0.90	26.08
Carpel length(cm)	2.77±0.05	2.37-3.16	7.59	6.81	80.5	0.35	12.64
Pollen fertility count (%)	48.82±2.52	38.77-60.50	13.31	11.72	77.5	10.37	21.24
Pedicel length(cm)	2.14±0.06	1.66-2.86	13.48	13.08	94.2	0.56	26.16
Fruit length at marketable stage(cm)	12.71±0.22	9.02-17.86	13.83	13.66	97.6	3.53	27.77
Fruit width at marketable stage(cm)	1.76±0.03	1.44-2.08	8.45	8.09	91.7	0.28	15.91
Number of ridges per fruit	5.21±0.78	5.00-7.00	18.27	0.61	03.5	0.50	9.59
Fruit length at mature stage(cm)	17.10±0.43	13.25-22.08	12.84	12.45	94.0	4.26	24.91
Number of fruits per plant	31.44±1.41	17.33-61.00	31.10	30.61	96.9	19.52	62.09
Fresh fruit weight (g)	16.91±0.66	8.00-25.67	21.08	20.53	94.9	6.97	41.23
Length of beak(cm)	3.53±0.16	2.32-3.87	9.50	7.72	66.0	0.46	13.03
Dry fruit weight (g)	6.54±0.33	4.00-11.00	19.05	18.04	89.7	2.30	35.17
Number of seeds per fruit	53.49±1.58	37.67-70.17	14.60	14.15	93.9	15.10	28.23
Seed weight per fruit (g)	3.46±0.18	2.33-5.00	16.96	15.76	86.3	1.04	30.06
Shelling percentage (%)	53.60±4.03	37.45-67.68	13.40	9.74	52.9	7.82	14.59
100 seed weight (g)	6.01±0.19	4.83-7.50	9.98	9.20	85.1	1.05	17.47
Seed yield per plant (g)	110.64±8.18	50.56-232.35	38.55	37.47	94.5	83.02	75.04

Table 2.c. Estimates of genetic parameters for various characters in okra genotypes (Pooled)

Characters	Mean ± SE	Range	Coefficient of variation (%)		Heritability % (Broad sense)	Genetic Advance	Genetic Advance as % age of mean
			PCV	GCV			
Sepal size (mm^2)	72.81 ± 1.97	48.46 – 99.41	16.36	16.03	95.9	23.54	32.33
Petal Size(mm^2)	89.53 ± 2.67	51.93 – 129.28	20.17	19.84	96.7	35.98	40.19
Flower circumference(cm)	15.23 ± 0.14	11.48 – 20.75	12.31	12.26	99.1	3.83	25.15
Mature bud length(cm)	3.45 ± 0.03	2.88 – 3.88	6.38	6.31	97.8	0.44	12.75
Carpel length(cm)	2.77 ± 0.03	2.39 – 3.13	6.95	6.93	99.3	0.39	14.08
Pollen fertility count	39.44 ± 5.15	28.92 – 84.42	24.83	19.99	58.5	11.80	29.92
Pedicel length(cm)	2.14 ± 0.00	1.73 – 2.85	13.15	13.14	99.9	0.58	27.10
Fruit length at marketable stage(cm)	12.69 ± 0.06	9.15 – 17.82	13.60	13.58	99.8	3.55	27.97
Fruit width at marketable stage(cm)	1.75 ± 0.00	1.44 – 2.09	8.20	8.18	99.7	0.30	17.14
Number of ridges per fruit	5.23 ± 0.89	5.00 – 7.00	19.19	0.60	05.5	0.50	9.56
Fruit length at mature stage(cm)	17.13 ± 0.15	13.23 – 22.76	12.97	12.93	99.3	4.55	26.56
Number of fruits per plant	31.16 ± 0.34	17.50 – 49.88	29.12	29.09	99.8	18.65	59.85
Fresh fruit weight (g)	16.80 ± 0.15	8.03 – 25.77	20.59	20.56	99.7	7.11	42.32
Length of beak(cm)	3.41 ± 0.09	2.16 – 3.82	10.42	9.91	90.3	0.66	19.35
Dry fruit weight (g)	6.55 ± 0.05	4.07 – 11.07	18.47	18.45	99.8	2.49	38.02
Number of seeds per fruit	53.37 ± 0.27	37.15 – 69.95	14.26	14.25	99.8	15.65	29.32
Seed weight per fruit (g)	3.46 ± 0.04	2.37 – 5.00	16.27	16.22	99.4	1.15	33.24
Shelling percentage (%)	53.41 ± 0.56	41.51 – 67.92	10.85	10.77	98.6	11.76	22.02
100 seed weight (g)	6.00 ± 0.04	4.92 – 7.45	9.03	8.99	99.0	1.11	18.50
Seed yield per plant (g)	110.26 ± 1.47	51.19 – 228.20	37.32	37.29	99.8	84.61	76.74