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MI Makhdoomi
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J & K, India

Kouser P Wani
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J & K, India

Nayeema Jabeen
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J & K, India

Ambreen Nabi
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J & K, India

Baseerat Afroza
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J & K, India

K Hussain
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J & K, India

PK Singh
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J & K, India

Correspondence
MI Makhdoomi
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, J & K, India

Variability analysis in okra (*Abelmoschus esculentus* (L.) Moench)

MI Makhdoomi, Kouser P Wani, Nayeema Jabeen, Ambreen Nabi, Baseerat Afroza, K Hussain and PK Singh

Abstract
The present investigation entitled "Variability analysis in Okra (*Abelmoschus esculentus* (L.) Moench)" was carried out at three different locations viz., Vegetable Experimental Farm, Division of Vegetable Science, SKUAST-K, Shalimar (E_1), Regional Research Station and Faculty of Agriculture, Wadura (E_2) and Mountain Research Centre for Field Crops, Khudwani (E3) to study the extent of genetic variability present in the materials. The observations were recorded on days to first flowering, days to first fruit picking, plant height (cm), number of nodes plant^{-1}, internodal length(cm), pod length(cm), pod girth(cm), pod weight(g), number of pods plant^{-1}, pod yield plant^{-1}(g), number of seeds pod^{-1}, 100 seed weight(g), seed yield plant^{-1} and pod yield(t/ha). Analysis of variance revealed highly significant differences among parents and crosses for all traits in all environments as well as in pooled analysis indicating that the materials used for the present study were diverse. For all the traits, the significant interaction of genotypes with environments revealed that the genotypes behaved differently under different environments. The parents x environment and crosses x environment interaction were also significant for all the traits indicating that parents and crosses behaved differently under different environments with respect to these traits. Genotypic coefficients of variation were closely associated with their corresponding phenotypic coefficients of variation indicating that the traits were less affected by the environment. High to moderate values of PCV and GCV were suggestive of the fact that there is wide scope for the improvement of such traits. The genotypic coefficient of variation was highest for pod yield per plant.

Keywords: Variability, okra

1. Introduction
Okra (*Abelmoschus esculentus* L. (Moench) is an economically important vegetable crop grown in the tropical and subtropical parts of the world. This crop is suitable for cultivation as a garden crop as well as on commercial farms. It is grown commercially in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Burma, Japan, Malaysia, Brazil, Ghana, Ethiopia, Cyprus and Southern United States. Okra is known by many names in different parts of the world. It is commonly known as lady finger in England, gumbo in USA, guino-gumbo in Spanish, guiberio in Portuguese, bhindi in India and bamiah in Arabic. It is quite popular in India because of easy cultivation, dependable yield and adaptability to varying moisture conditions. Okra is mentioned in the ancient books of India and the documents of ancient Egypt. Okra is thought to be of African or Asiatic origin, perhaps both. Okra is cultivated for its green, immature, non-fibrous fruits or pods containing round seeds. Okra is known as a multipurpose plant. Its immature fruits are used as vegetable, roots and stem for clarification of sugar cane juice to make gur, ripe seeds are roasted and used as a substitute for coffee in some countries, mature fruits and stems containing crude fibre are used in the paper industry. Extracts from the seeds of okra is an alternative source for edible oils. The greenish yellow edible oil has a pleasant taste and odour and is high in unsaturated fats like oleic acid and linolic acid. The oil content of the seeds is quite high at about 40%.
The important varieties of okra grown in India are Pusa sawani, Prabhani kranti, Azad ganga, Punjab padmani etc. The major constraint in the production of okra is the yellow vein mosaic virus which reduces the production of okra in the country. Many new varieties are being developed through introduction, selection and hybridization. Improvement in any crop species largely depends on the magnitude of genetic variability available in the crop species. A comprehensive knowledge of the available variability within a breeding material of a crop species for desired character enables the breeder to identify the most potential genotype. Observed phenotypic variation arises as a result of interaction between the genotype and environment and for making effective selections, it is the genetic variation which is heritable is most important.

The information on variability parameters namely genotypic coefficient of variation, heritability and genetic gain becomes essential for selection of genetically superior types. Hence present sudy was undertaken to assess the extent of genetic variation, genetic variability and genetic advance for various growth and yield parameters.

Material method

The present investigation was conducted during *Kharif* 2012 at three locations viz., Vegetable Experimental Farm, SKUAST-Kashmir, Shalimar; Mountain Research Centre for Field Crops, Khudwani and Regional Research Station and Faculty of Agriculture, Wadura. The basic materials consisted of ten diverse genotypes of okra (*Abelmoschus esculentus* L. (Moench) viz.SKBS-11, Pant bhindi, IC-117018, Azad ganga, Prabhani kranti, Lam-1, GO-2, Red bhindi, Arka anamika and Pusa swani. These lines/ varietes have been maintained by the Division of Vegetable Science, SKUAST-K, Shalimar and have been selected for the present study on the basis of genetic variability for various agronomic traits and maturity parameters. At each location the experiment was laid out in completely randomized block design with three replications. The row to row and plant to plant spacing was maintained at 45 x 25 cm. Recommended package of practices were adopted to raise a healthy crop at all the locations. The data was recorded on days to first flowering, days to first pod picking, plant height (cm), number of nodes, internodal length (cm), pod length (cm), pod girth (cm), avg. pod weight (g), number of pods per plant, pod yield per plant (g), number of seeds per pod, 100 seed weight (g), seed yield per plant (g) and pod yield (t/ha).

Results and Discussion

4.1 Analysis of variance

Analysis of variance for maturity, morphological and yield attributing traits in individual and pooled over environments is presented in table-1.1 and 1.2.Perusal of the results revealed significant mean squares for the environments for all the characters. Highly significant differences were found among the parents and their crosses for all the traits under consideration in the individual as well as data pooled over environments. This indicated that the lines selected for the present study and the crosses generated from them were diverse for all the traits. The genotype x environment interaction was significant for all the traits, indicating that the genotypes under study behaved differently for almost all the characters under diverse environments. Parent and environment interaction and Crosses x environment interactions were also found significant for all traits under study. Analysis of variance revealed significant mean squares for the environments for all the characters and highly significant differences among the parents and their crosses for all the traits in all the environments as well as in pooled analysis, indicating that the parents as well as the crosses generated from them were diverse for all the traits.Significant amount of variability for yield and yield attributing traits in okra was also reported by Nichal *et al*. (2000) [5], Singh *et al*. (2001) [8], Sood (2001), Jindal *et al*. (2005) [4]. Yadav *et al*. (2007) [9] also reported highly significant differences for traits like plant height, days to first flowering, fruit length, fruit number and internodal length. Ramya *et al*. (2010) [6] also reported high significant differences among the parents and crosses for days to first fruit harvest, fruit weight, fruit length and fruit yield plant^{-1}. Similarly Ali *et al*. (2013) [1] observed significant differences for fruit length, fruit girth, and average fruit weight in a diallel cross of okra, which are in agreement with the present findings.

Variability parameters

Variability parameters viz., mean, range, phenotypic and genotypic coefficient of variation, phenotypic and genotypic variance and genetic gain were estimated from the data from the data pooled over environments and are presented in table-2. Wide range of variability was observed for most of the traits under study. Days to first flowering exhibited a range of 56.69 to 67.59 with mean value of 62.02. Days to first fruit picking exhibited a range of 61.7 to 74.50 with a mean of 69.73. Plant height showed a range of 160.42 to 233.34 with a mean of 194.67. The number of nodes and internodal distance showed a mean of 23.78 and 8.63 and range of 18.27 to 27.70 and 7.51 to 12.11 respectively. Pod length, pod girth and average pod weight demonstrated mean values of 8.72, 4.13 and 9.02 with a range of 7.32 to 11.26, 3.40 to 5.32 and 7.53 to 11.03, respectively. The mean values of 22.43, 193.62 and 60.23 were recorded for number of pods per plant, pod yield per plant and number of seeds per pod with a range of 17.22 to 26.45, 135.37 to 258.97 and 46.83 to 77.60 respectively.100 seed weight, seed yield per plant and pod yield exhibited mean values of 6.39, 75.28 and 14.64, with range of 5.50 to 7.08, 49.65 to 106.54 and 10.54 to 19.05 respectively.

The phenotypic coefficients of variation were found to be higher than the corresponding genotypic coefficients of variation. Low PCV and GCV were observed for days to first flowering, days to first fruit picking, number of seeds pod^{-1} and 100 seed weight. Plant height, number of nodes, internodal distance, pod length, pod girth, average pod weight and seed yield plant^{-1} showed moderate values of PCV and GCV, while as number of pods plant^{-1}, pod yield plant^{-1}, pod yield and quality traits showed high values of PCV and GCV. Highest genotypic and phenotypic variances were recorded for number of seeds pod^{-1}, followed by plant height, pod yield plant^{-1} and days to first fruit picking.

Mean, range, phenotypic and genotypic coefficients of variation, phenotypic and genotypic variance and genetic advance depicted wide range of variability among parents and F_1's for most of the traits under study revealing that there is ample scope for selecting the desirable types. The phenotypic coefficients of variation were higher than the corresponding genotypic coefficients of variation indicating the close association between phenotypic and genotypic values. Since the difference between the phenotypic and the corresponding genotypic coefficient of variability were less for all the traits it revealed that these traits were least affected by environment and selection for these traits based on phenotype would be meaningful. Most of the yield and yield attributing traits recorded moderate to high PCV and GCV which were indicative of the presence of substantial magnitude of variability and thereby ensuring wide scope for improvement through selection. Similar results have been reported by Sengupta and Verma (2009) [7] and Choudhary *et al* (2009) [2]. High genetic advance (as per cent of mean) indicates that concerned characters might be governed by additive gene action and could be improved through phenotypic selection. Similar results have been reported by Gaurav *et al* (2005) [3] and Choudhary *et al*. (2009) [2] which are all in agreement with the present findings.

Table 1.1: Analysis of variance for maturity and yield attributing traits in Okra (*Abelmoschus esculentus* L. Moench)

Source of variation	D.F.	Days to first flowering	Days to first fruit picking	Plant height	Pod length	Number of nodes	Internodal distance	Pod Girth
		Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Environments	2	6467.21**	9601.47**	1594.14**	124.87**	49.37**	42.93**	10.39**
Replications	2	--	--	--	--	--	--	--
Replications within environments	6	1.27	1.78	3.34	0.039	0.66	0.06	0.047
Genotypes	54	25.57**	34.68**	1804.89**	5.61**	46.74**	5.22**	1.46**
Parents	9	49.42**	95.63**	5040.67**	4.12**	56.17**	3.07**	2.57**
Crosses	44	312.57**	424.12**	1061.33**	3.95**	33.78**	3.25**	1.12**
Parents vs. Crosses	1	65.75**	387.11**	5399.51**	9.21**	532.07**	111.30**	6.50**
Genotypes x Environments	108	69.12**	78.72**	80.71**	1.65**	0.68**	0.57**	1.13**
Parents x Environments	18	0.12**	1.27**	443.49**	0.64**	0.18**	2.89**	1.15**
Crosses x Environments	88	78.65**	71.06**	0.03**	1.71**	0.58**	0.06**	0.09**
Parents x Crosses x Environments	2	14.21**	11.94**	365.69**	7.92**	1.09**	2.28**	1.91**
Error	--							
Individual	108	--	--	--	--	--	--	--
Pooled	324	12.75	17.45	42.41	0.12	0.73	0.033	0.007

*, ** Significant at 5 and 1 per cent levels, respectively

Table 1.2: Analysis of variance for maturity and yield attributing traits in Okra (*Abelmoschus esculentus* L. Moench)

Source of variation	D.F.	Average pod weight	Number of pods plant^{-1}	Pod yield plant^{-1}	Number of seeds plant^{-1}	100 seed weight	Seed yield plant^{-1}	Total pod yield
		Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Environments	2	34.08**	47.02**	3638.97**	443.93**	31.68**	3047.54**	92.97**
Replications	2	--	--	--	--	--	--	--
Replications within environments	6	0.007	0.072	7.11	1.23	0.023	3.19	0.04
Genotypes	54	5.61**	44.37**	5860.68**	596.13**	1.15**	1790.73**	32.13**
Parents	9	5.82**	51.43**	2961.38**	625.93**	1.33**	2154.32**	16.22**
Crosses	44	4.33**	33.82**	3944.26**	490.34**	1.11**	973.36**	21.62**
Parents vs Crosses	1	60.45**	444.88**	1162.07**	4982.09**	1.28**	4481.76**	637.47**
Genotypes x Environments	108	0.09**	0.81**	86.05**	4.32**	0.059**	40.61**	0.47**
Parents x Environments	18	0.07**	1.12**	99.06**	1.92**	0.034**	104.52**	0.54**
Crosses x Environments	88	0.09**	1.10**	85.34**	5.19**	0.065**	25.26**	0.46**
Parents x Crosses x Environments	2	0.06**	1.17**	81.32**	3.74**	0.013**	140.85**	0.32**
Error	--							
Individual	108	--	--	--		--	--	--
Pooled	324	0.009	0.033	25.24	0.25	0.009	5.02	0.13

*, ** Significant at 5 and 1 per cent levels, respectively

Table 2: Variability parameters for different traits in parents and F_1 generations of Okra (*Abelmoschus esculentus* L. Moench) (Pooled data)

S. No.	Characters	Mean	Range	Genotypic coefficient of variation (GCV) %	Phenotypic coefficient of variation (PCV) %	Genotypic variance ($\hat{\sigma}^2 g$)	Phenotypic variance ($\hat{\sigma}^2 p$)	Heritability broad sense (%)	Genetic Advance (%age of mean)
	Days to first flowering	62.02	56.69-67.59	4.93	5.16	9.36	10.27	91.14	12.42
	Days to first fruit picking	69.73	61.87-74.50	4.17	5.07	8.46	12.51	67.63	9.06
	Plant height(cm)	194.67	160.42-233.34	7.43	7.45	20.68	21.40	96.64	19.60
	Number of nodes	23.78	18.27-27.70	9.64	10.02	5.26	5.69	92.44	24.48
	Internodal distance(cm)	8.63	7.51-12.11	10.24	10.44	0.78	0.81	96.30	26.55
	Pod length(cm)	8.72	7.32-11.26	8.91	9.44	0.61	0.67	91.04	22.22
	Pod girth(cm)	4.13	3.40-5.32	8.68	8.84	0.16	0.19	84.21	0.49
	Average pod weight(g)	9.02	7.53-11.03	9.82	10.09	0.61	0.63	96.83	22.48
	Number of pods plant^{-1}	22.43	17.22-26.45	13.44	13.82	4.85	5.13	94.54	25.22
10	Pod yield plant^{-1}(g)	193.62	135.37-258.97	13.45	13.56	16.15	17.89	90.27	34.53
11	Number of seeds pod^{-1}	60.23	46.83-77.60	5.78	6.02	65.70	66.76	98.41	35.24

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