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Shehal Rathod
Department of Genetics and Plant Breeding, NM College of Agriculture, Navsari, Agricultural University, Navsari, Gujarat, India

VL Parmar
Department of Genetics and Plant Breeding, NM College of Agriculture, Navsari, Agricultural University, Navsari, Gujarat, India

AI Patel
Department of Genetics and Plant Breeding, NM College of Agriculture, Navsari, Agricultural University, Navsari, Gujarat, India

Correspondence
Shehal Rathod
Department of Genetics and Plant Breeding, NM College of Agriculture, Navsari, Agricultural University, Navsari, Gujarat, India

Genetic variability, heritability and genetic advance for quantitative traits in f_2 population in okra [*Abelmoschus esculentus* (L.) Moench]

Shehal Rathod, VL Parmar and AI Patel

Abstract
The experiment was carried out during *kharif*-2016 at Regional Horticultural Research Station, Navsari Agricultural University, Navsari, Gujarat. Genetic variability, heritability and genetic advance as per cent of mean of 12 quantitative characters in 148 F_2 plants from cross AOL-09-02 x AOL-10-22 and 160 F_2 plants from cross AOL-09-02 x GAO-5 were studied. Significant differences among F_2 population were observed for all the characters under study. The characters *viz.*, number of branches/plant at final harvest, internodal length, fruit yield/plant, number of fruits/ plant and plant height at final harvest showed high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) in F_2 populations of both crosses. High heritability was recorded for plant height at final harvest, fruit yield/plant, number of fruits/plant, days to first picking, days to first flowering and number of branches/plant at final harvest in F_2 populations of both crosses. While, fruit weight was observed in F_2 population of cross AOL-09-2 x AOL-10-22. High heritability coupled with high genetic advance as per cent of mean was recorded for plant height at final harvest, number of branches/plant at final harvest, number of fruits/plant and fruit yield/plant in F_2 populations of both crosses. While, in F_2 population of AOL-09-2 x GAO-5, days to first flowering also showed high heritability coupled with high genetic advance as per cent of mean suggested the preponderance of additive genes for the inheritance of these characters.

Keywords: Genetic variability, heritability and genetic advance as per cent of mean

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench], 2n=130 has occupied a prominent position among vegetables; it is one of the choicest fruit vegetable grown extensively in the subtropical to tropical warm area of the world including India, Africa, Turkey and other neighbouring countries. It is widely grown during summer and rainy seasons for its tender green fruits, is one of the most important vegetable crops of India, however its tender green leaves are also eaten in the far east countries. It is also known by many local names in different parts of the world. It is called Lady's finger in England, Gumbo in the U.S.A. and Bhindi in northern India. It is a polyploidy, belonging to the family Malvaceae with 2n = 8x = 72 or 144 chromosomes. It is an often cross pollinated crop, without crossing to an extent of 4–19 per cent with the maximum of 42.2 per cent under insect assisted pollination. In India 60 per cent share of export goes to okra among fresh vegetables. In our country there exists a wide variation amongst the okra varieties expressing wide degree of variation for quantitative and qualitative traits *viz.*, plant height, number of primary branches plant per plant, number of fruits plant per plant, size of fruit *i.e.*, length, breadth and weight *etc.* are the yield contributing characters while, colour of fruit and fibre content determine the quality of fruit. A logical way to start any crop improvement programme is to assess the variation existing in the available materials. 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 on pattern of inheritance of various characters of economic importance is essential, while determining the most appropriate breeding procedures for crop improvement.

Heritability is a suitable measure for assessing the magnitude of genetic portion of total variability and aid to make improvement in crop by selection for various characters. Heritability is an index of transmissibility of a character from parents to their off springs. But heritability alone does not give true picture of genetic improvement through selection, therefore, study of Genetic advance coupled with heritability are more useful in predicting the

resultant effect of selection. Genetic advance gives an idea about additive nature of gene action. In the present investigation, an attempt has been made to assess the variability of important yield and yield contributing traits, along with indices of variability *i.e.*, GCV and PCV, heritability (h^2) and genetic advance as per cent of mean (GAM) which would facilitate an understanding behind expression of character and also the role of environment.

Materials and methods

The experimental material comprised of 3 parents AOL-09-02, AOL-10-22 and GAO-5, two hybrids *viz*., AOL-09-2 x AOL-10-22 and AOL-09-2 x GAO-5 and their F_2 generations. The materials were evaluated in non-replicated trial as segregating F_2 generations are involved. Observations on quantitative characters *viz*., days to first flowering, days to first picking, fruit length, fruit girth, fruit weight, plant height at final harvest, number of branches/plant at final harvest, number of fruits/plant, internodal length, number of seeds/fruit, 100 seed weight and fruit yield/plant were recorded from parents, F_1s and their F_2 populations. The mean and variances were analyzed based on the formula given by Singh and Chaudhary (1985). The genotypic and phenotypic coefficient of variation was computed according to Burton and Devane (1953). Heritability in broad sense was estimated as the ratio of genotypic to phenotypic variance and expressed in percentage by Hanson *et al.*, (1956). Genetic advance and Genetic advance as per cent of mean were computed according to the formula proposed by Johnson *et al.*, (1955).

Result and discussion

The mean, range, phenotypic and genotypic coefficient of variation, heritability, genetic advance and genetic advance as per cent of mean for 12 traits are presented in table 1 and table 2. In the present investigation, the genotypic and phenotypic variance was greater than environmental variance for all the characters in both crosses under study which indicated that influence of environment on expression of traits was lower or negligible, hence selection would be effective. PCV was higher than the respective GCV for all the traits in F_2 populations of both crosses, denoting the environmental factors influencing their expression to some degree which is in accordance with findings of Kandasamy (2015) [10] and Jadhav *et al.*, (2016) [8]. The higher magnitude of PCV and GCV was observed in F_2 populations of AOL-09-2 x AOL-10-22 and AOL-09-2 x GAO-5 for number of branches/plant at final harvest, internodal length, fruit yield/plant, number of fruits/ plant and plant height at final harvest. This higher magnitude of PCV and GCV for above characters suggested greater phenotypic and genotypic variability among the F_2 segregating populations indicated that these characters can be improved through phenotypic selection. The similar results were obtained by Jadhav *et al.*, (2016) [8] for number of branches/plant at final harvest; Kandasamy (2015) [10] for internodal length; Kerure *et al.*, (2017) [12] for fruit yield/plant and number of fruits/plant; Shivaramegowda *et al.*, (2016) [18] for plant height at final harvest. In F_2 population of AOL-09-2 x GAO-5, the moderate magnitude of PCV and GCV was observed for days to first flowering. Similar findings were reported by Dhankar and Dhankar (2002) [4]. The low/moderate magnitude of PCV and GCV was observed for days to first picking, fruit girth, fruit length, fruit weight, number of seeds/fruit, 100 seed weight in F_2 populations of both crosses. While, days to first flowering observed in F_2 populations of AOL-09-2 x AOL-10-22. Similar results were obtained by Makhdoomi *et al.*, (2018) [15] for days to first picking and fruit girth; Jadhav *et al.*, (2016) [8] for fruit length; Katagi *et al.*, (2013) [11] for fruit weight; Kumar *et al.*, (2012) [1, 6] for number of seeds/fruit; Kandasamy (2015) [10] for 100 seed weight; Annapurna *et al.*, (2012) [1] for days to first flowering.

The present investigation, high heritability was exhibited by plant height at final harvest, fruit yield/plant, number of fruits/plant, days to first picking, days to first flowering and number of branches/plant at final harvest in F_2 populations of both crosses. While, high heritability have been noticed for fruit weight in F_2 populations of cross AOL-09-2 x AOL-10-22. Similar results were reported by Makhdoomi *et al.*, 2018 [15] for plant height at final harvest; fruit yield/plant, and for number of fruits/plant; Kandasamy (2015) [10] for days to first picking; Kumar *et al.*, (2016) for days to first flowering; Kerure *et al.*, (2017) [12] for number of branches/plant at final harvest; Makhdoomi *et al.*, (2018) [15] for fruit weight. Higher values of heritability of these characters expressed that they were less influenced by the environmental factors. It reflected that the phenotypes were the near representative of their genotypes and selection based on phenotypic performance would be reliable. Moderate estimates of heritability were recorded in F_2 populations of AOL-09-2 x AOL-10-22 for fruit length and number of seeds/fruit. While, internodal length and fruit weight were recorded in F_2 populations of AOL-09-2 x GAO-5, which indicated that selection based on phenotypic performance would be rewarding on partitioning of environmental variances. These findings are in accordance with Jadhav *et al.*, (2016) [8] for fruit length and Mazid *et al.*, (2013) for number of seeds/fruit and for fruit weight; Kumar *et al.*, (2012) [1, 6] for internodal length. Estimates of heritability were recorded low in F_2 populations of both crosses for fruit girth and 100 seed weight.

Table 1: Range, mean and components of variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean for various traits in F_2 population of AOL-09-2 x GAO-5 in okra

Sr. No.	Characters	Range	Mean	Components of variance			GCV %	PCV %	h^2_{bs} %	GAM
				σ^2p	σ^2g	σ^2e				
1	Days to first flowering	31.00-55.00	47.91	28.09	20.22	7.88	9.38	11.06	71.96	16.40
2	Days to first picking	37.00-61.00	53.97	28.13	20.25	7.88	8.34	9.83	71.99	14.57
3	Plant height at final harvest (cm)	33.00-116.00	73.28	297.90	273.27	24.63	22.56	23.55	91.73	44.51
4	Number of branches/plant at final harvest	0.00-8.00	2.18	1.63	1.11	0.52	48.34	58.66	67.90	82.05
5	Internodal length (cm)	1.00-7.00	3.77	1.91	0.53	1.39	19.31	36.73	27.64	20.92
6	Fruit length (cm)	11.00-18.30	13.30	1.57	0.66	0.91	6.13	9.43	42.33	8.22
7	Fruit girth (cm)	1.30-1.63	1.47	0.006	0.0001	0.0059	0.68	5.27	1.67	0.18
8	Fruit weight (g)	12.00-19.86	14.88	2.78	2.17	0.60	9.90	11.20	78.24	18.05
9	Number of fruits/plant	2.00-24.00	11.69	20.84	16.53	4.32	34.78	39.06	79.29	63.79
10	100 seed weight (g)	3.10-4.90	3.90	0.27	0.08	0.19	7.26	13.40	29.34	8.10

11	No. of seeds/ fruit	30.40-73.20	39.62	38.39	11.74	26.65	8.65	15.64	30.58	9.85
12	Fruit yield/plant (g)	26.40-377.34	174.90	5358.00	4311.19	1046.81	37.54	41.85	80.46	69.37

Table 2: Range, mean and components of variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean for various traits in F_2 population of AOL-09-2 x GAO-5 in okra

Sr. No.	Characters	Range	Mean	Components of variance			GCV %	PCV %	h^2_{bs} %	GAM
				σ^2p	σ^2g	σ^2e				
1	Days to first flowering	36.00-55.00	46.26	30.80	26.64	4.16	11.16	12.00	86.50	21.38
2	Days to first picking	42.00-62.00	52.31	30.87	26.22	4.65	9.79	10.62	84.95	18.59
3	Plant height at final harvest (cm)	30.20-178.40	68.19	473.22	450.99	22.23	31.14	31.90	95.30	62.63
4	Number of branches/plant at final harvest	0.00-6.00	1.99	1.81	1.21	0.60	55.40	67.71	66.93	93.37
5	Internodal length (cm)	1.00-7.20	3.45	1.86	1.11	0.75	30.53	39.57	59.53	48.52
6	Fruit length (cm)	12.05-18.10	13.50	1.13	0.16	0.97	2.94	7.88	13.89	2.25
7	Fruit girth (cm)	1.30-1.63	1.43	0.0093	0.0005	0.008	1.62	6.76	5.71	0.80
8	Fruit weight (g)	11.20-20.03	14.41	3.12	1.76	1.37	9.20	12.26	56.28	14.22
9	Number of fruits/plant	1.00-28.00	11.63	29.80	25.91	3.88	43.79	46.96	86.96	84.12
10	100 seed weight (g)	2.90-4.80	3.89	0.22	0.017	0.20	3.32	12.03	7.63	1.89
11	No. of seeds/ fruit	30.20-49.80	40.61	26.82	6.96	19.86	6.49	12.75	25.94	6.81
12	Fruit yield/plant (g)	12.20-420.00	169.02	6898.00	5699.67	1198.33	44.67	49.14	82.63	83.65

This is indicative of the fact that characters are rather more influenced by the environment and may not respond much to selection. These findings are in accordance with Annapurna *et al.,* (2012) [1] for fruit girth; Deo, (2014) for 100 seed weight. In F_2 population of AOL-09-2 x AOL-10-22, internodal length showed the low heritability. This finding is an accordance with Kerure *et al.,* (2017) [12] for internodal length. In F_2 population of AOL-09-2 x GAO-5, estimates of heritability were recorded low for fruit length and number of seeds/fruit. These findings are an accordance with Sundaram, (2015) [20] for fruit length; Manivannan *et al.,* (2007) [16] for number of seeds/fruit. Heritability however indicates only the effectiveness with which selection of a genotype can be based on phenotypic performance, but fails to indicate the genetic progress. Heritability estimates along with genetic gains are more effective and reliable in predicting the improvement through selection. High heritability coupled with high genetic advance as per cent of mean was recorded in F_2 populations of both crosses for characters like plant height at final harvest, number of branches/plant at final harvest, number of fruits/plant and fruit yield/plant suggested the preponderance of additive genes. It also indicated higher response for selection of high yielding genotypes as these characters were governed by additive genes. Similar results were reported by Makhdoomi *et al.,* (2018) [15] for plant height at final harvest; for number of fruits/plant and fruit yield/plant while Kerure *et al.,* (2017) [12] for number of branches/plant at final harvest. High heritability coupled with high genetic advance as per cent of mean indicate that the character is controlled by additive gene action and selection would be effective which was in agreement with the findings of Kerure *et al.,* (2017) [12]. While, in F_2 population of AOL-09-2 x GAO-5, days to first flowering also showed high heritability coupled with high genetic advance as per cent of mean. High heritability along with moderate genetic advance was observed in F_2 populations of both crosses for days to first picking. This result was in close proximity to that of by Kandasamy, (2015) for days to first picking. While, in F_2 populations of AOL-09-2 x AOL-10-22, also showed high heritability along with moderate genetic advance for days to first flowering and fruit weight. This result was in close proximity to that of by Kumar *et al.,* (2012) [1, 6] for days to first flowering; Goswami *et al.,* (2012) [6] for fruit weight. Moderate heritability in conjunction with moderate GAM was observed in F_2 population of AOL-09-2 x GAO-5 for fruit weight which indicates the role of both additive and non-additive gene action governing the inheritance of this trait and offers the best possibility of improvement through progeny selection or any modified selection procedures aiming to exploit the additive gene effects. Moderate heritability in conjunction with moderate GAM was observed in F_2 population of AOL-09-2 x GAO-5 for fruit weight which indicates the role of both additive and non-additive gene action governing the inheritance of this trait and offers the best possibility of improvement through progeny selection or any modified selection procedures aiming to exploit the additive gene effects. Low heritability along with low genetic advance was observed in F_2 populations of both crosses for fruit girth and 100 seed weight indicating high influence of environment and consequently its selection may not be effective. This result was in close proximity to that of by Yadav *et al.,* (2007) [21] for fruit girth; Manivannan *et al.,* (2007) [16] for 100 seed weight. In F_2 population of AOL-09-2 x GAO-5, low heritability along with low genetic advance was observed for fruit length and number of seeds/fruit. Similar results were reported by Sundaram, (2015) [20] for fruit length; Gangashetty *et al.,* (2012) [5] for number of seeds/fruit. Low heritability along with high genetic advance was observed in F_2 populations of AOL-09-2 x AOL-10-22 for internodal length. This result was in close proximity to that of by Kerure *et al.,* (2017) [12].

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