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Research Article

Studies on genetic parameters in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract
The present investigation was conducted at a vegetable research farm, BUAT, Banda during the summer and rainy seasons, 2019, to determine the extent of variability, heritability and genetic advance. Analysis of variance indicated a significant difference among the genotypes for different characters. During the summer season the characters, yield (q ha^{-1}) and yield per plant exhibited higher PCV and GCV estimates than rest of the characters and during rainy season days to 50% germination exhibited higher PCV and GCV estimates suggesting that there is the possibility of improving these traits through selection. The difference between PCV and GCV values during the summer season was high for fruit length, days to 50% germination and node to the first flower appear. Whereas, for the rainy season difference was high for fruit length and the number of fruits per plant suggesting the role of environment in expression of these traits. In present study, heritability estimates were high for yield (q ha^{-1}), yield per plant, days to 50% flowering, days to first harvesting, the number of leaves at 90 DAS and the number of fruits per plant during the summer season and for the rainy season heritability estimates were high for yield (q ha^{-1}), plant height at 90 DAS, the number of leaves at 90 DAS, yield per plant and days to 50% germination indicating that the selection based on phenotypic performance of these characters would be more operative. High genetic advance as per cent of mean for the summer season was recorded for yield (q ha^{-1}), yield per plant and the number of fruits per plant. Whereas, for rainy season it was recorded high for days to 50% germination and plant height at 90 DAS. On the basis of mean performance, the fruit yield (q ha^{-1}) was recorded maximum in genotype Kashi Pragati followed by Arka Nikita, Hisar Unnat and Phule Vimukta during the summer season. Whereas, for the rainy season genotype Hisar Naveen having maximum yield (q ha^{-1}) followed by Varsha Uphar, Pusa Sawani and Akola Bahar.

Keywords: Okra, variability, heritability, performance

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.)] is an important vegetable crop and is widely grown in the tropical and subtropical parts of the world (Tindall, 1983). Cultivated okra has significant variations in the chromosome's numbers but most frequently observed chromosome number is 2n = 130 (Joshi and Hardas, 1956). It belongs to the family Malvaceae. It is one of the important vegetables grown for its immature green non-fibrous edible pods. It is an excellent source of iodine thus, it could be used in the control of goitre (Purewal and Randhwa, 1947). Okra seeds are a source of oil, protein and also used as a coffee substitute, while ground-up okra seeds have been used as a substitute for aluminium salts in water purification (Camciuc *et al.,* 1998). The nutritional value of 100ng of the edible portion of okra contains 1.9 g of protein, 0.2 g of fat, 6.4 g of carbohydrate, 0.7 g of minerals and 1.2 g of fibre (Tiwari *et al*., 1998). Crop improvement depends upon the magnitude of genetic variability and

the extent to which desirable characters are heritable. Genetic variability for yield and yield components is essential in the base population for successful crop improvement (Allard, 1960). Heritability denotes the proportion of phenotypic variation repeatable and is due to genes and thus helps the plant breeders to select the promising variety for a character. However, heritability indicates only the effectiveness with which selection of a genotype can be based on phenotypic performance but it fails to indicate the expected genetic progress in one cycle of selection. Heritability variation can be effectively used with a greater degree of accuracy when heritability is studied in concurrence with genetic advance (Johnson *et al.,* 1955).

MATERIALS AND METHODS

The present study with eighteen genotypes of okra was evaluated in a randomized block design (RBD) at the vegetable research farm of the Department of Vegetable Science, College of Horticulture, Banda University of Agriculture and Technology, Banda during the summer and rainy seasons, 2019-2020. Each variety was planted in three rows replicated thrice with a spacing of 45 cm ×20 cm and 60 cm ×30 cm during the summer and rainy seasons, respectively. Observations were recorded from five randomly selected plants from the middle row of each variety in each replication for twelve plant characters *viz.,* days to 50% flower, days to first harvest, plant height (cm) at 90 DAS, the number of nodes at 90 DAS, the number of leaves at 90 DAS, node to first flower appear, the number of fruits per plant, fruit length (cm), fruit diameter (cm), fruit yield per plant (kg) and fruit yield (q ha^{-1}). Mean values of five plants were used for statistical analysis. Phenotypic and Genotypic coefficients of variability, heritability (h^2) broad sense and expected genetic advance were estimated as suggested by Johnson *et al.* (1955), respectively. Data were processed by Windostat Version 9.2 from indostat services, Hyderabad.

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among the genotypes for all the characters studied during both the seasons (**Table 1 and 2**), which revealed the existence of wide variability in the germplasm. The mean performance of the genotypes revealed a wide range of variability for all the characters (**Tables 3 and 4**). The variety Kashi Pragati took minimum days to 50% germination for the summer season and was on par with Hisar Uphar and NDO-10. Whereas, days taken 50% germination for the rainy season were recorded minimum in genotype Phule Vimukta and Punjab Suhavani, and was on par with P-8 and Akola Bahar. Days to the first harvest were recorded minimum in genotype Kashi Pragati for the summer season and was on par with Arka Nikita, Hisar Unnat. Whereas, days to first harvesting were recorded as minimum in genotype Akola Bahar for the rainy season and was at par with Arka Nikita, Hisar Unnat, Hisar Naveen, Varsha Uphar.Plant height at 90 DAS was recorded as maximum in the genotype Phule Vimukta

Table 1. Analysis of variance for various characters in okra during summer season

Source of variation		Days to 50% germination	Days to 50% flower	Days to first harvest	Plant height 90 DAS	Number of nodes (90 DAS)	Number of leaves (90 DAS)	Node to first flower appear	Number of fruits per plant	Fruit length	Fruit diameter	Fruit yield per plant	Fruit yield (q ha^{-1})
Source of variation	Replication d.f (2)	3.02	3.77	3.94	21.13	6.54	1.25	0.059	0.15	0.62	0.0006	0.00001	0.492
	Genotype d.f (17)	5.04**	53.20**	47.40**	16.83**	5.24**	12.87**	0.392**	2.44**	2.08	0.0079*	0.0005**	621.428**
	Error d.f (34)	1.293	1.510	1.592	2.074	1.545	0.618	0.139	0.163	1.320	0.004	0.000	0.588

Table 2. Analysis of variance for various characters in okra during rainy season

Source of variation		Days to 50% germination	Days to 50% flower	Days to first harvest	Plant height 90 DAS	Number of nodes (90 DAS)	Number of leaves (90 DAS)	Node to first flower appear	Number of fruits per plant	Fruit length	Fruit diameter	Fruit yield per plant	Fruit yield (q ha^{-1})
Source of variation	Replication d.f (2)	0.67	11.36	9.30	77.56	3.86	0.85	0.043	13.21	0.39	0.06	0.00003	0.50
	Genotype d.f (17)	9.22**	17.63**	16.55**	866.73**	11.10**	9.85**	0.951**	16.76**	1.70	0.03	0.00151**	301.89**
	Error d.f (34)	0.65	2.48	2.16	45.82	1.03	0.64	0.099	6.83	1.39	0.02	0.00011	0.93

Table 3. Performance of okra genotypes for different characters in summer season

Genotypes	Days to 50% germination	Days to 50% flower	Days to first harvest	Plant height (cm) 90 DAS	Number of nodes (90 DAS)	Number of leaves (90 DAS)	Node to first flower appear	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit yield per plant (g)	Fruit yield (q ha^{-1})
Kashi Kranti	10.33	59.88	63.69	53.00	16.87	20.93	3.34	4.49	9.66	1.23	0.05	49.38
Kashi Pragati	6.33	46.67	50.90	55.62	17.85	21.25	3.17	7.25	9.82	1.28	0.09	96.86
Kashi Vibhuti	9.00	58.08	63.04	54.92	20.75	25.43	3.31	4.52	11.23	1.25	0.05	56.47
Arka Anamika	6.33	54.25	57.72	57.13	21.37	24.57	3.22	5.56	10.27	1.28	0.07	72.81
Arka Abhay	9.67	58.15	60.58	55.39	21.85	23.73	3.30	4.96	10.23	1.23	0.05	53.28
Arka Nikita	7.33	47.83	52.08	54.55	19.28	22.83	4.17	6.55	9.83	1.27	0.08	88.92
Hisar Unnat	7.00	48.17	51.38	56.11	20.63	26.10	3.23	6.75	10.67	1.30	0.08	88.38
Hisar Naveen	8.33	56.25	58.53	56.41	21.52	28.10	3.50	4.68	12.67	1.33	0.06	59.82
Varsha Uphar	7.33	53.00	57.08	55.03	19.43	26.20	3.36	6.79	10.83	1.23	0.07	81.58
Pusa A-4	7.33	54.87	57.75	56.17	21.21	25.57	2.78	5.35	11.13	1.23	0.06	71.10
NDO-10	10.00	57.20	61.63	53.40	20.52	25.37	3.53	4.70	10.61	1.37	0.05	52.55
Azad Bhindi-1	8.33	58.92	60.28	53.77	20.46	23.23	3.43	5.70	11.17	1.33	0.06	65.22
Punjab Suhavani	9.33	56.78	60.18	54.89	20.61	25.50	3.80	4.46	9.83	1.37	0.05	55.50
P-8	7.33	57.07	60.35	54.80	21.62	27.90	4.20	4.79	10.27	1.27	0.06	68.11
Phule Vimukta	6.67	50.33	54.58	59.51	20.32	27.83	3.15	5.14	10.88	1.17	0.08	83.49
Akola Bahar	7.33	52.67	56.52	55.11	21.18	25.60	3.19	6.01	9.00	1.27	0.07	67.81
Kashi Vardan	7.67	57.18	60.22	49.96	21.31	23.90	2.98	5.40	9.97	1.27	0.06	64.82
Pusa Sawani	9.67	60.04	63.29	49.26	19.73	23.63	3.46	4.54	9.65	1.30	0.05	53.71
Mean	8.07	54.85	58.32	54.72	20.36	24.87	3.40	5.42	10.43	1.28	0.06	68.32
C.V.	14.08	2.24	2.16	2.63	6.11	3.16	10.97	7.44	11.02	4.91	4.76	1.12
S.E.	0.66	0.71	0.73	0.83	0.72	0.45	0.22	0.23	0.66	0.04	0.00	0.44
C.D. 5%	1.89	2.04	2.09	2.39	2.06	1.30	0.62	0.67	-	0.10	0.01	1.27
C.D. 1%	2.53	2.74	2.81	3.21	2.77	1.75	0.83	0.90	-	0.14	0.01	1.71
Maximum	10.33	60.04	63.69	59.51	21.85	27.90	4.20	7.25	12.67	1.37	0.09	96.86
Minimum	6.33	46.66	50.9	49.26	16.87	20.93	3.15	4.54	9.00	1.17	0.05	49.38

during the summer season and was on par with Arka Anamika. Whereas, the genotype Pusa Sawani exhibited the maximum plant height during the rainy season and was on par with Punjab Suhavani, P-8, Phule Vimukta. Significantly maximum variation was recorded for plant height and findings are in close harmony with Senapati *et al.* (2011) and Lodhi *et al.* (2015) for plant height.

The genotype Arka Abhay had a maximum number of nodes at 90 DAS during the summer season and was on par with Kashi Vibhuti, Hisar Unnat, Hisar Naveen, Pusa A-4, NDO-10, Azad Bhindi-1, Punjab Suhavani, P-8, Phule Vimukta, Akola Bahar and Kashi Vardan. Whereas, genotype P-8 had a maximum number of nodes at 90 DAS during the rainy season and was on par with Hisar Uphar, Punjab Suhavani, Phule Vimukta, Kashi Vardan and Pusa Sawani., Hisar Naveen had a maximum number of leaves at 90 DAS during summer season and was on par with Hisar Unnat, P-8, Varsha Uphar and Phule Vimukta. Whereas, genotype Kashi Vardan had a maximum number of leaves at 90 DAS. The minimum node to the first flower were observed in genotype Phule Vimukta during the summer season and was on par with Kashi Kranti, Kashi Pragati, Kashi Vibhuti, Arka Anamika, Arka Abhay, Hisar Unnat, Hisar Naveen, Varsha Uphar, Pusa A-4, NDO-10, Azad Bhindi-1, Akola Bahar, Kashi Vardan and Pusa Sawani. Whereas, minimum node to the first flower were observed in genotype Kashi Pragati during the rainy season and was on par with Kashi Kranti, Hisar Unnat, Akola Bahar and Pusa Sawani.

The genotype Kashi Pragati had a maximum number of fruits per plant during the summer season and was on par with Hisar Unnat and Varsha Uphar. Whereas, genotype Hisar Naveen had a maximum number of fruits per plant during the rainy season and was on par with Arka Anamika, Arka Nikita, Varsha Uphar, Akola Bahar and Pusa Sawani.

Table 4. Performance of okra genotypes for different characters in rainy season

Genotypes	Days to 50% germination	Days to 50% flower	Days to first harvest	Plant height (cm) 90 DAS	Number of nodes (90 DAS)	Number of leaves (90 DAS)	Node to first flower appear	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit yield per plant (g)	Fruit yield (qha^{-1})
Kashi Kranti	7.33	46.88	51.98	86.83	21.84	32.95	5.00	18.35	11.28	1.60	0.19	105.79
Kashi Pragati	8.33	46.71	52.71	99.20	20.66	32.49	4.83	21.11	12.25	1.63	0.20	108.17
Kashi Vibhuti	7.33	48.00	53.00	91.57	22.60	33.62	5.67	16.70	10.63	1.63	0.19	103.52
Arka Anamika	7.33	48.63	53.13	105.97	21.68	34.95	5.83	21.40	10.43	1.77	0.20	110.86
Arka Abhay	6.33	47.08	53.42	103.83	20.78	34.26	5.58	17.47	11.34	1.67	0.19	108.66
Arka Nikita	6.67	43.53	49.53	101.37	21.24	31.90	6.00	19.82	10.30	1.67	0.22	122.92
Hisar Unnat	6.67	44.18	49.51	117.37	22.74	35.71	5.00	17.65	10.17	1.83	0.22	122.55
Hisar Naveen	7.00	44.52	49.18	125.10	24.36	35.10	5.67	22.85	11.33	1.50	0.25	135.66
Varsha Uphar	7.00	41.48	47.48	125.27	25.52	32.28	5.83	21.27	12.36	1.70	0.25	133.58
Pusa A-4	8.33	46.39	51.05	105.90	23.46	35.06	6.17	15.46	10.20	1.47	0.22	119.16
NDO-10	8.00	46.28	52.28	115.67	22.34	32.39	5.92	15.07	11.13	1.60	0.20	110.18
Azad Bhindi-1	8.33	49.83	55.83	127.10	24.56	31.00	6.50	17.69	10.13	1.57	0.20	112.18
Punjab Suhavani	3.33	49.92	54.92	135.83	25.64	35.06	6.50	14.90	10.22	1.70	0.20	110.57
P-8	3.67	48.17	53.17	135.83	26.43	32.97	6.25	18.21	10.68	1.60	0.19	105.42
Phule Vimukta	3.33	45.57	50.57	135.40	25.53	35.59	5.50	16.34	11.67	1.80	0.24	125.42
Akola Bahar	4.00	42.67	47.33	117.50	23.41	35.12	4.92	19.89	10.55	1.80	0.26	126.16
Kashi Vardan	4.67	49.00	52.83	133.30	24.84	38.59	6.33	17.73	9.73	1.60	0.20	113.51
Pusa Sawani	6.33	44.94	50.94	145.70	26.42	34.50	4.92	20.63	11.40	1.70	0.24	127.64
Mean	6.33	46.32	51.60	117.15	23.56	34.09	5.69	18.47	10.88	1.66	0.21	116.78
C.V.	12.70	3.40	2.85	5.78	4.31	2.35	5.54	14.15	10.82	8.09	4.80	0.83
S.E.	0.46	0.91	0.85	3.91	0.59	0.46	0.18	1.51	0.68	0.08	0.01	0.56
C.D. 5%	1.33	2.61	2.44	11.23	1.68	1.33	0.52	4.34	-	-	0.02	1.60
C.D. 1%	1.79	3.51	3.27	15.08	2.26	1.78	0.70	5.82	-	-	0.02	2.15
Maximum	8.33	49.92	55.83	145.7	26.43	38.59	6.50	22.85	12.36	1.83	0.26	135.66
Minimum	3.33	41.48	47.33	86.83	20.66	31.00	4.83	14.90	9.37	1.47	0.19	103.52

In the summer season, Hisar Naveen had maximum fruit length while genotype Akola Bahar had a minimum fruit length. The general mean for fruit length was 10.43 cm. Whereas, in the rainy season Varsha Uphar had a maximum fruit length while genotype Kashi Vardan had a minimum fruit length. The general mean for fruit length was 10.88. In the summer season, genotypes NDO-10 and Punjab Suhavani had a maximum fruit diameter while genotype Phule Vimukta had a minimum fruit diameter. The general mean for fruit diameter was 1.28 cm. Whereas, in the rainy season Hisar Unnat had a maximum fruit diameter while Pusa A-4 had a minimum fruit diameter. The general mean for fruit diameter was 1.66 cm.

Fruit yield per plant was recorded maximum in genotype Kashi Pragati and was on par with Arka Nikita, Hisar Unnant and Phule Vimukta. Whereas, for the rainy season genotype Akola Bahar had maximum yield per plant and was on par with Hisar Naveen, Varsha Uphar, Phule Vimukta and Pusa Sawani.

The fruit yield (q ha^{-1}) was recorded maximum in genotype Kashi Pragati during the summer season. Whereas for the rainy season genotype Hisar Naveen had yield (q ha^{-1}). Significantly maximum variation was recorded for yield (q ha^{-1}) and findings are in close harmony with Vani *et al.* (2012) for yield (q ha^{-1}) in okra.

The genetic parameters for different characters are presented in **Tables 5 and 6**. GCV and PCV which are the indices of variability, it was observed that PCV estimates were greater than that of GCV for all the characters, revealing the role of environment in the phenotypic expression of these traits. The findings of Prakash *and* Pitchaimuthu (2010) also stated that PCV estimates were greater than that of GCV.

During summer season the characters, fruit yield (q ha^{-1}), and fruit yield per plant exhibited higher PCV and GCV estimates than rest of the characters and during the rainy season character days to 50% germination exhibited higher PCV and GCV estimates suggesting that there is

Table 5. Genetic parameters for various characters in okra during summer season

Characters	Days to 50% germination	Days to 50% flower	Days to first harvest	Plant height 90 DAS	Number of nodes (90 DAS)	Number of leaves (90 DAS)	Node to first flower appear	Number of fruits per plant	Fruit length	Fruit diameter	Fruit yield per plant	Fruit yield (q ha^{-1})
PCV (%)	19.75	7.89	7.04	4.83	8.18	8.719	13.92	17.72	12.02	5.67	20.73	21.09
GCV (%)	13.84	7.56	6.7	4.053	5.44	8.126	8.56	16.08	4.82	2.83	20.18	21.06
h^2(%)	49.1	91.9	90.6	70.3	44.3	86.9	37.9	82.4	16.00	24.9	94.7	99.7
GA	1.61	8.2	7.7	3.83	1.52	3.88	0.37	1.63	0.41	0.037	0.03	29.59
GAM	19.99	14.95	13.13	7.00	7.47	15.60	10.86	30.06	3.97	2.91	40.45	43.31

Table 6. Genetic parameters for various characters in okra during rainy season

Characters	Days to 50% germination	Days to 50% flower	Days to first harvest	Plant height 90 DAS	Number of nodes (90 DAS)	Number of leaves (90 DAS)	Node to first flower appear	Number of fruits per plant	Fruit length	Fruit diameter	Fruit yield per plant	Fruit yield (q ha^{-1})
PCV (%)	29.55	5.92	5.11	15.26	8.89	5.65	10.88	17.24	11.22	8.98	11.164	8.62
GCV (%)	26.69	4.85	4.25	14.12	7.79	5.14	9.36	9.85	2.97	3.90	10.08	8.58
h^2(%)	81.50	67.10	69.00	85.70	76.50	82.80	74.10	32.60	7.00	18.90	81.50	99.10
GA	3.14	3.79	3.75	31.54	3.30	3.29	0.95	2.14	0.18	0.06	0.04	20.54
GAM	49.64	8.19	7.26	26.92	14.01	9.64	16.60	11.59	1.62	3.49	18.75	17.59

a possibility of improving these traits through selection. The findings are in close harmony with the result of Yadav *et al.* (2016) for yield (q ha^{-1}), Saryam *et al.* (2015) and Sravanthi *et al.* (2016) for yield per plant in okra. Moderate for the number of fruits per plant and days to 50% germination for the summer season and for the rainy season it was noted moderate for characters such as plant height at 90 DAS and fruit yield per plant. Similar observations have been reported by Koundinya *et al.*(2013) for the number of fruits per plant and plant height; Nikitha *et al.* (2016) for yield per plant and Thulasiram *et al.* (2017) for plant height and low for plant height at 90 DAS, the number of leaves at 90 DAS, the number of nodes at 90 DAS, days to 50% flower, days to first harvest and fruit diameter during the summer season and for the rainy season characters days to 50% flower, days to first harvest, the number of nodes at 90 DAS, the number of leaves at 90 DAS and fruit diameter exhibited low PCV and GCV estimates indicating limited scope for improvement for these traits using these genotypes. Similar observations have been reported by Kumar *et al.* (2010) for fruit diameter and Koundinya *et al.* (2013) for days to 50% flowering, days to first harvest and fruit diameter in okra.

The difference between PCV and GCV values during the summer season was high for fruit length, days to 50% germination and node to the first flower appear. Whereas, for the rainy season difference was high for fruit length, the number of fruits per plant, suggesting the role of the environment in expression of these traits and the difference was low for yield (q ha^{-1}) and the number of leaves at 90 DAS for the summer season. Whereas, for the rainy season difference was low for yield (q ha^{-1}), days to 50% flower and days to first harvest, suggesting a little role of environment in the expression of these traits and one may rely on mean phenotypic values for direct selection.

In the present study, heritability estimates were high for yield (q ha^{-1}), yield per plant, days to 50% flower, days to first harvest, the number of leaves at 90 DAS and the number of fruits per plant during the summer season and for rainy season heritability estimates were high for yield (q ha^{-1}), plant height at 90 DAS, the number of leaves at 90 DAS, yield per plant, days to 50% germination indicating that the selection based on phenotypic performance of these characters would be more operative and these were witnessed by Koundinya *et al.* (2013) for plant height, days to 50% flower, the number of fruits per plant, days to first harvest, yield per plant; Vani *et al.* (2012) for yield (q ha^{-1}) and yield per plant; Ibaad *et al.*(2016) for yield per plant, days to 50% flower, days to first harvest; Senapati *et al.*(2011) for days to 50% flower and Kumar *et al.* (2012) for days to first harvest in okra.

High genetic advance as per cent of mean for the summer season was recorded for yield (q ha^{-1}), yield per plant and the number of fruits per plant. Whereas, for the rainy season it was recorded a high for days to 50% germination, plant height at 90 DAS. Similar result was obtained by Koundinya *et al.* (2013) for plant height

and the number of fruits per plant; Kumar *et al.* (2010) for fruit yield per plant, plant height and the number of fruits per plant; Saryam *et al.* (2015) and Nikitha *et al.* (2016) for yield per plant and the number of fruits per plant. Moderate for the number of leaves at 90 DAS, days to 50% germination, days to 50% flower, days to first harvest and node to first flower appear for the summer season and for the rainy season moderate for yield per plant, yield (q ha^{-1}), node to first flower appears, the number of nodes at 90 DAS, the number of fruits per plant. Similar result was reported by Kumar *et al.* (2010) for the number of nodes**.** Low for plant height at 90 DAS, fruit length, fruit diameter for the summer season and for the rainy season low for characters number of leaves at 90 DAS, days to 50% flower, days to first harvest, fruit diameter and fruit length. These findings are in close harmony with koundinya *et al.* (2013) for days to 50% flower and days to first harvest in okra.

Panse (1957) stated that a character with high heritability in association with high genetic advance as per cent of mean is an indication of expression of additive gene action. Characters without such combination arise generally because of non-additive gene action (Liang and Walter, 1968). Therefore, it may be stated that among the characters study, yield (q ha^{-1}), yield per plant, the number of fruits per plant for the summer season and for the rainy season plant height at 90 DAS, and days to 50% germination are likely to be operated by additive genes. Improvement in these characters would be effective by selection on the basis of phenotype. Similar results were obtained by Sravanthi *et al.* (2017) for yield per plant and the number of fruits per plant; Thulasiram *et al.* (2017) for yield per plant and Yadav *et al.* (2016) for plant height in okra. High heritability with moderate genetic advance was observed for days to 50% flower, days to first harvest, the number of leaves at 90 DAS for the summer season and for the rainy season yield per plant and yield (q ha^{-1}). High heritability and low GAM values were observed for the number of leaves at 90 DAS for the rainy season. This showed the influence of non-additive gene action and the considerable influence of environment on the expression of these traits.

It is concluded from the present study that during both the season analysis of variance indicated significant differences among the genotypes for all the characters studied. During the summer season the characters, fruit yield (q ha^{-1}), and fruit yield per plant exhibited a higher PCV and GCV estimates than rest of the characters and during the rainy season character days to 50% germination exhibited higher PCV and GCV estimates suggesting that these traits can be improved through selection. Heritability estimates were high for yield (q ha^{-1}), fruit yield per plant, days to 50% flower, days to first harvest, the number of leaves at 90 DAS and the number of fruits per plant during the summer season and for the rainy season heritability estimates were high for yield(q ha^{-1}), plant height at 90 DAS, the number of leaves at 90 DAS, fruit yield per plant, days to 50% germination indicating that the selection based on phenotypic performance of these characters would be more operative. Character with high heritability in association with high genetic advance as per cent of mean is an indication of expression of additive gene action. Among the characters study, yield (q ha^{-1}), fruit yield per plant, the number of fruits per plant for the summer season and for the rainy season plant height at 90 DAS, and days to 50% germination are likely to be operated by additive genes. Improvement in these characters would be effective by selection on the basis of phenotype.

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REFERENCES

Allard, R.W.1960. Principle of Plant Breeding. *John Wiley and Sons Inc.,* New York, USA.

Camciuc, M. M., Deplagne., Vilarem, G. and Gaset, A.1998. Okra [*Abelmoschus esculentus* (L.) Moench] a crop with economic potential for set aside acreage in France. *Industrial Crops and Products*., **7:** 257–264. [Cross Ref]

Ibaad, M. H., Srinivasa, V. and Shruthi, H. T. 2016. Genetic variability, heritability and genetic advance. *Green Farming*., **7**: 602-605.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Estimates of genetic and environmental variability in soyabean. *Agronomy Journal*., **48:** 267-82.

Joshi, A. B. and Hardas, M. W. 1956. Alloploid nature of okra, *Abelmoschus esculentus* (L.) Moench. Nature, **178**: 1190. [Cross Ref]

Koundinya, A.V.V., Dhankhar, S. K. and Yadav, A. C. 2013. Genetic variability and divergence in okra (*Abelmoschus esculentus*). *Indian Journal of Agricultural* Sciences., **83**: 685–8.

Kumar, P., Akotkar, DK. De. and Pal, A. K. 2010. Genetic variability and diversity in okra (*Abelmoschus esculentus* L. Moench). *Electronic Journal of Plant* Breeding., **1**: 393-398.

Kumar, P., Singh, K. V., Singh, B., Kumar, S. and Singh, O. 2012. Genetic variability, heritability and genetic advance in okra [*Abelmoschus esculentus* (L.) Moench]. *Annals* of *Horticulture*., **5**: 69-73.

Liang, G. H. and T. L, Walter. 1968. Heritability estimates and

gene effects for agronomic trails in grain sorghum *Crop Science*., **8**: 77-80. [Cross Ref]

Lodhi, D. S., Pal, M. and Panwar, G. S. 2015. Genetic variability in different varieties of okra [*Abelmoschus esculentus* (L.) Moench] in Bundelkhand Region of U.P. *Environment & Ecology*., **33**: 1485-1488.

Nikitha, J., Arya, K. and Darshan, S. 2016. Genetic variability studies of yield & yield parameters in okra [*Abelmoschus esculentus* (L.) Moench]. *Advances in life* sciences., **5**: 6539-6541.

Panse V.G. 1957. Genetics of quantitative character in relation to plant breeding. *Indian J. Genet.*, **17**: 317-28.

Purewal, S. S. and Randhwa, G. E. 1947. Studies in *Hibiscus esculentus* (Ladyfinger) (Okra) L. chromosome and pollen studies. *Indian J. agric. Sci*., **17:** 129–136.

Prakash, K., and Pitchaimuthu, M. 2010. Nature and magnitude of genetic variability and diversity studies in okra (*Abelmoschus esculentus* L. Moench). *Electronic Journal of Plant Breeding*., **1**: 1426-1430.

Saryam, D. K., Mittra, S. K., Sunil, Pal., S.O.M. and Mehta, A. K. 2015. Assessment of genetic variability for various yield & yield attributing traits in okra [*Abelmoschus esculentus* (L.) Moench] under kymore plateau & satpura hills agro-climatic regions of Madhya Pradesh. *Current advances in agricultural* sciences, **7**: 177-179. [Cross Ref]

Senapati, N., Mishra, H. N., Beura, S. K., Darla, S. K., Prasad, G. and Patnaik, A. 2011. Genetic analysis in okra hybrids. *Environment and Ecology*, **29**: 1240-1244.

Sravanthi, V. 2016. Studies on variability, heritability and genetic advance in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Agricultural Engineering and food Technology*, **3**: 281-284. [Cross Ref]

Sravanthi, V. 2017. Studies on variability, heritability and genetic advance in okra. *International Journal of current Microbiology and Applied Sciences*, **6**: 1834-1838.

Thulasiram, L. B, Bhople, S. R., Srikanta, M. and Nayak, B. R. 2017. Genetic variability and heritability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Plant archives*., **17**: 907-910.

Tindall. H. D. 1983. Vegetables in the tropics. Macmillan Press Ltd., London and Basingstoke. pp: 25-328. [Cross Ref]

Tiwari, K. N., Mal, P. K, Singh, R. M. and Chattopadhyay, A. 1998. Response of okra (*Abelmoschus esculentus* (L.) Moench.) to drip irrigation under mulch and non-mulch conditions. *Agricultural Water Management*., **38**: 91-102. [Cross Ref]

Vani, V. M., Singh, A. K., Raju, S. V. S., Singh, B. K. and Singh, S. P. 2012. Variability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Environment and Ecology*., **30**: 1203-1206.

Yadav, R. K., Syamal, M. M., Pandiyoraj, P., Nagarajan, K., Nimbolakar, P. K. and Kumar, M. 2016. Evaluation of genetic variation heritability and genetic advance for various traits in okra [*Abelmoschus esculentus* (L.) Moench] under north genetic plains of Uttar Pradesh. *International Journal of Agriculture, Environment and Biotechnology*., **9**: 175-180. [Cross Ref]