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Investigation of genetic variability and characters association in F6 generation of okra

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Abstract

The present investigation was undertaken to assess the genetic variability and character association in twenty genotypes of okra (*Abelmoschus esculentus* L. Moench) during the 2025-2026 kharif season at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Analysis of variance revealed highly significant differences among the genotypes for all characters studied, indicating substantial genetic variability and scope for selection. The phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all traits. The highest GCV and PCV were recorded for fruit diameter (31.32 and 32.05%) followed by number of branches per plant, internodal length, fruit yield per plot, fruit yield per plant and fruit yield per hectare. High heritability coupled with high genetic advance as per cent of mean was observed for plant height, number of branches per plant, internodal length, fruit diameter, number of fruits per plant and fruit yield, indicating good prospects for genetic improvement through selection. Fruit yield per plant exhibited a highly significant positive association with number of fruits per plant at both genotypic ($r = 0.912^{**}$) and phenotypic ($r = 0.762^{**}$) levels, along with significant positive associations with number of branches per plant, fruit length, fruit weight and plant height. Path analysis revealed the highest positive direct effect of number of fruits per plant (0.9678), followed by fruit weight (0.4168), days to first flowering (0.1304) and fruit diameter (0.0573) on fruit yield per plant. Among the evaluated genotypes, AKOH-3, AKO-11, AKOR-25 and AKO-10 showed superior yield performance. These findings suggest that number of fruits per plant, fruit weight and other associated traits can serve as useful selection criteria for improving fruit yield in okra.

Keywords: Genetic variability, GCV, PCV, heritability, GAM, Correlation, Path analysis

1. Introduction

Okra [*Abelmoschus esculentus* (L.) Moench], popularly known as lady's finger, bhindi or gumbo, is an economically important vegetable crop belonging to the family Malvaceae. The crop is widely appreciated for its nutritional value and its ability to thrive under diverse tropical and subtropical growing conditions (Temam *et al.*, 2021) ^[19]. It has a somatic chromosome number of $2n = 130$ and is generally believed to have originated in Africa. Over the years, its adaptability and versatility have contributed to its widespread cultivation across different parts of the world.

India holds a prominent position in global okra cultivation and production, contributing nearly 72 per cent of the total world output. In the country, okra is cultivated over an area of approximately 554 thousand hectares, producing about 7,289 thousand tonnes of tender fruits annually, with an average productivity of 13.15 tonnes per hectare. The crop is predominantly cross-pollinated, and insects serve as the major agents responsible for pollen transfer among flowers. Natural outcrossing in okra is not constant and may vary from about 4 to 19 per cent depending upon environmental conditions and the activity of pollinating insects. Such a degree of cross-pollination contributes to the maintenance and generation of genetic variability, thereby offering substantial opportunities for selection and genetic improvement of important yield and yield-related traits.

2. Materials and methods

The present study entitled "Investigation of Genetic Variability and Characters Association in F6 Generation of Okra" was conducted at the Instructional Farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the kharif

season of 2025-2026. The experiment comprised 20 genotypes collected from different sources and was laid out in a Randomized Block Design (RBD) with uniform agronomic practices. The experimental site is situated at 307.42 m above mean sea level, 20.42° N latitude and 77.02° E longitude, and experiences a tropical climate with extremely hot summers and dry, cold winters. Each plot measured 3.0 m × 1.6 m, with a spacing of 60 cm × 30 cm between plants and rows.

Observations were recorded on five representative plants from each genotype in every replication for quantitative and qualitative traits, including plant height, days to first flower initiation, days to 50% flowering, internodal length, number of branches per plant, length of fruit, fruit diameter, fruit weight, number of ridges per fruit, number of fruits per plant, fruit yield per plot, fruit yield per plant, fruit yield per hectare, percent YVMV incidence and percent fiber content. The recorded observations were averaged and subjected to statistical analysis to estimate GCV, PCV, heritability, genetic advance, correlation and path coefficients analysis. The analyses were performed using MS Excel, OPSTAT, Agri Analyzer and R studio software.

Table 1: Name of okra genotypes and sources

Sr. No	Name of genotypes	Source
1.	Korchi	Department of Vegetable Science, Akola.
2.	AKO-1-P-2	Department of Vegetable Science, Akola.
3.	Kokan Bhendi	Dr. BSKKV, Dapoli.
4.	AKOR-24	Department of Vegetable Science, Akola.
5.	Arka Anamika	IIHR Bangalore.
6.	AKOR-25	Department of Vegetable Science, Akola.
7.	AKO-1	Department of Vegetable Science, Akola.
8.	AKO-2	Department of Vegetable Science, Akola.
9.	AKO-7	Department of Vegetable Science, Akola.
10.	AKO-10	Department of Vegetable Science, Akola.
11.	AKO-11	Department of Vegetable Science, Akola.
12.	F7-3	Department of Vegetable Science, Akola.
13.	F7-4	Department of Vegetable Science, Akola.
14.	IC-42472	NBPGR, New Delhi
15.	EC-3293384	NBPGR, New Delhi.
16.	AKOH-1	Department of Vegetable Science, Akola.
17.	AKOH-2	Department of Vegetable Science, Akola.
18.	AKOH-3	Department of Vegetable Science, Akola.
19.	AKOH-4	Department of Vegetable Science, Akola.
20.	AKOH-5	Department of Vegetable Science, Akola.

3. Results and Discussion

The experimental data on quantitative traits were subjected to analysis of variance (ANOVA) as described by Panse and Sukhatme (1967) ^[14] to test the significance of differences among genotypes. Genotypic and phenotypic coefficients of variation (GCV and PCV), proposed by Burton and Devane (1953) ^[2], were used to assess genetic and total phenotypic variability. Heritability, as suggested by Lush (1949), indicates the proportion of phenotypic variation due to genetic effects, while genetic advance (GA) and genetic advance as per cent of mean (GAM), as described by Johnson *et al.* (1955) ^[7], indicate the expected progress through selection.

Genotypic, phenotypic and environmental correlations were estimated following Johnson *et al.* (1955) ^[7] to determine the strength and direction of relationships among traits. Path coefficient analysis, as proposed by Dewey and Lu (1959), was used to partition correlations into direct and indirect

effects on fruit yield per plant. Together, these analyses helped identify genetically important and yield-contributing traits that could serve as effective selection criteria for improving fruit yield in okra.

Analysis of variance

The analysis of variance revealed that the treatment mean squares were highly significant for all the characters studied, indicating the presence of significant differences among the evaluated okra genotypes. The highest treatment variation was recorded for plant height followed by fruit yield per hectare and fruit yield per plant showing considerable variability for growth and yield attributes.

Overall, the significant treatment effects for all characters demonstrate adequate genetic variability among the studied genotypes, which is essential for effective selection and breeding of superior-yielding okra genotypes.

Table 2: Analysis of variance for different characters in okra

Sr. No	Name of characters	Mean sum of square		
		Replication	Treatment	Error
	Degree of freedom	2	19	38
1	Plant height (cm)	161.828	3202.339**	165.256
2	Number of branches per plant	0.127	3.828**	0.167
3	Internodal length (cm)	0.344	19.681**	0.768
4	Fruit weight (g)	0.522	2.568**	0.447
5	Fruit diameter (mm)	0.539	50.168**	0.781
6	Length of fruit (cm)	0.470	5.652**	0.390
7	Days to first flowering	2.766	69.396**	5.152
8	Days to 50% flowering	6.448	62.394**	7.165
9	Number of fruits per plant	6.872	79.357**	5.778
10	Fruit yield per plot (kg)	0.317	4.865**	0.304
11	Fruit yield per hectare (q/ha)	86.257	2075.054**	132.523
12	Fruit yield per plant (g)	547.907	7693.667**	487.498

Phenotypic and genotypic variance

The PCV values were slightly higher than GCV values for all the traits, indicating a small influence of environmental factors on trait expression. The highest variability was observed for fruit diameter (GCV 31.32%, PCV 32.05%) followed by number of branches per plant and internodal length. Moderate to high variability was recorded for plant height (21.14%, 22.80%), number of fruits per plant (22.36%, 24.85%), fruit yield per plot (24.39%, 26.71%), fruit yield per hectare (24.20%, 26.56%), fruit yield per plant (24.24%, 26.59%) and length of fruit (17.24%, 19.07%) suggesting appreciable genetic variation and good scope for selection. These findings are supported by Koundinyal *et al.* (2013) and Syfullah *et al.* (2018) ^[18]. The lowest variability was recorded for days to 50 per cent flowering (GCV 9.10%, PCV 10.73%) followed by fruit weight (9.20%, 11.76%) and days to first flowering (10.70%, 11.92%). The narrow differences between GCV and PCV indicate that environmental effects were comparatively limited, while the genetic component contributed considerably to trait expression. Similar findings have been reported in okra by Khajuria *et al.* (2016) ^[8].

Heritability and genetic advance mean:

The estimates of heritability and genetic advance indicated substantial genetic control for most of the traits studied. Fruit diameter recorded the highest heritability (95.47%)

along with the highest genetic advance as per cent of mean (63.04%) followed by internodal length (89.14%, 52.64%), number of branches per plant (87.99%, 52.91%) and plant height (85.97%, 40.37%). The high heritability coupled with high GAM for these traits due to additive gene action resulting that these traits can be opted as selection criteria for okra breeding programme. Similar findings were reported by Koundinyal *et al.* (2013) and Chetana *et al.* (2021) [3]. Moderate genetic advance was observed for fruit weight (GAM 14.84%), days to first flowering (19.79%) and days to 50 per cent flowering (15.91%), while their

heritability values were 61.29, 80.61 and 71.98 per cent, respectively. These results indicate that selection for these characters may be useful, although the expected response would be comparatively moderate. Fruit yield per plant showed high heritability (83.13%) with high GAM (45.53%), indicating considerable scope for genetic improvement through selection. Comparable results for high heritability combined with high genetic advance in yield and related traits were reported by Mohammed *et al.* (2022) [12], Gohil *et al.* (2024) [5].

Table 3: Genetic parameters in respect of different quantitative traits in okra genotypes

Sr. No	Character	Range		Mean	GCV %	PCV %	(h ²) %	GA	GAM (%)
		Min	Max						
1	Plant height (cm)	77.90	195.86	150.53	21.14	22.80	85.97	60.77	40.37
2	Number of branches per plant	1.98	5.68	4.09	27.38	29.19	87.99	2.13	52.91
3	Internodal length (cm)	4.70	8.50	6.85	27.07	28.67	89.14	4.88	52.64
4	Fruit weight (g)	7.87	11.02	9.14	9.20	11.76	61.29	1.36	14.84
5	Fruit diameter (mm)	5.80	18.10	12.95	31.32	32.05	95.47	8.17	63.04
6	Length of fruit(cm)	7.47	12.33	9.06	17.24	19.07	81.79	2.47	32.12
7	Days to first flowering	37.01	52.67	43.29	10.70	11.92	80.61	8.56	19.79
8	Days to 50% flowering	39.98	55.88	47.13	9.10	10.73	71.98	7.50	15.91
9	Number of fruits per plant	12.87	30.47	21.74	22.36	24.85	80.93	9.18	41.44
10	Fruit yield per plot (kg)	2.73	7.41	5.06	24.39	26.71	83.36	2.32	45.87
11	Fruit yield per hectare (q/ha)	56.87	154.41	105.14	24.20	26.56	83.01	47.76	45.43
12	Fruit yield per plant (g)	109.2	297.00	202.20	24.24	26.59	83.13	92.05	45.53

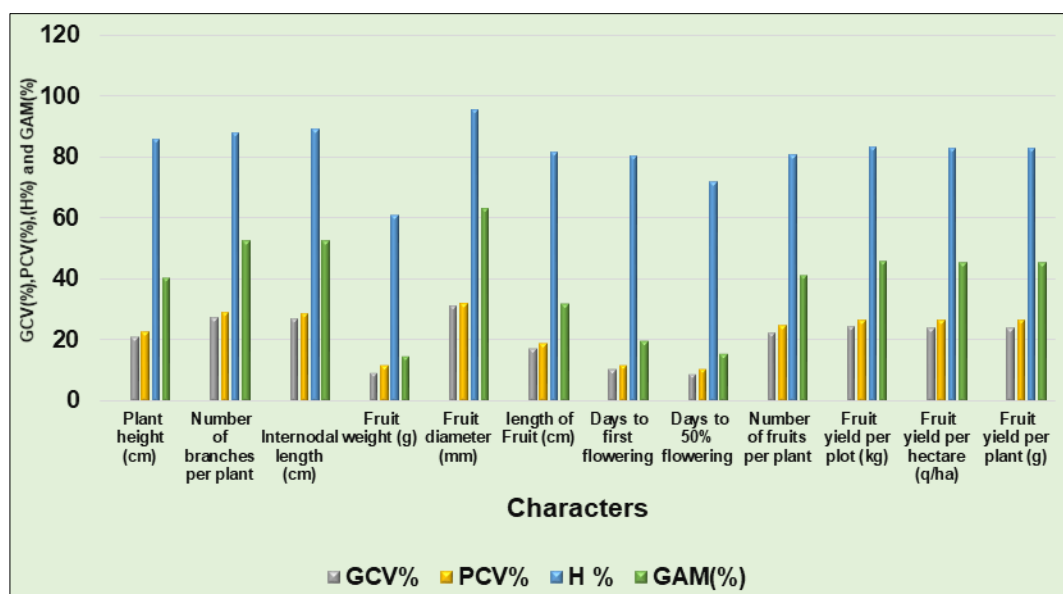


Fig 1: Estimation of GCV, PCV, heritability and Genetic advance as% of mean

Character association

The genotypic correlation

Analysis revealed that fruit yield per plant had the highest positive and significant association with number of fruits per plant ($r = 0.912^{**}$) followed by number of branches per plant ($r = 0.488^{**}$) and fruit weight ($r = 0.295^{**}$). Plant height ($r = 0.108^*$) and fruit length ($r = 0.184$) also showed positive associations with yield. Similar positive associations of yield with important yield components were reported by Jagan *et al.* (2013) [6], Mishra *et al.* (2015) [11] and Syfullah *et al.* (2018) [18]. On the other hand, internodal length ($r = 0.014$), fruit diameter ($r = 0.044$), days to first flowering ($r = 0.063$) and days to 50 per cent flowering ($r = 0.152$) showed positive but non-significant genotypic associations with fruit yield per plant. Similar finding reported by Sharma *et al.* (2022) [17].

Overall, number of fruits per plant emerged as the most important trait associated with fruit yield, indicating its usefulness as a selection criterion for yield improvement in okra. The findings are also supported by Nwangburuka *et al.* (2012) [13] and Syfullah *et al.* (2018) [18], who reported significant associations among yield and its contributing traits.

The phenotypic correlation

Analysis revealed that fruit yield per plant showed the highest positive and highly significant association with number of fruits per plant ($r = 0.762^{**}$), followed by number of branches per plant ($r = 0.464^{**}$) and fruit weight ($r = 0.220^{**}$). Plant height ($r = 0.122^*$) and fruit length ($r = 0.184$) also showed positive significant associations with yield, indicating their importance in improving fruit

productivity. Similar positive associations of fruit yield with number of fruits, fruit weight, fruit length and other yield components were reported by Balakrishnan and Sreenivasan (2010) [1] and Walling *et al.* (2020) [20]. On the other hand, internodal length ($r = 0.006$), fruit diameter ($r = 0.031$), days to first flowering ($r = 0.075$) and days to 50 per cent flowering ($r = 0.176$) showed positive but non-significant genotypic associations with fruit yield per plant. Similar

finding reported by Sharma *et al.* (2022) [17].

Overall, number of fruits per plant emerged as the most important phenotypic correlate of fruit yield, suggesting its usefulness as a selection criterion for yield improvement. The present findings are also supported by Jagan *et al.* (2013) [6], who observed highly significant positive phenotypic associations of fruit yield with number of branches and number of fruits per plant.

Table 4: Estimation of genotypic correlation coefficient for different characters in okra

Characters	Plant height (cm)	Number of branches per plant	Internodal length (cm)	Fruit weight(g)	Fruit diameter (mm)	Length of fruit (cm)	Days to first flowering	Days to 50% flowering	Number of fruits per plant	Fruit yield per plant (g)
Plant height (cm)	1.000	0.370**	0.540**	0.040	0.003	-0.379**	-0.011	-0.008	0.100	0.108*
Number of branches per plant		1.000	-0.262**	0.252**	-0.063	0.062	0.066	0.148**	0.404**	0.488**
Internodal length (cm)			1.000	-0.097	0.107*	-0.474**	0.063	0.024	0.069	0.014
Fruit weight(g)				1.000	0.442**	0.628**	-0.100	-0.034	-0.090	0.295**
Fruit diameter (mm)					1.000	0.580**	0.133*	0.182**	-0.138**	0.044
Length of fruit (cm)						1.000	0.191**	0.242**	-0.051	0.184**
Days to first flowering							1.000	0.987**	0.111*	0.063
Days to 50% flowering								1.000	0.178**	0.152
Number of fruits per plant									1.000	0.912**
Fruit yield per plant (g)										1.000

Table 5: Estimation of phenotypic correlation coefficient for different characters in okra

Characters	Plant height (cm)	Number of branches per plant	Internodal length (cm)	Fruit weight (g)	Fruit diameter (mm)	Length of fruit (cm)	Days to first flowering	Days to 50% flowering	Number of fruits per plant	Fruit yield per plant (g)
Plant height (cm)	1.000	0.338**	0.485**	0.049	0.001	-0.329**	0.033	-0.015	0.085	0.122*
Number of branches per plant		1.000	-0.249**	0.217**	-0.064	0.057	0.058	0.143**	0.344**	0.464**
Internodal length (cm)			1.000	-0.088	0.090	-0.403**	0.049	-0.013	0.044	0.006
Fruit weight (g)				1.000	0.360**	0.518**	-0.055	-0.040	-0.091	0.220**
Fruit diameter (mm)					1.000	0.519**	0.117*	0.170**	-0.121*	0.031
Length of fruit (cm)						1.000	0.157**	0.211**	-0.049	0.184**
Days to first flowering							1.000	0.841**	0.091	0.075
Days to 50% flowering								1.000	0.161**	0.176
Number of fruits per plant									1.000	0.762**
Fruit yield per plant (g)										1.000

Path analysis

The path coefficient analysis revealed that number of fruits per plant exhibited the highest positive direct effect on fruit yield per plant (0.9678), followed by fruit weight (0.4168), days to first flowering (0.1304), fruit diameter (0.0573) and plant height (0.0029). The strong direct contribution of number of fruits per plant, together with its high positive

genotypic correlation with yield ($r = 0.9127$), indicates that it is the most important trait for improving yield through direct selection. Similar importance of number of fruits per plant and fruit weight in determining yield was reported by Yadav *et al.* (2010) [21], Ramanjinappa *et al.* (2011) and Sharma and Prasad (2015) [16].

In contrast, days to 50 per cent flowering showed the highest negative direct effect (-0.1206), followed by

internodal length (−0.0694), fruit length (−0.0886) and number of branches per plant (−0.0088). The negative direct effect of internodal length suggests that excessive vegetative elongation may not favour yield formation. Similarly, the negative direct effect of days to 50 per cent flowering indicates that delayed flowering may reduce yield potential. Interestingly, number of branches per plant showed a positive genotypic correlation with yield ($r = 0.4889$) despite its negative direct effect, mainly because of its strong positive indirect contribution through number of fruits per plant (0.3915) and fruit weight (0.1052). Similar negative direct effects of branches and flowering-related traits have been reported by Sharma and Prasad (2015)^[16].

The number of fruits per plant recorded the highest positive direct effect (0.9678) and also showed the strongest positive genotypic correlation with fruit yield (0.9127**), clearly establishing it as the most important selection criterion for yield improvement. The residual effect was low (0.087), indicating that most of the variation in fruit yield was explained by the characters included in the path analysis. Similar findings emphasizing number of fruits per plant and fruit weight as important selection criteria have been reported by Ramanjinappa *et al.* (2011)^[15], and Sharma and Prasad (2015)^[16].

Table 6: Path coefficient showing direct and indirect effects of various traits on fruit yield per plant of okra

Character	Plant height (cm)	Number of branches per plant	Internodal length (cm)	Fruit weight(g)	Fruit diameter (mm)	Length of Fruit (cm)	Days to first flowering	Days to 50% flowering	Number of fruits per plant	Genotypic correlation with fruit yield/plant (g)
Plant height (cm)	0.0029	-0.0033	-0.0375	0.0168	0.0002	0.0336	-0.0015	0.0010	0.0967	0.1089*
Number of branches per plant	0.0011	-0.0088	0.0182	0.1052	-0.0036	-0.0055	0.0087	-0.0179	0.3915	0.4889**
Internodal length (cm)	0.0016	0.0023	-0.0694	-0.0406	0.0061	0.0420	0.0083	-0.0029	0.0668	0.0143
Fruit weight(g)	0.0001	-0.0022	0.0068	0.4168	0.0253	-0.0557	-0.0131	0.0041	-0.0867	0.2956**
Fruit diameter (mm)	0.0000	0.0006	-0.0074	0.1843	0.0573	-0.0514	0.0173	-0.0219	-0.1339	0.0448
Length of fruit(cm)	-0.0011	-0.0005	0.0329	0.2618	0.0333	-0.0886	0.0249	-0.0292	-0.0493	0.1840**
Days to first flowering	-0.0000	-0.0006	-0.0044	-0.0418	0.0076	-0.0169	0.1304	-0.1190	0.1077	0.0633
Days to 50% flowering	-0.0000	-0.0013	-0.0016	-0.0143	0.0104	-0.0215	0.1287	-0.1206	0.1723	0.1522
Number of fruits per plant	0.0003	-0.0036	-0.0048	-0.0373	-0.0079	0.0045	0.0145	-0.0215	0.9678	0.9127**

Residual effect= 0.087, direct effect= bold diagonal, *, ** significant at 5% and 1% level

4. Conclusion

The present study revealed substantial genetic variability among the evaluated okra genotypes, providing good scope for effective selection and further genetic improvement. AKOH-3, AKO-11, AKOR-25 and AKO-10 were identified as promising genotypes for fruit yield. High heritability coupled with high genetic advance for several yield and yield-contributing traits indicated considerable scope for selection. Correlation analysis showed a strong positive association of number of fruits per plant with fruit yield, while path analysis revealed its highest positive direct effect (0.9678). Therefore, number of fruits per plant may be considered an important selection criterion for improving fruit yield in okra. The identified superior genotypes and important yield-associated traits can be effectively utilized in future selection and hybridization programmes.

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