



ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 1730-1733
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www.thepharmajournal.com

Received: 02-05-2022

Accepted: 08-06-2022

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Genetic variability and association analysis in Okra [*Abelmoschus esculentus* (L.) Monech]

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Abstract

A study of genetic variability and association analysis in 28 okra genotypes for 14 traits was laid out in randomized block design with three replications during kharif 2021. High genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were recorded for yield per plant followed by number of fruit per plant and plant height. High heritability estimate was recorded for yield per plant, number of fruit per plant, nodes to first fruit appearance, plant height and crop duration. The characters which showed high genetic advance as per cent of mean was yield per plant. The characters which showed high heritability associated with high genetic advance is yield per plant. Yield per plant is highly significant positive correlation with plant height, number of branches per plant, fruit length, days to first flower, days to first fruit appearance, nodes to first fruit appearance, crop duration, average weight of fruit and number of fruit per plant, significant positive correlation with days to first flower, nodes to first fruit appearance and days to fifty percent flowering. In path coefficient analysis number of fruit per plant expressed a highest positive direct effect on fruit yield per plant followed by crop duration, nodes to first flower appearance, average weight of fruit, number of branches per plant followed by days to first fruit appearance, fruit length, days to first flower and fruit girth. The characters such as number of fruit per plant and yield per plant should be considered, while making selection strategies for improvement of yield in okra.

Keywords: Genetic, association, coefficient, Okra, *Abelmoschus esculentus* L.

Introduction

Okra [*Abelmoschus esculentus* (L.) Monech], often known as lady's finger, gumbo, or bhindi, is a crop of tropical and subtropical region. In Chhattisgarh it is grown during rainy and summer season. Okra is a herbaceous annual plant of Malvaceae family. Most of cultivated varieties are amphidiploids with $2n=130$. Being an often-cross pollinated crop, the extent of cross-pollination is 4-19% where 42.2% is due to insect attracted by large attractive flowers and also by protogyny nature.

India is the largest producer and consumer of okra in the world with an area of 544 thousand hectare with an annual production of 6494 thousand metric tonnes (Anonymous 2020) which share about 62%. It is also cultivated in the countries like Africa, Brazil, and China. In India major okra cultivating states is West Bengal with an area of 77.55 thousand hectare with annual production of 914.86 thousand metric tonnes. In Chhattisgarh area under okra production is 31.65 thousand hectare and its production is 351.26 thousand metric tonnes (Anonymous., 2021) [2]. Productivity of okra in Chhattisgarh is 10.47 metric tonnes per hectare. (Anonymous., 2018) [1]. Major okra producing districts in Chhattisgarh is Kondagaon with the area of 3.89 thousand hectare with annual production of 34.48 metric tonnes. Raipur share area of 2.13 thousand hectare with the production of 21.76 metric tonnes (Anonymous., 2021) [2]. Mucilage present in okra is due to polysaccharides (galacturonic and glucuronic acid). Vavilov considered tropical Africa as the main *center of origin*. It is a day neutral plant and is very nutritious vegetable where 100 g of edible okra contain 10.40 g of dry matter, 1.08 g protein, 1.8 g vitamin C, 0.90 g calcium, 0.01 g iron, 0.01 g carotene, 0.07 mg vitamin B1, 0.08 mg vitamin B2 and 0.08 mg vitamin B3.

Materials and Method

The experiment was conducted using 28 okra genotypes at the Horticultural Research cum Instructional Farm, at Department of Vegetable Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India during kharif 2021 to evaluate the genetic variability and heritability and correlation and path coefficient analysis in okra.

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The recommended package of cultural practices was adopted for raising the crop. Observations were recorded on 14 economically important traits viz. plant height (cm), number of branches per plant, days to 1st flower, nodes to 1st flower appearance, days to 1st fruit appearance, days to 50% flowering, nodes to 1st fruit appearance, days to 1st picking, fruit girth (cm), fruit length (cm), average weight of fruit (g), number of fruit per plant, yield of fruit per plant and crop duration. The soil of plot was sandy loam in texture having good fertility, properly leveled and well drained. Five plants in each genotype were selected randomly and were tagged and used for recording observations for the above characters. The phenotypic and genotypic components of variance were computed according to formulae given by Lush (1940) [13]. However, Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) in percentage were calculated according to Burton and De Vane (1953) [4]. Heritability estimates for fruit yield and its components was calculated based on the ratio of genotypic variance to the phenotypic variance and was expressed in percentage Honson *et al.* (1956) [8]. Genetic advance was estimated by using the method suggested by Johnson *et al.* (1955) [10] At the genotypic, phenotypic levels, correlation coefficients were calculated as given by Searle *et al.* (1961) [19]. The direct and indirect effects of path coefficient were calculated using

Dewey and Lu's technique (1959) [6].

Results and Discussion

Result of genetic variability (Table 1) revealed that phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) in all studied traits which indicates that environment having masking effect on the expression of genetic variability as shown in Table 1. Similar result were reported by Mehta *et al.* (2006) [14]. High genotypic coefficient of variation (GCV) were recorded for yield per plant (31.03) followed by number of fruit per plant (26.00) and plant height (21.67). Moderate value genotypic coefficient of variation (GCV) were recorded for number of branches per plant (13.05). Low value of genotypic coefficient of variation (GCV) were recorded for average weight of fruit (9.12) followed by nodes to first flower appearance (5.76), fruit length (5.69), crop duration (4.36), days to first flower (2.14), days to fifty percent flowering (2.098), days to first fruit appearance (2.02), days to first picking (1.76) and fruit girth (1.75). The result was supported by Khajuria *et al.* (2015) [11] reported high magnitude of GCV & PCV for number of fruit per plant and Walling *et al.* (2020) for plant height.

Table 1: Genetic parameters of Variation for yield and its component in okra

	Parameters→ Characters↓	Mean	Range		Coefficient of variation (%)		h ² (b)	Genetic Advance	Genetics advance as % of mean
			Minimum	Maximum	Genotypic	Phenotypic			
1.	Plant height (cm)	75.00	44.26	103.2	21.67	24.94	75.52	29.10	38.80
2.	Number of branches per plant	2.79	1.80	3.96	13.05	21.93	35.41	0.44	16.00
3.	Fruit girth (cm)	5.23	5.01	5.64	1.75	4.30	16.65	0.07	1.47
4.	Fruit length (cm)	11.36	9.86	16.66	5.69	16.74	11.55	0.45	3.98
5.	Days to 1st flower	46.50	44.46	48.80	2.14	2.99	51.33	1.47	3.16
6.	Days to 1st fruit appearance	48.96	46.93	51.00	2.02	3.15	41.14	1.30	2.67
7.	Nodes to 1st fruit appearance	5.41	4.53	6.00	7.70	8.62	79.82	0.76	14.18
8.	Crop duration	99.63	92.00	106.00	4.36	5.03	75.23	7.77	7.80
9.	Days to 50% flowering	56.88	54.00	59.66	2.09	3.58	34.17	1.43	2.52
10.	Nodes to 1st flower appearance	5.20	4.53	5.60	5.76	7.06	6.58	0.50	9.68
11.	Days to 1st picking	53.40	50.20	55.00	1.76	2.77	40.38	1.23	2.31
12.	Average weight of fruit (g)	12.00	9.50	16.15	9.12	15.44	34.89	1.33	11.10
13.	No.of fruit per plant	5.71	2.43	9.08	26.00	29.02	80.26	2.74	47.99
14.	Yield per plant (g)	68.56	28.19	124.25	31.03	33.86	83.97	40.17	58.59

Table 2: Association analysis (genotypic and phenotypic) among yield and its contributing character in okra

Character↓→		PH	BPP	FG	FL	DFP	DFPt	NFFt	CD	FF	NFF	DFP	AW	NFP	YP
PH															
BPP	rg	0.289**													
	rp	0.198													
FG	rg	0.17	-0.326**												
	rp	0.147	-0.272*												
FL	rg	0.120	-0.138	0.409**											
	rp	0.018	-0.084	0.101											
DFP	rg rp	0.501**	0.484**	-0.557**	-0.739**										
		0.278*	0.286**	-0.284**	-0.198										
DFPt	rg	0.705**	0.704**	-0.610**	-0.193	0.120**									
	rp	0.374**	0.344**	-0.221*	-0.169	0.880**									
NFFt	rg rp	-0.188	0.255*	-0.243*	-0.015	0.196	0.188								
		-0.113	0.173	-0.100	-0.088	0.157	0.150								
CD	rg	0.745**	0.158	0.200	0.522**	0.453**	0.697**	0.037							
	rp	0.545**	0.047	0.089	0.184	0.287**	0.384**	-0.033							
FF	rg rp	0.131	-0.044	0.482**	0.412**	0.319**	0.362**	0.772**	0.277*						
		0.009	0.026	-0.101	0.068	0.308**	0.188	0.436**	0.041						
NFF	rg rp	-0.377**	0.056	-0.234*	-0.417**	0.098	-0.065	0.904**	-0.227*	0.753**					
		-0.246*	0.077	-0.135	-0.067	0.105	0.067	0.819**	-0.237*	0.419**					

DFP	rg rp	0.601** 0.334**	0.588** 0.253*	-0.607** -0.007	-0.047** -0.139	0.840** 0.708**	0.902** 0.675**	-0.048 -0.061	0.542** 0.317**	0.042 0.037	-0.278* -0.117				
AW	rg rp	0.388** 0.332**	0.240* -0.034	-0.267* 0.087	0.525** 0.075	0.539** 0.206	0.732** 0.291**	0.283** 0.152	0.725** 0.413**	0.583** -0.019	0.118 -0.08	0.497** 0.163			
NFP	rg rp	0.589** 0.461**	0.314** 0.205	0.07 0.062	0.239* 0.038	0.164 0.097	0.384** 0.198	0.227* 0.193	0.608** 0.487**	0.063 0.046	0.006 0.039	0.017 0.035	0.432** -0.002		
YP	rg rp	0.608** 0.559**	0.354** 0.213	-0.095 0.103	0.356** 0.06	0.308** 0.227*	0.549** 0.352**	0.308** 0.248*	0.763** 0.603**	0.275* 0.068	0.063 0.016	0.137 0.155	0.668** 0.398**	0.965** 0.893**	

PH= Plant height (cm), BPP= Number of branches per plant, FG= Fruit girth (cm), FL= Fruit length (cm), DFF= Days to 1st flower, DFFt= Days to 1st fruit appearance, NFFt= Nodes to 1st fruit appearance, CD= Crop duration (days), FF= Days to 50% flowering, NFF= Nodes to 1st flower appearance, DFP= Days to 1st picking, AW= Average weight of fruit (g), NFP= No. of fruit per plant, YP= Yield per plant (g).

Table 3: Genotypic path coefficient for yield and yield contributing character in okra

Character	PH	BPP	FG	FL	DFF	DFFt	NFFt	CD	FF	NFF	DFP	AW	NFP	r
PH	-0.037	0.024	0.001	0.006	0.015	0.049	0.027	0.195	-0.010	-0.098	-0.055	0.065	0.426	0.608
BPP	-0.011	0.082	-0.011	-0.007	0.015	0.049	-0.036	0.041	0.003	0.015	-0.054	0.040	0.227	0.354
FG	-0.006	-0.109	0.008	0.019	-0.017	-0.042	0.035	0.052	-0.035	-0.061	0.056	-0.045	0.051	-0.095
FL	-0.004	-0.011	0.003	0.047	-0.023	-0.013	0.002	0.136	-0.030	-0.108	0.096	0.088	0.173	0.356
DFF	-0.018	0.040	-0.004	-0.035	0.031	0.071	-0.028	0.118	-0.023	0.025	-0.077	0.091	0.118	0.308
DFFt	-0.026	0.058	-0.005	-0.009	0.032	0.070	-0.027	0.182	-0.026	-0.017	-0.083	0.123	0.278	0.549
NFFt	0.007	0.021	-0.002	-0.001	0.006	0.013	-0.142	0.010	-0.056	0.235	0.004	0.048	0.164	0.308
CD	-0.027	0.013	0.002	0.025	0.014	0.049	-0.005	0.261	-0.020	-0.059	-0.050	0.122	0.439	0.763
FF	-0.005	-0.004	0.004	0.019	0.010	0.025	-0.110	0.072	-0.072	0.196	-0.004	0.098	0.045	0.275
NFF	0.014	0.005	-0.002	-0.020	0.003	-0.005	-0.129	-0.059	-0.055	0.260	0.026	0.020	0.004	0.063
DFP	-0.022	0.048	-0.005	-0.049	0.026	0.063	0.007	0.141	-0.003	-0.072	-0.092	0.084	0.012	0.137
AW	-0.014	0.020	-0.002	0.025	0.017	0.051	-0.040	0.189	-0.042	0.031	-0.046	0.168	0.313	0.668
NFP	-0.022	0.026	0.001	0.011	0.005	0.027	-0.032	0.159	-0.005	0.002	-0.002	0.073	0.723	0.965

Residual are -0.02020.

PH= Plant height (cm), BPP= Number of branches per plant, FG= Fruit girth (cm), FL= Fruit length (cm), DFF= Days to 1st flower, DFFt= Days to 1st fruit appearance, NFFt= Nodes to 1st fruit appearance, CD= Crop duration (days), FF= Days to 50% flowering, NFF= Nodes to 1st flower appearance, DFP= Days to 1st picking, AW= Average weight of fruit (g), NFP= No. of fruit per plant, YP= Yield per plant (g).

Table 4: Phenotypic path coefficient for yield and yield contributing character in okra

Character	PH	BPP	FG	FL	DFF	DFFt	NFFt	CD	FF	NFF	DFP	AW	NFP	r
PH	-0.0089	0.0067	0.0057	0.0002	0.0005	0.0177	0.0003	-0.0122	0.0003	0.0005	0.0098	0.1297	0.4094	0.5590
BPP	-0.0018	0.0338	-0.0105	-0.0009	0.0005	0.0163	-0.0004	-0.0011	0.0008	-0.0001	0.0074	-0.0131	0.1818	0.2120
FG	-0.0013	-0.0092	0.0386	0.0011	-0.0005	-0.0105	0.0002	-0.0020	-0.0029	0.0003	-0.0002	0.0340	0.0549	0.1020
FL	-0.0002	-0.0028	0.0039	0.0110	-0.0003	-0.0080	0.0002	-0.0041	0.0020	0.0001	-0.0041	0.0294	0.0334	0.0600
DFF	-0.0025	0.0097	-0.0110	-0.0022	0.0017	0.0416	-0.0004	-0.0065	0.0089	-0.0002	0.0207	0.0804	0.0865	0.2260
DFFt	-0.0033	0.0116	-0.0085	-0.0019	0.0015	0.0473	-0.0004	-0.0086	0.0054	-0.0001	0.0198	0.1136	0.1761	0.3520
NFFt	0.0010	0.0058	-0.0039	-0.0010	0.0003	0.0071	-0.0023	0.0007	0.0126	-0.0015	-0.0018	0.0595	0.1710	0.2470
CD	-0.0049	0.0016	0.0034	0.0020	0.0005	0.0182	0.0001	-0.0224	0.0012	0.0004	0.0093	0.1616	0.4322	0.6030
FF	-0.0001	0.0009	-0.0039	0.0008	0.0005	0.0089	-0.0010	-0.0009	0.0288	-0.0008	0.0011	-0.0075	0.0410	0.0670
NFF	0.0022	0.0026	-0.0052	-0.0007	0.0002	0.0032	-0.0019	0.0053	0.0121	-0.0019	-0.0034	-0.0312	0.0346	0.0150
DFP	-0.0030	0.0085	-0.0003	-0.0015	0.0012	0.0319	0.0001	-0.0071	0.0011	0.0002	0.0293	0.0637	0.0309	0.1550
AW	-0.0030	-0.0011	0.0034	0.0008	0.0004	0.0138	-0.0004	-0.0093	-0.0006	0.0002	0.0048	0.3909	-0.0019	0.3970
NFP	-0.0041	0.0069	0.0024	0.0004	0.0002	0.0094	-0.0005	-0.0109	0.0013	-0.0001	0.0010	-0.0008	0.8874	0.8920

Residual are 0.03618.

PH= Plant height (cm), BPP= Number of branches per plant, FG= Fruit girth (cm), FL= Fruit length (cm), DFF= Days to 1st flower, DFFt= Days to 1st fruit appearance, NFFt= Nodes to 1st fruit appearance, CD= Crop duration (days), FF= Days to 50% flowering, NFF= Nodes to 1st flower appearance, DFP= Days to 1st picking, AW= Average weight of fruit (g), NFP= No. of fruit per plant, YP= Yield per plant (g).

The characters studied, high heritability estimate was recorded for yield per plant (83.97%), number of fruit per plant (80.26%), nodes to first fruit appearance (79.82%), plant height (75.52%), crop duration (75.23%), whereas medium heritability estimate was recorded for nodes to first flower appearance (66.58%) and days to first flower (51.33%), low heritability estimate was recorded for days to first fruit appearance (41.14%), days to first picking (40.38%), number of branches per plant (35.41%), average weight of fruit (34.89%), days to fifty percent flowering (34.17%), fruit girth (16.65%) and fruit length (11.55%).

The only character which showed high genetic advance as per cent of mean was yield per plant (58.59%) whereas moderate genetic advance as per cent of mean were number of fruit per

plant (47.99) and plant height (38.80%), character showed low genetic advance as per cent of mean were number of branches per plant (16.00%), nodes to first fruit appearance (14.18%), average weight of fruit (11.10%), nodes to first flower appearance (9.68), crop duration (7.80%), fruit length (3.98%), days to first flower (3.16%), days to first fruit appearance (2.67%), days to fifty percent flowering (2.52%), days to first picking (2.31%) and fruit girth (1.47%). Similar findings were mentioned by Mohammed *et al.* (2022) [15], Kumar *et al.* (2020) [12] and Rathava *et al.* (2019) [17].

High heritability associated with moderate genetic advance was shown by plant height, number of fruit per plant that was supported by result of Indurani *et al.* (2005) [9], Duggi *et al.* (2013) [7], Samiksha *et al.* (2019) [18] and Kumar *et al.* (2020) [12].

Genotypic correlation coefficients were found higher than the phenotypic correlation coefficients in most of the cases which indicated that character correlation had not been largely influenced by environmental factors. Similar findings were reported by Mehta *et al.* (2006) [14]. Yield per plant is highly significant positive correlation with plant height (rg= 0.608 and rp= 0.599), number of branches per plant (rg= 0.354), fruit length (rg= 0.356), days to first flower (rg= 0.308), days to first fruit appearance (rg= 0.549 and rp= 0.352), nodes to first fruit appearance (rg= 0.308), crop duration (rg= 0.763 and rp= 0.603), average weight of fruit (rg= 0.668 and rg= 0.398) and number of fruit per plant (rg= 0.965 and rp= 0.893). Significant positive correlation with days to first flower (rp= 0.227), nodes to first fruit appearance (rp= 0.248) and days to fifty percent flowering (rg= 0.275).

Path coefficient resulted that number of fruit per plant (0.723) expressed a highest positive direct effect on fruit yield per plant followed by crop duration (0.261), nodes to first flower appearance (0.260), average weight of fruit (0.168) whereas, lowest positive direct effect on number of branches per plant (0.082) followed by days to first fruit appearance (0.069), fruit length (0.047), days to first flower (0.030), fruit girth (0.008), among them negative direct plant height (-0.036), days to fifty percent flowering (-0.072), days to first picking (-0.091) and nodes to first fruit appearance (-0.142). The result of negative direct effect indicated that these characters had a low association with fruit yield per plant and selection for these characters would lead to decrease in yield. The above finding were in agreement with the Mohapatra *et al.* (2007) [16], Mehta *et al.* (2006) [14] and Das *et al.* (2012) [5].

Conclusion

Variability, correlation analysis and path coefficient analysis studies exhibited that number of fruit per plant and yield per plant should be considered, while making selection strategies for improvement of yield in okra.

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