



Short communication

Genetic variability, correlation coefficient and path analysis in okra

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Okra belongs to family malvaceae and has chromosome number $2n = 130$. It is sixth most important vegetable crop extensively grown in tropical to subtropical and warmer part of temperate zone of the country. Okra cultivation is an area of 4.10 lakh ha with the production 4.20mt and West Bengal is a leading state in terms of area i.e. 71500 ha with the production 0.815mt. It is cultivated during summer and rainy season. Okra is specially valued for its tender and delicious fruits. However, to a limited extent, it is canned, dehydrated and processed.

Dry seed of okra contains 18-20% oil (Martin and Rhodes, 12) and 20-23% crude proteins (Berry, 2). The oil is used in soap, cosmetic industry as vanaspati while protein is used for fortified feed preparation. The crushed seed is fed to cattle for more milk production and the fibre is utilized in jute, textile and paper industry. Roasted and grinded seed used as a coffee substitute. It has a great potential as foreign exchange earner vegetable and accounts for about 60% of the export of total fresh vegetables excluding onion.

Genetic variability plays an important role in crop breeding for selecting the elite genotypes for making rapid improvement in yield and other desirable characters as well as to select the potential parent for hybridization programme. Heritability is an index for calculating the relative influence of environment on expression of genotypes. It becomes very difficult to judge how much of the variability is heritable and how much is non-heritable. This emphasizes to go for the study of extent of variability present in different genotype.

The experiment was conducted at Vegetable Research Farm, Department of Horticulture, Allahabad Agricultural Institute-Deemed University, Allahabad during the year 2006 and 2007. Twenty five germplasm were taken for the present study all the germplasm were collected from Indian Institute of Vegetable Research, Varanasi. These were grown in a Randomised Block Design with three replication. The planting distance was 20x30 cm spacing. Observations were recorded on five randomly selected competitive plants for plant height

(cm), number of leaf /plant, number of branches/plant, days to first flowering, fruit length (cm), fruit diameter (cm), weight of green fruit (g), number of fruits/plant, fruit yield/plant, fruit yield/plot, fruit yield/ha (tones), vitamin C (mg/100 g), percentage plant affected by YVMV and percentage plant affected by Mealybug. The data were analyzed as per the method of Panse and Sukhatme (13). The genotypic and phenotypic coefficient of variation were calculated as per the method of Burton and De Vena (3), and heritability by the following the method of Johanson *et al.* (10). The correlation coefficient was calculated as suggested by Al-Jibouri *et al.* (1) and path coefficient of various characters was calculated as per the procedure of Dewey and Lu (5).

The analysis of variance revealed significant differences among the genotypes for all the traits (Table 1). It indicated that there is sufficient variability in the present materials. Maximum range of variability was recorded for fruit yield/plant, followed by plant height, percentage plant affected by YVMV, percentage plant affected by mealybug whereas minimum in fruit diameter (Table 1). Similar results were also reported by Dhankar and Dhankar (7) and Singh *et al.* (16). The range of variability gives a rough estimates of variability present in the population. The magnitude of phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the character (Table 1). Minimum variation between PCV and GCV was recorded for the character days to 50% flowering, followed by plant height, yield/ha, yield/plant, vit.C, no. of leaf /plant, number of fruits/plant and maximum variation in % plant affected by YVMV. Lower variation between PCV and GCV revealed greater stability of the character against environmental fluctuation. Higher values of genotypic coefficient of variation are an indication of greater range of variability among the population and the scope of improvement of these characters through simple selection. Gandhi *et al.* (9) reported similar results for number of branches per plant, fruit yield per plant and plant height. Pathak and Singh (14), Ravindra *et al.* (15), Jaiprakashnarayan *et al.* (10) and Singh *et al.* (16) also reported similar results in okra.

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Table 1. Range, PCV, GCV, heritability and genetic advance as per cent of mean for different traits.

Character	Range		GCV(%)	PCV(%)	Heritability (Broad sense) (%)	Genetic Advance as per cent of mean
	Max.	Min.				
Plant height	66.60	33.46	18.18	19.56	86	34.83
No. of leaf/plant	18.86	11.63	10.14	14.51	48	14.61
No. of branches /plant	2.93	0.73	36.46	45.87	63	59.70
Days to first flowering	46.93	35.80	5.32	5.63	89	10.38
No. of fruits per plant	7.00	5.00	14.30	22.11	41.9	19.06
Av. fruit weight	8.26	3.93	9.36	15.04	38.8	12.02
Fruit length	15.11	9.20	10.11	13.20	58.7	15.97
Fruit diameter	2.81	1.90	9.33	18.83	0.246	9.52
Fruit yield/plant	134.73	52.87	17.10	19.07	0.80	31.61
Yield/ha	22.45	8.81	24.07	25.59	0.88	46.64
Viamin C	19.25	8.81	9.084	13.73	0.437	12.37
% plant affected by YVMV	35.00	0.00	47.37	163.57	0.084	28.33
% plant affected by Mealybug	5.55	0.00	36.27	167.39	0.047	16.19

The concept of heritability is an important to determine whether phenotypic differences observed among individuals are due to genetic or environmental factors. The heritable variation can be determined with greater degree of accuracy if genetic advance is also studied along with heritability. The high heritability values in broad sense are also helpful in selection if coupled with high phenotypic performance. Data pertaining to heritability and genetic advance as percent of mean are presented in table1. In the present investigation high heritability was found for most of the traits viz. plant height, days to first flowering, number of ridges per fruit and percentage plant affected by YVMV. Although estimates of high heritability are useful to breeder as they provide basis of transmissible genes from parent to progeny and more reliable conclusion can be drawn when heritability is considered along with the genetic advance. Johnson *et al.* (11) had also suggested that high heritability coupled with high genetic advance could be helpful in establishing close relationship between genotypic and phenotypic characters. High heritability estimates coupled with high expected genetic advance as percent of mean were observed for plant height. This indicates substantial contribution of additive genetic variance for these characters. On the other hand, moderate heritability associated with high genetic advance as percent of mean were observed for number of branches per plant. Moderate heritability associated with moderate genetic advance as percent of mean were observed for number of fruits per fruit, leaf per plant. This indicates the predominance of non-additive variance in the expression of these characters.

The estimates of phenotypic and genotypic correlation coefficient are presented in table 2&3. Yield /ha is the interaction of no. of inter related attributing traits. Therefore, selection should be based on these component characters after assessing their correlation with yield/ha. In general genotypic correlations were higher than the phenotypic correlation for most of the traits (table2) thereby, denoting strong inherent association among the characters studied. The plant height showed significant positive correlation with no. of leaf /plant, fruit length, no. of fruits/plant and fruit yield/plant and fruit yield/plot whereas significant negative correlation with days to first flowering and ridges /fruit. Number of leaves plant was positively correlated with branches /plant, no. of fruits/plant and fruit yield /plant. The no. of branches showed significant positive correlation with days to first flowering and negative with ridges /fruit. Days to first flowering negatively and significantly correlated with fruit length, fruits/plant, fruit yield/plant and positively with ridges /fruit. The fruit length showed significant positive correlation with vitamin C. Significant and positive correlation was recorded for fruit diameter with ridges per fruit. The ridges per fruit had significant positive correlation with % plant affected by YVMV. The fruit weight significantly and positively correlated with yield per plant and yield per plot. The no. of fruits per plant showed significant positive correlation with yield per plant and yield per plot as well as yield per plant with yield per plot. This indicated that yield can be improved by making selection on the basis of fruit weight, no. of fruits per plant, yield per plant. Dudi and Dhankar (8) and Dhankar and Dhankar (6) also

Table 2. Phenotypical Correlation among 14 characters of okra.

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plant ht. (cm)	1.0000	0.2900**	-0.2229	-0.5632**	0.3535**	-0.2180	-0.3713**	-0.0573	0.3467**	0.2839**	0.2816**	0.0612	0.2052	-0.1840
No. of leaves/plant		1.0000	0.2578**	-0.1799	-0.0046	-0.1572	-0.1135	-0.0322	0.3872**	0.2934**	0.2860**	-0.0737	0.2085	-0.0326
No. of branches/plant			1.0000	0.3747**	-0.2035	0.0104	0.2657**	0.0861	0.0713	0.0986	0.0960	-0.0489	-0.1009	0.0014
Days to 1 st flowering				1.0000	-0.3087**	0.1690	0.4233**	0.0797	-0.3507**	-0.2602**	-0.2650**	-0.0457	-0.2266	-0.0146
Fruit length (cm)					1.0000	-0.1030	-0.1094	0.1630	0.0510	0.0853	0.0838	0.4231**	0.0200	-0.0514
Fruit diameter (cm)						1.0000	0.2520**	-0.2065	0.0201	-0.0893	-0.0832	0.1461	-0.0128	0.1179
Ridges/fruit							1.0000	0.1585	-0.1871	-0.0727	-0.0781	-0.0580	-0.2294	0.1619
Weight of fruit (gm)								1.0000	0.1734	0.5763**	0.5713**	0.0857	-0.0331	0.0528
No. of fruits/plant									1.0000	0.8710**	0.8685**	-0.0634	0.2953**	0.0219
Fruit yield/plant (kg)										1.0000	0.9966	-0.0179	0.2176	0.0401
Fruit yield/plot (kg)											1.0000	-0.0210	0.2157	0.0370
Vitamin C (mg/100 g)												1.0000	-0.0316	0.0957
% plant affected by YVMV													1.0000	-0.1992
% plant affected by Mealybug														1.0000

**Significance at 5%

1. Plant height, 2. No. of leaves/plant, 3. No. of branches/plant, 4. Days to 1st flowering, 4. Fruit length, 6. Fruit diameter, 7. Ridges/fruit, 8. Weight of fruit, 9. No. of fruits/plant, 10. Fruit yield/plant, 11. Fruit yield/plot, 12. Vitamin C, 13. % plant affected by YVMV, 14. % plant affected by Mealybug

Table 3. Genotypic Correlation among 14 characters of okra

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plant ht. (cm)	1.0000	0.3492	-0.3586	-0.6267	0.5094	-0.3101	-0.3987	-0.0072	0.5816	0.5113	0.5139	0.0088	0.6610	0.5105
No. of leaves/plant		1.0000	0.4876	-0.1742	-0.1373	-0.2525	-0.1382	-0.0353	0.5639	0.3889	0.3838	-0.2359	0.2834	-0.0920
NO of branches/plant			1.0000	0.4790	-0.2184	0.2097	0.3232	0.1354	0.2101	0.2647	0.2469	-0.0663	-0.1955	-0.4787
Days to 1 st flowering				1.0000	-0.4533	0.2518	0.4474	0.1322	-0.4584	-0.3089	-0.3157	-0.0501	-0.6041	0.4940
Fruit length (cm)					1.0000	-0.2783	-0.1428	0.2659	0.1549	0.2056	0.2171	0.4875	-0.2809	-0.4021
Fruit diameter (cm)						1.0000	0.3213	-0.2139	0.0254	-0.0841	-0.0852	0.1376	0.1525	-0.7170
Ridges/fruit							1.0000	0.2115	-0.2806	-0.1119	-0.1217	-0.0855	-0.6867	-0.8604
Weight of fruit (gm)								1.0000	0.1802	0.6106	0.6065	0.2533	0.0861	0.7203
No. of fruits/plant									1.0000	0.8908	0.8935	-0.0471	1.0618	0.4807
Fruit yield/plant (kg)										1.0000	1.0001	0.0339	0.9320	0.8228
Fruit yield/plot (kg)											1.0000	0.0039	0.9565	0.8812
Vitamin C (mg/100 g)												1.0000	-0.1688	-0.9376
% plant affected by YVMV													1.0000	-0.0313
% plant affected by Mealybug														1.0000

**Significance at 5%

1. Plant height, 2. No. of leaves/plant, 3. No. of branches/plant, 4. Days to 1st flowering, 4. Fruit length, 6. Fruit diameter, 7. Ridges/fruit, 8. Weight of fruit, 9. No. of fruits/plant, 10. Fruit yield/plant, 11. Fruit yield/plot, 12. Vitamin C, 13. % plant affected by YVMV, 14. % plant affected by Mealybug

Table 4. Genotypic path coefficient among 14 characters of okra

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plant ht. (cm)	-0.0038	-0.0013	0.0014	0.0024	-0.0020	0.0012	0.0015	0.0000	-0.0022	-0.0020	-0.0020	0.0000	-0.0025	-0.0020
No. of leaves/plant	0.0027	0.0077	0.0037	-0.0013	-0.0011	-0.0019	-0.0011	-0.0003	0.0043	0.0030	0.0030	-0.0018	0.0022	-0.0007
No. of branches/plant	-0.0032	0.0044	0.0090	0.0043	-0.0020	0.0019	0.0029	0.0012	0.0019	0.0024	0.0022	-0.0006	-0.0018	-0.0043
Days to 1 st flowering	0.0229	0.0064	-0.0175	-0.0365	0.0165	-0.0092	-0.0163	-0.0048	0.0167	0.0113	0.0115	0.0018	0.0221	-0.0180
Fruit length (cm)	-0.0046	0.0012	0.0020	0.0041	-0.0090	0.0025	0.0013	-0.0024	-0.0014	-0.0019	-0.0020	-0.0044	0.0025	0.0036
Fruit diameter (cm)	-0.0055	-0.0045	0.0037	0.0045	-0.0050	0.0179	0.0057	-0.0038	0.0005	-0.0015	-0.0015	0.0025	0.0027	-0.0128
Ridges/fruit	0.0009	0.0003	-0.0007	-0.0010	0.0003	-0.0007	-0.0022	-0.0005	0.0006	0.0003	0.0003	0.0002	0.0015	0.0019
Weight of fruit (gm)	0.0001	0.0004	-0.0017	-0.0017	-0.0034	0.0027	-0.0027	-0.0126	-0.0023	-0.0077	-0.0077	-0.0032	-0.0011	-0.0091
No. of fruits/plant	-0.0249	-0.0242	-0.0090	0.0196	-0.0066	0.0011	0.0120	-0.0077	0.0429	-0.0382	-0.0383	0.0020	-0.0455	-0.0206
Fruit yield/plant (kg)	0.5237	0.3984	0.2711	-0.3164	0.2107	-0.0862	-0.1146	0.6255	0.9125	0.9954	1.0245	0.0347	0.9548	0.8428
Fruit yield/plot (kg)	0.0085	0.0063	0.0041	-0.0052	0.0036	-0.0014	-0.0020	0.0100	0.0147	0.0165	0.0165	0.0001	0.0158	0.0145
Vitamin C (mg/100 g)	0.0000	-0.0013	-0.0004	-0.0003	0.0026	0.0007	-0.0005	0.0014	-0.0003	0.0002	0.0000	0.0053	-0.0009	-0.0050
% plant affected by YVMV	-0.0112	-0.0048	0.0033	0.0102	0.0048	-0.0026	0.0116	-0.0015	-0.0180	-0.0158	-0.0162	0.0029	-0.0170	0.0005
% plant affected by Mealybug	0.0056	-0.0010	-0.0053	0.0054	-0.0044	-0.0079	-0.0095	0.0079	0.0053	0.0091	0.0097	-0.0103	-0.0003	0.0110
Fruit yield/ha ton	0.5111	0.3881	0.2638	-0.3118	0.2051	-0.0841	-0.1138	0.6124	0.8895	1.0000	1.0000	0.0291	0.9325	0.8020
Partial R ²	-0.0020	0.0030	0.0024	0.0114	-0.0019	-0.0015	0.0003	-0.0077	-0.0381	1.0244	0.0165	0.0002	-0.0158	0.0088

1. Plant height, 2. No. of leaves/plant, 3. No. of branches/plant, 4. Days to 1st flowering, 4. Fruit length, 6. Fruit diameter, 7. Ridges/fruit, 8. Weight of fruit, 9. No. of fruits/plant, 10. Fruit yield/plant, 11. Fruit yield/plot, 12. Vitamin C, 13. % plant affected by YVMV, 14. % plant affected by Mealybug

Table 5. Phenotypic path coefficient among 14 characters of okra

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plant ht. (cm)	-0.0029	-0.0008	0.0006	0.0016	-0.0010	0.0006	0.0011	0.0002	-0.0010	-0.0008	-0.0008	-0.0002	-0.0006	0.0005
No. of leaves/plant	-0.0002	-0.0008	-0.0002	0.0001	0.0000	0.0001	0.0001	0.0000	-0.0003	-0.0002	-0.0002	0.0001	-0.0002	0.0000
No. of branches/plant	-0.0002	0.0002	0.0008	0.0003	-0.0002	0.0000	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	-0.0001	0.0000
Days to 1 st flowering	0.0033	0.0011	-0.0022	-0.0059	0.0018	-0.0010	-0.0025	-0.0005	0.0021	0.0015	0.0016	0.0003	0.0013	0.0001
Fruit length (cm)	-0.0014	0.0000	0.0008	0.0012	-0.0038	0.0004	0.0004	-0.0006	-0.0002	-0.0003	-0.0003	-0.0016	-0.0001	0.0002
Fruit diameter (cm)	-0.0002	-0.0002	0.0000	0.0002	-0.0001	0.0010	0.0002	-0.0002	0.0000	-0.0001	-0.0001	0.0001	0.0000	0.0001
Ridges/fruit	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Weight of fruit (gm)	-0.0001	0.0000	0.0001	0.0001	0.0002	-0.0003	0.0002	0.0014	0.0002	0.0008	0.0008	0.0001	0.0000	0.0001
No. of fruits/plant	-0.0001	-0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0002	-0.0002	-0.0002	0.0000	-0.0001	0.0000
Fruit yield/plant (kg)	0.2718	0.2809	0.0944	-0.2491	0.0817	-0.0855	-0.0696	0.5517	0.8339	0.9574	0.9542	-0.0172	0.2083	0.0384
Fruit yield/plot (kg)	0.0117	0.0119	0.0040	-0.0110	0.0035	-0.0033	-0.0033	0.0238	0.0362	0.0415	0.0416	-0.0009	0.0090	0.0015
Vitamin C (mg/100 g)	0.0001	-0.0001	-0.0001	-0.0001	0.0006	0.0002	-0.0001	0.0001	-0.0001	0.0000	0.0000	0.0015	0.0000	0.0001
% plant affected by YVMV	0.0002	0.0002	-0.0001	-0.0002	0.0000	0.0000	-0.0002	0.0000	0.0003	0.0002	0.0002	0.0000	0.0008	-0.0002
% plant affected by Mealybug	0.0003	0.0001	0.0000	0.0000	0.0001	-0.0002	-0.0003	-0.0001	0.0000	-0.0001	-0.0001	-0.0002	0.0004	-0.0018
Fruit yield/ha ton	0.2825	0.2922	0.0981	-0.2627	0.0828	-0.0882	-0.0737	0.5759	0.8708	0.9998	0.9967	-0.0180	0.2188	0.0391
Partial R ²	-0.0008	-0.0002	0.0001	0.0015	-0.0003	-0.0001	0.0000	0.0008	-0.0002	0.9572	0.0415	0.0000	0.0002	-0.0001

1. Plant height, 2. No. of leaves/plant, 3. No. of branches/plant, 4. Days to 1st flowering, 4. Fruit length, 6. Fruit diameter, 7. Ridges/fruit, 8. Weight of fruit, 9. No. of fruits/plant, 10. Fruit yield/plant, 11. Fruit yield/plot, 12. Vitamin C, 13. % plant affected by YVMV, 14. % plant affected by Mealybug

observed similar strong correlation between no. of fruits per plant and fruit yield.

Path analysis allows the correlation coefficient into direct and indirect effect of the traits contributing towards the dependent variable. Genotypic path coefficient analysis showed highest positive direct effect for yield per plant, followed by fruits diameter, fruit yield per plot, no. of fruits per plant, % plant affected by Mealybug, no. of branches per plant, leaves per plant and vitamin C with the dependent variable yield per hectare (Table 4). On the other hand negative and direct effect was observed for the character fruit length, days to first flowering, plant height, ridges per fruit and % plant affected by YVMV with the dependent variable yield per hectare (Table 4). Dhankar and Dhankar (6) and Chandra Deo, Singh and Panda (4) also reported similar results.

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