Electronic Journal of Plant Breeding, 8(2): 620-625 (June 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00094.1

Research Note

Correlation and path analysis studies in okra

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(Received: 20 June 2016; Revised: 08 June 2017; Accepted: 15 June 2017)

Abstract
Thirty genotypes belonging to okra (*Abelmoschus esculentus*) were utilized, to work out the correlation and path coefficient. The genotypic and phenotypic correlation indicated that yield per plant was significantly associated with plant height, number of leaves per plant, number of lobes per leaves, number of primary branches per plant, number of nodes per plant and number of fruits per plant. Thus there is an ample scope for improving character through direct selection. Based on positive direct effects of different yield components on yield, it would be rewarding to give emphases on the number of primary branches per plant, number of nodes per plant, number of leaves per plant, leaf area, diameter of fruit and node at which fruit appears, number of lobes per leaves, plant height, internodal length, number of fruits per plant and weight of fruit, however for positive indirect effect number of nodes per plant, plant height, node at which first fruit appears, length of fruit, weight of fruit, number of fruits per plant, chlorophyll content of leaves and incidence of YVMV while formulating selection indices for improvement of yield in okra.

Key words
Okra, correlation, yield

Okra (*Abelmoschus esculentus* (L.) Monech) (Chromosome No. 130) is commercially important annual vegetable crop in tropical and subtropical parts of the world. It belongs to family Malvaceae. It is also known as Bhendi or Lady's Finger. Its tender green fruits are used as a vegetable and are generally marketed in the fresh condition, but sometimes in canned or dehydrated form. Okra is rich in vitamins, calcium, potassium and mineral matters. The nutritional value of okra (per 100 g edible portion) contains the major elements like moisture (89.6 g), carbohydrate (6.4 g), protein (1.9 g), iron (1.5 g), sodium (6.9 g), potassium (10.3 g), fibre (1.2 g), calcium (66 mg), magnesium (43 mg), phosphorus (56 mg), sulphur (30 mg), vit-A (88 IU) and vit- C (13 mg) (Bose *et al*. 2003).

The mucilage of root and stem is used as juice clarifier in jaggary and brown sugar industry. The mature fruits and stem contains more crude fibre and are used in paper industry. It is also useful against genito-urinary disorders, spermatorrhoea and chronic dysentery. Okra is grown for the fresh market and also for export and processing. Okra has a vast potential as one of the foreign exchange earner crop and accounts maximum share of export of fresh vegetable excluding onion and potato. It is a cash crop and fetches higher price during summer where other vegetable are in short supply in market. It is also used in canned and dehydrated form.

The information about correlation among different components of yield is necessary for designing efficient plant breeding programme through selection and for simultaneous improvement of yield components. Therefore, such information can be obtained by the studying genotypic and phenotypic correlation coefficient between yield and yield contributing characters. The character like yield is dependent character and it is the resultant effect of number of component characters, but direct selection for yield is essential to bring a rational improvement in the desirable traits. Correlation coefficient analysis measures the mutual relationship between various plant characters on which selection can be based for improvement in yield.

An estimate of genotypic and phenotypic correlations will be useful in planning and evaluating breeding programmes. Simple correlation coefficient does not express anything about the cause and effect relationship between characters. The significant correlation is in fact the concentrate proof of any casual relationship. As there are number of factors involved in the correlation studies, their indirect association becomes more complex and confusing, but path coefficient analysis helps to avoid this complication. Hence it is also essential to study the path coefficient analysis.

Path coefficient analysis is helpful in partioning the observed correlation coefficient into direct and indirect effect and their effective use in selection programme.

Thirty genotypes of Okra obtained from National Bureau of Plant Genetic Resources, New Delhi and Department of Horticulture, Dr.PDKV, Akola. The experiment was laid out in randomized block design with three replications at Main Garden, Department of Horticulture, Dr.PDKV, Akola. 2014. The observations were recorded on five randomly selected plants in each replication for each genotype on 18 characters namely plant height, number of leaves per plant, number of lobes per leaves, internodal length, days to first flowering, leaf area, node at which first fruit appear, number of primary branches per plant, number of nodes per plant, days to first harvest, number of fruits per plant, length of fruit, diameter of fruit, weight of fruit, number of ridges per fruit, chlorophyll content of leaves, incidence of YVMV, crude fibre content of fruit and yield per plant. The data were subjected to statistical analyzed to calculate genotypic and phenotypic correlation coefficient as per Singh and Chaudhary (1985). The genotypic correlation was subjected to calculate path coefficient analysis as per method suggested by Dewey and Lu (1959).

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The data in respect of genotypic correlation presented in table 1. Yield per plant was positively and significantly correlated with plant height (r= 0.552), number of leaves per plant (r = 0.516), number of lobes per leaves (r= 0.634), number of primary branches (r= 0.604), number of nodes per plant (r= 0.825) and number of fruits per plant (r= 0.994). However, phenotypic correlation yield per plant was positively and significantly correlated with plant height (r= 0.437), number of leaves per plant (r= 0.439), number of primary branches (r= 0.449), number of nodes per plant (r= 0.714) and number of fruits per plant (r= 0.747). These findings were supported by Vijay and Manohar (1990), Sood *et al*. (1993), Hazare and Basu (2000), Dakahe *et al*. (2007), Sharma *et al*. (2007), Singh *et al*. (2007) and Pal *et al*. (2008). On the other hand, diameter of fruit showed negative and non-significant correlation with yield plant^{-1}. This indicated the fact that increase in one trait may generally be accompanied by corresponding decrease in the other. The observations of similar nature were also reported in okra by Vijay and Manohar (1990).

Among the yield contributing characters themselves, the plant height was positively and significantly correlated with leaf area, number of leaves per plant, number of lobes per leaves, number of primary branches per plant, number of nodes per plant, number of fruits per plant and yield per plant. This indicated the importance of the character plant height in increasing the number of nodes per plant, number of fruits per plant, internodal length, and yield per plant. Similar results were also reported by Singh *et al.* (2007) for plant height with internodal length, number of fruits per plant, fruit length and yield per plant Vijay and Manohar (1990), Sood *et al.* (1993), Dakahe *et al*. (2007), Sharma *et al*. (2007) and Pal *et al*. (2008) also confirmed these results.

The plant height was negatively and significantly correlated with, internodal length, days to first flowering, days to first harvest, incidence of YVMV. Thus it could be concluded that direct selection procedure to increase plant height results into reduction in number of ridges per fruit which may affect fruit yield per plant. Sood *et al*. (1993) observed same results of plant height with girth of marketable fruit in okra.

The number of nodes per plant was positively and significantly correlated with number of fruits per plant and yield per plant. The number of primary branches per plant was positively and significantly correlated with number of nodes per plant, number of fruits per plant and yield per plant. These are both genotypic and phenotypic correlation.

The number of fruits per plant was positively and significantly correlated with yield per plant. While it was negatively significant with incidence of YVMV and crude fibre content of fruit. Dakahe *et al.* (2007) also reported highly significant association of number of fruits per plant with fruit yield in okra. Singh *et al*. (2007) and Sharma *et al*. (2007) were also found similar results in okra.

The incidence of YVMV noted significant but positive correlation with crude fiber content of fruit (r= 0.509). However, significant but negative correlation exhibited with yield per plant (r = -0.835). Thus the correlation studies revealed the importance of characters like number of fruits per plant, number of nodes per plant, plant height, number of leaves per plant, number of lobes per leaves and number of primary branches per plant because of their strong genotypic correlation with yield per plant.

In the present investigation, the characters exhibiting significant positive phenotypic correlation with yield per plant were found to be correlated with plant height, number of leaves per plant, number of primary branches per plant, number of nodes per plant and number of fruits per plant. These characters were also positively interlinked among themselves. Thus, it indicated the importance of these characters while selection.

In the integrated structure of the plant, the overall correlation observed between two attributes is a function of a series of direct and indirect association between the component characters. In order to know these specific forces in building up the total correlation, it is essential to resort to path coefficient analysis. Path analysis originally suggested by Wright (1921) and further outlined by Dewey and Lu (1959), which is simply a standardized partial regression coefficient and measures the direct influence of one component on the other and permits the partitioning of the total correlation coefficient into its components of direct and indirect effects.

Results obtained for path coefficient analysis at genotypic level revealed that the character plant height showed positive direct effect on yield per plant (0.818). The positive indirect effect *via* number of nodes per plant was highest (4.083) still the correlation in this case was positive because of high positive indirect effect *via* number of nodes per plant (4.168), it was followed by incidence of YVMV (1.500). Plant height exhibited highest indirect positive effect on yield per plant (1.370). These results are in confirmedly with the findings, who reported largest negative direct effect of plant height on yield per plant. Shukla (1990) and Gondane *et al*. (1995) reported similar findings in okra.

The number of per leaves indicated positive correlation (r = 0.516), positive direct effect (2.770) and positive indirect effect (3.287) with yield per plant. The number of lobes per leaves showed positive direct effect (0.928) but negative indirect effect (-0.293), the results are in consonance of findings of Sawant (2009). The internodal length exhibited positive direct effect (0.435) on yield per plant with negative significant correlation (r = -0.397). Vijay and Manohar (1990) also reported high positive direct effect of internodal length on fruit yield in okra. The positive and significant correlation (r = 0.145) was also observed between leaf area and yield per plant. The direct effect of leaf area was positive on yield per plant (1.837), but it had negative indirect effect (-1.692) on yield per plant *via* number of nodes per plant and number of leaves per plant. The node at which first fruit appears exhibited negative non-significant (r = -0.064) correlation with yield per plant. It showed positive direct effect (1.165) on yield with positive corresponding indirect effect (1.101). The number of primary branches per plant had positive and significant correlation (r = 0.604) with yield per plant. Whereas, it indicated positive direct effect (4.463) on yield. The indirect effect was positive (- 3.858) due to weight of fruit hence the correlation observed between them was positive. This result was supported by the finding of Vijay and Manohar (1990), Dhankar and Dhankar (2002) and Singh *et al*. (2007). The number of nodes per plant showed positive direct effect (4.084) on yield per plant, while positive indirect effect (4.168) on yield plant through number of nodes per plant. This finding was in consonance with the findings of Jayprakashnarayan and Mulge (2004).

The length of fruit exhibited negative direct effect on yield per plant (- 0.568) while indirect effect *via* number of leaves per plant and number of nodes per plant was found to be high and positive. Which resulted into the positive association of length of fruit and yield per plant (r = - 0.198) and indicates the negative direct effect of length of fruit on yield per plant (Vijay and Manohar, 1990 and Shukla, 1990 in okra).

The diameter of fruit exhibited positive direct effect on fruit yield per plant (1.544). It had show the high negative indirect effect through number of primary branches per plant (-3.858) and leaf area (-1.692). Senapati *et al*. (2011) reported high direct effect of diameter of fruit on fruit yield in okra. The weight of fruit recorded high positive direct effect on yield per plant (0.179) with positive and non-significant correlation (r = 0.342), the results are in consonance of findings of the Shukla (1990) and Niranjan and Mishra (2003).

The character number of fruits per plant exhibited highest magnitude of direct effect (0.182). It had shown high magnitude of indirect effect (0.812) *via* number of primary branches per plant (r = 0.604). Thus, it might have resulted into strong positive and significant (r = 0.994) correlation. This indicated the importance of characters number of fruits per plant and number of primary branches per plant while selection for improvement in okra. The results of similar finding were also reported by Vijay and Manohar (1990), Shukla (1990), Pathak (1993) and Singh *et al*. (2007).

The incidence of YVMV observed negative direct effect (-3.348) on yield per plant, where as positive indirect effect (1.500) *via* length of fruit and chlorophyll content of leaves. The number of leaves per plant and number of lobes per leaves exhibited positive and significant correlation with yield per plant. However, the number of leaves per plant shows positive direct effect and number of lobes per leaves indicates negative indirect effect. The path analysis further suggested that the number of fruits per plant, number of primary branches per plant were most reliable and effective characters for selection when high yield is the objective.

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Electronic Journal of Plant Breeding, 8(2): 620-625 (June 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00094.1

Table 1. Estimates of genotypic and phenotypic correlation coefficients for various characters

Characters		No. of leaves/ plant	No. of lobes/ leaves	Internodal length (cm)	Days to 1^{st} flower	Leaf area (cm^2)	Node at which 1^{st} fruit	Primary branches	No. of nodes/ plant	Days to 1^{st} harvest	Length of fruit (cm)	Diameter of fruit (cm)	Wt. of fruit (gm)	No. of fruits/ plant	Chlorophyll Content	Incidence of YVMV (%)	Crude fibre Fibre (%)	Yield/ plant (gm)
Plant height	G	0.671**	0.847**	-0.470**	-0.531**	0.547**	-0.123	0.499**	0.662**	-0.511**	-0.279	0.018	-0.052	0.547**	-0.026	-0.497**	-0.341	0.552**
	P	0.566**	0.418*	-0.257	-0.352	0.417*	-0.078	0.349	0.536**	-0.368**	-0.233	0.026	-0.048	0.392*	-0.041	-0.432*	-0.285	0.437*
No. of leaves/ plant	G	1.000	0.855**	-0.426*	-0.539**	0.444*	-0.386*	0.788**	0.766**	-0.416*	-0.110	0.112	-0.121	0.534**	-0.127	-0.329	-0.039	0.516**
	P	1.000	0.435*	-0.306	-0.397*	0.380*	-0.275	0.566**	0.723**	-0.327	-0.109	0.103	-0.110	0.371*	-0.115	-0.270	-0.041	0.439*
No .of lobes/ leaves	G		1.000	-0.709**	-0.540**	0.172	-0.277	0.951**	0.904**	-0.391*	-0.012	-0.173	-0.16	0.856**	0.041	-0.618**	-0.117	0.634**
	P		1.000	-0.255	-0.154	0.168	-0.173	0.322	0.446*	-0.143	-0.092	-0.118	-0.198	0.311	-0.015	-0.246	-0.044	0.252
Inter nodal length	G			1.000	0.695**	-0.088	0.172	-0.255	-0.450*	0.244	0.295	-0.127	0.050	-0.415*	-0.207	0.568**	0.202	-0.397*
	P			1.000	0.395*	-0.057	0.212	-0.115	-0.331	0.187	0.234	-0.080	0.052	-0.221	-0.152	0.343	0.153	-0.283
Days to 1^{st} flowering	G				1.000	-0.117	0.402*	-0.447*	-0.453*	0.772**	0.229	-0.20	0.077	-0.469*	0.131	0.441*	0.265	-0.47**
	P				1.000	-0.097	0.271	-0.284	-0.288	0.616**	0.173	-0.169	0.050	-0.315	0.142	0.302	0.223	-0.354
Leaf area	G					1.000	-0.075	0.176	0.315	-0.177	0.222	-0.047	0.22	0.013	0.0589	-0.152	-0.079	0.145
	P					1.000	0.015	0.114	0.252	-0.113	0.172	-0.052	0.164	-0.016	0.060	-0.137	-0.067	0.130
Node at which 1^{st} fruit	G						1.000	-0.152	-0.317	0.273	0.045	-0.199	0.137	-0.047	0.012	0.010	-0.072	-0.064
	P						1.000	-0.051	-0.177	0.209	0.035	-0.160	0.07	0.043	0.054	0.030	-0.034	-0.013
Primary branches	G							1.000	0.794	-0.190	0.150	-0.188	-0.063	0.692**	0.053	-0.308	-0.202	0.604**
	P							1.000	0.597**	-0.121	0.095	-0.110	-0.012	0.400*	0.065	-0.182	-0.143	0.449*
No .of nodes/ plant	G								1.000	-0.309	-0.138	-0.002	-0.031	0.847**	0.065	-0.684**	-0.421*	0.825**
	P								1.000	-0.189	-0.123	0.009	-0.040	0.619**	0.043	-0.580**	-0.374*	0.714**
Days to 1^{st} harvest	G									1.000	0.2359	-0.190	-0.077	-0.219	0.420*	0.259	0.220	-0.368*
	P									1.000	0.1838	-0.135	0.006	-0.17	0.284	0.192	0.161	-0.224
Length of fruit	G										1.000	-0.575**	0.055	-0.135	0.056	0.269	0.285	-0.198
	P										1.000	-0.524**	0.099	-0.089	0.028	0.208	0.267	-0.162
Diameter of fruit	G											1.000	-0.305	-0.241	-0.058	0.214	-0.085	-0.098
	P											1.000	-0.243	-0.142	-0.055	0.194	-0.086	-0.07
Weight of fruit	G												1.000	0.121	0.323	-0.210	-0.221	0.342
	P												1.000	0.064	0.194	-0.211	-0.164	0.286
No. of fruits/ plant	G													1.000	0.224	-0.886**	-0.485**	0.994**
	P													1.000	0.130	-0.609**	-0.341	0.747**
Chlorophyll content	G														1.000	-0.339	-0.302	0.263
	P														1.000	-0.258	-0.214	0.210
Incidence of YVMV	G															1.000	0.509**	-0.835**
	P															1.000	0.453*	-0.682**
Crude fibre content	G																1.000	-0.534**
	P																1.000	-0.476*

*, ** Significant at 5 and 1 per cent level, respectively

Electronic Journal of Plant Breeding, 8(2): 620-625 (June 2017)
ISSN 0975-928X
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Table 2. Path coefficient analysis showing direct (underlined) and indirect effects of various characters on yield in okra

Traits	Plant height (cm)	No. of leaves/ plant	No. of lobes/ leaves	Internodal length (cm)	Leaf area (cm^2)	Node at which 1st fruit	Primary branches	No. of nodes/ plant	Length of fruit (cm)	Diameter of fruit (cm)	Wt. of fruit (gm)	No. of fruits/ plant	Chlorophyll Content	Incidence of YVMV (%)	Yield/ plant (gm)
Plant height	**-0.8183**	-0.549	-0.6932	0.3848	-0.4479	0.1008	-0.4083	-0.5422	0.229	-0.0153	0.0427	-0.4484	0.0219	0.4071	0.552**
No. of leaves/ plant	-1.859	**-2.7706**	-2.3699	1.1818	-1.2305	1.0711	-2.1833	-2.1227	0.3067	-0.3103	0.3362	-1.4818	0.353	0.9134	0.516**
No. of lobes/ leaves	0.7863	0.794	**0.9282**	-0.6586	0.1602	-0.2579	0.8831	0.8395	-0.0116	-0.1608	-0.1485	0.7946	0.0389	-0.5738	0.634**
Internodal length	-0.2047	-0.1857	-0.3089	**0.4353**	-0.0386	0.0749	-0.1112	-0.1963	0.1286	-0.0555	0.0221	-0.181	-0.0904	0.2474	-0.397*
Leaf area	1.0057	0.816	0.3171	-0.1628	**1.8373**	-0.1378	0.3236	0.5797	0.4087	-0.087	0.4042	0.0249	0.1081	-0.28	0.145
Node at which 1st fruit	0.1437	0.4507	0.3239	-0.2006	0.0874	**-1.1657**	0.1771	0.3703	-0.0535	0.233	-0.1606	0.0557	-0.0139	-0.0121	-0.064
Primary branches	2.2271	3.5172	4.2465	-1.1405	0.7861	-0.6782	**4.4632**	3.5475	0.6723	-0.8409	-0.2852	3.09	0.2398	-1.3788	0.604**
No. of nodes/ plant	-2.7059	-3.1288	-3.6937	1.8416	-1.2886	1.2971	-3.2459	**-4.0838**	0.5667	0.0097	0.1271	-3.4589	-0.2686	2.7932	0.825**
Length of fruit	0.1592	0.0629	0.0071	-0.1679	-0.1265	-0.0261	-0.0857	0.0789	**-0.5686**	0.3271	-0.0315	0.0767	-0.0322	-0.1534	-0.198
Diameter of fruit	0.0288	0.173	-0.2676	-0.1969	-0.0732	-0.3088	-0.291	-0.0037	-0.8885	**1.5445**	-0.4715	-0.3728	-0.0908	0.3307	-0.098
Weight of fruit	-0.0094	-0.0218	-0.0288	0.0091	0.0395	0.0248	-0.0115	-0.0056	0.01	-0.0549	**0.1797**	0.0219	0.0581	-0.0379	0.342
No.of fruits/ plant	0.1	0.0976	0.1562	-0.0759	0.0025	-0.0087	0.1264	0.1546	-0.0246	-0.0441	0.0222	**0.1825**	0.041	-0.1618	0.994**
Chlorophyll content	0.0331	0.1575	-0.0518	0.2568	-0.0728	-0.0148	-0.0664	-0.0813	-0.0699	0.0727	-0.3999	-0.2775	**-1.2364**	0.4192	0.263
Incidence of YVMV	1.6655	1.1038	2.0698	-1.903	0.5103	-0.0348	1.0343	2.29	-0.9034	-0.7168	0.7054	2.9688	1.1352	**-3.3481**	-0.835**