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Correlation and Path Coefficient Studies in Okra [*Abelmoschus esculentus* (L.) Moench]

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A B S T R A C T

The present study was undertaken on 31 genotypes of okra to determine the nature of association among different yield attributes and their direct and indirect contribution towards yield at experimental site college farm, N. M. College of Agriculture, NAU, Navsari, Gujarat. Fruit yield per plant has exhibited positive and highly significant correlation with plant height, number of fruits per plant, average fruit length and fiber content at both genotypic and phenotypic level, indicating mutual association of these traits. Path coefficient analysis revealed that number of fruit per plant had maximum direct contribution towards fruit yield followed by average fruit weight, average fruit diameter and plant height. However, average fruit length had the higher negative direct effect on fruit yield per plant followed by days to 50 % flowering, number of branches, internodal length and fiber content. These important traits may be viewed in selection programme for the further improvement of okra.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is commonly known as Lady's Finger in England, Gumbo in the USA and Bhindi in India. It is ancient and economically important vegetable crop cultivated throughout the world and is a native of tropical Africa. Okra is an annual vegetable crop propagated by seeds in tropical and subtropical region of the world like India, Africa, Turkey and other neighbouring countries. Its tender fruits are used as a vegetable and are generally marketed in fresh state, but sometimes in canned or dehydrated form. In India, okra is one of the most important vegetable crops grown for its tender green fruits during summer and rainy seasons. It is a member of Mallow or Malvaceae family with 2n=8x=72 to 144 chromosomes and is polyploid in nature. There are 30 species under genus *Abelmoschus* in the old world and four in the new world (Joshi and Hardas, 1956). Out of them, *Abelmoschus esculentus* (2n=130) is the only species known to be cultivated extensively. Okra is a self-pollinated crop, however occurrence of out crossing to an extent of 4 to 19 per cent (Choudhury and Choonsai, 1970) by insects has been reported which renders considerable genetic diversity.

A wide range of variation in quantitative characters provides the basis for selection in plant breeding programme. The knowledge of association among the characters is useful to the breeder for improving the efficiency of selection. Correlation coefficient analysis measures the mutual relationship between plant characters and determines the component characters on which selection can be made for genetic improvement of yield. Investigation regarding the presence of component and nature of association among themselves is essential and prerequisite for improvement in yield. Correlation coefficient provides a clear picture of the extent of association between a pair of traits and indicates whether simultaneous improvement of the correlated traits may be possible or not.

Path coefficient analysis technique used to find the relative contribution of component characters directly on the main characters and indirectly through other characters to increase the efficiency in selection programmes. The correlation between dependent and independent characters is due to the direct effect of the characters, it reflects a true relationship between them and selection can be practiced for such a character in order to improve dependent variable. The study of correlation will help in identifying the traits which have strong association with yield. Path coefficient analysis helps for sorting out the total correlation into direct and indirect effects and is useful for choosing the most useful traits to be used for yield improvement through selection. Such information reveals the possibility of simultaneous improvement of various attributes and also helps in increasing the efficiency of selection of complex inherited traits. Keeping this in view, the present investigation was aimed at assessing the association of various characters and direct and indirect path effects of 9 independent components on fruit yield in 31 genotypes.

Materials and Methods

The current study on correlation and path coefficient analysis in okra were undertaken during the year 2018 in *kharif* season at experimental site college farm, N. M. College of Agriculture, NAU, Navsari, Gujarat.

The thirty one genotypes were evaluated in randomized block design with three replications. Planting was done on ridges and furrows with a spacing of 60 x 30 cm. Two to three seeds per hill were dibbled. For recording observations, five randomly selected plants, excluding the border ones, in each genotype of all the three replications were tagged and used for recording the observations. Data was recorded on ten parameters *viz.,* days to 50 % flowering, internodal length, number of branches per plant, plant height, number of fruits per plant, fruit length, fruit diameter, fruit weight, fruit yield per plant and fiber content (Table 1).

The correlation co-efficient among all possible character combinations were estimated employing formula given by Miller *et al.,* (1958). Path co-efficient analysis suggested by Wright (1921) and Dewey and Lu (1959) was carried out to know the direct and indirect effect of the morphological traits on plant yield. Genotypic correlation coefficients of ten variables with fruit yield were used to estimate the path coefficients for the direct effect of various independent characters on dependent character fruit yield per plant.

Results and Discussion

Correlation

Yield is the resultant of combined effect of several component characters and environment. Understanding the interaction of characters among themselves and with environment has been of great use in the plant breeding. Correlation studies provide information on the nature and extent of association between only two pairs of metric characters. The genotypic correlations were higher than the phenotypic correlations in the present study indicating high heritable nature of the characters. Also the result showed that there was not much difference between genotypic and phenotypic correlation among characters studied. This indicates that the influence of environment is least on correlation.The results of correlation between different pairs of ten characters are described below.

Fruit yield per plant Vs. yield component

The association analysis (Table 2) showed Fruit yield per plant has exhibited positive and highly significant correlation with plant height (r_g = 1.082, r_p = 0.729), number of fruits per plant (r_g = 1.043, r_p = 0.822), average fruit length (r_g = 1.094, r_p = 0.651) and fiber content (r_g = 0.516, r_p = 0.291) at both genotypic and phenotypic level, indicating the possibility of simultaneous selection for these traits. It could be suggested from correlation estimates that yield could be improved through selection based on these characters. Similar results were reported by Vandana *et al.,* (2015), Sanganamoni *et al.,* (2016), Mohammad and marker (2017b) and Thulasiram *et al.,* (2017) for number of fruits per plant; by Nirosha *et al.,* (2014), Swamy *et al.,* (2014), Meenakshee and Sharma (2017) and Prasath *et al.,* (2017) for plant height; by Balai *et al.,* (2014), Sawant *et al.,* (2014), Vandana *et al.,* (2015), Prasath *et al.,* (2017) for average fruit length, which indicated that selection criteria based on number of fruits per plant and fruit length can provide better result for improvement of fruit yield.

Days to 50 % flowering (r_g = -0.313) and average fruit weight (r_g = -0.290) exhibited negative and highly significant correlation with fruit yield per plant at genotypic level. Such results were also reported by Reddy *et al.,* (2013), Swamy *et al.,* (2014), Kumar and Reddy (2016) and Meenakshee and Sharma (2017) for days to 50 % flowering and Prajna *et al.,* (2015) for average fruit weight at genotypic level, which indicated that selection of early flowering and fruit weight would beneficial for attaining higher fruit yield in okra.

Correlation among yield components

Days to 50 % flowering has depicted negative and highly significant correlation with plant height (r_g = -0.358) at genotypic level and significant correlation (r_p = -0.233) at phenotypic level, while average fruit length (r_g = -0.507, r_p = -0.339) at both genotypic and phenotypic level. It also recorded negative and significant correlation with number of fruits per plant (r_g = -0.225). Similar results were reported by Reddy *et al.,* (2013) and Pithiya *et al.,* (2017) for plant height and average fruit length and by Ahiakpa *et al.,* (2013) and Kumar and Reddy (2016) for number of fruits per plant.

Internodal length has recorded positive and highly significant correlation with fiber content (r_g = 0.420, r_p = 0.288) at both genotypic and phenotypic level. However, it has recorded negative and highly significant correlation with number of branches per plant (r_g = -0.397) and average fruit diameter (r_g = -0.288) at genotypic level only. It closely similar to Reddy *et al.,* (2013), Singh *et al.,*

(2017) for number of branches per plant and Reddy *et al.*, (2013) for average fruit diameter.

Number of branches per plant showed negative and highly significant correlation with fiber content (r_g = -1.071, r_p = -0.363) at both genotypic and phenotypic level. It has also exhibited positive and significant correlation with average fruit diameter (r_g = 0.600) while negative and significant correlation with internodal length (r_g = -0.397) at genotypic level only. These results are in close harmony with the findings of Reddy *et al.*, (2013), Singh *et al.*, (2017) for internodal length and Singh *et al.*, (2017) for average fruit diameter.

Plant height recorded positive and highly significant correlation with number of fruits per plant (r_g = 0.950, r_p = 0.824), average fruit length (r_g = 0.953, r_p = 0.737) and fiber content (r_g = 0.416, r_p = 0.297) while significant and negative correlation with days to 50% flower (r_g = -0.358, r_p = -0.233) at both genotypic and phenotypic levels.

It also exhibited significant and negative correlation with average fruit weight (r_g = -0.239) at genotypic level. These results are in corroborated with the findings of Swamy *et al.*, (2014), Archana *et al.*, (2015), Meenakshee and Sharma (2017), Prasath *et al.*, (2017) and Thulasiram *et al.*, (2017) for number of fruits per plant; Sawant *et al.*, (2014), Vandana *et al.*, (2015), Pithiya *et al.*, (2017) and Prasath *et al.*, (2017) for average fruit length. Similar findings for negative association with days to 50 % flowering reported by Reddy *et al.*, (2013), Singh *et al.*, (2016) and Pithiya *et al.*, (2017).

Table.1 List of okra genotypes used in experiment

Sr. No.	Genotypes	Sources	Sr. No.	Genotypes	Sources
1.	Parbhani Kranti	MKV, Parbhani	17.	NOL-17-10	NAU, Navsari
2.	Arka Abhay	IIHR, Bangalore	18.	GAO-5	AAU, Anand
3.	Arka Anamika	IIHR, Bangalore	19.	AOL-09-2	AAU, Anand
4.	Kashi kranti	IIVR, Varanasi	20.	AOL-12-52	AAU, Anand
5.	Pusa Sawani	IARI, New Delhi	21.	AOL-13-73	AAU, Anand
6.	VRO-6	IIVR, Varanasi	22.	AOL-13-144	AAU, Anand
7	HRB-55	HAU, Hissar	23.	AOL-14-32	AAU, Anand
8.	NOL-16-3	NAU, Navsari	24.	JOL-08-2	JAU, Junagadh
9.	NOL-16-6	NAU, Navsari	25.	JOL-08-4	JAU, Junagadh
10.	NOL-17-1	NAU, Navsari	26.	JOL-09-4	JAU, Junagadh
11.	NOL-17-2	NAU, Navsari	27.	JOL-09-5	JAU, Junagadh
12.	NOL-17-3	NAU, Navsari	28.	JOL-11-12	JAU, Junagadh
13.	NOL-17-5	NAU, Navsari	29.	JOL-13-05	JAU, Junagadh
14.	NOL-17-6	NAU, Navsari	30.	JOL-14-10	JAU, Junagadh
15.	NOL-17-7	NAU, Navsari	31.	JDNOL-11-12	JAU, Junagadh
16.	NOL-17-8	NAU, Navsari			

Table.2 Genotypic and phenotypic correlations among different characters in okra genotypes

Trait	r	DFF	IL	NBP	PH	NFP	AFL	AFD	AFW	FYP	FC
DFF	r_g	**1.000**									
	r_p	**1.000**									
IL	r_g	0.075	**1.000**								
	r_p	0.103	**1.000**								
NBP	r_g	-0.034	-0.397**	**1.000**							
	r_p	0.100	-0.095	**1.000**							
PH	r_g	-0.358**	0.112	-0.071	**1.000**						
	r_p	-0.233*	0.096	-0.032	**1.000**						
NFP	r_g	-0.225*	0.130	-0.018	0.950**	**1.000**					
	r_p	-0.174	0.077	-0.040	0.824**	**1.000**					
AFL	r_g	-0.507**	0.009	-0.018	0.953**	0.879**	**1.000**				
	r_p	-0.339**	0.011	-0.044	0.737**	0.751**	**1.000**				
AFD	r_g	0.007	-0.288**	0.600**	-0.069	-0.086	-0.070	**1.000**			
	r_p	0.033	-0.180	0.185	0.001	-0.014	-0.045	**1.000**			
AFW	r_g	0.026	-0.043	0.060	-0.239*	-0.454**	-0.010	-0.049	**1.000**		
	r_p	0.049	-0.011	0.123	-0.023	-0.248*	0.012	0.149	**1.000**		
FYP	r_g	-0.313**	0.109	-0.043	1.082**	1.043**	1.094**	-0.135	-0.290**	**1.000**	
	r_p	-0.177	0.022	-0.068	0.729**	0.822**	0.651**	0.087	0.164	**1.000**	
FC	r_g	-0.049	0.420**	-1.071**	0.416**	0.448**	0.472**	-0.132	-0.265*	0.516**	**1.000**
	r_p	-0.032	0.288**	-0.363**	0.297**	0.287**	0.271**	-0.123	-0.175	0.219*	**1.000**

***, ** Significant at 5.0 and 1.0 per cent level of significance, respectively**.

DFF = Days to 50 % flowering
IL= Internodal length (cm)
NBP = Number of branches per plant
PH = Plant height (cm)

NFP = Number of fruits per plant
AFL = Average fruit length (cm)
AFD = Average fruit diameter (cm)

AFW = Average fruit weight (g)
FYP = Fruit yield per plant (g)
FC = Fiber content (%)

Table.3 Direct and indirect effects of nine causal variables on fruit yield per plant of thirty-one genotypes of okra

Trait	Direct effect on FYP	DFF	IL	NBP	PH	NFP	AFL	AFD	AFW	FC
DFF	**-0.3640**		-0.0275	0.0125	0.1302	0.0819	0.1846	-0.0024	-0.0096	0.0179
IL	**-0.1723**	-0.0130		0.0684	-0.0193	-0.0223	-0.0016	0.0496	0.0075	-0.0724
NBP	**-0.3035**	0.0104	0.1205		0.0215	0.0054	0.0056	-0.1820	-0.0181	0.3250
PH	**0.0067**	-0.0024	0.0008	-0.0005		0.0064	0.0064	-0.0005	-0.0016	0.0028
NFP	**2.3169**	-0.5212	0.3002	-0.0415	2.2016		2.0365	-0.1994	-1.0514	1.0391
AFL	**-1.0913**	0.5534	-0.0102	0.0200	-1.0403	-0.9592		0.0760	0.0112	-0.5146
AFD	**0.1540**	0.0010	-0.0443	0.0923	-0.0106	-0.0132	-0.0107		-0.0076	-0.0202
AFW	**0.7639**	0.0202	-0.0331	0.0455	-0.1827	-0.3467	-0.0078	-0.0377		-0.2022
FC	**-0.0592**	0.0029	-0.0249	0.0634	-0.0246	-0.0265	-0.0279	0.0078	0.0157	
r of FYP	-	**-0.3126****	**0.1092**	**-0.0434**	**1.0825****	**1.0426****	**1.0937****	**-0.1346**NS	**-0.2901****	**0.5162****

Residual effect: 0.0645

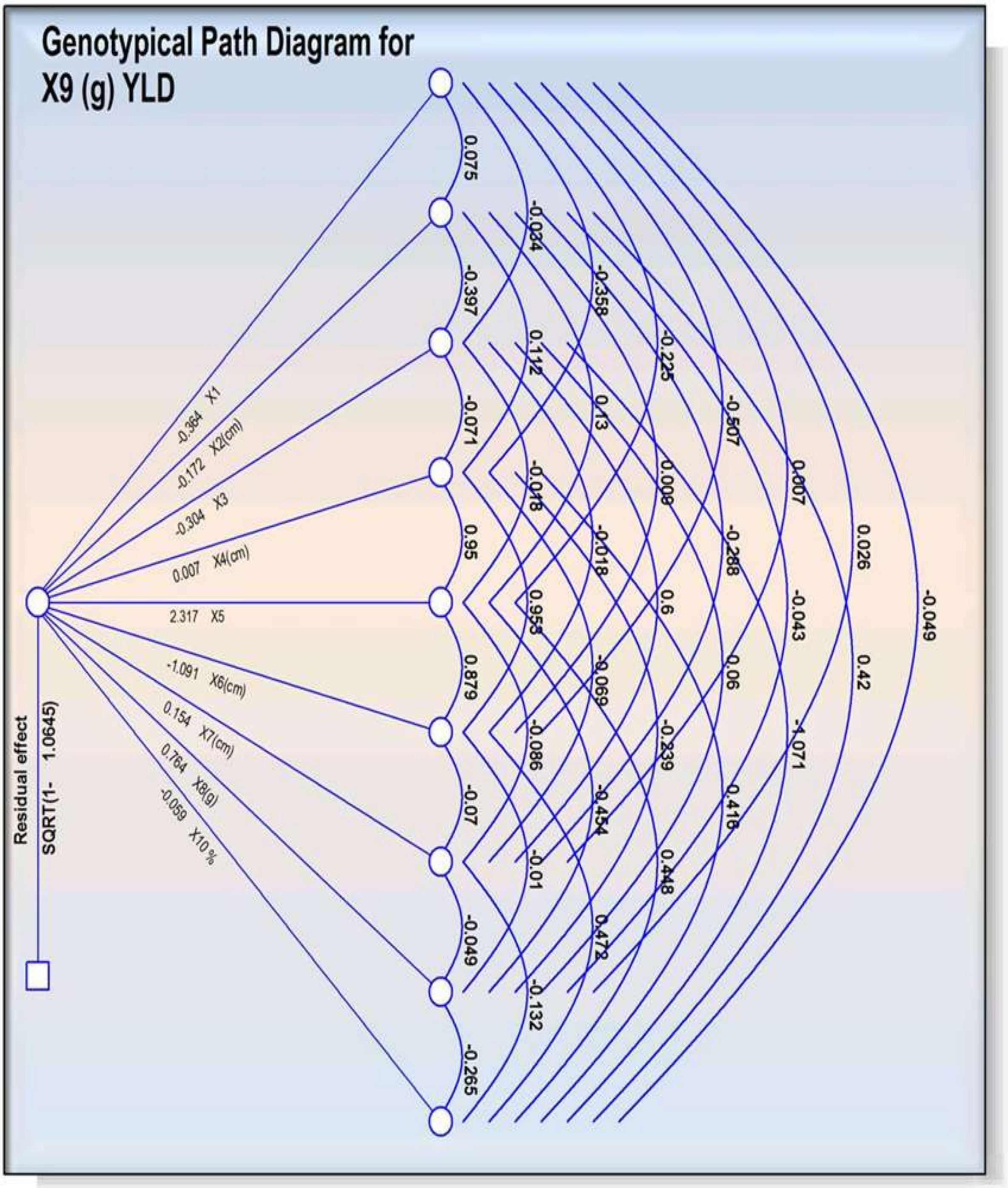
*****, ****** Significant at 5.0 and 1.0 per cent level of significance, respectively; **r** = Correlation

DFF = Days to 50 % flowering
IL= Internodal length (cm)
NBP = Number of branches per plant
PH = Plant height (cm)

NFP = Number of fruits per plant
AFL = Average fruit length (cm)
AFD = Average fruit diameter (cm)
r = Correlation

AFW = Average fruit weight (g)
FYP = Fruit yield per plant (g)
FC = Fiber content (%)

Fig.1 Path diagram in okra genotypes based on morphological characters



X1 -	Days to 50 % flowering	X6 -	Average fruit length (cm)
X2 -	Internodal length (cm)	X7 -	Average fruit diameter (cm)
X3 -	Number of branches per plant	X8 -	Average fruit weight (g)
X4 -	Plant height (cm)	X9 -	Fruit yield per plant
X5 -	Number of fruits per plant	X10 -	Fiber content (%)

It also exhibited negative and significant correlation with plant height (r_g = -0.239) and fiber content (r_g = -0.265) at genotypic level. These results are in close harmony with the findings of Prajna *et al.,* (2015) and Sanganamoni *et al.,* (2016) for number of fruits per plant and for Prajna *et al.,* (2015) fruit yield per plant.

Fiber content was displayed positive and highly significant correlation with internodal length (r_g = 0.420, r_p = 0.288), plant height (r_g = 0.416, r_p = 0.297), number of fruits per plant (r_g = 0.448, r_p = 0.287) and average fruit length (r_g = 0.472, r_p = 0.271) while negative and highly significant correlation with number of branches per plant (r_g = -1.071, r_p = -0.363) at both levels. Average fruit weight (r_g = -0.265) also reported negative significant correlation with fiber content at genotypic level.

Path coefficient analysis

The immediate objective of the breeder is to find remedies for specific defects to a complex aim of maximizing the yield potential. Yield is a complex character and is the multiplicate end product of several component traits. Some of them may be grouped as main component which directly contribute towards yield, whereas, other may not contribute directly to the yield but indirectly may influence the yield by changing the behavior and growth of different components, therefore it would be better to know how the yield is directly and indirectly influenced by other characters.

The path analysis method is adopted to partition the correlation into direct and indirect effects, so that a relative merit of each trait is established and their number is reduced in selection programmes. In order to achieve a clear picture of inter-relationship of various component traits with yield, direct and indirect effects were calculated using path analysis at genotypic level. The estimates of genotypic path coefficient are furnished in the Table 3 and shown in figure 1.

Direct effect

Path coefficient analysis of different characters contributing towards fruit yield per plant showed that number of fruit per plant (2.3169) had highest positive direct effect followed by average fruit weight (0.7639), average fruit diameter (0.1540) and plant height (0.0067). These results are in close harmony with the findings of Singh *et al.*, (2016), Mohammad and Marker (2017), Singh *et al.*, (2017), Thulasirum *et al.*, (2017), Yadav *et al.*, (2017) and Niraja *et al.*, (2018) for the number of fruit per plant; Kumar and Reddy (2016), Sanganmoni *et al.*, (2016), Thulasirum *et al.,* (2017) and Yadav *et al.*, (2017) for average fruit weight; Saryam *et al.*, (2015), Sanganmoni *et al.*, (2016), Meenakshee and Sharma (2017) and Mohammad and marker (2017b) for average fruit diameter and Prajna *et al.*, (2015), Saryam *et al.*, (2015), Kumar and Reddy (2016), Meenakshee and Sharma (2017), Pithiya *et al.*, (2017) and Niraja *et al.*, (2018) for plant height.

While, average fruit length (-1.0913) had the higher negative direct effect on fruit yield per plant followed by days to 50 % flowering (-0.3640), number of branches (-0.3035), internodal length (-0.1723) and fiber content (-0.0592). The similar findings for negative direct effect of average fruit length by Sawant *et al.*, (2014), Meenakshee and Sharma (2017), Prasath *et al.*, (2017) and Thulasirum *et al.*, (2017); for days to 50 % flowering by Kumar and Reddy (2016),), Pithiya *et al.*, (2017), Prasath *et al.*, (2017) and Singh *et al.*, (2017); for number of branches per plant by Balai *et al.*, (2014), Sawant *et al.*, (2014), Vandana *et al.*, (2015), and Prasath *et al.*, (2017); for internodal length by Nirosha *et al.*, (2014), Swamy *et al.*, (2014), Saryam *et al.*, (2015), Singh *et al.,* (2016) and Singh *et al.,* (2017).

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