Correlation and Path Analysis of Okra (*Abelmoschus esculentus* L. Monech) Germplasms for Fruit Yield and its Components

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Field experiment was conducted at AICRP on Vegetable Crops of OUAT, Bhubaneswar during Kharif, 2018-19 to study the correlation of okra germplasm. Study on correlation between several characters shows that selection for fruit yield based on plant height, stem diameter, nodes plant[-1], leaflet length, average fruit weight, fruit length, fruit girth, days to 1st flowering, days to 50% flowering, number of fruits plant[-1], PDI at 30DAS, PDI at 45DAS, PDI at 60DAS, PDI at 75DAS. In

present study genotypic correlation was observed to be higher than the corresponding phenotypic correlations for all the character combinations and therefore it shows that the suppression of phenotypic expression under the influence of environmental factors. Path coefficient analysis of total fruit yield contributing attributes estimated that like average fruit weight had the highest positive effects followed by number of fruits plant[-1], days to 1st flowering, plant height, PDI for YVMV at 60 DAS, stem diameter, node at 1st flowering, nodes plant[-1], which indicated that these traits have to give much importance in selection programme for yield improvement in okra.

1. INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] belongs to the family Malvaceae is one of the most important vegetable crop of world widely cultivated almost throughout India. Tropical Africa was considered as centre of origin [1]. Okra fruits are a good source of 37 mucilage, fats, fibres, minerals, ascorbic acid, carotene, vitamins [2], proteins, carbohydrates [3], 38 and edible oil [4,5]. However, Lamont (1999), suggest that okra has native to South Africa and 1st recorded reference by Egyptian during 1216 A.D. India stands first in okra production producing 6146'000 MT with a productivity of 11.6 MTha[-1] from an area of 528'000 ha, [6]. Okra is commercially grown as annual crop both in kharif and summer season in India. The correlation coefficient between yield and a particular yield component was the net result of direct effect of that attribute and indirect effect through other yield contributing traits so in order to determine the yield components of a commercial crop, correlation and path coefficient analysis are the chief biometrical techniques. The characters which are of positively correlated with yield are the most important to plant breeder for selection purpose. Correlation coefficient analysis appraises the mutual relationship between two plant characters and establishes the yield components upon which selection is to be done for improvement in yield [7]. Path analysis splits the correlation coefficients into the measure of direct and indirect effects and consequently providing an understanding of the direct and indirect contribution of each character towards yield. So, keeping this in view, the present investigation was under taken together with the objective in order to understand the character association between the various characters as well as their direct and indirect effects on yield in okra. The details on corresponding aspects can be of great help in formulating an appropriate breeding strategy through selection efficiency for genetic upliftment of this commercial vegetable crop [8]. Genetic improvement of okra for yield is significant because of the nutritional, economic and health benefits inherent in it and to overcome the low genetic potential of the existing varieties and environmental factors which are the major constraints to okra yield [9].

2. MATERIALS AND METHODS

The field experiment was conducted at All India Co-ordinated Research Project on Vegetable Crops, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India during during *kharif*, 2018-19 to study the performance of okra germplasms for yield and other yield attributing characters along with tolerance to YVMV. The experiment was laid out in Randomized Block Design and replicated twice, with 46 genotypes including four released varieties as check. All the recommended package of practices were adopted uniformly to all the genotypes in order to raise a good crop. Observations on vegetative, flowering, fruit yield and yield attributes were collected from randomly selected plants and were subjected to statistical analysis. The correlation and path coefficient was given by using the formula of Dewey and Lu [10]; Singh et al. (2010).

3. RESULTS AND DISCUSSION

The correlation among fruit yield per plant along with several yield attributes and among the characteristics were presented (Table 1). The phenotypic and genotypic correlation computed among sixteen characters. Out of sixteen characters, fruit yield plant[-1] had positive and significant correlation with plant height (0.632 and 0.557), nodes plant[-1] (0.551 and 0.506), fruit length (0.227 and 0.209), average fruit weight (0.560 and 0.522), number of fruits plant[-1] (0.718 & 0.645) at both genotypic and phenotypic level of significance at 1 percent. Plant height also showed positive and highly

significant correlation at both phenotypic and genotypic level with nodes plant[-1] (0.666 and 0.743), leaflet length (0.241and 0.255), fruit length (0.179 and 0.202), a v e r a g e fruit weight. (0.250 and 0.257) and fruits plant[-1] (0.662 and 0.737). The traits like nodes plant[-1] (-0.213 and -0.238), leafletlength (-0.277 and -0.286) and fruits plant[-1](-0.176 and -0.195) showed negative and highly significant correlation at both phenotypic and genotypic level with stem diameter. But fruit girth showed positive significant correlation only at genotypic level (0.183). In contrast to this, positive and non-significant correlation was also observed by leaflet length (0.037 and 0.035) and average fruit weight (0.077 and 0.082) at both phenotypic and genotypic levels. Correlation studies of 1st fruiting node revealed significant positive correlation with PDI of YVMV at 60 DAS (0.197 and 0.355) and PDI of YVMV at 75 DAS (0.197 and 0.295) at both genotypic and phenotypic levels. But, it exhibited significant negative correlation with days to 1st flowering (-0.175), days to 50% flowering (-0.178), leaflet length (-0.188), fruit length (-0.257), fruit girth (-0.243), average fruit weight (-0.171) and PDI of YVMV at 30 DAS (-0.248) only at genotypic level. Whereas, PDI of YVMV at 45DAS (0.331) showed significant positive correlation at genotypic level. The results on correlation studies of days to 1st flowering revealed significant positive correlation with days to 50%flowering (0.961 and 0.984), fruit girth (0.254 and 0.286), average fruit weight (0.256 and 0.264) and PDI of YVMV at 30DAS (0.340 and0.485) at both phenotypic and genotypic levels and negative significant correlation with PDI of YVMV at 30 DAS (-0.262 and -0.294) and PDI of YVMV at 60 DAS (-0.201 and - 0.219) at both the levels. Positive and significant association of days to 50%flowering was found with fruit girth (0.250 and 0.295), average fruit weight (0.273 and 0.281) and PDI of YVMV at 30DAS (0.299 and 0.426). But the character like PDI of YVMV at 45 DAS (-0.251 and -0.288) and PDI of YVMV at 60 DAS (-0.198 and -0.220) had showed negative and significant result at both phenotypic and genotypic level. Days to1st flowering registered positive and highly significant association with days to 50% flowering (0.961 and 0.984), fruit girth (0.254 and 0.286), average fruit weight (0.256 and 0.264) and PDI of YVMV at 30DAS (0.340 and 0.485) both at phenotypic and genotypic level. At both the levels, PDI of YVMV at 45DAS (-0.262 and -294) and PDI of YVMV at 60DAS (-0.201 and -0.219), it was correlated significantly and negatively.

Days to 50% flowering conveyed positive and highly significant correlations with fruit girth (0.250 and 0.295), average fruit weight (0.273 and 0.281) and PDI of YVMV at 30 DAS (0.299 and 0.426) at both phenotypic and genotypic level, whereas, it exhibited negative significant correlation with PDI of YVMV at 45 DAS (-0.251 and -288) and PDI of YVMV at 60 DAS (-0.198 and -0.220) at both the levels. The traits like nodes at 1st flowering was positive but non-significantly correlated with yield plant[-1] at both phenotypic and genotypic level. On the other hand in this study, non-significant negative correlation of total yield plant[-1] with stem diameter, leaflet length and PDI of YVMV at 60 DAS were recorded. Also for the traits, like days to 1st flowering, days to 50%flowering, fruit girth showed negative and non-significant correlation at genotypic level and positive non-significant correlation at phenotypic level with yield plant[-1]. The traits like PDI of YVMV at 30 DAS and PDI of YVMV at 45 DAS showed negative and non-significant correlation at phenotypic level with yield plant[-1]. Among those traits studied, strong inherent relationship was establishing and thus these findings were clearly shows that genotypic correlations were of higher magnitude to the corresponding phenotypic correlation. It can be concluded that the selection criteria based on yield per plant[-1] can provide better results for yield improvement in okra. Similar results were also obtained by Singh et al. [11], Singla [12], Rathava et al. [13] and Temam et al. [14]

At both phenotypic and genotypic level the direct as well as indirect effects of several traits on fruit yield presented (Table 1). In phenotypic path, average fruit weight (0.503) resulted maximum positive direct effect followed by n o. of fruits plant[-1] (0.429), days to 1st flowering (0.360) , fruit weight (0.278), plant height (0.251), PDI for YVMV at 60 DAS (0.106), stem diameter (0.091),node at 1st flowering (0.052), nodes plant[-1](0.015) showed that these are the main pioneer to fruit yield which is in consonance with the findings of Umrao et al. [15] and Singh et al. (2018). Whereas, negative effects was recorded in days to 50% flowering (-0.444) followed by leaflet length (-0.132), P D I f o r Y V M V a t 45 DAS (-0.199), PDI for YVMV at 30 DAS (-0.159), fruit length (0.061), fruit girth (-0.041), PDI for YVMV at 75DAS (0.026). Number of fruits plant-1(0.429) exhibited second highest positive direct effect on total fruit yield plant-1. It had negligible positive indirect effect via days to first flowering (0.092), fruits plant-1 (0.067), plant height (0.063), and a negative indirect effect via

Table 1. Correlation analysis in Okra Germplasms

		SD	NP	FN	DFF	D50F	LL	FL	FG	AFW	F/P	PDI30	PDI45	PDI60	PDI75	Y/P
PH	P	-0.211*	0.666**	-0.089NS	0.069NS	0.103NS	0.241**	0.179*	-0.050NS	0.250**	0.662**	0.100NS	-0.100NS	-0.066NS	-0.137NS	0.557**
	G	-0.232**	0.743**	-0.146NS	0.081NS	0.113NS	0.255**	0.202*	-0.063NS	0.257**	0.737**	0.087NS	-0.109NS	-0.074NS	-0.176*	0.632**
SD	P		-0.213*	-0.069NS	0.106NS	0.154NS	-0.277**	-0.145NS	0.143NS	-0.027NS	-0.176*	0.098NS	0.040NS	0.065NS	0.103NS	-0.059NS
	G		-0.238**	-0.086NS	0.110NS	0.163NS	-0.286**	-0.168*	0.183*	-0.037NS	-0.195*	0.134NS	0.037NS	0.058NS	0.140NS	-0.053NS
NP	P			0.008NS	-0.093NS	-0.106NS	0.037NS	0.113NS	-0.138NS	0.077NS	0.668**	-0.107NS	-0.097NS	-0.062NS	-0.080NS	0.506**
	G			-0.044NS	-0.104NS	-0.115NS	0.035NS	0.135NS	-0.150NS	0.082NS	0.732**	-0.172*	-0.095NS	-0.053NS	-0.127NS	0.551**
FN	P				-0.102NS	-0.117NS	-0.122NS	-0.146NS	-0.131NS	-0.123NS	0.056NS	-0.011NS	0.134NS	0.197*	0.197*	0.013NS
	G				-0.175*	-0.178*	-0.188*	-0.257**	-0.243**	-0.171*	0.061NS	-0.248**	0.331**	0.355**	0.295**	0.014NS
DFF	P					0.961**	0.051NS	0.041NS	0.254**	0.256**	-0.120NS	0.340**	-0.262**	-0.201*	-0.080NS	0.003NS
	G					0.984**	0.050NS	0.037NS	0.286**	0.264**	-0.131NS	0.485**	-0.294**	-0.219**	-0.112NS	-0.022NS
D50F	P						0.088NS	0.093NS	0.250**	0.273**	-0.085NS	0.299**	-0.251**	-0.198*	-0.069NS	0.003NS
	G						0.092NS	0.095NS	0.295**	0.281**	-0.087NS	0.426**	-0.288**	-0.220**	-0.131NS	-0.011NS
LL	P							-0.091NS	0.139NS	-0.044NS	0.238**	-0.075NS	-0.055NS	-0.054NS	-0.001NS	-0.009NS
	G							-0.097NS	0.154NS	-0.044NS	0.253**	-0.110NS	-0.062NS	-0.057NS	0.010NS	-0.013NS
FL	P								0.201*	0.514**	0.075NS	0.109NS	-0.078NS	-0.015NS	-0.049NS	0.209*
	G								0.219**	0.540**	0.103NS	0.195*	-0.090NS	-0.030NS	-0.083NS	0.227**
FG	P									0.288**	-0.088NS	0.057NS	-0.123NS	-0.030NS	0.076NS	0.006NS
	G									0.315**	-0.110NS	0.129NS	-0.123NS	-0.043NS	0.132NS	-0.009NS
AFW	P										0.155NS	0.126NS	-0.063NS	-0.045NS	-0.109NS	0.522**
	G										0.169*	0.190*	-0.082NS	-0.047NS	-0.154NS	0.560**
F/P	P											-0.188*	-0.113NS	-0.089NS	-0.076NS	0.645**
	G											-0.329**	-0.133NS	-0.105NS	-0.119NS	0.718**
PDI30	P												-0.135NS	-0.090NS	0.018NS	-0.132NS
	G												-0.147NS	-0.104NS	0.067NS	-0.178*
PDI45	P													0.869**	0.626**	-0.141NS
	G													0.982**	0.830**	-0.198*
PDI60	P														0.693**	-0.131NS
	G														0.980**	-0.148NS
PDI75	P															-0.187*
	G															-0.308**

PH- Plant height at final harvest(cm), SD- Stem diameter(cm), NP- Nodes plant[-1], FN- Nodes at first flowering, DFF- Days to 1st flowering, D50F- Days to 50% flowering, FL- Fruit length (cm), FG- Fruit girth (cm), AFW- Average fruit weight (g), F/P- Fruits plant[-1], PDI30 -YVMV% at 30 DAS, PDI45 -YVMV% at 45 DAS, PDI60 -YVMV% at 60 DAS, PDI75 -YVMV% at 75 DAS, Y/P- fruit yield plant[-1](g)

Table 2. Path analysis in Okra Germplasms

	PH	SD	NP	FN	DFF	D50F	LL	FL	FG	AFW	F/P	PDI 30	PDI 45	PDI 60	PDI 75
PH	**0.251**	-0.019	0.010	-0.005	0.025	-0.046	-0.032	-0.011	0.002	0.126	0.284	-0.016	0.020	-0.007	0.004
SD	-0.053	**0.091**	-0.003	-0.004	0.038	-0.068	0.036	0.009	-0.006	-0.014	-0.076	-0.016	-0.008	0.007	-0.001
NP	0.167	-0.019	**0.015**	0.000	-0.033	0.047	-0.005	-0.007	0.006	0.039	0.287	0.017	0.019	-0.007	0.001
FN	-0.022	-0.006	0.000	**0.052**	-0.037	0.052	0.016	0.009	0.005	-0.062	0.024	0.002	-0.027	0.021	-0.004
DFF	0.017	0.010	-0.001	-0.005	**0.360**	-0.427	-0.007	-0.002	-0.010	0.129	-0.052	-0.054	0.052	-0.021	0.003
D50F	0.026	0.014	-0.002	-0.006	0.346	**-0.444**	-0.012	-0.006	-0.010	0.137	-0.036	-0.048	0.050	-0.021	0.003
LL	0.061	-0.025	0.001	-0.006	0.018	-0.039	**-0.132**	0.006	-0.006	-0.022	0.102	0.012	0.011	-0.006	0.002
FL	0.045	-0.013	0.002	-0.008	0.015	-0.041	0.012	**-0.061**	-0.008	0.258	0.032	-0.017	0.016	-0.002	0.002
FG	-0.013	0.013	-0.002	-0.007	0.091	-0.111	-0.018	-0.012	**-0.041**	0.145	-0.038	-0.009	0.024	-0.003	0.000
AFW	0.063	-0.002	0.001	-0.006	0.092	-0.121	0.006	-0.031	-0.012	**0.503**	0.067	-0.020	0.013	-0.005	0.003
F/P	0.166	-0.016	0.010	0.003	-0.043	0.038	-0.031	-0.005	0.004	0.078	**0.429**	0.030	0.022	-0.009	0.003
PDI 30	0.025	0.009	-0.002	-0.001	0.122	-0.133	0.010	-0.007	-0.002	0.063	-0.081	**-0.159**	0.027	-0.010	0.002
PDI 45	-0.025	0.004	-0.001	0.007	-0.094	0.111	0.007	0.005	0.005	-0.032	-0.048	0.022	**-0.199**	0.092	-0.016
PDI 60	-0.017	0.006	-0.001	0.010	-0.072	0.088	0.007	0.001	0.001	-0.023	-0.038	0.014	-0.173	**0.106**	-0.015
PDI 75	-0.040	0.005	-0.001	0.007	-0.045	0.050	0.010	0.004	0.000	-0.051	-0.053	0.011	-0.121	0.062	**-0.026**

PH- Plant height at final harvest(cm), SD- Stem diameter(cm), NP- Nodes plant[-1], FN- Nodes at first flowering, DFF- Days to 1st flowering, D50F- Days to 50% flowering, FL- Fruit length (cm), FG- Fruit girth (cm), AFW- Average fruit weight (g), F/P- Fruits plant[-1], PDI30 -YVMV% at 30 DAS, PDI45 -YVMV% at 45 DAS, PDI60 -YVMV% at 60 DAS, PDI75 -YVMV% at 75 DAS, Y/P- fruit yield plant[-1](g)

days to 50% flowering (-0.121) on total fruit yield plant[-1]. The remaining character showed negligible positive or negative indirect effect on yield. Negative direct effect of plant height at final harvest (-0.623) exhibited via indirect positive effect of characters of plant height at peak fruiting stage (0.728), average fruit weight (0.062) and fruit length (0.040).In direct negative effect was observed with respect to fruits plant[-1] (-0.250). Rest other characters were indirectly associated either positively or negatively. Stem diameter showed a positive direct effect of 0.091 on total fruit yield plant[-1].It had positive indirect effect via days to 1st flowering (0.038) followed by leaflet length (0.036) and a negative indirect effect of (-) 0.068 via days to 50% flowering. The remaining characters showed negligible positive or negative indirect effect on total fruit yield plant[-1]. Nodes plant[-1](0.015) had positive direct effect on total fruit yield plant[-1]via indirect positive effect of characters like fruits plant-1(0.287), plant height at final harvest (0.167), days to 50% flowering (0.047), average fruit weight (0.039), PDI for YVMV at 45 DAS (0.019), PDI for YVMV at 30 DAS (0.017), fruit girth (0.006) and PDI for YVMV at 75 DAS (0.001). All other traits had indirect negative effect on total fruit yield plant[-1]. Similarly, node at 1st fruiting recorded low positive direct effect of 0.052 on yield plant[-1] and a positive indirect effect via days to 50% flowering (0.052) on total fruit yield plant[-1].Days to 1st flowering (0.360) showed positive direct effect via negative indirect effect of characters like days to 50% flowering (-0.427), PDI for YVMV at 30 DAS (-0.054) and fruits plant-1(-0.052).Moderate positive indirect effect was observed for character like PDI for YVMV at 45 DAS (0.052). Rest of the characters had negligible effect either in positive or negative direction. Days to 50% flowering showed negative direct effect (-0.444) on total yield plant[-1] and showed moderate positive indirect effect for days to 1st flowering (0.346). Negative direct effect was observed for leaflet length (-0.132) via higher indirect negative effect with respect to days to 50% flowering (-0.039), stem diameter (-0.025), average fruit weight (-0.022), node at 1st fruiting (-0.006), fruit girth (-0.006) and PDI for YVMV at 60 DAS (-0.006). Moderate positive indirect effect was observed for traits like plant height at final harvest stage (0.061). Rest other traits exhibited indirect effect positively. Fruit length exhibited negative direct effect (-0.061) on total yield plant[-1] and moderate positive indirect effect on fruit yield was exhibited by this trait through average fruit weight (0.258) followed by plant height at final harvest stage (0.045) and no.

of fruits plant[-1] (0.032). Fruit girth (-0.041) had negative direct effect on total yield plant[-1] and moderate positive indirect effect on fruit yield was observed through the traits like average fruit weight (0.145), days to 1st flowering (0.091), PDI for YVMV at 60 DAS (0.024) and stem diameter (0.013) . Rest other characters were indirectly associated in a negative direction. Positive direct effect (0.503) was recorded in average fruit weight on total fruit yield plant-1 and it showed low positive indirect effect on yield via days to 1st flowering (0.092) followed by no. of fruits plant[-1](0.067),plant height (0.063) and PDI of YVMV at 45 DAS (0.013) whereas, other characters were indirectly associated in a positive or negative direction. Fruits plant[-1] (0.429) exhibited positive direct effect on total yield plant-1whereas, it showed positive indirect effect through plant height at final harvest (0.166) on fruit yield plant-1. Rest other positive characters had negligible effect. PDI for YVMV at 30DAS (-0.159) exhibited negative direct effect via highest indirect effect of positive characters like days to 1st flowering (0.122), average fruit weight (0.063), PDI for YVMV at 45DAS (0.027) and plant height at final harvest (0.025). Remaining characters exhibited non-significant indirect positive or negative effect. PDI for YVMV at 45 DAS (-0.199) showed negative direct effect while the characters showed positive indirect effect through days to 50% flowering (0.111) on fruit yield plant[-1]. Rest other positive and negative characters had negligible effect. PDI for YVMV at 60 DAS exhibited positive direct effect (0.106) on total yield plant[-1] and moderate negative indirect effect on fruit yield was exhibited by this trait through average fruit weight (-0.173) followed by plant height at final harvest stage (0.045) and no. of fruits plant[-1] (0.032).Similarly, PDI for YVMV at 75 DAS manifested negative direct effect (-0.026) on fruit yield. It exhibited positive indirect effect on fruit yield through PDI for YVMV at 60 DAS (0.062),days to 50% flowering (0.050), PDI for YVMV at 30 DAS(0.011), leaflet length (0.010),node at 1st fruiting (0.007), stem diameter (0.005) and fruit length (0.004).Rest of the traits had negative indirect effect.

4. CONCLUSION

In present investigation genotypic correlation had observed to be higher than the corresponding phenotypic correlations for all the character combinations, it may due to strong inherent association between various characters and significant G x E interaction. From the present

study path coeficient analysis of total fruit yield contributing characters estimated that the average fruit weight showed maximum positive direct effect followed by no. of fruits plant[-1], days to 1st flowering, plant height, PDI for YVMV at 60 DAS ,stem diameter, node at 1st flowering, nodes plant[-1],. The selection based on these characters will results in development of high fruit yield plant[-1].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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