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Path co-efficient analysis in okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT : The study on direct and indirect effects of seventeen different growth, physiological and fruit related traits on yield of okra had revealed the presence of very high direct positive effect of fruit number on yield plant^{-1}. The traits *viz.*, number of fruits plant^{-1}, plant height and fruit weight were identified as the important yield determinants through path co-efficient analysis and these traits could be relied upon for selection of high yielding genotypes in okra. Leaf area index was found to be the second ranking trait with high positive direct effect followed by stem diameter. The indirect effect of fruit length as well as fruit girth on yield through fruit weight were also found to be positive, indicating their importance in exercising selection.

KEY WORDS : Okra, Direct effect, Indirect effect

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Okra [*Abelmoschus esculentus* (L.) Moench] commonly known as lady's finger is an important short duration vegetable crop, cultivated in an area of 5.18 Lha with a total production of 62.60 lt. in our country (Tiwari *et al*., 2012).

Vegetables form an integral part of a balanced diet as they are rich in vitamins, minerals and antioxidants. India is next only to China in global vegetable production with a contribution of 14 per cent and at present India has a total area of 8.98 m ha under vegetables, producing 156.32 mt annually (Tiwari *et al*., 2012). However, there seems to be a plateau with regard to production and enhancing productivity under poor soil and other stress conditions becomes imperative. For selection of any desire genotype for a given environment partioning the association of various yield contributing traits into direct and indirect effects to understand the relative importance of each trait that influences the yield becomes essential. Crop improvement through conventional breeding requires an insight into the magnitude of direct and indirect effects of yield component present in a crop species as it forms the basis of effective selection and hence, the present study on path co-efficient analysis in okra was taken up.

RESEARCH METHODS

Studies were taken up involving thirty three genotypes of okra [*Abelmoschus esculentus* (L.) Moench] at the Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Union Territory of Puducherry during summer 2012-2013. The soil of the experimental field was sandy loam and total of 33 genotypes including a variety (Arka Anamika) was used for the study. Thirty accessions were collected from the Indian Institute of Vegetable Research (IIVR), Varanasi and two ecotypes, one each from Tiruchirappalli and Coimbatore of Tamil Nadu were also included for the study. The observations were recorded on five randomly selected plants per replication for each genotype on twenty important characters. The direct and indirect effects were obtained by the method suggested by Dewey and Lu (1959).

RESEARCH FINDINGS AND DISCUSSION

The study on direct and indirect effects of seventeen different growth, physiological and fruit related traits on yield of okra had revealed the presence of very high direct positive effect of fruit number on yield plant^{-1}. Such a high positive direct effect of fruit number on yield had been reported earlier by Vijay and Manohar (1990); Gondane *et al.* (1995); Dhankhar and Dhankhar (2002) and Adiger *et al.* (2011).

The highest positive direct effect on yield plant^{-1} was exerted by stem diameter (3.878). All the other growth traits except plant height were found to have a negative direct effect on yield (Table 1). The direct negative effect was the maximum with days to flowering (-1.614), followed by internodal length (-1.548) and primary branches at flowering (-1.088). Leaf area index was found to exert the highest positive direct effect among the physiological traits on yield (Table 2). Positive indirect effect of days to flowering on yield through leaf area index (2.112), internodal length (0.628), fruit weight (0.407), stem diameter (0.386), hundred seed weight (0.086), fruit girth (0.079) and primary branches at final harvest (0.070) were also recorded. Direct positive effect of number of leaves on yield was reported by Karri and Acharyya (2012) and Kumar *et al.* (2012), while the direct influence of stem diameter was observed by Kumar *et al.* (2012). The direct effect of total chlorophyll, pedicel length, fruit girth and plant height were also found to be positive. The findings of Kumar *et al.* (2012) with regard to direct effect of stem diameter and plant height in okra was in line with the present observation. Node of first flower had positively and indirectly influenced the yield plant^{-1} through leaf area index (1.887), internodal length (0.837), fruit weight (0.154), relative water content (0.097), fruit length (0.091), hundred seed weight (0.026) and fruit girth (0.007). Plant height was found to influence the yield indirectly and positively through days to flowering (0.611), primary branches at flowering (0.488), fruit girth (0.319), relative water content (0.253), leaf area index (0.161), fruit number (0.118), node of first flower (0.028) and seed number (0.028).

Direct effect of higher magnitude on negative direction was exerted by fruit weight and this was in conformity to the earlier finding of Balakrishnan and Sreenivasan (2010). In conformity to the findings of Gangashetty *et al.* (2010a) negative direct effect of days to flowering and internodal length on yield was observed

Table 1 : Direct and indirect effects of growth traits on fruit yield of okra

Characters	DF (cm)	NFF	PH (cm)	PBF	PBFH	IL (cm)	SD (cm)	LAI	RWC (per cent)	TC (mg g^{-1})	PL (cm)	FL (cm)	FG (cm)	FW (g)	FN	SN	HSW (g)	r_g with YPP
DF	-1.614	-0.108	-0.117	-0.351	0.070	0.628	0.386	2.112	-0.357	-0.299	-0.055	-0.031	0.079	0.407	-0.551	-0.039	0.086	0.546*
NFF	-0.746	-0.233	-0.038	-0.420	-0.030	0.837	-0.681	1.887	0.097	-0.246	-0.051	0.091	0.007	0.154	-1.380	-0.009	0.026	-0.733**
PH	0.611	0.028	0.310	0.488	-0.026	-1.061	-0.089	0.161	0.253	-0.227	-0.369	-0.057	0.319	-0.701	0.118	0.028	-0.005	-0.217*
PBF	-0.520	-0.090	-0.139	-1.088	0.001	0.559	-0.174	0.110	-0.205	-0.629	-0.035	0.144	-0.037	0.535	1.734	-0.003	0.035	-0.197*
PBFH	0.760	-0.045	0.054	0.005	-0.150	0.145	0.427	-0.304	-0.064	-0.165	0.067	0.058	-0.010	0.570	-1.156	0.010	-0.120	0.082
IL	0.655	0.126	0.212	0.393	0.014	-1.548	-0.287	-1.509	0.337	0.398	0.187	-0.185	0.244	-0.847	1.677	0.034	0.025	-0.376**
SD	-0.161	0.041	-0.007	0.049	-0.016	0.115	3.878	-0.758	-0.268	-0.346	-0.018	-0.018	0.128	-0.840	-2.073	0.004	0.060	-0.230*

Residual effect = 0.331; Bold figures indicate direct effects; r_g - Genotypic correlation co-efficient; DF- Days to flowering; NFF - Node of first flower; PH - Plant height (cm); PBF - Primary branches at flowering; PBFH - Primary branches at final harvest; IL - Internodal length (cm); SD - Stem diameter (cm); LAI - Leaf area index; RWC - Relative water content (%); TC - Total chlorophyll (mg g^{-1}); PL - Pedicel length (cm); FL - Fruit length (cm); FG - Fruit girth (cm); FW - Fruit weight (g); FN - Fruit number; SN - Seed number; HSW - Hundred seed weight (g); YPP- Yield plant^{-1}

in the present study (Table 1).

Primary branches at flowering contributed positively and indirectly to yield plant^{-1} in okra through fruit number (1.734), internodal length (0.559), fruit weight (0.535), fruit length (0.144), leaf area index (0.110), hundred seed weight (0.035) and primary branches at final harvest (0.001). The indirect effects were negative with regard to days to flowering (-0.520), stem diameter (-0.174), plant height (-0.139) and node of first flower (-0.090).

The study of direct and indirect effects of various physiological traits on yield had revealed that the maximum positive direct effect was exerted by leaf area index (4.908), followed by total chlorophyll content (2.182). However, the direct effect of relative water content (-1.059) was found to be negative (Table 2). Positive and indirect effect of leaf area index towards yield was found to be exerted through internodal length (0.476), fruit girth (0.297), plant height (0.010) and primary branches at final harvest (0.009). Relative water content had contributed positively and indirectly towards yield through leaf area index (1.757), stem diameter (0.982), internodal length (0.492), fruit weight (0.382), fruit girth (0.262), fruit length (0.183) and node of first flower (0.021). More or less similar findings were obtained by Nasit *et al.* (2009); Chaukhande *et al.* (2011) and Meena *et al.* (2013).

Fruit number was found to be the important yield component trait showing the maximum direct positive effect on yield (5.129), followed by pedicel length (2.052), fruit girth (1.353) and hundred seed weight (0.331). The highest direct negative effect on yield was registered by fruit weight, (-2.842) followed by fruit length (-0.576) and seed number (-0.093) as seen in Table 3. Pedicel length was found to influence the yield indirectly and positively through relative water content (0.618), total chlorophyll (0.047), days to flowering (0.043), hundred seed weight (0.041), primary branches at flowering (0.018), node of first flower (0.006) and seed number (0.001). The study revealed indirect positive effect of fruit weight on yield through stem diameter (1.146), fruit girth (0.744), total chlorophyll (0.380), fruit number (0.254), days to flowering (0.231), primary branches at flowering (0.205), pedicel length (0.158), relative water content (0.142), hundred seed weight (0.101), leaf area index (0.080), plant height (0.076), primary branches at final harvest (0.030), seed number (0.018) and node of first flower (0.013). Negative indirect effects were observed through internodal length (-0.462) and fruit

Table 2 : Direct and indirect effects of physiological traits on fruit yield of okra

Characters	DF	NFF	PH (cm)	PBF	PBFH	IL (cm)	SD (cm)	LAI	RWC (per cent)	TC (mg g^{-1})	PL (cm)	FL (cm)	FG (cm)	FW (g)	FN	SN	HSW (g)	r_g with YPP
LAI	-0.695	-0.090	0.010	-0.024	0.009	0.476	-0.599	4.908	-0.379	-0.861	-0.497	-0.006	0.297	-0.046	-2.367	-0.035	-0.041	0.259**
RWC	-0.544	0.021	-0.074	-0.210	-0.009	0.492	0.982	1.757	-1.059	-0.024	-1.198	0.183	0.262	0.382	-0.464	-0.026	-0.044	0.428**
TC	0.221	0.026	-0.032	0.314	0.011	-0.282	-0.615	-1.486	0.012	2.182	0.044	-0.108	0.214	-0.495	-0.204	-0.001	0.046	-0.153

Residual effect = 0.3311; Bold figures indicate direct effects; r_g – Genotypic correlation co-efficient; DF- Days to flowering; NFF - Node of first flower; PH - Plant heighl (cm); PBF - Primary branches at flowering; PBFH - Primary branches at final harvest; IL - Internodal length (cm); SD - Stem diameter (cm); LAI - Leaf area index; RWC - Relative water content (%); TC - Total chlorophyll (mg g^{-1}); PL - Pedicel length (cm); FL - Fruit length (cm); FG - Fruit girth (cm); FW - Fruit weight (g); FN - Fruit number; SN - Seed number; HSW - Hundred seed weight (g); YPP - Yield plant^{-1}, ** indicate significance of values at P=0.05, respectively

Table 3 : Direct and indirect effects of fruit related traits and yield of okra

Characters	DF	NFF	PH (cm)	PBF	PBFH	IL (cm)	SD (cm)	LAI	RWC (per cent)	TC (mg g-1)	PL (cm)	FL (cm)	FG (cm)	FW (g)	FN	SN	HSW (g)	rg with YPP
PL	0.043	0.006	-0.056	0.018	-0.005	-0.141	-0.033	-1.188	0.618	0.047	2.052	-0.121	-0.582	-0.219	-0.504	0.001	0.041	-0.023
FL	-0.086	0.037	0.030	0.271	0.015	-0.498	0.120	0.054	0.337	0.411	0.432	-0.576	0.305	-0.771	-0.068	-0.011	0.048	0.051
FG	-0.095	-0.001	0.073	0.030	0.001	-0.279	0.368	1.077	-0.205	0.345	-0.883	-0.130	1.353	-1.563	-0.035	0.013	0.074	0.144
FW	0.231	0.013	0.076	0.205	0.030	-0.462	1.146	0.080	0.142	0.380	0.158	-0.156	0.744	-2.842	0.254	0.018	0.101	0.121
FN	0.173	0.063	0.007	-0.368	0.034	-0.506	-1.568	-2.265	0.096	-0.087	-0.202	0.008	-0.009	-0.141	5.129	0.018	0.002	0.382**
SN	-0.683	-0.023	-0.092	-0.038	0.017	0.558	-0.167	1.857	-0.293	0.008	-0.019	-0.068	-0.194	0.554	-0.984	-0.093	-0.146	0.194
HSW	-0.419	-0.019	-0.005	-0.116	0.054	-0.117	0.703	-0.612	0.142	0.305	0.251	-0.083	0.304	-0.867	0.028	0.041	0.331	-0.080

Residual effect = 0.3311; Bold figures indicate direct effects. rg – Genotypic correlation co-efficient; DF - Days to flowerirg; NFF - Node of first flower; PH - Plant height (cm); PBF - Frimary branches at flowering; PBFH - Primary branches at final harvest; IL - Internodal length (cm); SD - Stem diameter (cm); LAI - Leaf area index; RWC - Reative water content (%); TC - Tctal chlorophyll (mg g -1); PL - Pedicel length (cm); FL - Fruit length (cm); FG - Fruit girth (cm); FW -Fruit weight (g); FN - Fruit number; SN - Seed number; HSW - Hundred seed weight (g); YPP- Yield plant- 1; ** indicate significance of value at P= (.05

length (-0.156) as evidenced from Table 3. Seed number influenced the yield plant^{-1} positively and indirectly through leaf area index (1.857), internodal length (0.558), fruit weight (0.554), primary branches at final harvest (0.017) and total chlorophyll (0.008).

The study had shown the importance of days to flowering, leaf area index, primary branches at flowering, internodal length and fruit number in selecting high yielding genotypes of okra. The indirect effect of fruit length as well as fruit girth on yield through fruit weight were also found to be positive indicating their importance too in exercising selection. Selection of high yielding genotype in okra on the basis of number of fruits plant^{-1}, number of branches plant^{-1}, plant height and fruit weight had already been emphasized by Gangashetty *et al*. (2010b); Balakrishnan and Sreenivasan (2010); Adiger *et al.* (2011) and Kumar *et al*. (2012).

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