Correlation and path analysis for growth, yield, quality, shoot, and fruit borer incidence in brinjal, *Solanum melongena*. L.

ABSTRACT

The study was conducted using sixty brinjal genotypes to evaluate yield quality as well as shoot and fruit borer incidence with an objective to study the correlation and path coefficient analysis. In most cases, genotypic correlations were higher than phenotypic correlations indicating the highly heritable nature of the character. Fruit yield per plant showed a significant positive correlation with fruits per plant, fruit weight, the weight of infested fruit, the girth of fruit, plant height, number of primary branches per plant, percentage of medium- styled flowers, percentage of long- styled flowers, length of fruits at the genotypic level. It a exhibited significant negative correlation with SFB fruit infestation as well as SFB shoot infestation both at phenotypic and genotypic levels. Path coefficient revealed that fruits per plant showed a high and positive direct effect on yield followed by fruit weight, long -styled flowers, medium -styled flowers, and days to first harvest. Direct selection for these traits would be rewarding for improvement in the fruit yield per plant.

Keywords: *Solanum melongena*, *Correlation, Shoot and fruit borer, Path coefficient*

1. INTRODUCTION

Brinjal, *Solanum melongena* L., is an important vegetable crop in the tropical world and is grown on a large scale in India, Bangladesh, Pakistan, China, and the Philippines. In India, it is a very popular and main vegetable crop cultivated throughout the country and around the year owing to its wide adaptability to diverse agro-climatic regions. Eggplant is considered to have originated in India and therefore wide range of diversity is found in the crop concerning fruit shape, size, and color (1, 2). It is eaten by wide range of individuals from all social classes, making it to be called as "vegetable of the masses" (3). In addition to its known medicinal

property for diabetes and liver problems, it is also known for its antioxidant, hypotensive, cardioprotective, and hepatoprotective properties (4).

Yield is a complex character which affected and expressed by interaction of several component characters (5). Some characters may have positive or negative impact on yield. Yield can improved through selection for the desired component characters. Therefore, it is essential to know the component characters which can be known through correlation study which reveals the association between yield and its component characters, whether it is positive or negative. However, correlation analysis alone may not be sufficient to select the genotypes based on the particular traits as some characters might indirectly affect the yield, but their association may not be significant statistically. In such cases, path coefficient analysis is an effective tool which partitions the coefficients into direct and indirect effects. The path coefficient technique helps estimate the direct and indirect contribution of various components in building up the correlation toward yield. This study will help the breeder to know the degree of association between traits, which can be used for crop improvement through a selection of component traits.

2. MATERIALS AND METHODS

The present study was carried out to assess the association of the characters with direct and indirect effects through path analysis in 60 diverse genotypes of brinjal. The experiment was conducted at the college of Agriculture, Vellayani, Thiruvananthapuram during the year 2017-18. The experimental site (Vellayani) is located at 8^{o} $5^{'}$ N latitude and 77^{o} $1^{'}$ E longitude at an altitude of 29 m above mean sea level. The recommended package of practices was followed to maintain the crop properly till the last harvest. Observations on growth and yield- contributing characters were recorded on five randomly selected plants in each replication at different stages of the crop. Observations were taken for plant height (cm), number of primary branches $plant^{-1}$, days to first flower, percentage of long -styled flowers, percentage of medium- styled flowers, intra- cluster distance (cm), inter cluster-distance (cm), number of fruits $plant^{-1}$, fruit length (cm), fruit girth (cm), fruit weight (g), days to first harvest of fruits, days to last harvest of fruits, fruit yield per plant (g), SFB shoot damage, SFB fruit damage, calyx length (cm), RLPS (Ratio of peripheral seed ring to total length of fruit), RLSA (Ratio of seedless area to total length of fruit), weight of infested fruits (g), total sugars (mg/100 g) and total phenols (mg/100 g). The percentage of infested shoots and fruits per plant was calculated by dividing the number of

shoots or fruits showing damage by symptoms to the total number of shoots or fruits, respectively which were multiplied by 100. Estimation of total sugars in a fruit sample was done by using anther method and the total phenol content of fruit was estimated by using Folin-Ciocalteau reagent (6). The correlation coefficient among all possible character combinations at a phenotypic and genotypic level was estimated employing formula given by (7). Path coefficient analysis was executed as suggested by (8) to know the direct and indirect effect of the morphological traits on fruit yield.

3. RESULTS AND DISCUSSION

3.1 Correlation Coefficient Analysis

The estimates of phenotypic and genotypic correlation coefficients between different characters of Eggplant genotypes are presented in Tables **1 and 2**, respectively. Phenotypic (P) and genotypic (G) correlation coefficients among twenty- three yield and yield attributes in sixty genotypes of brinjal revealed that the estimates of genotypic correlations were greater than the estimates of their phenotypic correlations indicating less influence of the environment and strong inherent relationship among the characters. In phenotypic correlation **(Table 1**), fruit yield per plant showed a significant positive correlation with fruits per plant (0.821), fruit weight (0.465), weight of infested fruit (0.408), girth of fruit (0.305), plant height (0.387), number of primary branches per plant (0.368), percentage of medium -styled flowers (0.277), length of fruits (0.239) and percentage of long- styled flowers (0.229). It exhibited a significant negative correlation with fruit infestation by fruit and shoot borer (-0.428), SFB shoot infestation (-0.374), percentage of short styled flowers (-0.028), calyx length (-0.316), intra cluster distance (-0.192), RLSA (-0.226) and days to last harvest (-0.215). In case of genotypic correlation (Table 2.), fruit yield per plant showed a significant positive correlation with fruits per plant (0.849), fruit weight (0.469), weight of infested fruit (0.410), girth of fruit (0.306), plant height (0.392), number of primary branches per plant (0.390), percentage of medium- styled flowers (0.384), percentage of long- styled flowers (0.265), length of fruits (0.240). It exhibited a significant negative correlation with SFB fruit infestation (-0.439) as well as SFB shoot infestation (-0.378), percentage of short - styled flowers (-0.021), calyx length (-0.321), intra cluster distance (-0.193), RLSA (-0.234), and days to last harvest (-0.216). The positive associations between characters imply the possibility of correlated responses to selection and it follows that with increase in one, will entail an increase in

another and the negative correlation preclude the simultaneous improvement of those traits along with each other. SFB shoot infestation showed a significant positive correlation with SFB fruit infestation (0.707) and total sugars (0.460). It also showed a significant negative correlation with RLPS (-0.530) and total phenols (-0.577). SFB fruit infestation showed a significant positive correlation with RLSA (0.556), total sugars (0.408) and calyx length (0.254). It also showed a significant negative correlation with RLPS (-0.665), RLSA (-0.536), and calyx length (-0.523), total phenols (-0.473), and weight of infested fruits (-0.194) at phenotypic as well as genotypic level. The same line of work was reported by (5, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22). Thus, the present findings indicated the importance of these characters in selection for fruit yield and direct selection based on these characters would be rewarding for further improvement of aforesaid traits and yield in Eggplant.

3.2 Path Coefficient Analysis

The path analysis divides the correlation coefficient between two characters into direct and indirect effects which reveals whether the association of component characters with yield is due to their direct effect on yield, or due to their indirect effect via some other character(s). The plant height exhibited a positive direct effect (0.088) and a strong positive correlation with fruit yield per plant (0.392). This is mainly due to its indirect positive effect through number of primary branches (0.051), fruits per plant (0.041), fruit length (0.022) percentage of long- styled flowers (0.013) and indirect negative effect through days to first harvest (-0.020), fruit weight (-0.009), and girth of fruit (-0.016). The number of primary branches per plant showed positive direct effect (0.033) on fruit yield per plant (0.390). However, its strong positive association with fruit yield was mainly of its positive indirect effect through plant height (0.019), number of fruits per plant (0.117) , and negative indirect effect through percentage of medium styled flowers (-0.008) and days to first harvest (-0.015). The genotypic correlation of days to the first flower with yield was -0.1278. Most of it was contributed by negative direct effect (-0.0663), and by indirect positive effect through days to the first harvest (0.058), and number of fruits per plant (0.011). It also contributed by negative indirect effect through plant height (-0.008), percentage of medium-styled flowers (-0.004) and percentage of long styled flowers (-0.015). These findings are in agreement with earlier reports in brinjal by (13, 14, 15, 16, 17, 18, 19, 20, 21, 22).

The percentage of medium- styled flowers showed a positive direct effect (0.460), and had a strong positive association with fruit yield per plant (0.021). This is mainly due to its indirect positive effect through the number of fruits per plant (0.021), and indirect negative effect through percentage of long -styled flowers (-0.017), fruit weight (-0.002), number of primary branches per plant (-0.001), and plant height (-0.0019). The percentage of long -styled flowers showed a positive direct effect (0.511), and had a strong positive association with fruit yield per plant (0.265). This is mainly due to its indirect positive effect through percentage of medium-styled flowers (0.057), plant height (0.123), number of fruits per plant (0.022), number of primary branches (0.016), and indirect negative effects through mainly days to first flower (-0.015), and days to the first harvest (-0.020). The genotypic correlation of a number of fruits per plant with yield was 0.849. Most of it was contributed by positive direct effect (0.832) and by indirect positive effect through number of primary branches per plant (0.428), plant height (0.386), percentage of long -styled flowers (0.281), fruit length (0.175), a girth of fruit (0.057), and fruit weight (0.062). It also contributed by negative indirect effect through days to the first flower (-0.125), and days to first harvest (-0.187). Fruit length despite its negative direct effect (-0.025), and had a strong positive association with fruit yield per plant (0.240). This is mainly due to its indirect positive effect through percentage of medium- styled flowers (0.002), a girth of fruit (0.007) and negative indirect effect through plant height (-0.0065), a number of branches per plant (-0.0052), days to the first flower (-0.004) and a girth of fruit (-0.007). Fruit girth showed a negative direct effect (-0.059), and had a strong positive association with fruit yield per plant (0.306). This is mainly due to its indirect positive effect through fruit girth (0.139), fruit length (0.018), plant height (0.010), days to the first flower (0.007), and indirect negative effects through fruit weight (-0.039), and a number of fruits per plant (-0.024). Fruit weight showed a positive direct effect (0.469), and had a strong positive association with fruit yield per plant (0.469). This is mainly due to its indirect positive effect through girth of fruit (0.310), fruit length (0.072), percentage of long-styled flowers (0.079), number of fruits per plant (0.035) and indirect negative effect through number of primary branches (-0.024), the percentage of medium- styled flowers (-0.064), plant height (-0.049), and days to the first flower (-0.016). Days to the first harvest showed a positive direct effect (0.081), and had a negative association with fruit yield per plant (-0.155). This is mainly because of its high indirect positive effects through days to the first flower (0.071), fruit length (0.009) but its indirect negative contribution to the yield is

mainly through the number of fruits per plant (-0.018), plant height (-0.018), and the number of branches per plant (-0.013). These results are in agreement with the findings of (20, 21, 22). The path analysis exhibited that the traits like fruits per plant, fruit weight, and long- styled flowers, medium- styled flowers and days to the first harvest were the most important yield contributing characters owing to their high direct effects and indirect effects via other traits. The characters which had a high positive association with fruit yield and also had a high positive direct effect on fruit yield the genotypic level are useful for selection. Thus, these characters deserve greater weightage and the direct selection of these traits would be effective for developing high- yielding Eggplant varieties.

4. CONCLUSION

It can be concluded that more emphasis should be given to major yield contributing characters like fruits per plant, fruit weight, girth of fruit, number of primary branches per plant, percentage of medium- styled flowers, percentage of long- styled flowers, length of fruits to improve the yield in brinjal crop. Path coefficient revealed that fruits per plant showed a high and positive direct effect on yield followed by fruit weight, long -styled flowers, medium- styled flowers, and days to the first harvest. Direct selection in these traits would be rewarding for improvement in the fruit yield per plant in brinjal.

Table 1. Phenotypic correlation for growth and yield characters in brinjal

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22
X1	1.000																					
X2	0.553**	1.000																				
X3	-0.126	-0.099	1.000																			
X4	0.085	-0.064	-0.037	1.000																		
X5	0.120	0.231*	-0.216*	-0.719**	1.000																	
X6	-0.277**	-0.203*	0.353**	-0.390**	-0.318**	1.000																
X7	-0.174	-0.198*	-0.078	0.072	-0.049	-0.033	1.000															
X8	0.030	-0.162	0.149	0.138	-0.240	0.130	0.082	1.000														
X9	0.449**	0.485**	-0.135	-0.054	0.247**	-0.240**	-0.293	-0.190*	1.000													
X10	0.247**	0.192*	0.160	-0.026	0.187*	-0.207*	-0.001	0.313**	0.202*	1.000												
X11	-0.181*	0.022	-0.122	-0.007	-0.010	-0.001	0.140	-0.243**	0.069	-0.307**	1.000											
X12	-0.103	-0.047	-0.031	-0.118	0.132	-0.020	0.068	0.005	0.075	0.153	0.657**	1.000										
X13	-0.225*	-0.143	0.842**	0.051	-0.255**	0.258**	0.111	0.101	-0.216*	0.118	-0.018	0.003	1.000									
X14	-0.304**	-0.254**	0.716**	0.054	-0.211*	0.210*	0.160	0.111	-0.274**	0.133	-0.068	-0.057	0.917**	1.000								
X15	0.387**	0.368**	-0.123	-0.028	0.229*	-0.277**	-0.192	-0.113	0.821**	0.239*	0.305**	0.465**	-0.154	-0.215*	1.000							
X16	-0.385**	-0.211*	-0.018	0.153	-0.273**	0.161	-0.140	-0.288**	-0.492**	-0.117	-0.011	-0.033	0.029	0.141	-0.374**	1.000						
X17	-0.386**	-0.270**	-0.021	0.158	-0.294**	0.173	0.275**	0.115	-0.468**	-0.267**	0.055	-0.171	0.067	0.176	-0.428**	0.684**	1.000					
X18	-0.287**	-0.247**	0.152	0.047	-0.170	0.149	0.121	0.417**	-0.480**	0.019	-0.133	0.052	0.216*	0.203*	-0.316**	-0.515**	0.245**	1.000				
X19	0.212*	0.207*	0.167	-0.271**	0.251**	0.060	-0.262	-0.031	0.245**	0.222*	-0.281**	-0.023	-0.031	-0.119	0.111	-0.514**	0.643**	-0.097	1.000			
X20	-0.063	-0.037	-0.035	0.129	-0.251**	0.153	0.059	0.188*	-0.251**	-0.051	-0.223*	-0.133	-0.084	-0.080	-0.226*	-0.514**	0.533**	0.232*	-0.352**	1.000		
X21	-0.067	-0.001	-0.008	-0.138	0.187*	-0.080	-0.014	-0.026	0.077	0.165	0.570**	0.878**	-0.005	-0.054	0.408**	-0.061	-0.188*	0.027	0.005	-0.195*	1.000	
X22	-0.074	-0.060	-0.006	0.113	-0.202*	0.148	-0.028	0.189*	-0.145	-0.108	-0.057	-0.011	0.031	0.074	0.013	0.451**	0.393**	0.300**	-0.403**	0.354**	-0.097	1.000
X23	0.117	0.164	0.091	-0.150	0.281**	-0.186*	-0.012	-0.159	0.271**	0.257**	0.001	-0.017	0.020	-0.066	0.087	-0.565**	-0.461**	-0.274**	0.536**	-0.470**	0.065	-0.864**

*Significant at 5% and **Significant at 1% level of significance

X1=Plant height (cm), X2=No. of Primary branches, X3=Days to first flowering, X4=Medium styled flowers (%), X5=Long styled flowers (%), X6=Short styled flowers (%), X7=Intra cluster distance (cm), X8=Inter cluster distance (cm), X9=Fruits per plant, X10=Length of fruit (cm), X11=Girth of fruit (cm), X12=Fruit weight (g), X13=Days to first harvest, X14=Days to last harvest, X15=Fruit yield per plant (g), X16=FSB Shoot damage (%), X17=FSB Fruit damage (%), X18=Calyx length (cm), X19=RLPS, X20=RLSA, X21=Weight of infested fruits, X22=Total sugars (mg/100g) and X23=Total phenols (mg/100g)

Table 2. Genotypic correlation for growth and yield characters in brinjal

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22
X1	1.000																					
X2	0.578**	1.000																				
X3	-0.133	-0.091	1.000																			
X4	0.091	-0.085	-0.062	1.000																		
X5	0.146	0.247**	-0.230*	-0.847**	1.000																	
X6	-0.392**	-0.242**	0.459**	-0.506**	-0.078	1.000																
X7	-0.186*	-0.209*	-0.091	0.076	-0.028	-0.084	1.000															
X8	0.032	-0.176	0.152	0.162	-0.301**	0.162	0.090	1.000														
X9	0.464**	0.515**	-0.150	-0.067	0.338**	-0.423**	-0.320**	-0.199*	1.000													
X10	0.254**	0.202*	0.167	-0.023	0.214*	-0.280**	-0.003	0.317**	0.211*	1.000												
X11	-0.184*	0.022	-0.125	-0.002	-0.015	-0.001	0.144	-0.249**	0.069	-0.308**	1.000											
X12	-0.105	-0.051	-0.034	-0.137	0.168	-0.043	0.066	0.004	0.074	0.155	0.660**	1.000										
X13	-0.230*	-0.160	0.875**	0.062	-0.306**	0.380**	0.120	0.108	-0.225*	0.120	-0.017	0.006	1.000									
X14	-0.307**	-0.274**	0.733**	0.064	-0.250**	0.286**	0.167	0.113	-0.285**	0.134	-0.068	-0.056	0.927**	1.000								
X15	0.392**	0.390**	-0.127	-0.021	0.265**	-0.384**	-0.193*	-0.119	0.849**	0.240**	0.306**	0.469**	-0.155	-0.216*	1.000							
X16	-0.401**	-0.220*	-0.017	0.155	-0.330**	0.260**	-0.141	-0.308**	-0.517**	-0.117	-0.011	-0.035	0.036	0.150	-0.378**	1.000						
X17	-0.396**	-0.273**	-0.021	0.175	-0.323**	0.215*	0.279**	0.119	-0.499**	-0.269**	0.055	-0.176	0.074	0.183*	-0.439**	0.707**	1.000					
X18	-0.292**	-0.248**	0.155	0.045	-0.201*	0.228*	0.118	0.436**	-0.494**	0.019	-0.136	0.053	0.221*	0.207*	-0.321**	-0.523**	0.254**	1.000				
X19	0.218*	0.221*	0.165	-0.321	0.325**	0.060	-0.275**	-0.033	0.251**	0.224*	-0.283**	-0.025	-0.027	-0.119	0.113	-0.530**	0.665**	-0.102	1.000			
X20	-0.068	-0.039	-0.042	0.164	-0.304**	0.183*	0.059	0.192*	-0.271**	-0.051	-0.232*	-0.138	-0.087	-0.085	-0.234*	-0.536**	0.556**	0.246**	-0.368**	1.000		
X21	-0.066	0.001	-0.004	-0.146	0.216*	-0.090	-0.014	-0.023	0.082	0.165	0.572**	0.883**	-0.008	-0.055	0.410**	-0.063	-0.194*	0.025	0.007	-0.200*	1.000	
X22	-0.074	-0.060	-0.005	0.123	-0.249**	0.226*	-0.021	0.200*	-0.155	-0.109	-0.057	-0.011	0.028	0.076	0.011	0.460**	0.408**	0.309**	-0.408**	0.375**	-0.100	1.000
X23	0.118	0.173	0.092	-0.168	0.334**	-0.252**	-0.014	-0.165	0.284**	0.258**	0.001	-0.017	0.022	-0.067	0.089	-0.577**	-0.473**	-0.277**	0.542**	-0.490**	0.066	-0.869**

*Significant at 5% and **Significant at 1% level of significance

X1=Plant height (cm), X2=No. of Primary branches, X3=Days to first flowering, X4=Medium styled flowers (%), X5=Long styled flowers (%), X6=Short styled flowers (%), X7=Intra cluster distance (cm), X8=Inter cluster distance (cm), X9=Fruits per plant, X10=Length of fruit (cm), X11=Girth of fruit (cm), X12=Fruit weight (g), X13=Days to first harvest, X14=Days to last harvest, X15=Fruit yield per plant (g), X16=FSB Shoot damage (%), X17=FSB Fruit damage (%), X18=Calyx length (cm), X19=RLPS, X20=RLSA, X21=Weight of infested fruits, X22=Total sugars (mg/100g) and X23=Total phenols (mg/100g)

Table 3. Direct and indirect effects (genotypic) of yield components in brinjal

Character	Plant height (cm)	No. of primary branches/ plant	Days to first flower	Medium styled flowers (%)	Long styled flowers (%)	No. of fruits/ plant	Length of fruit (cm)	Girth of fruit (cm)	Fruit weight (g)	Days to first harvest	Fruit yield per plant (g)
Plant height (cm)	**0.088**	0.051	-0.011	0.008	0.013	0.041	0.022	-0.016	-0.009	-0.020	0.392
No. of primary branches/plant	0.019	**0.033**	0.003	0.002	-0.008	0.117	-0.006	-0.000	0.0017	0.005	0.390
Days to first flower	0.008	0.006	**-0.066**	0.004	0.015	0.011	-0.011	0.008	0.002	-0.05	-0.127
Medium styled flowers (%)	0.001	-0.001	-0.001	**0.460**	-0.017	-0.001	-0.000	0.009	-0.002	0.001	-0.021
Long styled flowers (%)	-0.012	-0.016	0.015	0.057	**0.511**	-0.022	-0.014	0.001	-0.011	0.020	0.265
No. of fruits/ plant	0.386	0.428	-0.125	-0.056	0.281	**0.832**	0.175	0.057	0.062	-0.187	0.849
Length of fruit (cm)	-0.006	-0.005	-0.004	0.000	-0.005	-0.005	**-0.025**	0.007	-0.004	-0.003	0.240
Girth of fruit (cm)	0.010	-0.001	0.007	0.000	0.000	-0.004	0.018	**-0.059**	0.139	0.001	0.306
Fruit weight (g)	-0.049	-0.024	-0.016	-0.064	0.079	0.035	0.072	0.311	**0.469**	0.002	0.469
Days to first harvest	-0.018	-0.013	0.071	0.005	-0.025	-0.018	0.009	-0.001	0.000	**0.081**	-0.155

Diagonal indicates direct effect, Residual effect = 0.0313

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