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Research Article
ASSOCIATION ANALYSIS AND SELECTION INDICES IN EGGPLANT (*Solanum melongena* L.) GENOTYPES

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Abstract: An experiment was conducted with the objective to evaluate the genetic relationships and develop selection indices between yield and significant yield-related variables using 30 genotypes of eggplant. Twenty-five accessions of *S. melongena* and five wild relatives of eggplant were evaluated in a field experiment in Randomized Block design with three replications during 2019-20. The study revealed significant and positive correlation of fruit yield with traits such as plant height, number of primary branches, leaf blade length, number of long styled flowers, fruit pedicel length, fruit length, fruit diameter, fruit weight and number of seeds per fruit showed significant and positive correlation with fruit yield at both genotypic and phenotypic levels. Path coefficient analysis revealed that days to first flowering, plant height, number of long-styled flowers, fruit weight and number of seeds per fruit had high positive direct effect on yield. Selection index involving discriminant functions based on the relative economic importance of various characters showed a combination of four characters (Fruit yield per plant + Number of long- styled flowers + Fruit diameter + Fruit weight) with maximum relative efficiency.

Keywords: *Eggplant, Correlation, Path coefficient analysis, Selection index*

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Introduction

Brinjal, eggplant or aubergine (*Solanum melongena* L.) belonging to Solanaceae family is a widely cultivated species in America, Europe and Asia. Eggplant fruits are reasonably good source of calcium, phosphorus, iron and vitamins mainly group B. It is well-known to possess therapeutic qualities and to benefit diabetic people [1]. It is a high source of phenolic acids which affect the cooking quality and antioxidant content of fruit [2].Its production has increased significantly in recent years globally, and this is mostly owing to the creation and use of improved varieties and hybrids. This has caused local landraces to be replaced, which has resulted in a narrowing of the eggplant genetic base. In contrast, the innumerable wild relatives of eggplant remain untapped as a potential source of wide variation. South India, especially the Western Ghats which includes Kerala, is known to have wide variability for eggplant landraces and its wild types [3]. Even though lots of studies have been conducted in taxonomy and phylogeny of wild species of eggplant, the information regarding growth, reproduction and agronomic traits of importance in wild resources are lacking. It is in this context, the present study was undertaken to know the association of economically important quantitative traits in a collection of eggplant genotypes consisting of landraces and wild relatives from different geographical areas especially northern districts of Kerala. These association studies reveal the type, scope, and direction of selection.

Quantitative traits often display complex mutual relationships having enormous significance in plant improvement and evolutionary processes. These relationships are the result of genetic correlations, which can be caused by pleiotropy (a phenomenon of a single gene affecting multiple traits) or linkage disequilibrium a phenomenon resulting from the non-random association of alleles [4]. However, genetic correlations can complicate progress of selection especially when there is unfavorable combination of traits. Path coefficient provides a better index for selection than correlation coefficient by splitting the correlation coefficient of yield and its components into direct and indirect impacts. Additionally, the progress of plant breeding programmes is determined by the breeder's decision to select superior individuals or families for various desirable characters to augment economic worth of a plant. A selection index, which is a combination of traits to select based on their relative importance, serves as the foundation for this decision. The breeder needs sufficient knowledge of selection index analysis because it would be cumbersome to take into account all the yield-contributing features at once.

Fruit yield in eggplant is a complex character resulting from various genetic as well as environmental factors, which are interrelated at different growth stages of plants. Hence, the goals of this research were to ascertain how yield and yield-contributing traits interrelate and to choose eggplant genotypes based on the selection indices and their relative efficiencies in improving yield.

Materials and Methods

The experimental material consisted of 30 genotypes of brinjal comprising 25 local cultivars and five wild relatives collected from different localities of North Kerala as well as those indented from Regional Station NBPGR (National Bureau of Plant Genetic Resources), Thrissur [Table-1]. The investigation was carried out in Rabi season (November 2019-April 2020) at the Department of Plant Breeding and Genetics, College of Agriculture, Padannakkad, Kerala Agricultural University. The experiment was laid in the field located at Regional Agricultural Research Station, Pilicode, Kasaragod located at 12°19'N latitude and 75°16'E longitude at an altitude 12 m above mean sea level. It comes under Agro-Ecological Unit (AEU-11) the Northern laterites delineated to represent agro-ecological zone of midland laterites of Kerala. The climate is tropical humid monsoon type (mean annual temperature 27.3°C; rainfall 3217 mm). One-month-old seedlings of 30 eggplant accessions were transplanted in Randomized Block Design (RBD) with three replications at spacing of 75cm x 60 cm. The fertilizer application and all other intercultural practices were carried out as per the Package of Practices (KAU, 2016) [5]. Twenty-two quantitative traits were observed based on IBPGR (1990) [6] descriptors.

Table-1 Details of 30 eggplant accessions used for study

Accession number	Place of collection	Fruit colour at commercial ripening	Accession number	Place of collection	Fruit colour at commercial ripening
SM-1	Malappuram	Green	SM-16	Malappuram	Milky white
SM-2 (*S.macrocarpon*)	Kannur	Green	SM-17	Malappuram	Green
SM-3	Malappuram	Green	SM-18	Malappuram	Purple
SM-4	Malappuram	Purple	SM-19	Malappuram	Green
SM-5	Malappuram	Milky white	SM-20	Kozhikode	Purple
SM-6	Kozhikode	Purple	SM-21	Malappuram	Purple
SM-7	Kozhikode	Milky white	SM-22 (*S. mammosam*)	Kasaragod	Yellow
SM-8	Malappuram	Purple	SM-23	Kasaragod	Purple
SM-9	Kozhikode	Purple	SM-24	Kasaragod	Purple
SM-10	Kannur	Purple	SM-25	NBPGR	Green
SM-11	Kannur	Purple	SM-26	NBPGR	Purple
SM-12	Kannur	Green	SM-27	NBPGR	Green
SM-13	Malappuram	Green	SM-28 (*S.incanum*)	NBPGR	Green
SM-14	Wayanad	Purple	SM-29 (*S.gilo*)	NBPGR	Green
SM-15	Kozhikode	Purple	SM-30 (*S.insanum*)	NBPGR	Green

These included plant height (cm), plant breadth (cm), number of primary branches, leaf blade length (cm), leaf blade width (cm), petiole length (mm), days to first flowering, days to 50 per cent flowering, number of flowers per inflorescence, number of long-styled flowers per inflorescence, number of medium-styled flowers per inflorescence, relative style length (mm) , fruit length (cm), fruit diameter (cm), relative fruit calyx length (%), fruit pedicel length (mm), fruit weight (g), number of days from anthesis to fruit set, number of days from fruit set to maturity, number of fruits per plant, number of seeds per fruit and fruit yield per plant (g). KAU GRAPES packages [7] were used to perform correlation and path coefficient analysis. Selection indices were formulated using the technique developed by [8] based on the discriminant function [9]. The projected genetic gain for each individual character and each combination of characters was examined using a genotypic and phenotypic variance-covariance matrix with economic weight. Genetic advances were calculated using 10 % selection intensity. The genetic advance estimates were expressed as a percentage of the genetic gain determined by fruit yield per plant alone, which was previously considered to be 100%. These were utilized to assess the comparative efficacy of the various selection indices.

Results and discussion

Correlation Analysis

The association between 22 quantitative characters in all possible combinations was worked out and the result is displayed in [Table-2]. Maximum characters displayed greater genotypic correlation values than phenotypic correlations, indicating that genetic factors have a larger influence on character associations than environmental factors do. Similar observation was made by [10].

Of the twenty-one quantitative variables, the dependent variable fruit yield per plant showed significant and high positive genotypic and phenotypic correlation with eight variables *viz*., plant breadh (rg 0.502, rp 0.492),, leaf length(rg 0.371, rp 0.370),, number of long-styled flowers (rg 0.326, rp 0.297),, fruit length(rg 0.498, rp 0.495), fruit diameter(rg 0.665, rp 0.662), fruit pedicel length(rg 0.683, rp 0.679), fruit weight (rg 0.890, rp 0.883) and number of seeds per fruit (rg 0.532, rp 0.526). Thus, indicating that selection for the increased value of these traits can bring about a concomitant increase in fruit yield. Similar findings were reported for number of long-styled flowers by [11], fruit length) [12], fruit diameter and fruit weight [13]. Negative significant correlation was observed between fruit yield and three characters related to flowering and fruit set duration *viz*., days to first flowering, days to 50% flowering and number of days from anthesis to fruit set. These results are consistent with those of [14] for days to first flowering and for days to 50 % flowering. Early flowering and fruit set increase the span of fruiting period and the number of harvests consequently increasing fruit yield.

Among the fruit characters, fruit length, fruit diameter and fruit pedicel length had significant correlation with fruit weight and number of seeds per fruit. All these characters also had significant positive correlation with yield. [15] noted comparable findings. The association of characters manifest due to correlated response, a phenomenon in consequence of pleiotropy and linkage. Pleiotropy is primarily responsible for character association when two traits that demonstrate joint correlation also exhibit correlation with dependent variable such as yield. Furthermore, such a correlation is mostly attributable to linkage rather than pleiotropy when some of these jointly associated traits exhibit no correlation with yield. The significant association of fruit characters such as fruit size with fruit weight and with yield in the current study suggests pleiotropy. There was significant negative correlation between fruit weight and the number of fruits per plant but insignificant negative correlation between number of fruits and fruit yield. Such an association may be due to linkage. This implies a mutual trade-off between the traits such as number of fruits and fruit weight in determining yield improvement.

Path Coefficient Analysis

In order to clearly see the cause and effect relationship, the genotypic correlations were divided into direct and indirect effects using path coefficient analysis [Table-3]. In the present study, parameters like plant height, plant breadth, leaf blade length, number of long-styled flowers, fruit diameter, fruit weight, number of fruits per plant, and number of seeds per fruit all had shown positive direct effects on fruit yield. The highest positive direct effect on fruit yield per plant was exhibited by days to first flowering (1.919) followed by fruit weight (0.806). Among these fruit weight had positive significant genotypic correlation with yield, whereas days to first flowering had negative significant genotypic correlation with yield. The negative correlation with fruit yield may be due to the very high negative indirect effect of the character through characters such as days to 50% flowering, fruit weight and days from anthesis to fruit set. The traits, leaf length (0.414) and number of long-styled flowers (0.366) and plant breadth (0.252) exhibited high to moderate positive direct effect, along with significant genotypic correlation with yield revealing the true association of these characters with fruit yield. This supports the conclusions of [16] and [17] for fruit weight.

The very high negative direct effect of days to 50% flowering (-1.809) and high negative direct effect of days from anthesis to fruit set(-0.475) and their significant negative genotypic correlation with yield indicate true association of these characters which is in line with results of [18].

Fruit length had high negative direct effect (-0.301) but a significant positive genotypic correlation with yield. The positive genotypic correlation of this character may be due to its high indirect effect via fruit weight. Fruit diameter had positive but negligible direct effect (0.056) on fruit yield but a high indirect effect through fruit weight (0.571) followed by days to 50% flowering (0.537) resulting in its significant genotypic correlation with yield.

Number of fruits per plant had high direct effect (0.493) over yield but an insignificant genotypic correlation with yield. The very high positive indirect effect of number of fruits per plant via days to first flowering and very high negative indirect effect via days to 50% flowering had a mutual cancellation effect resulting in insignificant correlation of this trait with yield. Number of seeds per fruit had negligible direct effect (0.084) on fruit yield. However, it showed a high positive indirect effect via days to 50% flowering (0.957) and fruit weight (0.366) resulting in significant genotypic correlation with yield.

Table-2 Genotypic and phenotypic correlation of 22 quantitative characters of eggplant

		A	B	C	D	E	F	G	H	I	J	K
A	Rg	1										
	Rp	1										
B	Rg	0.424**	1									
	Rp	0.424**	1									
C	Rg	-0.142	0.489**	1								
	Rp	-0.136	0.480**	1								
D	Rg	0.510**	0.343**	0.039	1							
	Rp	0.506**	0.336**	0.038	1							
E	Rg	0.600**	0.022	-0.304**	0.644**	1						
	Rp	0.595**	0.021	-0.302**	0.644**	1						
F	Rg	0.505**	0.165	-0.022	0.508**	0.708**	1					
	Rp	0.502**	0.162	-0.02	0.507**	0.706**	1					
G	Rg	0.029	-0.154	0.148	-0.458**	-0.051	0	1				
	Rp	0.03	-0.148	0.142	-0.452**	-0.05	0	1				
H	Rg	0.107	-0.161	0.116	-0.404**	-0.029	0	0.975**	1			
	Rp	0.107	-0.161	0.116	-0.402**	-0.029	0	0.957**	1			
I	Rg	0.251*	-0.016	0.257*	-0.051	0.154	0.023	0.447**	0.476**	1		
	Rp	0.247*	-0.016	0.246*	-0.05	0.151	0.023	0.436**	0.466**	1		
J	Rg	0.032	0.065	0.299**	0.319**	0.062	-0.016	-0.304**	-0.228*	0.490**	1	
	Rp	0.038	0.061	0.274**	0.292**	0.057	-0.017	-0.277**	-0.204	0.459**	1	
K	Rg	0.266*	-0.121	0.12	-0.178	0.081	0.09	0.445**	0.487**	0.897**	0.280**	1
	Rp	0.251*	-0.115	0.115	-0.168	0.075	0.09	0.421**	0.456**	0.851**	0.272**	1
L	Rg	0.153	0.215*	0.233*	0.263*	-0.168	-0.192	-0.392**	-0.279**	-0.042	0.481**	-0.169
	Rp	0.143	0.204	0.217*	0.253*	-0.161	-0.187	-0.369**	-0.271**	-0.052	0.423**	-0.166
M	Rg	0.238*	0.279**	-0.122	0.540**	0.127	0.11	-0.532**	-0.535**	-0.218*	0.274**	-0.176
	Rp	0.236*	0.273**	-0.121	0.540**	0.127	0.11	-0.525**	-0.532**	-0.215*	0.253*	-0.169
N	Rg	0.166	0.366**	-0.034	0.301**	0.175	0.032	-0.312**	-0.297**	-0.15	0.091	-0.13
	Rp	0.165	0.359**	-0.033	0.301**	0.175	0.032	-0.309**	-0.295**	-0.149	0.082	-0.127
O	Rg	0.016	-0.139	-0.246*	0.058	0.213*	0.101	-0.139	-0.086	-0.192	-0.053	-0.189
	Rp	0.013	-0.14	-0.237*	0.057	0.211*	0.099	-0.136	-0.089	-0.181	-0.063	-0.188
P	Rg	0.354**	0.438**	-0.02	0.599**	0.278**	0.230*	-0.539**	-0.537**	0.03	0.464**	-0.075
	Rp	0.349**	0.426**	-0.025	0.597**	0.276**	0.229*	-0.536**	-0.531**	0.03	0.420**	-0.074
Q	Rg	0.177	0.530**	0.089	0.432**	-0.005	-0.065	-0.527**	-0.529**	-0.135	0.254*	-0.19
	Rp	0.174	0.516**	0.086	0.430**	-0.004	-0.065	-0.521**	-0.523**	-0.132	0.237*	-0.18
R	Rg	0.400**	-0.031	0.059	-0.167	0.247*	0.265*	0.824**	0.791**	0.471**	-0.310**	0.451**
	Rp	0.377**	-0.033	0.052	-0.163	0.242*	0.259*	0.799**	0.766**	0.451**	-0.298**	0.425**
S	Rg	-0.343**	-0.13	0.311**	-0.296**	-0.186	-0.287**	0.631**	0.571**	0.196	-0.204	0.081
	Rp	-0.331**	-0.117	0.302**	-0.290**	-0.181	-0.281**	0.609**	0.557**	0.189	-0.187	0.073
T	Rg	0.458**	0.027	-0.065	-0.122	0.277**	0.286**	0.559**	0.557**	0.599**	0.682**	0.011
	Rp	0.446**	0.025	-0.065	-0.119	0.274**	0.283**	0.545**	0.546**	0.582**	0.634**	0.003
U	Rg	0.223*	0.502**	0.037	0.371**	0.054	-0.003	-0.430**	-0.443**	0.02	0.326**	-0.057
	Rp	0.222*	0.492**	0.036	0.370**	0.054	-0.005	-0.422**	-0.438**	0.022	0.297**	-0.054
V	Rg	-0.101	0.056	-0.04	0.093	-0.089	-0.347**	-0.457**	-0.529**	0	0.284**	-0.141
	Rp	-0.1	0.055	-0.041	0.092	-0.088	-0.345**	-0.448**	-0.519**	0.002	0.259*	-0.137
		L	M	N	O	P	Q	R	S	T	U	V
L	Rg	1										
	Rp	1										
M	Rg	0.241*	1									
	Rp	0.234*	1									
N	Rg	0.167	0.226*	1								
	Rp	0.162	0.226*	1								
O	Rg	0.211*	-0.242*	0.202	1							
	Rp	0.199	-0.238*	0.199	1							
P	Rg	0.387**	0.533**	0.584**	0.127	1						
	Rp	0.373**	0.530**	0.582**	0.125	1						
Q	Rg	0.339**	0.551**	0.708**	0.021	0.668**	1					
	Rp	0.323**	0.549**	0.705**	0.021	0.664**	1					
R	Rg	-0.302**	-0.409**	-0.308**	-0.052	-0.374**	-0.360**	1				
	Rp	-0.290**	-0.399**	-0.300**	-0.045	-0.361**	-0.345**	1				
S	Rg	-0.153	-0.356**	0.083	-0.025	-0.379**	-0.06	0.372**	1			
	Rp	-0.149	-0.348**	0.079	-0.02	-0.367**	-0.059	0.354**	1			
T	Rg	-0.441**	-0.161	-0.125	-0.246*	-0.078	-0.246*	0.618**	-0.001	1		
	Rp	-0.418**	-0.16	-0.124	-0.239*	-0.076	-0.245*	0.596**	0.006	1		
U	Rg	0.143	0.498**	0.665**	-0.131	0.683**	0.890**	-0.289**	-0.099	0.072	1	
	Rp	0.134	0.495**	0.662**	-0.126	0.679**	0.883**	-0.284**	-0.092	0.07	1	
V	Rg	0.079	0.225*	0.354**	-0.151	0.491**	0.454**	-0.355**	-0.217*	-0.083	0.532**	1
	Rp	0.084	0.223*	0.350**	-0.148	0.484**	0.447**	-0.349**	-0.205	-0.077	0.526**	1

*** Significance at 1% level, * significant at 5% level, Rg-Genotypic correlation Rp-phenotypic correlation*

A = Plant height (cm), B = Plant breadth (cm), C = Number of primary branches, D = Leaf blade length (cm), E = Leaf blade width (cm), F = Petiole length (mm), G = Days to first flowering, H = Days to 50 per cent flowering, I = Number of flowers per inflorescence, J = Number of long-styled flowers/ inflorescence, K = Number of medium styled flowers/ inflorescence, L = Relative style length (mm), M = Fruit length (cm), N = Fruit diameter (cm), O = Relative fruit calyx length (%), P = Fruit pedicel length (mm), Q = Fruit weight (g), R = Number of days from anthesis to fruit set, S = Number of days from fruit set to maturity, T = Number of fruits plant, U = Fruit yield/ plant (g), V = Number of seeds/ fruit.

Table-3 Genotypic path coefficient analysis using 22 quantitative characters of eggplant

	PH	PB	NPB	LL	LW	PL	DFF	D50%F	NF/I	NLS	NMS	RSL	FL	FD	RCL	FPL	FW	NAF	NFM	NF/P	NS/P
PH	**0.161**	0.068	-0.023	0.082	0.096	0.081	0.005	0.017	0.04	0.005	0.043	0.025	0.038	0.027	0.003	0.057	0.028	0.064	-0.055	0.073	-0.016
PB	0.107	**0.252**	0.123	0.086	0.006	0.042	-0.039	-0.041	-0.004	0.016	-0.03	0.054	0.07	0.092	-0.035	0.11	0.133	-0.008	-0.033	0.007	0.014
NPB	0.075	-0.259	**-0.531**	-0.021	0.162	0.012	-0.079	-0.062	-0.137	-0.159	-0.064	-0.123	0.065	0.018	0.131	0.011	-0.047	-0.031	-0.165	0.034	0.021
LL	0.211	0.142	0.016	**0.414**	0.267	0.21	-0.19	-0.167	-0.021	0.132	-0.074	0.109	0.224	0.125	0.024	0.248	0.179	-0.069	-0.123	-0.05	0.039
LW	-0.252	-0.009	0.128	-0.271	**-0.42**	-0.298	0.021	0.012	-0.065	-0.026	-0.034	0.071	-0.054	-0.074	-0.09	-0.117	0.002	-0.104	0.078	-0.116	0.037
PL	0.112	0.037	-0.005	0.113	0.157	**0.222**	0	0	0.005	-0.004	0.02	-0.043	0.024	0.007	0.023	0.051	-0.014	0.059	-0.064	0.063	-0.077
DFF	0.056	-0.296	0.284	-0.879	-0.097	0	**1.919**	1.871	0.858	-0.583	0.854	-0.753	-1.02	-0.599	-0.266	-1.035	-1.012	1.582	1.211	1.073	-0.878
D50%F	-0.194	0.292	-0.211	0.73	0.053	0	-1.763	**-1.809**	-0.86	0.412	-0.881	0.504	0.967	0.537	0.156	0.971	0.957	-1.431	-1.033	-1.008	0.957
NF/I	-0.007	0.0004	-0.007	0.001	-0.004	0	-0.012	-0.013	**-0.026**	-0.013	-0.024	0.001	0.006	0.004	0.005	-0.001	0.004	-0.012	-0.005	-0.016	0
NLS	0.012	0.024	0.11	0.117	0.023	-0.006	-0.111	-0.084	0.18	**0.366**	0.103	0.176	0.1	0.033	-0.02	0.17	0.093	-0.114	-0.075	0.004	0.104
NMS	0.002	-0.001	0.001	-0.001	0.001	0.001	0.003	0.003	0.005	0.002	**0.006**	-0.001	-0.001	-0.001	-0.001	0	-0.001	0.003	0.001	0.004	-0.001
RSL	0.024	0.033	0.036	0.041	-0.026	-0.03	-0.061	-0.043	-0.007	0.074	-0.026	**0.155**	0.037	0.026	0.033	0.06	0.052	-0.047	-0.024	-0.068	0.012
FL	-0.072	-0.084	0.037	-0.163	-0.038	-0.033	0.16	0.161	0.066	-0.082	0.053	-0.073	**-0.301**	-0.068	0.073	-0.161	-0.166	0.123	0.107	0.049	-0.068
FD	0.009	0.02	-0.002	0.017	0.01	0.002	-0.017	-0.017	-0.008	0.005	-0.007	0.009	0.013	**0.056**	0.011	0.033	0.04	-0.017	0.005	-0.007	0.02
RCL	-0.001	0.005	0.008	-0.002	-0.007	-0.003	0.005	0.003	0.007	0.002	0.006	-0.007	0.008	-0.007	**-0.034**	-0.004	-0.001	0.002	0.001	0.008	0.005
FPL	-0.128	-0.158	0.007	-0.216	-0.1	-0.083	0.194	0.194	-0.011	-0.167	0.027	-0.14	-0.192	-0.211	-0.046	**-0.36**	-0.241	0.135	0.137	0.028	-0.177
FW	0.143	0.428	0.072	0.349	-0.004	-0.052	-0.425	-0.427	-0.109	0.205	-0.154	0.273	0.444	0.571	0.017	0.539	**0.806**	-0.291	-0.048	-0.198	0.366
NAF	-0.19	0.015	-0.028	0.08	-0.118	-0.126	-0.392	-0.376	-0.224	0.147	-0.214	0.144	0.194	0.147	0.025	0.178	0.171	**-0.475**	-0.177	-0.294	0.169
NFM	-0.062	-0.024	0.056	-0.054	-0.034	-0.052	0.114	0.103	0.036	-0.037	0.015	-0.028	-0.064	0.015	-0.005	-0.069	-0.011	0.067	**0.181**	0	-0.039
NF/P	0.226	0.013	-0.032	-0.06	0.137	0.141	0.276	0.275	0.295	0.006	0.336	-0.218	-0.08	-0.062	-0.121	-0.039	-0.121	0.305	-0.001	**0.493**	-0.041
NS/P	-0.009	0.005	-0.003	0.008	-0.008	-0.029	-0.038	-0.045	0	0.024	-0.012	0.007	0.019	0.03	-0.013	0.041	0.038	-0.03	-0.018	-0.007	**0.084**
R(G)	**0.223**	**0.502**	**0.037**	**0.371**	**0.054**	**-0.003**	**-0.43**	**-0.443**	**0.02**	**0.326**	**-0.057**	**0.143**	**0.497**	**0.665**	**-0.131**	**0.683**	**0.89**	**-0.289**	**-0.099**	**0.072**	**0.532**

PH = Plant height (cm), PB = Plant breadth (cm), NPB= Number of primary branches, LL = Leaf blade length (cm), LW = Leaf blade width (cm), PL = Petiole length (mm), DFF = Days to first flowering, D50%F = Days to 50 per cent flowering, NF/I = Number of flowers per inflorescence, NLS= Number of long-styled flowers/ inflorescence, NMS = Number of medium styled flowers/ inflorescence, RSL = Relative style length (mm), FL = Fruit length (cm), FD = Fruit diameter (cm), RCL = Relative fruit calyx length (%), FPL = Fruit pedicel length (mm), FW = Fruit weight (g), NAF = Number of days from anthesis to fruit set, NFM= Number of days from fruit set to maturity, NF/P= Number of fruit/ plant, NS/P = Number of seeds/ fruit, R(G)= Genotypic correlation with yield per plant , R(G)= Genotypic correlation, Digital values = Direct effects

Table-4 Construction of selection indices in 30 eggplant genotypes

Selection index	Expected genetic gain	Relative efficiency over direct selection (%)
I1 = 0.837 X1	706.959	84.158
I2= 74.332 X2	723.58	86.14
I3 = 113.601 X3	406.949	48.444
I4 = 8.51 X4	607.936	72.37
I5 = 0.53 X5	354.36	42.184
I12 = 0.895 X1 + (-163.804 X2)	723.066	86.076
I13 = 0.955 X1 + (-40.425) X3	714.801	85.092
I14 = 1.079 X1 + (-3.136) X4	712.855	84.86
I15 = 0.865 X1 + (-0.064) X5	707.862	84.266
I23 = 39.224 X2 + 112.699 X3	408.723	48.655
I24 = (-83.225) X2 + 8.787 X4	612.991	72.972
I25 = (-24.667) X2 + 0.539 X5	355.115	42.274
I34 = (-21.539) X3 + 9.297 X4	610.227	72.643
I35 = 89.509 X3 + 0.356 X5	463.556	55.183
I45 = 7.906 X4 + 0.14 X5	613.556	73.039
I123 = 1.057 X1 +(-190.595) X2 + (-52.644) X3	735.601	87.568
I124 = 1.18 X1 + (-174.31) X2 + (-3.643) X4	730.772	86.993
I125 = 0.907 X1 + (161.51) X2 + (-0.03) X5	723.262	86.099
I134 = 1.095 X1 + (-32.112) X3 + (-2.131) X4	717.172	85.374
I135 = 0.984 X1 + (-40.664) X3 + (0.067) X5	715.781	85.208
I145 = 1.126 X1 + (-3.291) X4 + (-0.081) X5	714.281	85.03
I234 = (-92.943) X2 + (-26.574) X3 + 9.791 X4	616.378	73.375
I235 = (-20.37) X2 + 89.431 X3 + 0.364 X5	463.95	55.23
I245 = (-102.26) X2 + 8.12 X4 + 0.169 X5	620.862	73.909
I345 = (-23.005) X3 + 8.729 X4 + 0.144 X5	616.14	73.347
I1234 = 1.212 X1 + (-192.757) X2 + (-43.684) X3 + (-2.33) X4	738.351	87.895
I1235 = 1.069 X1 + (-188.402) X2 + (-52.602) X3 + (-0.029) X5	735.773	87.588
I1245 = 1.206 X1 + (-170.926) X2 + (-3.725) X4 + (-0.048) X5	731.248	87.05
I1345 = 1.14 X1 + (-31.751) X3 + (-2.293) X4 + (0.078) X5	718.492	85.531
I2345 = (-114.015) X2 + (29.524) X3 + 9.201 X4 + 0.177 X5	624.967	74.398
I12345 = 1.233 X1 + (-189.75) X2 + (-43.318) X3 + (-2.41) X4 + (-0.04) X5	738.685	87.935

Hence, in cases where the correlation appears to be caused by indirect effects, it is necessary to take indirect causal factors into account when making a decision.

The residual effect determines how well the causal effects elucidate the variability of the dependent variable, in this case, the fruit yield per plant. In the present investigation, a very low value of residual effect (0.047) was observed, indicating the sufficiency of the characters included in this study.

The results of association analysis thus reveal the importance of vegetative characters such as plant spread and leaf width, floral traits such as days to 50% flowering and number of long-styled flowers and component fruit trait *viz*., fruit weight on the basis of their true relationship with yield.

Selection Index

Identification and selection of parents with desirable character combinations for the improvement of yield in segregating generations/hybrids contributes significantly to crop enhancement and hybridization programs. Selection of plants using an index that gives each character the appropriate weight is more efficient than selection using a single trait or a number of traits independently. In the present study, selection indices were developed using the fruit yield/plant(X_1) as an independent variable index and five yield components *viz*., fruit yield per plant (X_1), number of long-styled flowers per inflorescence (X_2), fruit diameter(X_3), fruit weight (X_4) and number of seeds per fruit (X_5) based on significant positive correlation with yield and positive direct effect on fruit yield per plant at the genotypic level. This is in line with work of [19] in the construction of a selection index for mustard genotypes and [20] for chilli genotypes. The expected genetic gain and relative efficiency were calculated separately for each character as well as character combinations [Table-4].

Selection indices for individual characters revealed comparatively high genetic gain for the number of long-styled flowers (723.58) and yield per plant (706.96).

Table-5 Index score of 30 eggplant genotypes based on best index along with mean value

Genotype	Index score	No. of long-styled flowers/inflorescence	Fruit diameter [cm]	Fruit weight [g]	Fruit yield/ plant [g]
SM-1	354.962	3.70	3.98	71.67	765.33
SM-2	-6.725	1.07	5.48	67.89	458.67
SM-3	195.479	1.47	4.46	37.67	565.33
SM-4	294.304	1.67	3.41	100.00	770.67
SM-5	326.786	1.07	5.58	84.44	770.33
SM-6	503.507	1.00	6.47	95.00	902.00
SM-7	238.414	0.87	2.99	69.67	668.22
SM-8	699.007	1.33	4.42	88.33	1019.33
SM-9	192.406	0.93	4.02	62.00	592.33
SM-10	1015.40	1.00	4.99	73.33	1285.67
SM-11	604.408	0.87	4.42	88.67	983.00
SM-12	-24.028	1.47	3.02	29.04	292.67
SM-13	82.6533	2.07	2.71	62.33	442.44
SM-14	387.469	1.07	8.01	79.00	905.33
SM-15	511.56	2.47	5.34	102.30	1144.00
SM-16	297.331	1.07	3.12	56.26	576.67
SM-17	435.921	1.87	3.45	72.22	867.00
SM-18	697.645	2.67	3.90	97.48	1185.56
SM-19	405.834	3.00	6.90	68.67	996.78
SM-20	1024.70	0.93	3.42	92.67	1275.67
SM-21	385.547	2.83	2.78	62.00	799.55
SM-22	449.188	3.67	3.13	20.22	519.45
SM-23	995.431	1.13	4.82	108.00	1434.11
SM-24	768.795	1.07	5.46	99.67	1233.67
SM-25	812.194	1.67	4.40	96.33	1041.00
SM-26	208.158	1.87	4.59	67.33	614.11
SM-27	1422.03	1.93	10.5	192.70	2146.44
SM-28	638.404	2.70	3.66	56.85	1072.89
SM-29	-110.79	3.00	2.68	11.43	199.22
SM-30	-180.18	1.07	2.01	4.61	63.33

Similarly, a higher relative efficiency over direct selection for fruit yield in eggplant was reported by [21] for individual characters like weight per fruit, number of fruits in solitary cluster and number of fruits in inflorescence per plant. Minimum genetic gain (354.36) and relative efficiency (42.18%) was shown by the number of seeds per fruit. The inclusion of this character with other characters' combinations lowered the relative efficiency. In the selection index based on two characters, the maximum relative efficiency was observed in the combination of fruit yield per plant and number of long-styled flowers (86.08%) followed by the combination of fruit yield per plant and fruit diameter (85.09%). Minimum relative efficiency (42.27%) was recorded in character combination of long-styled flowers and number of seeds per fruit. In combinations including three characters, relative efficiency was recorded as maximum (87.57%) in the combination of fruit yield per plant, number of long-styled flowers and fruit diameter. Minimum relative efficiency was recorded in combination of number of long-styled flowers, fruit diameter and number of seeds per fruit (55.23%). The five- trait combination of fruit yield per plant, number of long-styled flowers, fruit diameter, fruit weight and number of seeds per fruit showed maximum expected genetic gain (738.69) and relative efficiency (87.94%) which was followed by the four-trait combination of fruit yield per plant, number of long-styled flowers, fruit diameter and number of seeds per fruit (735.77 and 87.59% respectively. The selection index constructed for the combination of five characters recorded maximum genetic gain (738.69) and relative efficiency (87.94%).

In the present study the index value for three (I123; 87.568%), four (I1234; 87.895%) and five (I12345; 87.935%) have shown more relative efficiency over direct selection. For breeding purpose constructing selection index using a combination of at least three characters is generally preferred as this makes selection more effective. The inclusion of trait, number of seeds per fruit in two traits, three traits, four traits' combinations and considered individually reduce the selection efficiency. Hence in this study, the most efficient and effective index was the four-trait combination (fruit yield per plant + number of long-styled flowers/inflorescence + fruit diameter + fruit weight). Using this selection index (I1234), scoring was carried out for the 30 eggplant accessions and the results are presented in [Table-5].

By considering the high index score, the genotypes SM-27 (1422.03), SM-20 (1024.7), SM-10 (1015.4), SM-23 (995.43), SM-25 (812.19), SM-24 (768.8), SM-8 (699) and SM-18 (697.65) are identified as superior among the cultivated (*S. melongena*) accessions. SM-27 with highest index score can be a parent in intra-specific hybridization. Among the wild relatives, SM-28 (*S. incanum*) had the highest index score while the rest had negative index score. Eggplant relatives are valuable source for resistance and tolerance to major diseases and pests [22, 23]. [24] report that *Solanum incanum* exhibits resistance to shoot and fruit borer. It is considered as a key pest causing drastic crop loss up to 85-90% [25]. The wild eggplant accessions SM-28 (*S. incanum*) and SM-30 (*S. insanum*) are identified as potential parents for developing introgression lines (ILs) an important step towards broadening of eggplant genetic base. The wild species *S. insanum* and *S. incanum* are classified under primary gene pool (GP1) based on its cross ability with cultivated *S. melongena* species as reported by [26] who could obtain large amount of seeds per fruit when *S. melongena* is used as a female parent in interspecific hybridization.

Conclusion

The present investigation revealed the importance of plant breadth, leaf width, number of long styled flowers, fruit diameter, fruit weight and number of seeds per fruit in eggplant based on association analysis. Further, it was observed that the most efficient and effective index was the four trait combination (fruit yield per plant + number of long-styled flowers/inflorescence + fruit diameter + fruit weight). Based on a high selection index score involving four-character combination two green fruited accessions SM 27, SM 25 and six purple fruited accessions SM-8, SM-10, SM-18, SM-20, SM-23 and SM 24 are identified as potential parents for future breeding programmes. The current study also showed that the discriminant function method of selection in plants appears to be more beneficial than simply selecting for seed yield alone. As a result, proper weight should be given to the significant selection indices when selecting for yield advancement in eggplant

Application of research: The most efficient and effective index was the four- trait combination (fruit yield per plant + number of long-styled flowers/inflorescence + fruit diameter + fruit weight). Based on high selection index score involving four-character combination two green fruited accessions SM 27, SM 25 and six purple fruited accessions SM-8, SM-10, SM-18, SM-20, SM-23 and SM 24 are identified as potential parents for future breeding programmes.

Research category: Genetics and Plant breeding

Abbreviations: Rg-Genotypic correlation, Rp-Phenotypic correlation

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Study area / Sample Collection: College of Agriculture, Padannakkad and Regional Agricultural Research Station, Pilicode, Kasargod, Kerala

Cultivar / Variety / Breed name: Eggplant/brinjal (*Solanum melongena* L.)

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References

[1] Shukla V. and Naik L.B. (1993) *Agro-techniques of solanaceous vegetables. In, Chadha, K.L. and Kalloo, G. (eds.), Advances in Horticulture, Vegetable Crops, Malhotra Pub. House, New Delhi*, 365-399.
[2] Stommel J.R., Whitaker B.D., Haynes K.G. and Prohens J. (2015) *Euphytica*, 205(3), 823-836.
[3] Sebastian S. (2000) *Collection and characterization of landraces of Brinjal (Solanum Melongena L.) in Kerala. M.Sc. (Hortic.) thesis, Kerala Agricultural University, Thrissur*, 166p.
[4] Lynch M. and Walsh B. (1998) *Genetics and analysis of quantitative traits. Sunderland, MA, Sinauer Associates,Inc*., 535-556
[5] KAU [Kerala Agricultural University] (2016) *Package of practices Recommendations, crops (14th Ed.). Kerala Agricultural University, Thrissur,* 360.
[6] IBPGR (1990) *Descriptors for eggplant. International Board for Plant Resources, Rome*, 1-23.
[7] Gopinath P.P., Parsad R., Joseph B. and Adarsh V.S. (2020) *GRAPES, General Rshiny Based Analysis Platform Empowered by Statistics. https, //www. kaugrapes.com/home. version* 1.0.0.
[8] Smith H.F. (1936) *Ann. of Eugenics*, 7, 240-250.
[9] Fisher R.A. (1936) *Annals of Eugenics*, 7, 179-188.
[10] Patel V.K., Singh U., Goswami A., Tiwari S.K. and Singh M. (2017) *Environ. Ecol*., 35(2A), 877-880.
[11] Anbarasi D. and Haripriya K. (2021) *Plant Cell Biotechnol. Mol. Biol*., 22(69-70), 53-59.
[12] Rameshkumar D., Swarna Priya R., Savitha B.K., Ravikesavan R. and Muthukrishnan N. (2021) *Electr. J. Plant Breed*, 12(1), 249-252.
[13] Sujin G.S., Karuppaiah P. and Saravanan K. (2017) *Indian J. Agric. Res*., 51 (2), 112-119.
[14] Anbarasi D. and Haripriya K. (2021) *Plant Cell Biotechnol. Mol. Biol*., 22(69-70), 53-59.
[15] Chauhan A., Chandel K.S. and Singh S.P. (2017) *Vegetos*, 30, 4,1-4.
[16] Anbarasi D. and Haripriya K. (2021) *Plant Cell Biotechnol. Mol. Biol*., 22(69-70), 53-59.,
[17] Konyak W.L., Kanaujia S.P., Jha A., Chaturvedi H.P. and Ananda A. (2020) *SAARC J.Agric*., 25, 345-352.
[18] Konyak W.L., Kanaujia S.P., Jha A., Chaturvedi H.P. and Ananda A. (2020) *SAARC J.Agric*., 25, 345-352.
[19] Rathod V.B., Mehta D.R., Solanki H.V. and Raval L.J. (2013) *Electr. J. Plant Bree*d, 4(4), 1344-1347.
[20] Hasan R., Akand M., Alam N., BasharA. And Huque A.K.M. M. (2016) *Mol. Plant Breed*.,7(19), 1-9
[21] Bashar A., Hasan R., Alam N., Hossain K., Hongan,N. V, and Huque, A. K. M. M. (2015*) Plant Gene and Trait*, 6(7), 1-18.
[22] Daunay M.C. and Hazra P. (2012) *In Handbook of Vegetables, eds K.V.Peter and P. Hazra ,Houston,TX, Studium Press*,257-322.
[23] Rotino G.L., Sala T. and Toppino L. (2014) *In Alien Gene Transfer in Crop Plants, Vol. 2, eds A. Pratap and J. Kumar, New York, NY, Springer*, 381–409.
[24] Anushma P.L., Rajasekharan P.E. and Singh T.H. (2018) *J. Plt. Development Sci*., 10(12), 645-657.
[25] Prasad B., Jat B. L., Sharma, P., Kumar V., Kumar V. and Singh B. (2017) *J. Entomol. Zool. Stud*., 5(4), 826-828.
[26] Plazas M., Andújar I., Vilanova S., Gramazio P.and Herraiz F.J. (2014) *Front. Plant Sci*., 5, 318.