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Character association and path coefficient studies for yield and yield related quantitative traits in cucumber

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Abstract
Ten genotypes of cucumber were evaluated under naturally ventilated polyhouse during the rabi and summer season to study the interrelationship and path coefficient analysis for fruit yield and yield attributing traits. Twelve quantitative traits such as days taken to anthesis of first female flower, nodal position of first female flower, days to first harvest, main vine length, number of primary branches per plant, number of nodes on main shoot, internodal length, average fruit weight, fruit length, fruit diameter, number of fruits per plant and fruit yield were studied. The data obtained were subjected to statistical analysis. During both the seasons, number of fruits per plant showed significant positive correlation while days to first picking showed significant negative correlation with fruit yield. Number of fruits per plant recorded highest positive direct effect on fruit yield during both the seasons while the character viz., node number to first female flower recorded highest negative direct effect on fruit yield.

Keywords: Correlation, cucumber, direct effect, indirect effect, path coefficient

1. Introduction
Cucumber (*Cucumis sativus* L.) belonging to the gourd family cucurbitaceae is an important and highly demandable vegetable crop grown worldwide. It is grown for its tender fruits, which are consumed either raw as salad, cooked as vegetable or as pickling cucumber in its immature stage. It is a rich source of vitamin B and C, carbohydrates, calcium and phosphorus (Yawalkar, 1985) [1]. It is being used both in fresh as well as processed form. Yield is a complex quantitative trait which is considerably affected by environment, therefore, selection of genotypes based on yield *per se* is not very effective. Correlation among the various quantitative traits and with yield is equally important for the selection of genotypes for yield improvement. A significant positive correlation between two characters indicates that these characters can be improved simultaneously in a selection programme and the selection of one trait will bring about improvement in the other trait. Although correlation studies help in determining the various components that contribute to yield but it does not give a clear picture of the nature and extent of contributions made by the independent traits. Path coefficient analysis helps in partitioning the correlation into components due to direct and indirect effects. Selection based only on correlation is not helpful as it measures only the degree of mutual association between two characters, so, path coefficient analysis is necessary to estimate the direct and indirect effect of various other characters on fruit yield and also permits critical examination of specific factors that provide a given correlation. Therefore, the present investigation was undertaken to assess the nature and magnitude of association among yield and its contributing characters for selecting high yielding genotypes of cucumber.

2. Materials and Methods
The experiment was conducted at Precision Farming Development Centre of the College of Technology, G. B. Pant University of Agriculture and Technology, Pantnagar during rabi season of 2012-13 and summer season of 2013. Ten genotypes i.e. five parthenocarpic varieties namely Hilton, Kian, Isatis, PPC-2 and PPC-3 and five monoecious F_1 hybrids namely Malini, Kamini, Sheetal, Alamgir CT-180 and NS-404, collected from different sources were tested in a randomized block design with four replications for their performance in a naturally ventilated polyhouse. Seed sowing was done on 1st November 2012 and 1st February 2013 with a spacing of 60 cm × 60 cm having five plants of each genotype. The data recorded on the characters viz., days taken to anthesis of first female flower, nodal position of first female flower, days to first harvest, main vine length, number of primary branches per plant, number of nodes on main shoot, internodal length, average fruit weight, fruit length,

fruit diameter, number of fruits per plant and fruit yield were subjected to statistical analysis. Correlation coefficient was estimated as per the formulae suggested by Searle (1961) [2] and path coefficient analysis was done according to the formulae given by Dewey and Lu (1959) [3].

3. Results and Discussion

The correlation coefficients among the different quantitative characters were worked out during both the seasons (Table 1). It revealed that fruit yield had positive correlation with number of fruits per plant (0.334*) during the rabi season, significant positive correlation with number of fruits per plant (0.692**) and number of nodes on main vine (0.659**) during the summer season. While, it had significant negative correlation with fruit diameter (-0.662**), negative correlation with days to first picking (-0.402*) and days to appearance of first female flower (-0.336*) during the rabi season and significant negative correlation with node number to first female flower (-0.612**), days to first picking (-0.417**) and negative correlation with days to appearance of first female flower (-0.354*) during the summer season. Similarly, Islam *et al*. (1993) [4], Ullah *et al*. (2012) [5], Nwofia *et al*. (2015) [6] and Ramirez *et al*. (1988) [7] also reported significant positive correlation between number of fruits per plant and fruit yield.

Number of fruits per plant was found to be positively correlated with node number to first female flower (0.330*) during the rabi season, highly significant and positively correlated with number of nodes on main vine (0.420**) during the summer season. While it was highly significant and negatively correlated with average fruit weight (-0.406**, -0.502**) during both the seasons and with days to first picking (-0.516**), node number to first female flower (-0.509**) during the summer season. Average fruit weight was found to be highly significant and positively correlated with fruit length (0.548**), days to first picking (0.460**) and fruit diameter (0.438**) and positively correlated with days to appearance of first female flower (0.376*) and node number to first female flower (0.360*) during the summer season; and positively correlated with internodal length (0.314*) during the rabi season. While it was highly significant and negatively correlated with days to first picking (-0.525**), days to application of first female flower (-0.501**), node number to first female flower (-0.446**), fruit diameter (-0.429**) and number of primary branches per plant (-0.422**) during the rabi season and with number of nodes on main vine (-0.403**) during the summer season.

Main vine length was highly significant and positively correlated with number of primary branches per plant (0.448**) and days to first picking (0.416**) during the rabi season and with fruit length (0.477**), number of primary branches per plant (0.372*), number of nodes on main vine (0.370*) and fruit diameter (0.322*) during the summer season. Similarly, Khan *et al*. (2015) [8]; Hossain *et al*. (2010) [9] and Abusaleha and Dutta (1988) [10] also reported positive correlation of main vine length with fruit width. It may be because of the reason that with the increase in main vine length, the number of nodes bearing female flowers also increased.

Internodal length was highly significant and negatively correlated with fruit diameter (-0.411**) during the rabi season. Fruit diameter was highly significant and positively correlated with days to first picking (0.418**) during the rabi season while, it showed significant positive correlation with fruit length (0.392*) during the summer season. Eifediyi *et al*. (2011) [11] also reported strong positive correlation between fruit diameter and fruit length. Fruit length was highly significant and negatively correlated with node number to first female flower (-0.416**) during the rabi season.

Days to first picking was highly significant and positively correlated with node number to first female flower (0.479**) and days to appearance of first female flower (0.388*) during the rabi season and with days to appearance of first female flower (0.588**) and node number to first female flower (0.519**) during the summer season.

Table 1: Correlation coefficient between different characters of cucumber genotypes during the rabi and summer season

Characters	Season	Days to appearance of first female flower	Node number to first female flower	Days to first picking	Fruit length (cm)	Fruit diameter (cm)	Number of nodes on main vine	Number of primary branches per plant	Internodal length (cm)	Main vine length (cm)	Average fruit weight (g)	Number of fruits per plant	Fruit yield (q/ha)
Days to appearance of first female flower	Rabi	1.000											
	Summer	1.000											
Node number to first female flower	Rabi	0.241	1.000										
	Summer	0.486**	1.000										
Days to first picking	Rabi	0.388*	0.479**	1.000									
	Summer	0.588**	0.519**	1.000									
Fruit length (cm)	Rabi	0.115	-0.416**	-0.057	1.000								
	Summer	0.228	0.027	0.090	1.000								
Fruit diameter (cm)	Rabi	0.348*	-0.013	0.418**	0.135	1.000							
	Summer	0.336*	0.165	0.210	0.392*	1.000							
Number of nodes on main vine	Rabi	-0.229	0.064	-0.222	-0.233	-0.176	1.000						
	Summer	-0.072	-0.380*	-0.337*	0.142	-0.042	1.000						
Number of primary branches per plant	Rabi	-0.153	0.248	0.326*	-0.069	0.106	0.333*	1.000					
	Summer	-0.163	-0.050	-0.007	0.084	-0.142	0.140	1.000					
Internodal length (cm)	Rabi	0.117	-0.011	-0.242	0.158	-0.411**	0.145	-0.189	1.000				
	Summer	0.249	0.086	-0.020	0.063	-0.192	0.069	-0.225	1.000				
Main vine length (cm)	Rabi	-0.118	0.130	0.416**	-0.196	0.206	0.399*	0.448**	0.100	1.000			
	Summer	0.207	0.079	0.155	0.477**	0.322*	0.370*	0.372*	0.200	1.000			
Average fruit weight (g)	Rabi	-0.501**	-0.446**	-0.525**	0.173	-0.429**	0.130	-0.422**	0.314*	-0.239	1.000		
	Summer	0.376*	0.360*	0.460**	0.548**	0.438**	-0.403**	0.292	-0.146	0.238	1.000		
Number of fruits per plant	Rabi	-0.031	0.330*	0.096	0.100	-0.167	0.018	0.149	-0.255	-0.173	-0.406**	1.000	
	Summer	-0.288	-0.509**	-0.516**	-0.273	-0.256	0.420**	0.177	-0.006	0.174	-0.502**	1.000	
Fruit yield (q/ha)	Rabi	-0.336*	-0.246	-0.402*	0.288	-0.662**	0.235	-0.239	0.273	-0.280	0.593**	0.334*	1.000
	Summer	-0.354*	-0.612**	-0.417**	0.106	0.040	0.659**	0.294	-0.207	0.292	-0.293	0.692**	1.000

*, ** Significant at 5% and 1% level of probability, respectively

The results of the path coefficient analysis are presented in Table 2. Positive direct effect on fruit yield was exhibited during both the seasons by number of fruits per plant (0.681, 0.616), number of nodes on main vine (0.144, 0.420), fruit length (0.039, 0.260) and days to first picking (0.131, 0.256). While negative direct effect on fruit yield was exhibited by node number to first female flower (-0.295, -0.141) during both the seasons. The results obtained from this study corroborates similar reports by Nwofia *et al*. (2015) [6] and Ene *et al*. (2016) [12] in their separate investigations in which they indicated that number of fruits per plant projected the greatest positive direct effect on total fruit yield of cucumber, an indication that this trait is one of the most reliable component for selecting high yielding cucumber genotypes.

Table 2: Path coefficient analysis showing the direct and indirect effect of different characters on fruit yield of cucumber during the rabi and summer season

Characters	Season	Days to appearance of first female flower	Node number to first female flower	Days to first picking	Fruit length (cm)	Fruit diameter (cm)	Number of nodes on main vine	Number of primary branches per plant	Internodal length (cm)	Main vine length (cm)	Average fruit weight (g)	Number of fruits per plant
Days to appearance of first female flower	Rabi	0.227	-0.059	0.051	0.005	-0.110	-0.033	-0.004	0.006	-0.003	-0.392	-0.021
	Summer	-0.286	-0.068	0.150	0.059	0.095	-0.030	-0.028	-0.009	-0.042	-0.018	-0.178
Node number to first female flower	Rabi	0.055	-0.245	0.063	-0.016	0.004	0.009	0.007	-0.001	0.004	-0.350	0.225
	Summer	-0.139	-0.141	0.133	0.007	0.047	-0.160	-0.009	-0.003	-0.016	-0.017	-0.314
Days to first picking	Rabi	0.088	-0.117	0.131	-0.002	-0.133	-0.032	0.009	-0.012	0.011	-0.411	0.066
	Summer	-0.168	-0.073	0.256	0.023	0.059	-0.142	-0.001	0.001	-0.031	-0.022	-0.318
Fruit length (cm)	Rabi	0.026	0.102	-0.007	0.039	-0.043	-0.033	-0.002	0.008	-0.005	0.136	0.068
	Summer	-0.065	-0.004	0.023	0.260	0.111	0.060	0.015	-0.002	-0.096	-0.026	-0.168
Fruit diameter (cm)	Rabi	0.079	0.003	0.055	0.005	-0.317	-0.025	0.003	-0.020	0.006	-0.337	-0.114
	Summer	-0.096	-0.023	0.054	0.102	0.283	-0.018	-0.025	0.007	-0.065	-0.021	-0.158
Number of nodes on main vine	Rabi	-0.052	-0.016	-0.029	-0.009	0.056	0.144	0.009	0.007	0.011	0.102	0.013
	Summer	0.021	0.054	-0.086	0.037	-0.012	0.420	0.024	-0.002	-0.074	0.019	0.259
Number of primary branches per plant	Rabi	-0.035	-0.061	0.043	-0.003	-0.034	0.048	0.028	-0.009	0.012	-0.331	0.102
	Summer	0.047	0.007	-0.002	0.022	-0.040	0.059	0.174	0.008	-0.075	-0.014	0.109
Internodal length (cm)	Rabi	0.027	0.003	-0.032	0.006	0.130	0.021	-0.005	0.049	0.003	0.246	-0.174
	Summer	-0.071	-0.012	-0.005	0.017	-0.054	0.029	-0.039	-0.034	-0.040	0.007	-0.003
Main vine length (cm)	Rabi	-0.027	-0.032	0.055	-0.008	-0.065	0.057	0.013	0.005	0.027	-0.187	-0.118
	Summer	-0.059	-0.011	0.040	0.124	0.091	0.155	0.065	-0.007	-0.201	-0.011	0.107
Average fruit weight (g)	Rabi	-0.113	0.109	-0.069	0.007	0.136	0.019	-0.012	0.015	-0.006	0.784	-0.277
	Summer	-0.108	-0.051	0.118	0.143	0.124	-0.169	0.051	0.005	-0.048	-0.048	-0.310
Number of fruits per plant	Rabi	-0.007	-0.081	0.013	0.004	0.053	0.003	0.004	-0.012	-0.005	-0.319	0.681
	Summer	0.082	0.072	-0.132	-0.071	-0.072	0.177	0.031	0.000	-0.035	0.024	0.616

Residual effect 0.1233 for rabi season and 0.1643 for summer season

Number of fruits per plant exhibited positive indirect effect on fruit yield via number of nodes on main vine (0.013, 0.259) and number of primary branches per plant (0.102, 0.109), while it exhibited negative indirect effect on fruit yield via average fruit weight (-0.277, -0.310), fruit diameter (-0.114, -0.158) during both the rabi and summer season respectively. Average fruit weight exhibited negative indirect effect on fruit yield via number of primary branches per plant (-0.331, -0.014), days to first picking (-0.411, -0.022), days to appearance of first female flower (-0.392, -0.018) and node number to first female flower (-0.350, -0.017) during both the rabi and summer season respectively.

The residual factor was 0.1233 and 0.1643 for rabi and summer season, respectively, *i.e*., the unexplained variation in path was 12.33 per cent and 16.43 per cent which predicted that 87.67 per cent and 83.57 per cent variation in fruit yield had been determined during the rabi season and summer season, respectively, due to the above characters studied. It further states the presence of some more factors, not considered here, which contribute to the fruit yield of cucumber.

4. Conclusion

Correlation and path coefficient analysis revealed that characters such as number of fruits per plant and average fruit weight significantly influenced the fruit yield of cucumber during both the seasons, hence, for breeding and selection of high yielding genotypes, these characters demand prime attention.

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