Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 342-345
Received: 04-09-2019
Accepted: 06-10-2019

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Studies on correlation and path analysis of yield attributes in cucumber (*Cucumis sativus* L.)

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Abstract
Studies were conducted to assess relationship between various horticulture traits and yield per plant in cucumber. Here, how the traits are correlated with yield per plant and also direct and indirect effect of traits on yield per plant was calculated. The yield per plant had genotypic and phenotypic significant positive correlation with length of vine, number of female flower, number of fruit per plant, fruit length, fruit diameter and fruit weight where as significant negative correlation with node number bearing first female flower, number of male flower and sex ratio. The yield per plant also had genotypic significant negative correlation with days to first female flower and days to first harvest. Number of fruits per plant had maximum positive direct and indirect effect on yield per plant.

Keywords: Genotypic correlation, phenotypic correlation and path analysis

Introduction
Cucumber (*Cucumis sativus* L.) is one of the important cucurbitaceous vegetable crops grown extensively in tropical and sub-tropical parts of the country. 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 (Sharma *et al*., 2017) [9]. It is a rich source of vitamin B and C, carbohydrates, calcium and phosphorus (Yawalkar, 1985) [13]. Cucurbits are composed of 118 genera and 825 species. Members of this family are distributed primarily in tropical and subtropical regions of the world (Wang *et al.* 2007) [12]. Cultivated species of *Cucumis sativus* L. originated from the wild progenitor *Cucumis hardwickii* in the Himalayan belt of Indo-China region and India is being the primary centre of origin. Now, it is extensively cultivated in diverse agroclimatic conditions ranging from tropical to subtropical regions of the world.

Information about the direct and indirect effect of the various characters towards yield will be helpful for breeder to select high yielding parents for hybridization. Phenotypic and genotypic coefficients of correlation for individual characters are to be known by breeder to select the superior parents for breeding programme. Correlation analysis of various traits will provide the direct and indirect effect of the traits to yield. Path coefficient analysis is a mean of partitioning correlation coefficient in to direct and indirect effects of various characters. It gives idea about the contribution of each independent character on dependent character *i.e.* yield. Path analysis forces researchers to explicitly specify how the variable relates to one another and thus encourages the development of clear and logical theories about the process influencing a particular outcome. Keeping these point on mind this study was conducted to assess relationship between various horticulture traits and yield per plant in cucumber and also to analyse the direct and indirect effect of various horticulture traits on yield per plant.

Materials and Methods

The experimental materials comprised of thirty six cucumber genotypes and the sources of the genotypes are mentioned below.

Sl. No	Genotypes	Source of Collection
1.	IC 613470, IC 613472, IC 613473, IC 613474, IC 613476, IC 613477, IC 613479, IC 613481, IC 613482, IC 613483, IC 613484, IC 613485, IC 539818, IC 366034, IC 469517, IC 595514, IC 595515, IC 595504, IC 595505, IC 277030, Swarna Ageti, IC 392530, IC 429930, IC 527400	NBPGR, New Delhi
2.	Pant Khira-1	G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand
3.	Peramangalam, Thillailampur, Musiri, Namanasamuthiram, Amaravathi	Local types of Tamil Nadu
4.	AVCU 1302, AVCU 1202, AVCU 1203, AVCU 1205, AVCU 1303, AVCU 1206	AVRDC. Taiwan.

The present investigation was carried out at the College Orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during late *kharif* 2018 which is situated at 11° N latitude and 77° E longitude and at an elevation of 426.6 m above mean sea level. A total of 36 genotypes of cucumber were raised in a randomized block design (RBD) with two replications. All recommended package of practices were followed during the crop production. Five plants at random were taken from each plot for recording the observations on length of vine (cm), number of primary branches, number of nodes per vine, node number bearing first male flower, node number bearing first female flower, days for first male flower, days for first female flower, days for first harvest, number of male flower, number of female flower, sex ratio, number of fruits per plant, fruit length (cm), fruit diameter (cm), fruit weight (g) and yield per plant (kg). The mean over replications for each character was subjected to statistical analysis by using the principles of 'Analysis of Variance' techniques as described by Panse and Sukhatme (1978) [7]. Correlation coefficients were computed according to the method suggested by Singh and Chaudhary (1985) using statistical software of TNAUSTAT. Path analysis was analysed with the help of formula suggested by Dewey and Lu (1959) [3] using TNAUSTAT software.

Results and Discussion

Correlation studies

The correlation coefficients among different characters are calculated for both at phenotypic and genotypic levels and presented in Table 1. In general, the genotypic correlation coefficients were higher in magnitude than phenotypic correlation coefficients. This can be interpreted as a strong inherent genotypic relationship between the characters studied through their phenotypic expression was impeded by environmental influence.

The genotypic and phenotypic correlation coefficients among different traits revealed that yield per plant had significant positive correlation with length of vine (0.522 and 0.458), number of female flower (0.573 and 0.566), number of fruit per plant (0.866 and 0.852), fruit length (0.424 and 0.427), fruit diameter (0.396 and 0.379) and fruit weight (0.749 and 0.740) where as significant negative correlation with node number bearing first female flower (-0.441 and -0.393), number of male flower (-0.363 and -0.342) and sex ratio (-0.501 and -0.480). The yield per plant also had genotypic significant negative correlation with days for first female flower (-0.356) and days for first harvest (-0.335).

Length of vine was significant genotypic and phenotypic positively correlated with number of primary branches (0.702 and 0.643), number of nodes per vine (0.590 and 0.536), number of fruits per plant (0.394 and 0.371), fruit length (0.602 and 0.549) and fruit weight (0.397 and 0.362) whereas number of primary branches significant genotypic and phenotypic positively correlated with number of nodes per vine (0.668 and 0.682) and fruit length (0.470 and 0.494) respectively. Number of female flowers showed significant positive correlation for number of fruits per plant (0.835 and 0.841) while significant negative correlation for sex ratio (-0.924 and -0.885) both at genotypic and phenotypic level respectively. The significant genotypic and phenotypic positive correlation also recorded for days to first male flower (0.490 and 0.653) and female flower (0.614 and 0.731) with days for first harvest, which is important for selection of the earliness variety. Similar correlation studies of yield with various other horticultural trait had also been reported by Dhiman and Chander (2005) [4], Kumar *et al.* (2008) [6], Arunkumar *et al.* (2011) [1], Veena *et al.* (2013) [11], Hasan *et al.* (2015) [5], Chinatu *et al.* (2017) [2] and Sharma *et al.* (2018) [8].

Table 1: Phenotypic and genotypic coefficients of correlation foe various traits in cucumber

Traits		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
X1	G	1	0.702^{**}	0.590^{**}	-0.094	-0.140	-0.273	-0.123	-0.139	0.099	0.159	-0.092	0.394^{*}	0.602^{**}	0.145	0.397^{*}	0.522^{**}
	P	1	0.643^{**}	0.536^{**}	-0.069	-0.117	-0.173	-0.072	-0.096	0.082	0.159	-0.093	0.371^{*}	0.549^{**}	0.134	0.362^{*}	0.458^{**}
X2	G		1	0.668^{**}	-0.188	0.154	-0.180	0.048	0.037	0.309	-0.073	0.073	0.178	0.470^{**}	-0.070	0.169	0.269
	P		1	0.682^{**}	-0.138	0.204	-0.001	0.161	0.132	0.326	-0.038	0.094	0.206	0.494^{**}	0.030	0.206	0.279
X3	G			1	-0.170	-0.124	-0.069	-0.023	-0.049	0.104	0.091	-0.117	0.279	0.382^{*}	0.216	0.104	0.327
	P			1	-0.099	-0.032	0.133	0.157	0.100	0.131	0.136	-0.083	0.314	0.425^{**}	0.312	0.163	0.334*
X4	G				1	0.279	-0.183	-0.274	-0.254	-0.534^{**}	0.474^{**}	-0.466^{**}	0.232	-0.187	-0.169	-0.146	0.065
	P				1	0.322	0.010	-0.070	-0.105	-0.491^{**}	0.495^{**}	-0.429^{**}	0.264	-0.124	-0.043	-0.088	0.075
X5	G					1	0.060	0.342^{*}	0.377^{*}	0.428^{**}	-0.579^{**}	0.432^{**}	-0.641^{**}	0.054	-0.400^{*}	-0.057	-0.441^{**}
	P					1	0.236	0.437^{**}	0.458^{**}	0.444^{**}	-0.493^{**}	0.444^{**}	-0.549^{**}	0.123	-0.202	0.015	-0.393^{*}
X6	G						1	0.662^{**}	0.490^{**}	-0.117	-0.109	-0.136	-0.219	-0.228	-0.143	-0.237	-0.167
	P						1	0.805^{**}	0.653^{**}	-0.002	0.038	-0.026	-0.039	-0.004	0.218	-0.023	-0.075
X7	G							1	0.614^{**}	0.227	-0.517^{**}	0.199	-0.503^{**}	-0.102	-0.309	-0.233	-0.356^{*}
	P							1	0.731^{**}	0.254	-0.280	0.224	-0.266	0.076	0.085	-0.034	-0.225
X8	G								1	0.212	-0.413^{*}	0.200	-0.431^{**}	0.024	0.014	-0.189	-0.335^{*}
	P								1	0.246	-0.260	0.228	-0.273	0.144	0.247	-0.045	-0.247
X9	G									1	-0.847^{**}	0.931^{**}	-0.636^{**}	0.254	-0.309	0.022	-0.363^{*}
	P									1	-0.806^{**}	0.932^{**}	-0.599^{**}	0.275	-0.213	0.050	-0.342^{*}
X10	G										1	-0.924^{**}	0.835^{**}	-0.132	0.260	0.031	0.573^{**}
	P										1	-0.885^{**}	0.841^{**}	-0.085	0.310	0.069	0.566^{**}
X11	G											1	-0.738^{**}	0.155	-0.369^{*}	-0.080	-0.501^{**}
	P											1	-0.703^{**}	0.177	-0.273	-0.053	-0.480^{**}
X12	G												1	0.210	0.314	0.325	0.866^{**}
	P												1	0.243	0.358^{*}	0.352^{*}	0.852^{**}
X13	G													1	0.267	0.478^{**}	0.424^{**}
	P													1	0.341^{*}	0.508^{**}	0.427^{**}
X14	G														1	0.173	0.396^{*}

	P														1	0.253	0.379*
X15	G															1	0.749**
	P															1	0.740**
*Significant at 5% level of significance; **Significant at 1% level of significance																	

Length of vine (X_1), Number of primary branches (X_2), Number of nodes per vine(X_3), Node Number bearing first male flower (X_4), Node Number bearing first female flower (X_5), Days for first male flower(X_6), Days for first female flower(X_7), Days for first harvest(X_8), Number of male flower (X_9), Number of female flower (X_{10}), Sex ratio (X_{11}) Number of fruits per plant (X_{12}), fruit length (X_{13}), Fruit diameter (X_{14}), Fruit weight (X_{15}), Yield per plant (X_{16})

Path Coefficient Analysis

The data on path coefficient analysis at genotypic level showing the direct and indirect effects of significant characters over fruit yield per plant have been presented in Table 2. The results showed that number of fruits per plant (1.0375) had maximum positive direct effect on yield per plant followed by number of male flower (0.9333) while sex ratio (-1.6981) had maximum negative direct effect on yield per plant followed by number of female flower (-1.5449). The trait number of fruits per plant (0.8656) had maximum positive indirect effect on yield per plant followed by fruit weight (0.7486) while sex ratio (-0.5014) had maximum negative indirect effect on yield per plant followed by node number bearing first female flower (-0.4413), similar results were also reported by Dhiman and Chander (2005) [4], Kumar *et al.* (2008) [6] and and Sharma *et al.* (2018) [8].

Table 2: Estimates of direct and indirect effects of various traits on yield in cucumber

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
X_1	0.1818	-0.1119	-0.0654	-0.0243	0.0398	-0.0366	0.0486	-0.0056	0.0926	-0.2451	0.1555	0.4092	-0.0054	-0.0138	0.1025	0.5219
X_2	0.1276	-0.1593	-0.0740	-0.0483	-0.0437	-0.0240	-0.0188	0.0015	0.2888	0.1134	-0.1246	0.1847	-0.0042	0.0066	0.0437	0.2692
X_3	0.1072	-0.1064	-0.1108	-0.0438	0.0352	-0.0093	0.0090	-0.0020	0.0971	-0.1406	0.1993	0.2890	-0.0034	-0.0206	0.0268	0.3267
X_4	-0.0171	0.0299	0.0189	0.2574	-0.0793	-0.0245	0.1084	-0.0103	-0.4983	-0.7321	0.7905	0.2408	0.0017	0.0162	-0.0375	0.0645
X_5	-0.0255	-0.0246	0.0138	0.0719	-0.2836	0.0080	-0.1352	0.0153	0.3995	0.8937	-0.7331	-0.6646	-0.0005	0.0382	-0.0146	-0.4413
X_6	-0.0497	0.0286	0.0077	-0.0471	-0.0170	0.1339	-0.2615	0.0199	-0.1088	0.1689	0.2307	-0.2267	0.0021	0.0136	-0.0612	-0.1666
X_7	-0.0224	-0.0076	0.0025	-0.0706	-0.0971	0.0886	-0.3950	0.0249	0.2119	0.7986	-0.3385	-0.5215	0.0009	0.0295	-0.0601	-0.3557
X_8	-0.0252	-0.0059	0.0055	-0.0654	-0.1068	0.0656	-0.2426	0.0405	0.1981	0.6373	-0.3387	-0.4476	-0.0002	-0.0013	-0.0488	-0.3354
X_9	0.0180	-0.0493	-0.0115	-0.1374	-0.1214	-0.0156	-0.0897	0.0086	0.9333	1.3090	-1.5801	-0.6596	-0.0023	0.0294	0.0058	-0.3627
X_{10}	0.0288	0.0117	-0.0101	0.1220	0.1641	-0.0146	0.2042	-0.0167	-0.7908	-1.5449	1.5690	0.8663	0.0012	-0.0248	0.0080	0.5732
X_{11}	-0.0166	-0.0117	0.0130	-0.1198	-0.1224	-0.0182	-0.0787	0.0081	0.8685	1.4275	-1.6981	-0.7660	-0.0014	0.0352	-0.0207	-0.5014
X_{12}	0.0717	-0.0284	-0.0309	0.0597	0.1817	-0.0292	0.1985	-0.0175	-0.5933	-1.2900	1.2536	1.0375	-0.0019	-0.0300	0.0839	0.8656
X_{13}	0.1093	-0.0749	-0.0423	-0.0481	-0.0152	-0.0305	0.0404	0.0010	0.2371	0.2039	-0.2635	0.2180	-0.0090	-0.0255	0.1235	0.4242
X_{14}	0.0263	0.0111	-0.0239	-0.0436	0.1135	-0.0191	0.1221	0.0006	-0.2881	-0.4021	0.6266	0.3261	-0.0024	-0.0954	0.0445	0.3961
X_{15}	0.0722	-0.0270	-0.0115	-0.0374	0.0161	-0.0317	0.0920	-0.0077	0.0209	-0.0480	0.1362	0.3373	-0.0043	-0.0165	0.2581	0.7486
Residual effect- 0.2468																
Length of vine (X_1), Number of primary branches (X_2), Number of nodes per vine(X_3), Node Number bearing first male flower (X_4), Node Number bearing first female flower (X_5), Days for first male flower(X_6), Days for first female flower(X_7), Days for first harvest(X_8), Number of male flower (X_9), Number of female flower (X_{10}), Sex ratio (X_{11}) Number of fruits per plant (X_{12}), fruit length (X_{13}), Fruit diameter (X_{14}), Fruit weight (X_{15}), Yield per plant (X_{16})																

Conclusion

The yield per plant had significant genotypic and phenotypic positive correlation with length of vine, number of female flower, number of fruit per plant, fruit length, fruit diameter and fruit weight whereas number of fruits per plant had maximum positive direct and indirect effect on yield per plant. According to this result the genotypes which are all having maximum length of vine, number of female flower, number of fruit per plant, fruit length, fruit diameter and fruit weight have to be selected for heterosis breeding programme.

Acknowledgement

The authors are thankful to Horticultural College and Research Institute, Coimbatore for providing necessary facilities in carrying out the present investigation.

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