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Studies on correlation and path-coefficient analysis for yield and its contributing characters in Cucumber (*Cucumis sativus* L.)

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Abstract
Twenty-five cucumber genotypes were evaluated during summer season of 2016 at the Horticultural Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The objective was to study the correlation and path-coefficient analysis for yield and its contributing characters in Cucumber (*Cucumis sativus L.*) Node at which first female flower appear showed positive and significant correlation with node at which first male flower appear. Days to first female flower appearance showed positive and significant correlation with node at which first female flower appear and days at 50% female flower. Days at 50% female flower showed positive and significant correlation with days to first female flower appearance and days at 50% male flower. Number of primary branches per plant showed positive correlation with vine length, fruit yield per plant and average fruit weight. Average fruit weight showed positive and significant correlation with fruit length and fruit yield per plant whereas, number of fruits per plant showed positive and significant correlation with fruit diameter and fruit yield per plant. At genotypic and phenotypic path coefficient analysis, high positive direct effect was exerted by average fruit weight, number of fruits per plant, fruit yield per plant followed vine length by towards fruit yield per plant.

Keywords: Cucumber, genotypic correlation, phenotypic correlation and path coefficient

Introduction
Cucumber is an important vegetable crop of India cultivated throughout the country. Globally, cucumber (*Cucumis sativus* L.) is regarded as second most widely cultivated cucurbit after watermelon and is also regarded as fourth most important vegetable after tomato, cabbage and onion (Tatlioglu, 1993). The cucumber is commonly a monoecious, annual, trailing or climbing vine with angled, hirsute or rough stem (Bailey, 1969) [2]. Cucumber is believed to be native to India or Southern Asia and has been apparently cultivated for the last 3000 years (De Candolle, 1886). Diversity in plant genetic resources provides an opportunity for plant breeders to develop new and improved cultivars with desirable characteristics, which include both farmer preferred traits (yield potential and large seed, etc.) and breeders preferred traits (pest and disease resistance and photosensitivity, etc.) (Govindaraj *et al*. 2015) [7]. Correlation and path coefficient analysis are the important biometrical tools, which are effective for determining the various yield components of different crops leading to the selection of superior genotypes. Therefore, for a rational approach to the improvement of yield, it is essential to have information on the association between different yield components and their relative contribution to yield. Knowledge of such relationship is essential in selection for the simultaneous improvement of yield components and which in turn affect the yield. Path coefficient analysis as suggested by (Wright, 1921) [11] on the other hand gives a clear picture about cause-effect as it splits the correlation into the estimates of the direct and indirect contribution of each character towards yield. Ultimately, this kind of analysis could help the breeder to design his selection strategies to improve yield. Therefore, the present study was undertaken to assess the nature and magnitude of association among yield and its contributing traits for selecting high yielding genotypes of cucumber.

Materials and Methods

The present study was carried out at the Horticultural Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during the summer season of 2016. The average annual rainfall is about 1110 mm. The major part of the rain occurs from July to September. The mean relative humidity is about 68 percent which rises up 81percent during July to September and falls down to 39 percent during the end of April to early June. The experiment was laid out in Randomized Block Design with three replications experiment material comprised of twenty-five genotypes. Seeds were sown on 12th april, 2016 in hills spaced 120 cm x 60 cm. standard cultural practices were followed for a healthy crop stand. Five plants were selected randomly from each plot and tagged for recording the observations like days to 50% germination, node at which first male flower appear, node at which first female flower appear, days to first male flower appearance, days at 50% male flower appearance, days to first female flower appearance, days at 50% female flower appearance, vine length (cm), primary branches per vine, fruit length (cm), fruit diameter (cm), fruits per plant, average fruit weight (kg), fruit yield per plant (kg), fruit yield per plot and fruit yield (q/ha). Both genotypic and phenotypic coefficients of correlation between two characters were determined by using the variance and covariance as suggested by A1-Jibouri *et al.* (1958) [1]. Path coefficient analysis was carried out using phenotypic correlation values of yield components on yield as suggested by Wright (1921) [11] and illustrated by Dewey and Lu (1959) [5].

Table 1: The cultivars/germplasm included in the trial

Symbol used	Name of germplasm	Source
T_1	South Kheera Long	KAU, Thrissur
T_2	Cucumber Moti	Market, Varanasi
T_3	Local Selection-1	Market, Varanasi
T_4	K-90	YSPUHF, Solan
T_5	Kheera Parshad-100	IIVR, Varanasi
T_6	Rajan	Market, Varanasi
T_7	Imperial Green	Market, Varanasi
T_8	Rajendra-1	RPCAU, Bihar
T_9	Lovely	Market, Haryana
T_{10}	Pusa Uday	IIVR, Varanasi
T_{11}	100 Number	Market, Varanasi
T_{12}	Local Selection-2	Market, Varanasi
T_{13}	SS-45	KAU, Thrissur
T_{14}	Subera	KAU, Thrissur
T_{15}	Swarna Agete	IIVR, Varanasi
T_{16}	Super Long Green	Market, Varanasi
T_{17}	Green Wonder	Market, Kanpur
T_{18}	Priya	Market, Kanpur
T_{19}	Mudi ki Local	KAU, Thrissur
T_{20}	Kamini-017	IIVR, Varanasi
T_{21}	Super Green	Market, Kanpur
T_{22}	Local Selection-3	Market, Varanasi
T_{23}	K-75	YSPUHF, Himachal Pardesh
T_{24}	Local Selection-4	Market, Varanasi
T_{25}	Swarna Sheetal	IIVR, Varanasi

Results and Discussion

Success of any breeding programme depends upon the efficiency of selection. Selection cannot be applied on the basis of single character because most of the characters are polygenic and are influenced by each other. Therefore, it is necessary to study the nature of association of the characters in question with other relevant traits. As such, knowledge of correlation is very essential in breeding programmes. In the present study, correlation on phenotypic and genotypic level, between the yield and its contributing characters and characters themselves have been worked out of sixteen characters in twenty-five diverse genotypes of cucumber. In this study, genotypic and phenotypic correlations were estimated for sixteen characters in twenty-five diverse genotypes of cucumber

Correlations Study

Traits like days to 50% germination has positive and significant correlation with primary branches per plant (0.209), vine length (0.195), days at 50% male flower (0.137) and fruit length (0.121). This indicates that the variety which have early germination habit are also early in producing primary branches per plant, vine length, days at 50% male flower and fruit length. These finding resembled with the findings of Kumar *et al.* (2008). Node at which first male flower appear showed positive and significant correlation with fruit yield per plant (0.222), number of fruits per plant (0.202), fruit diameter (0.102), number of primary branches per plant (0.065) and days to first male flower appear (0.0259). From above correlation it is clear that lowest the node at which first male flower appear has direct effect towards other traits like fruit yield per plant, number of fruits per plant, fruit diameter (cm), number of primary branches per plant and days to first male flower appears. These finding are resembled with the findings of Kumar *et al*. (2010) [9, 10], Kumar *et al*. (2010) [9, 10] and Das *et al*. (2003) [3]. In case of node at which first female flower appear showed positive and significant correlation with node at which first male flower appear (0.392), fruit length (0.031) and days to 50% germination (0.005). From above correlation it is clear that lowest the node at which first female flower appear has direct effect towards other traits like node at which first male flower

appear, fruit length and days to 50% germination. Character like days to first male flower appearance showed positive and significant correlation with days to first female flower appearance (0.224), number of fruits per plant (0.186), node at which first female flower appear (0.061) and node at which first male flower appear (0.025). This indicates that the variety which have ability to bear early first male flower appearance are also early in days to first female flower appearance, number of fruits per plant, node at which first female flower appear and node at which first male flower appear. These finding are resembled with the findings of Kumar *et al*. (2010) [9, 10], Kumar *et al*. (2010) [9, 10] and Das *et al*. (2003) [3]. Days at 50% male flower showed positive and significant correlation with days at 50% female flower (0.285), number of fruits per plant (0.236), days to 50% germination (0.137), days to first female flower appearance (0.1320) and fruit diameter (0.095). This indicates that the variety which have ability to have early days at 50% male flower are also early in days at 50% female flower, number of fruits per plant, days to 50% germination, days to first female flower appearance and fruit diameter. Another character like days to first female flower appearance showed positive and significant correlation with node at which first female flower appear (0.392), days at 50% female flower (0.357), days to first male flower appearance (0.224), days at 50% male flower (0.132) and number of fruits per plant (0.094). This indicates that the variety which have ability to bear early first female flower appearance are also early in node at which first female flower appear, days at 50% female flower, days to first male flower appearance, days at 50% male flower and number of fruits per plant. These finding are resembled with the findings of Dhiman and Chander (2005) [6] and Das *et al*. (2003) [3]. Days at 50% female flower showed positive and significant correlation with days to first female flower appearance (0.355), days at 50% male flower (0.285), average fruit weight (0.141), fruit length (0.133), fruit diameter (0.073) and number of primary branches per plant (0.042). This indicates that the variety which have ability to have early days at 50% female flower are also early in days to first female flower appearance, days at50% male flower, average fruit weight, fruit length, fruit diameter and number of primary branches per plant. These finding are resembled with the findings of Dhiman and Chander (2005) [6] and Das *et al*. (2003) [3]. Vine length showed positive and significant correlation with fruit length (0.663), average fruit weight (0.578), number of primary branches per plant (0.518), fruit yield per plant (0.430) while primary branches per plant showed positive and significant correlation with vine length (0.518), fruit yield per plant (0.386) and average fruit weight (0.295). From this correlation we can say that the variety which have more primary branches per plant have more vine length. Fruit length showed positive and significant correlation with vine length (0.663), average fruit weight (0.6058) and fruit diameter (0.490). Average fruit weight showed positive and significant correlation with fruit length (0.605), fruit yield per plant (0.588), vine length (0.578) and fruit diameter (0.430). The number of fruits per plant showed positive and significant correlation with fruit diameter (0.492), fruit yield per plant (0.357) and days at 50% male flower (0.236). These findings are resembled with the findings of Kumar *et al*. (2010) [9, 10] and Kumar *et al*. (2010) [9, 10].

Path coefficient analysis

Path coefficient analysis is a tool to partition the observed correlation coefficient into direct and indirect effect of yield components into yield to provide clear picture of character association for effective formulating effective selection strategy. Path analysis differs from simple correlation in that it plugs out the causes and their relative importance whereas, the latter measures simply the common association discounting the causation. In this present study, path coefficient analysis is carried out at phenotypic as well as genotypic level (Table 4 & 5). High positive direct effect was exerted by average fruit weight (0.931), number of fruits per plant (0.8799), fruit yield per plant (0.588), vine length (0.119), days at 50% female flower (0.034), fruit length (0.030) and node at which first female flower appear (0.010). However, days to first male flower appearance (-0.056), days at 50% male flower (-0.028), days to 50% germination (-0.026), primary branches per plant (-0.025), node at which first male flower appear (-0.016) and fruit diameter (-0.0051) resulted in substantial negative direct effect on fruit yield per plant. These finding are resembled with the findings of Hossain *et al*. (2010) [8]. Average fruit weight (0.432), days at 50% male flower (0.207), node at which first male flower appear (0.178), days to first male flower appearance (0.163), days to first male flower appearance (0.083) and primary branches per plant (0.072) exerted indirect effect on fruit yield per plant via fruits per plant. However, fruit length (-0.447), fruit diameter (-0.307), vine length (-0.226), days to 50% germination (-0.0112) and node at which first female flower appear (-0.009). Fruit length (0.564), vine length (0.538), fruit diameter (0.401), number of primary branches per plant (0.275) and days at 50% female flower (0.1314) exerted indirect effect on fruit yield per plant via average fruit weight. However, number of fruit per plant (-0.458), days to first male flower appearance (-0.357) and days to first female flower appearance (-0.240) exerted negative indirect effect. These finding are resembled with the findings of Hossain *et al*. (2010) [8].

Table 2: Genotypic correlation among yield and yield attributes for 16 characters of 25 genotypes of cucumber

S. No.	Character	Days to 50% Germination	Node At Which First Male Flower Appear	Node At Which First Female Flower Appear	Days to First Male Flower Appearance	Days At 50% Male Flower	Days to First Female Flower Appearance	Days At 50% Female Flower	Vine Length (cm)	Primary Branches Per Plant	Fruits/ Plant	Fruit Length (cm)	Fruit Diameter (cm)	Avg. Fruit Weight (kg)
1.	Days to 50% Germination	1.0000	-0.3482	-0.1060	-0.3948	0.1985	-0.2208	-0.0543	0.2137	0.4758	0.0467	0.0783	-0.1612	0.0787
2.	Node At Which First Male Flower Appear		1.0000	-0.4679	0.1400	-0.2248	-0.0915	-0.0183	-0.1354	0.3083	0.4681	-0.1248	0.3236	0.1038
3.	Node At Which First Female Flower Appear			1.0000	0.0118	-0.4171	0.4602	-0.0704	-0.0827	-0.2644	-0.0877	-0.0345	-0.2342	-0.4206
4.	Days to First Male Flower Appearance				1.0000	-0.1596	0.2525	0.0096	-0.4591	-0.1327	0.2647	-0.5691	-0.6258	-0.4728
5.	Days At 50% Male Flower					1.0000	0.1658	0.4114	-0.0448	0.0134	0.2904	-0.1418	0.0583	-0.1920
6.	Days to First Female Flower Appearance						1.0000	0.3700	-0.0648	-0.1693	0.1387	-0.1042	-0.0202	-0.2773
7.	Days At 50% Female Flower							1.0000	-0.0562	0.0137	-0.1864	0.1061	0.0697	0.1392
8.	Vine Length (cm)								1.0000	0.6915	-0.3447	0.7684	0.3840	0.6124
9.	Primary Branches Per Plant									1.0000	-0.1061	0.3709	0.1818	0.4368
10.	Fruits/ Plant										1.0000	-0.5960	-0.3520	-0.5160
11.	Fruit Length (cm)											1.0000	0.5270	0.6295
12.	Fruit Diameter (cm)												1.0000	0.4715
13.	Avg. Fruit Weight (kg)													1.0000

Table 3: Phenotypic correlation among yield attributes for 16 characters and 25 genotypes of cucumber

S. No.	Characters	Days to 50% Germination	Node At Which First Male Flower Appear	Node At Which First Female Flower Appear	Days to First Male Flower Appearance	Days At 50% Male Flower	Days to First Female Flower Appearance	Days At 50% Female Flower	Vine Length (cm)	Primary Branches Per Plant	Fruits/ Plant	Fruit Length (cm)	Fruit Diameter (cm)	Avg. Fruit Weight (kg)
1.	Days to 50% Germination	1.0000	-0.2243	0.0052	-0.2006	0.1373	-0.1583	-0.0545	0.1955	0.2091	-0.0127	0.1210	-0.0450	0.0901
2.	Node At Which First Male Flower Appear		1.0000	-0.1690	0.0259	-0.1000	-0.0431	0.0035	-0.0620	0.0653	0.2024	-0.0359	0.1024	0.0649
3.	Node At Which First Female Flower Appear			1.0000	0.0610	-0.3512	0.3926	-0.0426	-0.0916	-0.1924	-0.0105	0.0314	-0.1743	-0.3657
4.	Days to First Male Flower Appearance				1.0000	-0.0607	0.2243	0.0203	-0.3971	-0.0283	0.1860	-0.4399	-0.4374	-0.3842
5.	Days At 50% Male Flower					1.0000	0.1320	0.2852	-0.0535	0.0320	0.2360	-0.1517	0.0958	-0.1815
6.	Days to First Female Flower Appearance						1.0000	0.3557	-0.0657	-0.0922	0.0947	-0.0957	-0.0067	-0.2579
7.	Days At 50% Female Flower							1.0000	-0.0414	0.0422	-0.1419	0.1332	0.0736	0.1411
8.	Vine Length (cm)								1.0000	0.5182	-0.2573	0.6638	0.3126	0.5783
9.	Primary Branches Per Plant									1.0000	0.0823	0.1863	0.0936	0.2956
10.	Fruits/ Plant										1.0000	-0.5084	-0.3491	-0.4920
11.	Fruit Length (cm)											1.0000	0.4902	0.6058
12.	Fruit Diameter (cm)												1.0000	0.4307
13.	Avg. Fruit Weight (kg)													1.0000

Table 4: Direct and indirect effects of phenotypic path coefficient for 16 characters of 25 genotypes of cucumber

S.No..	Character	Days to 50% Germination	Node At Which First Male Flower Appear	Node At Which First Female Flower Appear	Days to First Male Flower Appearance	Days At 50% Male Flower	Days to First Female Flower Appearance	Days At 50% Female Flower	Vine Length (cm)	Primary Branches Per Plant	Fruits/ Plant	Fruit Length (cm)	Fruit Diameter (cm)	Avg. Fruit Weight (kg)
1.	Days to 50% Germination	-0.0267	0.0060	-0.0001	0.0054	-0.0037	0.0042	0.0015	-0.0052	-0.0056	0.0003	-0.0032	0.0012	-0.0024
2.	Node At Which First Male Flower Appear	0.0036	-0.0160	0.0027	-0.0004	0.0016	0.0007	-0.0001	0.0010	-0.0010	-0.0032	0.0006	-0.0016	-0.0010
3.	Node At Which First Female Flower Appear	0.0001	-0.0017	0.0100	0.0006	-0.0035	0.0039	-0.0004	-0.0009	-0.0019	-0.0001	0.0003	-0.0017	-0.0037
4.	Days to First Male Flower Appearance	-0.0029	0.0004	0.0009	0.0142	-0.0009	0.0032	0.0003	-0.0056	-0.0004	0.0026	-0.0063	-0.0062	-0.0055
5.	Days At 50% Male Flower	-0.0040	0.0029	0.0101	0.0018	-0.0289	-0.0038	-0.0082	0.0015	-0.0009	-0.0068	0.0044	-0.0028	0.0052
6.	Days to First Female Flower Appearance	0.0090	0.0024	-0.0223	-0.0127	-0.0075	-0.0568	-0.0202	0.0037	0.0052	-0.0054	0.0054	0.0004	0.0146
7.	Days At 50% Female Flower	-0.0019	0.0001	-0.0015	0.0007	0.0097	0.0121	0.0341	-0.0014	0.0014	-0.0048	0.0045	0.0025	0.0048
8.	Vine Length (cm)	0.0234	-0.0074	-0.0109	-0.0475	-0.0064	-0.0079	-0.0049	0.1195	0.0619	-0.0307	0.0793	0.0373	0.0691
9.	Primary Branches Per Plant	-0.0053	-0.0017	0.0049	0.0007	-0.0008	0.0024	-0.0011	-0.0132	-0.0255	-0.0021	-0.0048	-0.0024	-0.0075
10.	Fruits/ Plant	-0.0112	0.1781	-0.0092	0.1637	0.2076	0.0833	-0.1248	-0.2264	0.0724	0.8799	-0.4473	-0.3072	-0.4329
11.	Fruit Length (cm)	0.0037	-0.0011	0.0010	-0.0135	-0.0047	-0.0029	0.0041	0.0204	0.0057	-0.0157	0.0308	0.0151	0.0186
12.	Fruit Diameter (cm)	0.0002	-0.0005	0.0008	0.0020	-0.0004	0.0000	-0.0003	-0.0015	-0.0004	0.0016	-0.0023	-0.0047	-0.0020
13.	Avg. Fruit Weight (kg)	0.0839	0.0605	-0.3405	-0.3577	-0.1690	-0.2401	0.1314	0.5385	0.2752	-0.4581	0.5641	0.4010	0.9311
14.	Fruit Yield/ Plant (kg)	0.0719	0.2220	-0.3541	-0.2428	-0.0068	-0.2017	0.0112	0.4304	0.3861	0.3576	0.2256	0.1310	0.5885
15.	Partial R^2	-0.0019	-0.0035	-0.0036	-0.0035	0.0002	0.0115	0.0004	0.0514	-0.0099	0.3147	0.0069	-0.0006	0.5480

RESIDUAL EFFECT = 0.299; Diagonal value indicates direct effect; Values right and left indicates indirect effect

Table 5: Direct and indirect effects of genotypic path coefficient for 16 characters of 25 genotypes of cucumber

S.No.	Character	Days to 50% Germination	Node At Which First Male Flower Appear	Node At Which First Female Flower Appear	Days to First Male Flower Appearance	Days At 50% Male Flower	Days to First Female Flower Appearance	Days At 50% Female Flower	Vine Length (cm)	Primary Branches Per Plant	Fruits/ Plant	Fruit Length (cm)	Fruit Diameter (cm)	Avg. Fruit Weight (kg)
1.	Days to 50% Germination	0.0087	-0.0030	-0.0009	-0.0034	0.0017	-0.0019	-0.0005	0.0019	0.0041	0.0004	0.0007	-0.0014	0.0007
2.	Node At Which First Male Flower Appear	-0.0118	0.0338	-0.0158	0.0047	-0.0076	-0.0031	-0.0006	-0.0046	0.0104	0.0158	-0.0042	0.0109	0.0035
3.	Node At Which First Female Flower Appear	0.0107	0.0471	-0.1006	-0.0012	0.0420	-0.0463	0.0071	0.0083	0.0266	0.0088	0.0035	0.0236	0.0423
4.	Days to First Male Flower Appearance	0.0297	-0.0105	-0.0009	-0.0752	0.0120	-0.0190	-0.0007	0.0345	0.0100	-0.0199	0.0428	0.0471	0.0356
5.	Days At 50% Male Flower	-0.0080	0.0091	0.0168	0.0064	-0.0403	-0.0067	-0.0166	0.0018	-0.0005	-0.0117	0.0057	-0.0023	0.0077
6.	Days to First Female Flower Appearance	-0.0135	-0.0056	0.0281	0.0154	0.0101	0.0611	0.0226	-0.0040	-0.0104	0.0085	-0.0064	-0.0012	-0.0170
7.	Days At 50% Female Flower	0.0015	0.0005	0.0019	-0.0003	-0.0113	-0.0101	-0.0274	0.0015	-0.0004	0.0051	-0.0029	-0.0019	-0.0038
8.	Vine Length (cm)	0.0027	-0.0017	-0.0010	-0.0057	-0.0006	-0.0008	-0.0007	0.0125	0.0086	-0.0043	0.0096	0.0048	0.0076
9.	Primary Branches Per Plant	-0.0069	-0.0044	0.0038	0.0019	-0.0002	0.0024	-0.0002	-0.0100	-0.0144	0.0015	-0.0054	-0.0026	-0.0063
10.	Fruits/ Plant	0.0279	0.2801	-0.0525	0.1584	0.1737	0.0830	-0.1116	-0.2062	-0.0635	0.5984	-0.3566	-0.2106	-0.3087
11.	Fruit Length (cm)	0.0049	-0.0078	-0.0021	-0.0353	-0.0088	-0.0065	0.0066	0.0477	0.0230	-0.0370	0.0621	0.0327	0.0391
12.	Fruit Diameter (cm)	0.0108	-0.0217	0.0157	0.0419	-0.0039	0.0014	-0.0047	-0.0257	-0.0122	0.0236	-0.0353	-0.0670	-0.0316
13.	Avg. Fruit Weight (kg)	0.0874	0.1154	-0.4675	-0.5256	-0.2134	-0.3083	0.1547	0.6808	0.4856	-0.5736	0.6997	0.5241	1.1116
14.	Fruit Yield/ Plant (kg)	0.1441	0.4312	-0.5750	-0.4179	-0.0464	-0.2547	0.0282	0.5386	0.4670	0.0156	0.4133	0.3560	0.8807
15.	Partial R^2	0.0012	0.0146	0.0578	0.0314	0.0019	-0.0156	-0.0008	0.0067	-0.0067	0.0093	0.0257	-0.0238	0.9790

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