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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
Thirty-two cucumber genotypes were evaluated at College of Horticulture, Anantharajupeta during Late *Kharif* 2016. The study was conducted to assess the nature and magnitude of association among yield and its contributing traits in cucumber. The experiment was laid out in RBD with three replications. In this study, genotypic correlation was higher than phenotypic correlations indicating the highly heritable nature of the traits. It was observed that the traits *viz*., number of fruits per plant, fruit weight, number of primary branches per plant, fruit length and vine length have exhibited highly significant positive association with fruit yield per plant. The genetic improvement of fruit yield thus can be obtained by direct selection of these yield components. The path coefficient analysis revealed that the number of fruits per plant, fruit weight, number of primary branches per plant, fruit length, 100 seed weight, number of seeds per fruit, days to last fruit harvest, fruit diameter and number of nodes per vine have direct positive phenotypic and genotypic effect on yield. Hence, direct selection for these traits can be done for improving fruit yield per plant.

Keywords: cucumber genotypes; correlation; path-coefficient analysis

Introduction
Cucumber (*Cucumis sativus* L.) is one of the most important cucurbitaceous vegetable crops grown extensively in tropical and subtropical parts of the country, which is thought to be indigenous to India. It is considered as 4th most important vegetable crop after tomato, cabbage and onion. 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) [1]. It is a rich source of vitamin B and C, carbohydrates, Ca and P (Yawalkar, 1985) [4]. India is endowed with the wealth of cucumber germplasm, comprising of both wild and cultivated forms (Sharma *et al.*, 2018) [2]. In spite of being native to Indian sub-continent and endowed with enormous variability for different horticultural traits, cucumber remains underutilized in terms of its economic potential and unexploited from breeding point of view. Therefore, there is a need to screen cucumber germplasm for the identification of genotypes with improved quality and yield which may be directly used as varieties after extensive evaluation or as parents in the hybridization programme. (Kumar *et al.*, 2011) [3].
While selecting for yield, one should take into account the improvement of yield contributing traits, provided that the association of such traits with yield is known. Moreover, correlation and path coefficient analysis have been of immense help in selecting suitable plant type. Although, correlation coefficient indicates the nature of association among the traits, path analysis splits the correlation coefficients into measures of direct and indirect effects, thus providing an understanding on direct and indirect contribution of each character towards 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 (Saikia *et al.*, 1995) [5].

Materials and Methods
The present investigation was carried out during Late *kharif*, 2016 at College of Horticulture, Anantharajupeta, Dr. Y.S.R. Horticultural University, Andhra Pradesh. This location is at an elevation of 162 m (531 feet) above mean sea level lying between the $13^{0}59'$ North latitude

and 79^{0}19' East longitude. The total rainfall during growing season was 255 mm. The maximum and minimum temperatures ranged from 28.14 ^{0}C to 35.71 ^{0}C and 18.57 ^{0}C to 27.57 ^{0}C respectively. The relative humidity during the period of crop growth ranged between 33.14 to 99.71 %.

Planting material

The experiment was laid-out under a shade net in a randomized block design replicated thrice. In each replication, each genotype was grown in a single row of 6 m length with a spacing of 75 x 60 cm accommodating 10 plants in a replication. The experimental material (Table 1.) comprised of a set of 32 genotypes (30 accessions and 2 checks). Thirty genotypes were obtained from NBPGR, Regional Station, Thrissur and Jodhpur. The genotypes *viz*., Multistar RZ F1 and ICPCHI served as checks. The recommended fertilizer dose of N: P_2O_5:K_2O was applied at the time of field preparation at the rate of 400, 315 and 100 Kg ha^{-1} as calcium ammonium nitrate, single superphosphate, and muriate of potash, respectively. Seeds were sown in protrays initially, there after transplanted to beds on 15th day. Observations were recorded on vine length, No. of primary branches per plant, inter nodal length, No. of nodes per vine, node number at which first female flower appearance, days to first male & female flowering, days to 50% male & female flowering, days to first & last fruit harvest, fruit length, diameter, weight, No. of seeds per fruit, 100 seed weight, TSS, Carotenoid content, acidity, ascorbic acid, yield per plant, powdery mildew & aphid incidence in 10 random plants per treatment.

Genotypic and phenotypic correlation coefficients were calculated using the method given by Johnson *et al.* (1955) [6], by using analysis of variance and covariance matrix in which total variability has been split into replications, genotypes and errors. The genotypic and phenotypic correlation coefficients were used to find out their direct and indirect contributions towards yield per plot. The direct and indirect paths were obtained according to the method given by Dewey and Lu (1959) [6].

Table 1: List of cucumber genotypes along with their sources

S. No	Genotype	Accession No	Source/Place
1.	A1	SKY 613476	NBPGR, Thrissur, Kerala
2.	A2	SKY 613477	NBPGR, Thrissur, Kerala
3.	A3	SKY 613479	NBPGR, Thrissur, Kerala
4.	A4	SKY 613480	NBPGR, Thrissur, Kerala
5.	A5	SKY 613481	NBPGR, Thrissur, Kerala
6.	A6	SKY 613484	NBPGR, Thrissur, Kerala
7.	A7	SKY 613485	NBPGR, Thrissur, Kerala
8.	A8	KP 613474	NBPGR, Thrissur, Kerala
9.	A9	JJK 595518	NBPGR, Thrissur, Kerala
10.	A10	JS 541367	NBPGR, Thrissur, Kerala
11.	A11	JR 469517	NBPGR, Thrissur, Kerala
12.	A12	JB 595504	NBPGR, Thrissur, Kerala
13.	A13	JB 613462	NBPGR, Thrissur, Kerala
14.	A14	JB 613488	NBPGR, Thrissur, Kerala
15.	A15	JB 595508A	NBPGR, Thrissur, Kerala
16.	A16	JB 613470	NBPGR, Thrissur, Kerala
17.	A17	JB 595510	NBPGR, Thrissur, Kerala
18.	A18	JB 618083	NBPGR, Thrissur, Kerala
19.	A19	JB 595512	NBPGR, Thrissur, Kerala
20.	A20	JB 618084	NBPGR, Thrissur, Kerala
21.	A21	IC 567558-2	NBPGR, Jodhpur, Rajasthan
22.	A22	IC 321367	NBPGR, Jodhpur, Rajasthan
23.	A23	IC 567558-3	NBPGR, Jodhpur, Rajasthan
24.	A24	IC 321370	NBPGR, Jodhpur, Rajasthan
25.	A25	IC 567558-4	NBPGR, Jodhpur, Rajasthan
26.	A26	IC 321375	NBPGR, Jodhpur, Rajasthan
27.	A27	IC 567558-1	NBPGR, Jodhpur, Rajasthan
28.	A28	IC 567558-5	NBPGR, Jodhpur, Rajasthan
29.	A29	IC 321379	NBPGR, Jodhpur, Rajasthan
30.	A30	IC 550207	NBPGR, Jodhpur, Rajasthan
31.	A31	ICPCHI	F1 Hybrid
32.	A32	Multistar RZ F1	Rijk Zwaan

Results and Discussion

Correlation studies

The correlation coefficients among different characters were worked out both at phenotypic and genotypic levels (Table 2). It was observed that genotypic correlation coefficients were higher than that of phenotypic correlation coefficients for most of the characters studied in the present investigation. This could be interpreted on the basis that there was strong inherent genotypic relation between the characters studied, but the phenotypic expression was impeded by the influence of environmental factors.

Fruit yield per plant showed positive and significant correlation, phenotypically and genotypically with vine length, number of primary branches per vine, number of nodes per vine, number of fruits per plant, fruit length, fruit diameter, fruit weight, number of seeds per fruit, 100 seed weight and total soluble solids. The results indicated that vines with profuse branches, more number of nodes and yielding high number of fruits per plant would results in higher fruit yield per vine. These results are in agreement with the findings of Arunkumar *et al.*, 2011 [8].

A significantly negative correlation genotypic and phenotypic level was observed with inter nodal length, days to 50% first female flower, aphid incidence and powdery mildew incidence. These results are in agreement with Sandeep *et al.*, 2011 [9] and Golabadi *et al.*, 2013 [10]. Number of fruits per plant had significant positive correlation with number of primary branches per plant, and number of nodes per vine and 100 seed weight. While significantly negative correlation with aphid incidence and powdery mildew incidence. Fruit length had positive correlation with fruit diameter and fruit weight. While significantly negative correlation with, total soluble solids, ascorbic acid and aphid incidence. The same was proved by Afangide *et al.*, 2007 [11]. Fruit weight had significantly positive correlation with number of seeds per fruit and acidity. The same results were reported by Chikezie *et al.*, 2016 [12]. Ascorbic acid had positively correlated with number of nodes per vine, total soluble solids. While negatively correlated with vine length, fruit length, aphid incidence. Similar findings were also reported by Tomar *et al.*, 2008 [13] in muskmelon.

Table 2: Correlation coefficients among 24 characters in cucumber

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	1.00																								
2	0.14	1.00																							
3	-0.12	-0.37	1.00																						
4	-0.28	-0.23	0.48	1.00																					
5	0.37	0.25	0.22	-0.17	1.00																				
6	0.54	-0.09	-0.19	0.03	0.29	1.00																			
7	0.50	-0.10	-0.18	0.02	0.29	0.02	1.00																		
8	0.52	-0.09	-0.16	0.03	0.22	0.03	0.72	1.00																	
9	0.55	-0.10	-0.18	0.02	0.30	0.01	0.92	0.93	1.00																
10	0.57	-0.08	-0.15	0.01	0.31	0.98	0.99	0.98	0.99	1.00															
11	0.61	-0.06	-0.11	0.05	0.27	0.94	0.93	0.92	0.94	0.98	1.00														
12	0.33	0.19	0.00	-0.15	0.26	0.29	0.30	0.32	0.30	0.24	0.20	1.00													
13	0.20	0.27	0.14	0.02	0.25	0.20	0.21	0.23	0.19	0.19	0.18	0.84	1.00												
14	0.13	0.29	0.03	-0.25	0.06	-0.04	-0.04	-0.03	-0.04	0.02	0.05	-0.11	-0.11	1.00											
15	-0.04	0.18	-0.31	-0.27	-0.09	0.16	0.10	0.13	0.13	0.10	0.02	0.17	-0.04	0.32	1.00										
16	-0.24	0.81	-0.30	0.19	-0.05	-0.47	-0.46	-0.43	-0.48	-0.44	-0.39	-0.12	-0.07	0.50	0.29	1.00									
17	0.26	0.25	0.22	-0.06	0.44	0.13	0.15	0.14	0.15	0.12	0.09	0.28	0.07	-0.04	-0.08	0.11	1.00								
18	0.41	0.21	0.20	0.12	0.41	0.16	0.16	0.16	0.16	0.16	0.15	0.49	0.39	-0.30	0.11	0.10	0.33	1.00							
19	-0.24	-0.41	0.24	0.32	-0.28	-0.40	-0.39	-0.38	-0.39	-0.33	-0.34	-0.12	-0.07	-0.24	-0.04	-0.05	-0.05	-0.21	1.00						
20	0.26	0.10	-0.04	0.01	0.02	0.04	0.06	0.05	0.06	0.11	0.16	-0.19	0.13	-0.21	-0.36	-0.14	0.24	-0.11	-0.10	1.00					
21	-0.29	0.15	0.14	0.16	-0.11	-0.52	-0.50	-0.50	-0.50	-0.42	-0.38	-0.19	0.18	-0.26	-0.10	0.22	-0.27	-0.08	0.48	-0.02	1.00				
22	-0.26	-0.08	-0.13	0.36	0.01	0.14	0.16	0.16	0.15	0.18	0.13	-0.28	-0.02	-0.33	-0.18	-0.07	-0.03	-0.36	0.33	0.23	0.23	1.00			
23	-0.30	-0.35	0.05	0.47	-0.42	-0.17	-0.16	-0.17	-0.17	-0.10	-0.06	-0.24	-0.14	-0.22	-0.25	-0.13	-0.17	-0.24	0.57	0.11	0.39	0.31	1.00		
24	-0.13	0.01	-0.09	-0.09	-0.06	-0.02	-0.01	-0.02	-0.01	-0.02	-0.09	0.26	0.26	-0.04	-0.04	-0.07	0.07	-0.06	-0.07	-0.11	-0.16	-0.05	-0.33	1.00	
25	0.27	0.76	-0.18	0.13	0.01	-0.19	-0.20	-0.17	-0.20	-0.18	-0.18	0.30	0.50	0.37	0.32	0.92	0.06	0.25	0.22	0.13	0.15	0.05	-0.80	-0.89	1.00

*significant at p=0.05, ** significant at p=0.01

1. Vine Length (cm)
2. Number of primary branches per plant
3. Inter nodal length (cm)
4. Number of nodes per vine
5. Node number at which first female flower appearance
6. Days to first male flowering
7. Days to first female flowering
8. Days to 50% male flowering
9. Days to 50% female flowering
10. Days to first fruit harvest
11. Days to last fruit harvest
12. Number of fruits per plant
13. Fruit length (cm)
14. Fruit diameter (cm)
15. Fruit weight (g)
16. Number of seeds per fruit
17. 100 Seed weight (g)
18. TSS (0 Brix)
19. Carotenoids (µg/100 g)
20. Acidity (%)
21. Ascorbic Acid (mg/100 g fresh fruit weight)
22. Aphids incidence
23. Powdery mildew incidence
24. Yield/vine (kg)

Path coefficient analysis

Path coefficient analysis furnishes a means of measuring the direct and indirect effects of a variable through other variables on the end product. Yield being a complex and polygenic character, direct selection for yield may not be reliable approach because it is highly influenced by environmental factors. Therefore, it becomes essential to identify the component characters, through which yield improvement could be identified. Though correlation gives information about the components of complex character like yield, it will not provide an exact picture of relative importance of the direct and indirect contribution of the component characters to yield. The technique of path coefficient analysis involves a method of partitioning the total correlation between the dependent variable and the independent component variable *i.e.*, direct effect of independent variable and its indirect effect via third variable on the dependent variable.

Hence, path analysis is an important tool for partitioning the correlation coefficients into direct and indirect effects of independent variable and dependent variables. Thus, correlations in combination with path analysis would give a better insight into cause and effect relationship between different pairs of characters. Direct and indirect effects of plant characters on yield in different cucurbits were reviewed briefly here under.

Direct effect on yield

Number of fruits per plant (Table 3), fruit weight number of primary branches per plant, fruit length, 100 seed weight, number of seeds per fruit, days to last fruit harvest, fruit diameter and number of nodes per vine, have direct positive phenotypic and genotypic effect on yield. The results are in line with the findings of Arunkumar *et al.*, 2011 [8] and Chikezie *et al.*, 2016 [12]. The traits *viz.*, vine length, internodal length, node number at which first female flower appears, days to first fruit harvest and days to first male flowering have negative direct effect on yield. The same

results were proved by Arunkumar *et al.,* 2011 [8] and Sandeep *et al.,* 2011 [9] in cucumber.

Table 3: Path coefficient analysis showing direct and indirect effect of 15 characters on fruit yield in cucumber

S. No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	-0.022	0.588	0.326	-0.040	-0.811	-0.803	-0.160	-0.062	0.509	0.048	0.276	0.121	-0.414	0.089	0.797	0.331
2	-0.020	0.623	0.210	-0.012	-0.186	0.088	0.247	0.019	-0.092	0.111	0.318	0.158	0.194	0.148	0.133	0.464
3	0.012	0.300	-0.585	0.022	-0.140	0.001	0.574	0.043	-0.178	0.041	0.106	-0.256	-0.808	0.136	0.133	-0.251
4	0.030	0.448	-0.439	0.030	0.247	-0.779	-0.135	-0.015	0.114	-0.045	-0.555	-0.317	0.851	-0.047	0.128	0.235
5	-0.056	-0.619	-0.075	-0.007	-0.089	-0.182	-0.877	-0.081	0.393	0.091	0.222	0.001	-0.123	0.250	0.252	0.118
6	-0.079	0.237	0.105	0.001	-0.273	-0.667	-0.230	-0.470	0.437	0.080	0.015	0.108	-0.169	0.080	0.105	-0.198
7	-0.076	0.281	0.105	0.001	-0.300	-0.890	-0.187	0.275	0.454	0.083	-0.026	0.078	-0.234	0.089	0.103	-0.241
8	-0.083	0.254	0.090	0.002	-0.319	-0.237	-0.153	-0.278	0.533	0.068	0.030	0.080	-0.144	0.073	0.106	-0.188
9	-0.091	0.214	0.067	0.002	-0.274	-0.364	-0.972	-0.273	0.259	0.063	0.035	0.020	-0.045	0.057	0.098	-0.153
10	-0.082	-0.444	0.287	-0.005	-0.359	-0.778	-0.958	-0.068	0.354	0.824	-0.083	-0.143	-0.219	0.068	0.358	0.653
11	-0.005	-0.020	-0.055	-0.015	-0.215	-0.219	0.073	-0.007	0.048	-0.020	0.529	0.196	0.172	-0.014	-0.189	0.371
12	-0.003	-0.700	0.183	-0.012	-0.001	-0.202	-0.303	-0.027	0.038	-0.049	0.271	0.472	0.766	-0.051	0.071	0.323
13	0.036	-0.988	0.178	0.010	0.050	0.325	0.479	0.119	-0.612	-0.023	0.498	0.235	0.580	0.064	0.066	0.568
14	-0.039	-0.890	-0.132	-0.002	-0.452	-0.198	-0.472	-0.033	0.148	0.031	-0.025	-0.069	0.282	0.103	0.219	0.068
15	-0.060	-0.737	-0.119	0.006	-0.421	-0.687	-0.504	-0.045	0.234	0.152	-0.327	0.089	0.267	0.202	0.154	0.255

*significant at p=0.05, ** significant at p=0.01

1. Vine Length (cm)
2. Number of primary branches per plant
3. Inter nodal length (cm)
4. Number of nodes per vine
5. Node number at which first female flower appears
6. Days to first male flower appears
7. Days to first female flower appears
8. Days to first fruit harvest
9. Days to last fruit harvest
10. Number of fruits per plant
11. Fruit length (cm)
12. Fruit diameter (cm)
13. Fruit weight (g)
14. Number of seeds per fruit
15. 100 Seed weight (g)
16. Fruit yield/vine (kg)

Fruit weight (g)

Fruit weight had positive indirect effect on yield through number of primary branches per plant, number of nodes per vine, fruit length and fruit diameter, number of seeds per fruit and 100 seed weight. The fruit weight exhibited the negative indirect effect on fruit yield per vine through vine length, inter nodal length, node number at which first female flower appears, days to first male flowering, days to first female flowering, days to first fruit harvest, days to last fruit harvest and number of fruits per plant. Similar findings were also reported by Arunkumar *et al.,* 2011 [8] and Kumar *et al.,* 2008 [14] in cucumber.

Conclusion

In this study, genotypic correlation was higher than phenotypic correlations indicating the highly heritable nature of the traits. It was observed that number of fruits per plant has exhibited highly significant positive association with fruit yield per plant followed by fruit weight, number of primary branches per plant, fruit length and vine length. Direct selection based on these traits would improve yield. The path coefficient analysis revealed that the number of fruits per plant, fruit weight, number of primary branches per plant, fruit length, 100 seed weight, number of seeds per fruit, days to last fruit harvest, fruit diameter and number of nodes per vine have direct positive phenotypic and genotypic effect on yield. These findings showed that direct selection on the basis of above characters will be rewarding for crop improvement in cucumber.

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