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Correlation coefficient analysis of yield and yield attributing traits of Cucumber (*Cucumis sativus* L.) genotypes

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Abstract
The present investigation was conducted to assess nature and magnitude of association among yield and its yield attributing traits. The experiment was conducted at Vegetable Research Farm of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar during *kharif* season 2019 comprising twenty-one genotypes. Correlation studies revealed that the fruit yield per plant had significant positive genotypic and phenotypic correlation with average fruit weight, number of fruits per plant, number of primary branches and fruit diameter where none of the character showed significant negative correlation with fruit yield per plant. Path coefficient study revealed that traits such as average fruit weight and number of fruits per plant exhibited high and positive direct effect while, number of primary branches per plant and fruit diameter positive indirect effect via number of fruits per plant and average fruit weight, suggesting that during course of selection emphasis should be given to number of fruit per plant and average fruit weight traits to enhance the fruit yield per plant of cucumber.

Keywords: Cucumber, correlation, cucumber, character association, direct, indirect

Introduction
Cucumber is one of India's most commercial growing vegetable crops belongs to cucurbitaceous family (Lower and Edward, 1986) [11]. It is originated from Southern Himalayan foothills. *Cucumis sativus var. hardwickii* is the progenitor of cultivated cucumber (Kumar *et al*., 2018). It is the most economic and dietic important crop. It is cultivated for tender fruit that provided as raw or salad (Arun kumar *et al*., 2011) [2], cooked as a vegetable, in immature stage as pickling. Regarding growth habit, cucumber is an annual monocious vine with a climbing nature. It has been extensively cultivating in tropical as well as subtropical portion of the country. However, it can successfully grow in both rainy as well as summer seasons (Rastogi, 1998) [17]. Cucumber is susceptible to thermophilic and frost, and prefers warm weather with bright sunlight, usually, it prefers a temperature of above 20ºC for better growth and development (Sharma *et al.,* 2018) [18]. However, it can be grown at the temperature range of 18-30 ºC. Cucumber is day-neutral vine with an angled, hirsutus or rough stem. Leaves are triangular-ovate, three-lobed with acute curves. Staminate flowers are in clusters and short slender pedicels (Preethi *et al*., 2019) [15]. Solitary pistilate flowers with stout short pedicels. The monocious cucumber mainly has three-phase of sex expression, only staminate flowers produced in first phase then irregular alternating female flowers, male or mixed nodes, and final phase with only pistillate flowers . Knowledge and degree of association of yield with yield attributing traits is of great importance in selecting suitable plant type, because yield being a complex character may govern by number of interaction of number of component character among them. Therefore, it becomes difficult to evaluate yield directly. Although correlation studies are helpful to determine the component of yield but it does not provide clear picture of nature and extent of contribution made by number of component traits. Path coefficient helpful in partitioning the correlation component due to direct and indirect effect. 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.

Materials and Methods
The present investigation was carried out at Vegetable Research Farm RPCAU, Pusa Bihar

located at a longitude of 85.67^0 E, latitude of 25.98^0 N and at an altitude of 52.0 meter above mean sea level. Pusa's soil consists mainly alluvial and calcareous, deep light to heavy in texture with CaCo3 exceeding 10% up to 30%. The materials for study had twenty-two genotypes of cucumber including Pusa Bharka the check variety. The genotypes were gathered from the IARI New Delhi, IIVR Varanasi as well as CSAUAT Kanpur. Genotypes of cucumber were raised in a Randomized Block Design (RBD) with three replications. All recommended package of practices were followed during the crop production.

Table 1: List of genotypes and their source of collection

Sr. No.	Name of genotype	Source of Collection
1.	Punjab Naveen, Kanpur Local, Kalyanpur Long Green, Barsati Local, Barsa Rani, Pusa UdayDC-821, Mirpur Local, Baropata, PCUC-8, Swarna Ageti, Pusa Barkha	IARI, Pusa, New Delhi
2.	Barsati-012, Japanese Green Long, Mahatana, Kheera-M-40, Cucumber Summer Long-45, Swarna Sheetal DC-78, Raja (Golden)	C.S. Azad Univ. of Agri. & Tech., Kanpur
3.	Phule Subhangi, Dev Kamal, Seven Star	IIVR, Varanasi

Five plants at random were taken from each plot for recording the observations of vine length at final harvesting (cm), number of primary branches per plant, inter nodal length (cm), node number at which first female flower appeared, appearance of first male flower (days), appearance of first female flower (days), days to first fruit harvesting, number of fruits per plant, fruit length (cm), fruit diameter (cm), average fruit weight (g), shelf life and fruit 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) [13]. The correlation coefficients were resulted at both genotypic and phenotypic levels between pair of traits together with the adopting following formula was given by Al-Jibouri *et al.*, 1958 [1]. Path coefficients were obtained using phenotypic correlation coefficient given by Deway and Lu (1959) [5].

Table 2: Genotypic and Phenotypic correlation coefficient for thirteen characters in cucumber

Characters		VL	INL	NNFF	NPB	FMF	FFF	DFH	SL	FL	FD	NF/P	AFW	FY/P
VL(cm)	G	1	0.185	-0.244	0.476	-0.163	0.134	-0.184	0.305	0.592	0.498	0.38	0.461	0.609
	P	1	0.087	-0.203	0.336	-0.079	-0.106	-0.075	0.320	0.433*	0.300	0.077	0.274	0.284
INL (cm)	G		1	0.22	-0.375	0.158	0.137	0.065	-0.169	0.294	-0.155	-0.206	-0.316	-0.365
	P		1	0.176	-0.268	0.057	0.060	0.034	-0.052	0.250	-0.026	-0.158	-0.205	-0.244
NNFF	G			1	-0.188	0.682	0.882	0.94	0.149	0.162	-0.292	0.251	-0.344	-0.193
	P			1	0.160	0.379	0.394	0.454*	0.094	0.142	-0.224	0.166	-0.262	-0.137
NPB	G				1	-0.284	0.036	-0.123	0.201	0.455	0.444	0.647	0.661	0.884
	P				1	-0.051	0.117	-0.138	0.147	0.381	0.302	0.388	0.450*	0.574
FMF (days)	G					1	0.965	0.971	-0.021	0.136	0.12	0.417	-0.157	0.075
	P					1	0.622*	0.405	-0.112	0.038	-0.009	0.155	-0.082	0.019
FFF (days)	G						1	0.982	0.12	0.209	0.098	0.793	-0.01	0.366
	P						1	0.320	-0.100	0.145	0.139	0.234	-0.050	0.095
DFH(days)	G							1	0.087	0.122	0.103	0.343	0.002	0.175
	P							1	0.033	-0.011	0.063	0.242	-0.111	0.035
SL (days)	G								1	0.475	0.572	0.452	0.581	0.736
	P								1	0.362	0.401	0.058	0.337	0.301
FL (cm)	G									1	0.487	0.129	0.542	0.503
	P									1	0.409	0.061	0.397	0.339
FD (cm)	G										1	0.335	0.627	0.681
	P										1	0.145	0.439*	0.430*
NF/P	G											1	0.044	0.54
	P											1	0.041	0.613**
AFW (g)	G												1	0.862
	P												1	0.809**
FY/p(kg)	G													1
	P													1

VL = Vine Length, INL= Inter nodal Length, NNFF= Node number at which first female flower appeared, NPB= Number of primary branches per plant, FMF= Appearance of first male flower, FFF = Appearance of first female flower, DFH= Days to first fruit harvesting, SL= Shelf life, FL= Fruit length, FD= Fruit diameter, NF/P= Number of fruits per plant, AFW= Average fruit weight, FY/P = Fruit yield per plant

Table 3: Genotypic path coefficient analysis of twelve characters on fruit yield in cucumber

Characters	VL	INL	NNFF	NPB	FMF	FFF	DFH	SL	FL	FD	NF/P	AFW	FY/P
Vine length at final harvest (cm)	0.012	0.000	0.016	-0.054	0.002	0.004	0.005	-0.004	0.012	-0.038	0.228	0.426	0.609
Inter nodal length (cm)	0.002	-0.001	-0.014	0.043	-0.002	0.005	-0.002	0.002	0.006	0.012	-0.124	-0.292	-0.365
Node number at which first female flower appeared	-0.003	0.000	-0.064	0.021	-0.008	0.029	-0.025	-0.002	0.003	0.022	0.151	-0.318	-0.193
Number of primary branches per plant	0.006	0.000	0.012	-0.113	0.003	0.001	0.003	-0.002	0.009	-0.034	0.388	0.611	0.884
Appearance of first male flower (days)	-0.002	0.000	-0.044	0.032	-0.011	0.046	-0.044	0.000	0.003	-0.009	0.250	-0.146	0.075
Appearance of first female flower (days)	0.002	0.000	-0.056	-0.004	-0.016	0.033	-0.054	-0.001	0.004	-0.007	0.475	-0.009	0.366
Days to first fruit harvesting	-0.002	0.000	-0.060	0.014	-0.019	0.068	-0.026	-0.001	0.003	-0.008	0.206	0.002	0.175
Shelf life (days)	0.004	0.000	-0.010	-0.023	0.000	0.004	-0.002	-0.012	0.010	-0.044	0.271	0.537	0.736
Fruit length (cm)	0.007	0.000	-0.010	-0.052	-0.002	0.007	-0.003	-0.006	0.020	-0.037	0.077	0.501	0.503
Fruit diameter (cm)	0.006	0.000	0.019	-0.050	-0.001	0.003	-0.003	-0.007	0.010	-0.076	0.201	0.579	0.681
Number of fruits per plant	0.005	0.000	-0.016	-0.073	-0.005	0.026	-0.009	-0.005	0.003	-0.026	0.599	0.041	0.540
Average fruit weight (g)	0.006	0.000	0.022	-0.075	0.002	0.000	0.000	-0.007	0.011	-0.048	0.027	0.925	0.862

R square = 0.9973, Residual effect = 0.0516

Bold values show direct and normal values shows indirect effects

Table 4: Phenotypic path coefficient analysis of twelve characters on fruit yield in cucumber

Characters	VL	INL	NNFF	NPB	FMF	FFF	DFH	SL	FL	FD	NF/P	AFW	Y/P
Vine length at final harvest (cm)	0.029	0.001	0.006	-0.006	0.000	-0.002	0.002	0.003	-0.007	-0.003	0.046	0.215	0.284
Inter nodal length (cm)	0.003	0.012	-0.005	0.005	0.000	0.001	-0.001	-0.001	-0.004	0.000	-0.094	-0.161	-0.244
Node number at which first female flower appeared	-0.006	0.002	-0.029	0.003	0.000	0.009	-0.009	0.001	-0.002	0.002	0.098	-0.206	-0.137
Number of primary branches per plant	0.010	-0.003	0.005	-0.018	0.000	0.003	0.003	0.002	-0.006	-0.003	0.230	0.353	0.574**
Appearance of first male flower (days)	-0.002	0.001	-0.011	0.001	-0.001	0.014	-0.008	-0.001	-0.001	0.000	0.092	-0.064	0.019
Appearance of first female flower (days)	-0.003	0.001	-0.011	-0.002	0.000	0.023	-0.007	-0.001	-0.002	-0.001	0.139	-0.039	0.095
Days to first fruit harvesting	-0.002	0.000	-0.013	0.003	0.000	0.007	-0.020	0.000	0.000	-0.001	0.148	-0.087	0.035
Shelf life (days)	0.009	-0.001	-0.003	-0.003	0.000	-0.002	-0.001	0.011	-0.006	-0.004	0.035	0.265	0.301
Fruit length (cm)	0.013	0.003	-0.004	-0.007	0.000	0.003	0.000	0.004	-0.016	-0.004	0.036	0.312	0.339
Fruit diameter (cm)	0.009	0.000	0.006	-0.006	0.000	0.003	-0.001	0.004	-0.007	-0.009	0.086	0.345	0.430*
Number of fruits per plant	0.002	-0.002	-0.005	-0.007	0.000	0.005	-0.005	0.001	-0.001	-0.001	0.593	0.032	0.613**
Average fruit weight (g)	0.008	-0.002	0.008	-0.008	0.000	-0.001	0.002	0.004	-0.007	-0.004	0.025	0.785	0.809**

R square = 0.9923, Residual effect = 0.0877

Bold values show direct and normal values shows indirect effects

Results and Discussions

The correlation - coefficient for thirteen characters was recorded for both genotypic and phenotypic level and depicted in Table: 2. In general, the genotypic correlation coefficients were higher in magnitude than phenotypic correlation coefficients demonstrating that the observed relationships were due to genetic causes *i.e.* linkage or pleotropic effect. These finding is accordance with Dhiman and Chander, 2005 [6]; Parihar *et al*., 2007 [14]; Tomar *et al*., 2008 [20].

As yield is a complex character governs by many genes, therefore the influence of each character on yield could be known through correlation studies pertaining among yield and yield attributing traits. Fruit yield per plant have positive and significant correlation with number of primary branches per plant (0.574), fruit diameter (0.430), numbers of fruit pre plant (0.613) and average fruit weight (0.809). None of the characters showed negative significant correlation with yield. Average fruit weight has positive significant phenotypic correlation coefficient with number of primary branches per plant (0.450) and fruit diameter (0.439). Fruit length has significant positive phenotypic correlation with intermodal length (0.433) whereas; days to first harvest have positive significant phenotypic correlation with the character node number at which first female flower appeared (0.454). Appearance of first female flower is highly correlated with appearance of first male flower (0.622) as male flower came to the plant earlier than female flower. Such findings resulted that selection for any one of the above characters would bring in concurrent enhancement of other characters and eventually improve the fruit yield in cucumber. These finding is validation with Deepthi *et al*., 2016 [4]; Kumar *et al*., 2018 [9]; Sharma *et al*., 2018 [18]. The inter-relationship between yield and yield contributing characters were disturbing the selection for components traits either in favorable or unfavorable direction. Selection of superior genotypes based on yield as such may not be effective for the enhancement of yield and hence selection should be made for component traits. Path coefficient analysis helps in understanding magnitude of direct and indirect contribution of each character on the dependant character (Pramila *et al*., 2023) [16]. Hence Path coefficient analysis gives an idea about the contribution of each component character on the yield. Since the mutual relationship of component characters might vary both in magnitude and direction, it may tend to vitiate the association of fruit yield with other attributes. Therefore, it is necessary to partition the correlation into direct and indirect effects of each other. Both genotypic and phenotypic Path coefficients are showed in Table 3 & Table 4 respectively.

The studies revealed that positive direct effect was reported by the traits such as average fruit weight (0.785) followed by number of fruits per plant on the fruit yield per plant (0.593). Similar finding is agreement with Sundaram, 2010 [19]; Gupta *et al.*, 2015 [7]. The negative direct effect recorded by number of primary branches per plant (-0.018) with the high positive indirect effect was exhibited by average fruit weight (0.785) as well as number of fruits per plant while the fruit diameter also recorded negative direct effect (-0.009) whereas high positive indirect effect was exhibited by average fruit weight (0.345) followed by number of fruit per plant (0.086). These

findings were validation with Kumari *et al.*, 2018 [10]; Pal *et al.*, 2017 [12]; Karthik *et al.*, 2019 [8].

Conclusion

The fruit yield per plant had significant phenotypic positive correlation with number of primary branches per plant, fruit diameter, numbers of fruit pre plant and average fruit weight. According to this result the genotypes which are all having with maximum number of primary branches per plant, maximum fruit diameter, maximum numbers of fruit pre plant and high average fruit weight have to be selected for eventually increase in yield . The traits such as average fruit weight and number of fruits per plant have positive direct effect on yield per plant. Thus indicating that direct selection for yield improvement in cucumber can be performed.

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