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GENETIC VARIABILITYAND CHARACTER ASSOCIATION IN PARTHENOCARPIC CUCUMBER (*CUCUMIS SATIVUS* L.) UNDER PROTECTED CULTIVATION

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ABSTRACT

An investigation was done with 22 genotypes and 1 check variety (KPCH-1) of parthenocarpic cucumber, with the objective to study the genetic variability, correlation and path analysis of yield and yield contributing traits. The magnitude of PCV was higher than GCV for all the characters taken under the study. Higher heritability coupled with high genetic advance as per mean was observed in number of flowers per node followed by ascorbic acid, total soluble solid, number of nodes per vine, thickness of flesh, inter-nodal length and node to first flower. Yield per vine was significantly and positively correlated with number of fruits per vine, average fruit weight, and number of nodes per vine, number of flowers per node, span of harvest, fruit length and ascorbic acid at phenotypic and genotypic levels. Path coefficient analysis revealed vine length had maximum direct effect towards yield per vine followed by number of flowers per node, ascorbic acid, node to first flower, span of harvest, days to first flower, shelf life and number of fruits per vine.

Keywords: Parthenocarpic cucumber, genetic variability, heritability, correlation, path analysis

Introduction

Cucumber (*Cucumis sativus* L.) commonly known as khira in India. It is an important member of the family cucurbitaceae and believed to be originated in Himalayan foothills. Cucumber is commercially grown throughout India ranging from North Western Himalayan region to Southern peninsular region. The immature fruit are rich source of carbohydrates, Ca, P and vitamin C yield is a complicated variable governed by genetic factors that interact with the environment. The rate of success in any crop improvement breeding programme is defined by the genetic variability present in the population and the selection of the desired one. For efficient selection, it is necessary to investigate the nature of desired characters' associations with other characters, as well as their genetic variability. Path coefficient provides a better index for selection than correlation coefficient, thereby partitioning correlation coefficient into direct and indirect effects of different characters. It gives idea about the contribution of each independent character on dependent character i.e. yield. Therefore, the present study was undertaken to understand the nature and magnitude of variability, heritability, correlation coefficient and path analysis for different quantitative parameters in parthenocarpic cucumber.

Materials and Methods

The experiment was carried out at the Polyhouse complex of Department of Horticulture (Vegetable and Floriculture) Bihar Agricultural College, Bhagalpur, during spring-summer months of 2021. The experiment was laid out in 3 replications by Randomized Block Design on raised beds. Twenty-three genotypes of parthenocarpic cucumber including 1 check (KPCH-1) were used in experiment. The seeds were raised in pro trays to get healthy and uniform seedlings and 30 days old healthy seedlings were transplanted in double row planting (50 cm×50 cm) system at naturally ventilated polyhouse and the plant were trained on single trellis. The observations were recorded on five randomly selected plants in each replication for seventeen characters viz., days to first flower, node to first flower, number of flowers per node, inter-nodal length (cm), number of nodes per vine, days to first picking, span of harvest (days), average fruit weight (g), fruit length (cm), fruit diameter (cm), thickness of flesh (cm), number of fruits per vine, yield per vine (kg), vine length (cm) at last harvest, TSS (^{0}Brix), ascorbic acid (mg/100 g), shelf life (days).The phenotypic correlation coefficients(PCV) and genotypic correlation coefficients (GCV), heritability (h^2bs) and genetic advance were computed as per recommended by Burton and de Vane (1953), Lush (1940) and Johnson *et al.* (1955). Coefficients correlation measures the degree of association among two or more variables were computed as given by Al-Jibouri *et al.* (1958).The path coefficient was analyzed as recommended by Dewey and Lu (1959).

Results and Discussion

The estimates of phenotypic and genotypic coefficients of variability play important part in predicting amount variation present in the genotypes taken under study. The magnitude of PCV was higher than GCV indicating presence of variation due to both genetic factors and environmental factor in present investigation, Similar result was observed by Choudhary *et al.* (2015), Singh *et al.* (2017), Shah *et al.* (2018), Karthick *et al.* (2019) and Mehta (2020) also found higher PCV estimates than GCV in yield and its contributing characters. Estimates of different parameters of variability for seventeen characters in parthenocapic cucumber has been presented in Table 1. High level of GCV and PCV were recorded for number of flowers per node which indicate ample scope for enhancement through simple selection. Similar finding was reported by Singh *et al.* (2017) and Mehta P (2020).

Table 1 : Estimates of different parameters of variability for seventeen characters in parthenocapic cucumber

Characters	Range	GM	PCV	GCV	Heritability (%)	Genetic Advance	Genetic Advance as % of mean
Days to first flower	26.80-32.93	29.87	7.59	5.18	46.59	2.18	7.28
Node to first flower	3.27-4.80	4.15	13.04	11.38	76.09	0.85	20.45
Number of flowers per node	1.00-2.20	1.64	21.80	20.76	90.64	0.67	40.71
Days to first picking	39.80-47.40	43.64	6.58	4.05	37.91	2.24	5.14
Average fruit weight(g)	119.73-143.07	128.03	6.48	4.84	55.73	9.53	7.44
Fruit length(cm)	14.77-20.73	16.80	9.80	8.46	74.61	2.53	15.06
Fruit diameter (cm)	3.02-3.90	3.46	7.15	5.45	58.20	0.30	8.57
Thickness of flesh(cm)	1.02-1.30	1.14	7.89	7.42	88.56	0.16	14.39
Number of nodes per vine	22.20-34.40	29.40	12.68	11.95	88.75	6.82	23.18
Vine length (m)	2.39-3.15	2.83	7.73	5.81	56.58	0.26	9.01
Inter-nodal length(cm)	7.22-11.78	10.03	12.93	11.80	83.26	2.23	22.18
Number of fruits per vine	25.60-31.47	28.24	7.22	4.26	34.74	1.46	5.17
Span of harvest (days)	48.47-58.67	53.01	6.36	4.88	59.03	4.10	7.73
Yield per vine (kg)	3.14-3.96	3.59	8.36	5.32	40.48	0.25	6.97
Total soluble solid(°Brix)	2.57-3.87	3.22	10.04	9.71	93.55	0.62	19.34
Ascorbic acid (mg/100 g)	1.97-3.26	2.48	13.97	13.70	96.25	0.69	27.69
Shelf life (days)	4.27-6.27	5.46	10.92	9.60	77.37	0.95	17.40

Heritability and advances were identified to be crucial for selection parameters. Genetic variation, together with heritability, would provide a more accurate assessment of selection efficiency. Heritability estimation becomes significant when genotypic coefficients of variation provide information about the amount of variation existing for a certain trait across genotypes. The heritability of a character is the percentage of its variability that is passed down to offspring. According to Johnson et al. (1955), heritability estimates were classed as low when less than 30%, moderate between 30 and 60%, and high when greater than 60%.

Estimates for heritability indicate the effectiveness with which selection can be expected for exploiting the existing genetic variability (Burton and Dewane, 1952). In this experiment high heritability was observed by ascorbic acid (96.25 %) followed by number of flowers per node (90.64 %), total soluble solid (89.75 %), number of nodes per vine (88.75 %), thickness of flesh (88.56 %),inter-nodal length (83.26 %), node to first flower (76.09 %), yield per vine (78.14 %), number of fruits per vine (78.01 %), shelf life (77.37 %) and fruit length (76.27 %). Earlier workers have also obtained similar results, *viz,* high heritability for fruit length, number of fruits per vine, node to first flower, and yield per vine (Pushpalatha *et al.* 2016; Singh *et al.* 2018; Shah *et al.* 2018 and Gangadhara *et al.* 2019), (Gaikwad *et al.* 2011; Pushpalatha *et al.* 2016 and Pal *et al.* 2017), shelf life and number of nodes per vine (Pushpalatha *et al.* 2016), ascorbic acid Singh *et al.* 2017), total soluble solid Ranjan *et al.* (2015), number of flowers per node Mehta (2020) and inter-nodal length Singh *et al.* (2018).

When the estimate of genetic advance accompanies heritability, then the prediction of genetic gain under selection is more accurate (Johnson *et al.,* 1955).The classification of genetic advance as per cent of mean has been given by (Johnson *et al.* 1955) as low, when less than 10%, moderate when 10-20% and high when greater than 20%.Higher heritability coupled with high genetic advance as % mean was observed in number of flowers per node (90.64 %, 40.71 %) followed by ascorbic acid (96.25 %, 27.69 %), total soluble solid (89.75 %, 22.35 %), number of nodes per vine (88.75 %, 23.18 %), thickness of flesh (88.56 %, 14.39 %),inter-nodal length (83.26 %, 22.18 %) and node to first flower (76.09 %, 20.45 %). Earlier similar result was observed for number of flowers per node by Mehta P (2020), ascorbic acid Singh *et al.* (2017), node to first flower (Ranjan *et al.* 2015;Gangadhara *et al.* 2019 and Karthick *et al.* 2019), inter-nodal length Singh *et al.* (2018) and number of node per vine (Pushpalatha *et al.* 2016 and Karthick *et al.* 2019). It was found that when high heritability is coupled with high genetic advance, additive gene action is responsible for the inheritance of these attributes, implying that the attributes can be improved by simple selection. Burton and De Vane (1953) proposed that genetic coefficients of variability, together with heritability estimates, may be used to predict the degree of improvement predicted by selection.

The understanding of the degree of interaction of yield with different yield contributing characteristics is vital since yield is not an independent character but rather the outcome of interactions between a number of characters as well as environmental interactions. Each character's phenotypic expression is determined by its genotype, environment, and their interaction with one another. Furthermore, each trait is likely to be influenced by the action of genes present in plant genotypes as well as by the environment, making it impossible to evaluate this complicated attribute directly. As a result, a correlation study of yield with various characteristics was performed to determine the yield factors that contributed. Correlation coefficient at genotypic (G) and phenotypic (P) level between yield and yield attributes for seventeen characters of twenty-three genotype of parthenocarpic cucumber shown in Table 2. Higher correlation values of genotypic correlation coefficients than their corresponding phenotypic correlation coefficients for most of the characters under investigation indicating high heritable nature of characters. Earlier similar finding was reported by Singh *et al.* (2017), Sharma *et al.* (2018), Karthick *et al.* (2019) and Manivannan *et al.* (2020). From the correlation table, the yield per vine showed positiveand significant correlation with number of fruits per vine (1.329, 0.703), average fruit weight (0.621, 0.368), number of nodes per vine (1.143, 0.645), number of flowers per node (1.159, 0.725), span of harvest (1.111, 0.544) at both genotypic and phenotypic level whereas inter-nodal length (-1.035, -0.662), days to first flower (-1.027, -0.426), node to first flower (-0.564, -0.277) and days to first picking (-0.993, -0.459) was significantly and negatively correlated at both genotypic and phenotypic level. Earlier studies observed a positive significant correlation of yield per vine with number of fruits per plant and average fruit weight (Depaa *et al*., 2018; Kumar *et al*., 2019 and Mehta, 2020) and for span of harvesting and number of nodes per vine Kumar *et al.* (2011) whereas negative significant correlation with days to first flower and days to first picking (Singh *et al*., 2018 and Rajawat *et al*., 2018) and inter-nodal length Mehta (2020). In order to understand effects of different independent characters or in combination with other characters on yield, path coefficient analysis gives clear idea about degree of association among the characters for performing selection process. Direct and indirect effect of different traits on yield per vine at genotypic (G) and phenotypic (P) level has been presented in Table 3. Number of flowers per node, ascorbic acid, shelf life, vine length and number of fruits per vine and span of harvest had positive direct effect towards yield per vine at both genotypic and phenotypic level. Earlier similar result was observed for number of fruits per vine (Ahirwar *et al*., 2017; Karthick *et al*., 2019 and Mehta, 2020). For number of flowers per node and vine lengthSingh *et al.* (2017) whereas for span of harvest Kumar *et al.* (2011). While Days to first picking, fruit length, number of nodes per vine and inter-nodal length had negative direct effect towards yield per vine.

Table 2: Correlation coefficients at genotypic (G) and phenotypic (P) levels among yield and yield attributes.

Character		Days to first flower	Node to first flower	Number of flowers per node	Days to first picking	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Thickness of flesh (cm)	Total soluble solid (°Brix)	Ascorbic acid (mg/100 g)	Shelf life (days)	Number of nodes per vine	Vine length (m)	Inter-nodal length (cm)	Number of fruits per vine	Span of harvest (days)
Node to first flower	G	0.412**															
	P	0.162															
Number of flowers per node	G	-0.830**	-0.416**														
	P	-0.614**	-0.328**														
Days to first picking	G	1.310**	0.407**	-0.827**													
	P	0.507**	0.207	-0.530**													
Average fruit weight (g)	G	-0.480**	-0.142	0.478**	-0.439**												
	P	-0.220	-0.064	0.377**	-0.366**												
Fruit length (cm)	G	-0.004	0.127	0.315**	-0.104	0.180											
	P	-0.004	0.081	0.244*	-0.068	0.078											
Fruit diameter (cm)	G	0.212	-0.130	-0.337**	-0.040	0.109	-0.496**										
	P	0.002	-0.041	-0.246*	-0.018	0.074	-0.316**										
Thickness of flesh (cm)	G	0.036	0.016	-0.219	-0.069	0.207	-0.385**	1.069**									
	P	0.087	-0.001	-0.199	-0.018	0.170	-0.339**	0.702**									
Total soluble solid (°Brix)	G	-0.411**	0.282*	0.152	-0.340**	-0.150	0.261*	-0.421**	-0.352**								
	P	-0.275*	0.260*	0.141	-0.157	-0.101	0.220	-0.310**	-0.326**								

Ascorbic acid (mg/100 g)	G	0.260*	0.169	-0.098	0.307*	0.357**	0.192	0.180	0.146	0.085							
	P	0.141	0.149	-0.087	0.188	0.274*	0.150	0.094	0.154	0.075							
Shelf life (days)	G	0.026	-0.049	-0.038	-0.211	-0.068	-0.377**	0.003	0.091	-0.475**	-0.324**						
	P	-0.043	-0.051	-0.040	0.019	-0.069	-0.259*	-0.007	0.059	-0.413**	-0.290*						
Number of nodes per vine	G	-0.763**	-0.295*	0.872**	-0.791**	0.398**	0.403**	-0.371**	-0.305*	0.202	-0.078	-0.086					
	P	-0.480**	-0.240*	0.766**	-0.477**	0.291*	0.320**	-0.271*	-0.242*	0.181	-0.085	-0.045					
Vine length (m)	G	-0.245*	-0.233	0.255*	-0.225	0.354**	0.248*	0.229	0.084	0.216	-0.060	-0.690**	0.371**				
	P	-0.086	-0.159	0.224	-0.211	0.159	0.102	0.126	0.047	0.150	-0.081	-0.400**	0.397**				
Inter-nodal length (cm)	G	0.715**	0.236	-0.872**	0.835**	-0.374**	-0.386**	0.500**	0.370**	-0.106	0.062	-0.14	-0.976**	-0.091			
	P	0.477**	0.206	-0.709**	0.340**	-0.250*	-0.314**	0.341**	0.290*	-0.094	0.050	-0.156	-0.831**	0.088			
Number of fruits per vine	G	-1.103**	-0.511**	1.252**	-1.083**	0.682**	0.264*	-0.317**	-0.280*	0.105	-0.215	0.062	1.120**	0.322**	-1.096**		
	P	-0.398**	-0.265*	0.669**	-0.374**	0.226	0.186	-0.217	-0.101	0.017	-0.102	0.043	0.580**	0.124	-0.597**		
Span of harvest (days)	G	-1.083**	-0.489**	0.910**	-1.131**	0.358**	0.114	-0.187	-0.105	0.270*	-0.325**	0.186	0.897**	0.235	-0.901**	1.028**	
	P	-0.567**	-0.400**	0.648**	-0.600**	0.082	0.129	-0.099	-0.103	0.206	-0.219	0.043	0.618**	0.132	-0.542**	0.585**	
Yield per vine (kg)	G	-1.027**	-0.564**	1.159**	-0.993**	0.621**	0.306*	-0.207	-0.209	0.066	-0.197	0.030	1.143**	0.474**	-1.035**	1.329**	1.111**
	P	-0.426**	-0.277*	0.725**	-0.459**	0.368**	0.185	-0.258*	-0.109	0.072	-0.065	0.040	0.645**	0.184	-0.662**	0.703**	0.544**

**Significance at $P \leq 0.01$; *Significance at $P \leq 0.05$,

Table 3 : Direct and indirect effect of different traits on yield per vine at genotypic (G) and phenotypic (P) level

Character		Days to first flower	Node to first flower	Number of flowers per node	Days to first picking	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Thickness of flesh (cm)	Total soluble solid (°Brix)	Ascorbic acid (mg/100 g)	Shelf life (days)	Number of nodes per vine	Vine length (m)	Inter-nodal length (cm)	Number of fruits per vine	Span of harvest (days)	r
Days to first flower	G	**0.126**	0.147	-0.798	-0.900	0.300	0.001	0.013	-0.017	0.249	0.148	0.003	2.374	-0.381	-1.841	-0.072	-0.378	-1.027**
	P	**0.067**	0.000	-0.165	-0.066	-0.019	0.000	0.000	0.011	-0.002	0.005	-0.002	0.291	-0.034	-0.356	-0.107	-0.050	-0.426**
Node to first flower	G	0.052	**0.357**	-0.400	-0.280	0.089	-0.030	-0.008	-0.007	-0.171	0.096	-0.006	0.917	-0.362	-0.608	-0.033	-0.171	-0.564**
	P	0.011	**0.002**	-0.088	-0.027	-0.005	-0.004	0.008	0.000	0.002	0.006	-0.003	0.145	-0.063	-0.153	-0.071	-0.035	-0.277*
Number of flowers per node	G	-0.105	-0.148	**0.961**	0.568	-0.299	-0.075	-0.021	0.102	-0.092	-0.055	-0.005	-2.713	0.397	2.245	0.082	0.318	1.159**
	P	-0.041	-0.001	**0.268**	0.069	0.032	-0.012	0.049	-0.025	0.001	-0.003	-0.002	-0.464	0.089	0.528	0.180	0.057	0.725**
Days to first picking	G	0.165	0.145	-0.795	**-0.687**	0.275	0.025	-0.003	0.032	0.206	0.175	-0.025	2.463	-0.351	-2.151	-0.071	-0.395	-0.993**
	P	0.034	0.000	-0.142	**-0.130**	-0.031	0.004	0.003	-0.002	-0.001	0.007	0.001	0.288	-0.084	-0.253	-0.100	-0.052	-0.459**
Average fruit weight (g)	G	-0.060	-0.051	0.460	0.301	**-0.626**	-0.043	0.007	-0.096	0.091	0.203	-0.008	-1.240	0.551	0.962	0.045	0.125	0.621**
	P	-0.015	0.000	0.101	0.048	**0.084**	-0.004	-0.015	0.021	-0.001	0.010	-0.004	-0.176	0.063	0.186	0.061	0.007	0.368**
Fruit length (cm)	G	-0.001	0.045	0.303	0.071	-0.113	**-0.238**	-0.031	0.179	-0.158	0.109	-0.045	-1.253	0.386	0.994	0.017	0.040	0.306*
	P	0.000	0.000	0.065	0.009	0.007	**-0.051**	0.063	-0.042	0.002	0.006	-0.014	-0.193	0.041	0.234	0.050	0.011	0.185
Fruit diameter (cm)	G	0.027	-0.047	-0.324	0.027	-0.068	0.118	**0.063**	-0.497	0.255	0.102	0.000	1.153	0.356	-1.288	-0.021	-0.065	-0.207
	P	0.000	0.000	-0.066	0.002	0.006	0.016	**-0.198**	0.088	-0.002	0.004	0.000	0.164	0.050	-0.254	-0.058	-0.009	-0.258*
Thickness of flesh (cm)	G	0.005	0.006	-0.210	0.047	-0.129	0.092	0.068	**-0.465**	0.213	0.083	0.011	0.949	0.131	-0.954	-0.018	-0.037	-0.209
	P	0.006	0.000	-0.053	0.002	0.014	0.017	-0.139	**0.125**	-0.002	0.006	0.003	0.146	0.019	-0.216	-0.027	-0.009	-0.109

Total soluble solid (°Brix)	G	-0.052	0.101	0.146	0.234	0.094	-0.062	-0.027	0.164	**-0.605**	0.048	-0.057	-0.628	0.337	0.273	0.007	0.095	0.066
	P	-0.018	0.000	0.038	0.020	-0.009	-0.011	0.061	-0.041	**0.007**	0.003	-0.023	-0.109	0.060	0.070	0.004	0.018	0.072
Ascorbic acid (mg/100 g)	G	0.033	0.060	-0.094	-0.211	-0.223	-0.046	0.011	-0.068	-0.051	**0.568**	-0.039	0.242	-0.094	-0.159	-0.014	-0.114	-0.197
	P	0.009	0.000	-0.023	-0.025	0.023	-0.008	-0.019	0.019	0.001	**0.037**	-0.016	0.051	-0.032	-0.037	-0.027	-0.019	-0.065
Shelf life (days)	G	0.003	-0.017	-0.037	0.145	0.042	0.090	0.000	-0.043	0.288	-0.184	**0.120**	0.269	-1.075	0.359	0.004	0.065	0.030
	P	-0.003	0.000	-0.011	-0.002	-0.006	0.013	0.001	0.007	-0.003	-0.011	**0.055**	0.027	-0.160	0.116	0.012	0.004	0.040
Number of nodes per vine	G	-0.096	-0.105	0.838	0.543	-0.249	-0.096	-0.024	0.142	-0.122	-0.044	-0.010	**-3.112**	0.577	2.515	0.073	0.314	1.143**
	P	-0.032	0.000	0.205	0.062	0.025	-0.016	0.054	-0.030	0.001	-0.003	-0.002	**-0.605**	0.158	0.619	0.156	0.054	0.645**
Vine length (m)	G	-0.031	-0.083	0.245	0.155	-0.222	-0.059	0.015	-0.039	-0.131	-0.034	-0.083	-1.154	**1.557**	0.235	0.021	0.082	0.474**
	P	-0.006	0.000	0.060	0.027	0.013	-0.005	-0.025	0.006	0.001	-0.003	-0.022	-0.240	**0.398**	-0.066	0.033	0.012	0.184
Inter-nodal length (cm)	G	0.090	0.084	-0.838	-0.573	0.234	0.092	0.032	-0.172	0.064	0.035	-0.017	3.039	-0.142	**-2.576**	-0.072	-0.315	-1.035**
	P	0.032	0.000	-0.190	-0.044	-0.021	0.016	-0.067	0.036	-0.001	0.002	-0.009	0.503	0.035	**-0.746**	-0.160	-0.047	-0.662**
Number of fruits per vine	G	-0.139	-0.183	1.204	0.744	-0.427	-0.063	-0.020	0.130	-0.064	-0.122	0.007	-3.486	0.501	2.823	**0.065**	0.359	1.329**
	P	-0.027	0.000	0.179	0.049	0.019	-0.010	0.043	-0.013	0.000	-0.004	0.002	-0.351	0.050	0.445	**0.269**	0.051	0.703**
Span of harvest (days)	G	-0.137	-0.175	0.875	0.777	-0.224	-0.027	-0.012	0.049	-0.164	-0.185	0.022	-2.792	0.366	2.320	0.067	**0.349**	1.111**
	P	-0.038	-0.001	0.174	0.078	0.007	-0.007	0.020	-0.013	0.001	-0.008	0.002	-0.374	0.053	0.405	0.157	**0.087**	0.544**

Significance at $P \leq 0.01$; *Significance at $P \leq 0.05$, Residual effect **(G) = 0.26117**; (P) =** 0.30243; the bold values indicate direct effects; G = Genotypic level and P = Phenotypic level; r = correlation coefficient with yield per vine

Earlier similar result was observed for days to first picking and inter-nodal length by Ahirwar *et al*. (2017) and Kumar *et al*. (2018). Singh *et al*. (2017) and Gangadhara *et al*. (2019) whereas for number of nodes per vine Karthick *et al*. (2019). Horticulture trait which has high positive direct effect on yield per vine under protected cultivation indicating true relationship with yield per vine and direct selection for such trait will be rewarding.

Conclusion

All the characters studied were significant, indicating that presence of genetic variability which can be exploited in crop improvement program. High level of PCV, GCV, heritability and genetic advance as of % mean found in number of flowers per node. Number of fruits per vine, average fruit weight, number of nodes per vine, number of flowers per node, span of harvest was highly significant and positively correlated with yield per vine. The path coefficient analysis revealed that the number of flowers per node, ascorbic acid, shelf life, vine length and number of fruits per vine and span of harvest 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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