Original Research Article

Character association and path coefficient studies in cucumber (*Cucumis sativus* L.)

ABSTRACT

Thirty two cucumber genotypes were collected from different states of India and were evaluated for yield and quality characters at Bhubaneswar, Odisha during Rabi season of 2019. The relationships between fruit yield and yield components in cucumber genotypes were investigated and correlation studies revealed that yield per plant had positive and significant association with vine length, number of fruits per plant, fruit length, fruit diameter and average fruit weight, while significant negative correlations were observed with node at which first female flower appears, number of days to first female flower production, days to first harvest and severity of downy mildew percentage both at phenotypic and genotypic levels. Path coefficient analysis revealed that fruit diameter had maximum positive direct effect on yield per plant followed by fruit length, number of fruits per plant, days to first harvest, average fruit weight while, negative direct effect of number of days to first female flower production and severity of downy mildew percentage was observed on yield per plant. Future breeding should focus on selecting the characters having direct effects to improve yield per plant.

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

Introduction

Cucumber (*Cucumis sativus* L.) is an important member of the family Cucurbitaceae, with a chromosome number 2n = 14, which comprises of 117 genera and 825 species in warmer parts of the world. *Cucumis sativus var. hardwickii* is progenitor of cultivated cucumber (Gopalakrishnan, 2007). It is considered to have been originated from India and China is believed to be the secondary center of diversity. Generally, the tender fruits are used as salad ingredient, as a desert and pickles, cooked as vegetables and eaten raw with salt and pepper. It is grown primarily for fresh market (slicing) as well as for processing (pickling). It provides cooling effect prevents constipation and is also used as an antipyretic and astringent. The seeds are rich in protein and edible oil which are helpful for development of brain and body smoothness (Bhagat *et al.*, 2018). Cucumber juice is important medicinal food in treatment of the hyperacidity, gastric and duodenum ulcer and also useful in jaundice. In addition to this, cucumber has soothing and softening properties of fruits that are important for the cosmetic and soap industries (Wang *et al.,* 2007). In India cucumber occupies 1,16,000 ha with a production of 16,08,000 MT (Indiastat, 2021-22). Inspite of the extensive cultivation and consumption cucumbers have not much been taken up for systematic research work in order to understand the genetic architecture and endeavor in crop improvement programs in India. In crop improvement it is mainly concentrated on increasing yield and yield attributing characters. A study of correlation between different quantitative characters provides an idea of association. It could be effectively exploited to formulate selection strategies for improving yield and quality. Correlation study does not reveal the direct and indirect contribution of individual character towards yield. In order to have clear picture of yield components for effective selection programme, it would be desirable to consider the relative magnitude of various characters contributing 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 under Odisha conditions.

Materials and Methods

The experiment was conducted at the experimental field of Department of Vegetable Science, OUAT, Bhubaneswar, Odisha. The experimental materials comprised of 32 genotypes of Cucumber viz., Special Macharsasa, Tejas, Nandini, Khirasagar, Varshamangalam, Sachin, Barsamongal, Barsha, Bharatmata, Pant khira – 1, Rain special, Duranta, Barsha mangalsasha, Gautam-910, Saptarishi, Green long S-82, 12 pata sasa, Shubra, Rajamata, Barsha Rani, Swarn Sheetal, Sagar, Banki local, Kalpataru Sasa improve, Gangothri, Green long, Adimata, Kheera haralamba, Basumathi, Barshalaxmi, Mahaprasad and Priya collected from different parts of India. The experimental was laid out in Randomized Block Design. All required cultural practices were followed to maintain uniform crop growth. Observations on 10 quantitative traits, viz., node at which first female flower appears, number of days to first female flower production, days to first harvest, fruit length (cm), fruit diameter (cm), average fruit weight (g), number of fruits per plant, vine length (m), severity of downy mildew (%) and fruit yield per vine (kg) were recorded during the experiment.

The genotypic and phenotypic correlations were calculated as per Al-Jibouri *et al.* (1958) by using analysis of variance and covariance matrix. The genotypic and phenotypic correlation coefficients were used to find out their direct and indirect contributions towards yield per plant. The direct and indirect paths were obtained according to the method given by Dewey and Lu (1959).

Results and Discussion

Correlation studies

The correlation coefficients among the different characters were worked out at phenotypic and genotypic levels (Table 1). In general, the genotypic correlation coefficients were higher in magnitude than phenotypic correlation coefficients. The knowledge of degree of association of yield with the various yield contributing and horticultural traits is of great importance because, yield is not an independent character and it is the result of interaction of number of component traits among themselves as well as environmental interactions. The phenotypic expression of each trait is due to the genotype, the environment and the interaction of both. Further each character is likely to be modified by action of genes present in the genotypes of plant and also by the environment and it becomes difficult to evaluate this complex character directly. Therefore, correlation analysis of yield with various characters has been executed to find out the yield contributing factors.

Correlation studies revealed that yield per plant was positively correlated with fruit length (0.619, 0.541), fruit diameter (0.599, 0.523), average fruit weight (0.593, 0.561), number of fruits per plant (0.671, 0.568), vine length (0.695, 0.660); Singh and Dhillon (2022) in cucumber, while it recorded negative association at both levels for node at which first female flower appears (-0.242, 0.215), number of days to first female flower production (-0.385, -0.312) ,days to first harvest (-0.458, -0.310) and severity of downy mildew (%) (-0.800, -0.728) (Kumar *et al*. 2011, in cucumber). Similar results of negative association of fruit yield with days to first female flower were also reported by Pal *et al.* (2017) and Sharma *et al.* (2018) in cucumber. This indicates that, as delay in female flowering and days to first harvest, there is reduction in yield per vine.

The present study revealed that the traits *viz.*, fruit length, fruit diameter, average fruit weight, number of fruits per plant, and vine length exhibited high positive association with fruit yield at genotypic and phenotypic levels respectively. These findings are in accordance with Reddy *et al*., 2013 in ash gourd; Karthick *et al.* 2019, in cucumber. Node at which first female flower appears was positively correlated with number of days to first female flower production (0.855, 0.703), days to first harvest (0.911, 0.654) and average fruit weight (0.273, 0.263) at both genotypic and phenotypic levels respectively. Fruit length showed significant positive associations with number of fruits per plant (0.778, 0.506) and vine length (0.546, 0.416) but had negative non - significant association with fruit diameter (-0.138, -0.067) and non- significant positive association with fruit weight (0.047, 0.031) at both the levels. Fruit diameter showed significant positive associations with fruit weight (0.858, 0.725) and vine length (0.396, 0.317) at both the levels. Number of fruits per plant showed significant positive association with vine length (0.594, 0.508) and significant negative association with severity of downy mildew percentage (-0.577, 0.489) at both the levels. Vine length exhibited significant positive association with fruit length (0.546, 0.416), fruit diameter (0.396, 0.317), average fruit weight (0.321, 0.307) and number of fruits per plant (0.594, 0.508) at both genotypic and phenotypic levels and significant negative association with number of days to first female flower production (-0.1925) and days to first harvest (-0.292) at genotypic level. These results indicate the inverse relationship between earliness and growth parameters. These results were also reported earlier by Arun kumar *et al.*, (201l), Ene *et al.*, (2016) and Kumari *et al.*, (2018) in cucumber. Severity of downy mildew exhibited significant negative correlation with fruit length (-0.541, -0.447), fruit diameter (-0.321, -0.232), average fruit weight (0.349,-0.327), number of fruits per plant (-0.577, -0.489) and vine length (-0.546, -0.487) at both genotypic and phenotypic levels.

Path coefficient analysis

Path coefficient analysis is simply a standardized partial regression coefficient, which splits the correlation into direct and indirect effects. In other words, it measures the direct and indirect contribution of various independent characters on a dependent character. The concept of path analysis was developed by Wright (1921) and the technique was first used by Dewey and Lu (1959) that helps in determining yield contributing characters thus, useful in indirect selection.

In order to fulfill the requirement, path coefficient analysis was undertaken and the direct and indirect effects of different characters on yield per vine in cucumber are presented in Table 2.

Direct effects

The data presented revealed that the fruit diameter had the highest positive direct effect (0.4476) on fruit yield per vine followed by fruit length (0.2833), number of fruits per plant (0.2707), days to first harvest (0.1805), average fruit weight (0.0851)). Further, positive direct effects were also recorded for node at which first female flower production (0.0794) and vine length (0.0011). Other characters showed negative direct effect being highest in number of days to first female flower production (-0.3320), and severity of downy mildew percentage (-0.3166) at genotypic level. These finding are resembled with the findings of Hossain *et al.* (2010). At the phenotypic level, the average fruit weight had the highest positive direct effect (0.2920) on fruit yield per vine followed by fruit diameter (0.2293), number of fruits per plant (0.2005), fruit length (0.1949), vine length (0.1433) and number of days to first female flower production (0.0003). Other characters showed negative direct effect being highest in severity of downy mildew percentage (-0.2945) followed by node at which first female flower appears (-0.0894) and days to first harvest (-0.0477) at genotypic level. Hence, from the above finding, it may be concluded that selection for the fruit diameter, fruit length, number of fruits per plant and average fruit weight should be given importance in a selection programme to increase fruit yield.

Indirect effects:

Node at which first female flower appears exhibited positive indirect effect on yield per plant through days to first fruit harvest (0.0723) followed by days to first female flower appearance (0.0679), average fruit weight (0.0216). This trait exhibited negative indirect effect on number of fruits per plant (-0.0416) followed by fruit length (-0.0305), vine length (-0.0105) at genotypic level. Number of days to first female flower production exhibited positive indirect effect on yield per plant through number of fruits per plant (0.1996) followed by fruit length (0.1476), vine length (0.0639). This trait exhibited negative indirect effect on yield per plant through severity of downy mildew percentage (-0.0664) followed by fruit weight (-0.0398), days first harvest (-0.3493) at genotypic level.

Days to first harvest exhibited positive indirect effect on yield per plant through number of days to first female flower production (0.1899) followed by node at which first female flower appears (0.1645) and severity of downy mildew percentage (0.0520). This trait exhibited negative indirect effect on yield per plant through number of fruits per plant (-0.1378), fruit length (-0.1060) and vine length (-0.0527) at genotypic level. Fruit length exhibited positive indirect effect on yield per plant through number of fruits per plant (0.2203) followed by vine length (0.1546), fruit weight (0.0134). This trait exhibited negative indirect effect on yield per plant through days to first harvest (-0.1664) followed by severity of downy mildew percentage (-0.1534) and days to first female flower production (-0.1259) at genotypic level.

Fruit diameter exhibited positive indirect effect on yield per plant through average fruit weight (0.3840) followed by vine length (0.1773) and days to first harvest (0.0842). This trait exhibited negative indirect effect on yield per plant through severity of downy mildew percentage (-0.1435) followed by fruit length (-0.0618) and number of fruits per plant (-0.0166). Fruit weight exhibited positive indirect effect on yield per plant through fruit diameter (0.0730) followed by vine length (0.0273) and node at which first female flower appears (0.0232). This trait exhibited negative indirect effect on yield per plant through severity of downy mildew percentage (-0.0296) followed by number of fruits per plant (-0.0071) at genotypic level.

Number of fruits per plant exhibited positive indirect effect on yield per plant through fruit length (0.2105) and vine length (0.1608). This trait exhibited negative indirect effect on yield per plant through days to first harvest (-0.2067) followed by days to first female flower production (-0.1627) and severity of downy mildew percentage (-0.1561). Vine length (m) exhibited positive indirect effect on yield per plant through fruit length (0.0006) followed by number of fruits per plant (0.0006) and fruit diameter (0.0004). This trait exhibited negative indirect effect on yield per plant through severity of downy mildew percentage (-0.0006) followed by days to first harvest (-0.0003) and days to first female flower appearance (-0.0002). Severity of downy mildew percentage exhibited positive indirect effect on yield per plant through number of fruits per plant (0.1826) followed by vine length (0.1729), fruit length (0.1714). This trait exhibited negative indirect effect on yield per plant through severity of downy mildew percentage (-0.3166) followed by days to first harvest (-0.0913) and days to first female flower appearance (-0.0633). These finding are resembled with the findings of Hossain *et al.* (2010).

Conclusion

The correlation coefficients among the different characters were worked out at both phenotypic and genotypic levels. The results indicated that yield per plant had significant positive association with vine length, number of fruits per plant, fruit length, fruit diameter and average fruit weight. Thus, from the correlation studies it is concluded that selection should be made on the basis of higher vine length, number of fruits per plant and fruit length with minimum susceptibility to downy mildew disease to bring desired improvement in the yield of cucumber. The path coefficient analysis revealed that the high positive direct effects towards fruit yield per plant contributed by fruit diameter followed by fruit length, number of fruits per plant, days to first harvest, average fruit weight, node at which first female flower production and vine length, thus indicating that direct selection for yield improvement in cucumber can be performed.

Table 1: Genotypic and phenotypic correlation co-efficient (rp and rg) between all pairs of ten characters of genotypes in cucumber

Character		Node at which first female flower appears	Number of days to first female flower production	Days to first harvest	Fruit length (cm)	Fruit Diameter (cm)	Average fruit weight (g)	Number of fruits per plant	Vine length (m)	Severity of downy mildew (%)	Fruit yield per vine (kg)
Node at which first female flower appears	G	1.0000	0.855**	0.911**	-0.384**	0.1828	0.273*	-0.524**	-0.1317	0.1765	-0.242*
	P	1.0000	0.703**	0.654**	-0.300*	0.1679	0.263*	-0.430**	-0.1017	0.1691	-0.215*
Number of days to first female flower production	G		1.0000	1.0520	-0.445**	0.0697	0.1198	-0.601**	-0.1925*	0.1999	-0.385**
	P		1.0000	0.736**	-0.347**	0.0376	0.0838	-0.498**	-0.1649	0.1840	-0.312*
Days to first harvest	G			1.0000	-0.587**	0.1880	0.221*	-0.764**	-0.292*	0.288*	-0.458**
	P			1.0000	-0.384**	0.0752	0.1554	-0.507**	-0.1828	0.212*	-0.310*
Fruit length (cm)	G				1.0000	-0.1381	0.0473	0.778	0.546**	-0.541**	0.619**
	P				1.0000	-0.0679	0.0317	0.560**	0.416**	-0.447**	0.541**
Fruit diameter (cm)	G					1.0000	0.858**	-0.0370	0.396**	-0.321*	0.599**
	P					1.0000	0.725**	-0.0172	0.317*	-0.232*	0.523**
Average fruit weight (g)	G						1.0000	-0.0829	0.321**	-0.349**	0.593**
	P						1.0000	0.0763	0.307*	-0.327*	0.561**
Number of fruits per plant	G							1.0000	0.594**	-0.577**	0.671**
	P							1.0000	0.508**	-0.489**	0.568**
Vine length (m)	G								1.0000	-0.546**	0.695**
	P								1.0000	-0.487**	0.660**
Severity of downy mildew (%)	G									1.0000	-0.800**
	P									1.0000	-0.728**
Fruit yield per vine (kg)	G										1.0000
	P										1.0000

*** Significant at 5 % and ** Significant at 1 % level**

P Critical value at 0.05 and 0.001 is -0.187 and 0.309 for phenotypic and genotypic correlation

Table 2: Estimates of direct (diagonal) and indirect effects of component characters on yield of genotypes in cucumber

Character		Node at which first female flower appears	Number of days to first female flower production	Days to first harvest	Fruit Length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Number of fruits per plant	Vine length (m)	Severity of downy mildew (%)	Fruit yield per vine (kg)
Node at which first female flower appears	G	**0.0794**	0.0679	0.0723	-0.0305	0.0145	0.0216	-0.0416	-0.0105	0.0140	-0.242
	P	**-0.0894**	-0.0628	-0.0585	0.0268	-0.0150	-0.0235	0.0385	0.0091	-0.0151	-0.215*
Number of days to first female flower production	G	-0.2839	**-0.3320**	-0.3493	0.1476	-0.0232	-0.0398	0.1996	0.0639	-0.0664	-0.385**
	P	0.0002	**0.0003**	0.0002	-0.0001	0.0000	0.0000	-0.0001	0.0000	0.0000	-0.312*
Days to first harvest	G	0.1645	0.1899	**0.1805**	-0.1060	0.0339	0.0399	-0.1378	-0.0527	0.0520	-0.458**
	P	-0.0312	-0.0351	**-0.0477**	0.0183	-0.0036	-0.0074	0.0242	0.0087	-0.0101	-0.310*
Fruit length (cm)	G	-0.1088	-0.1259	-0.1664	**0.2833**	-0.0391	0.0134	0.2203	0.1546	-0.1534	0.619**
	P	-0.0585	-0.0676	-0.0748	**0.1949**	-0.0132	0.0062	0.1091	0.0728	-0.0533	0.523**
Fruit diameter (cm)	G	0.0818	0.0312	0.0842	-0.0618	**0.4476**	0.3840	-0.0166	0.1773	-0.1435	0.599**
	P	0.0385	0.0086	0.0172	-0.0156	**0.2293**	0.1662	-0.0039	0.0897	-0.0955	0.561**
Average fruit weight (g)	G	0.0232	0.0102	0.0188	0.0040	0.0730	**0.0851**	-0.0071	0.0273	-0.0296	0.593**
	P	0.0767	0.0245	0.0454	0.0092	0.2115	**0.2920**	-0.0223	0.1019	-0.0981	0.568**
Number of fruits per plant	G	-0.1418	-0.1627	-0.2067	0.2105	-0.0100	-0.0224	**0.2707**	0.1608	-0.1561	0.671**
	P	0.0863	-0.0999	-0.1016	0.1122	-0.0035	-0.0153	**0.2005**	0.1530	-0.0745	0.660**
Vine length (m)	G	-0.0001	-0.0002	-0.0003	0.0006	0.0004	0.0003	0.0006	**0.0011**	-0.0006	0.695**
	P	0.0156	-0.0252	-0.0280	0.0637	0.0486	0.0470	0.0778	**0.1433**	-0.2945	-0.728**
Severity of downy mildew (%)	G	-0.0559	-0.0633	-0.0913	0.1714	0.1015	0.1103	0.1826	0.1729	**-0.3166**	-0.800**
	P	-0.0498	-0.0542	-0.0623	0.1316	0.0684	0.0963	0.1441	0.1433	**-0.2945**	-0.728**
Fruit yield per vine (kg)	G	-0.242*	-0.385**	-0.458**	0.619**	0.599**	0.593**	0.671**	0.695**	-0.800**	**1.0000**
	P	-0.215*	-0.312*	-0.310*	0.541**	0.523**	0.561**	0.568**	0.660*	-0.728**	**1.0000**

Residual effect= 0.30900 Direct effects: diagonal elements

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