DOI : 10.5958/0974-0112.2017.00013.5

Indian J. Hort. 74(1), March 2017: 51-55

Combining ability for yield and yield related traits and its relationship with gene action in cucumber

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ABSTRACT

Combining ability studies was carried out to estimate general combining ability of 8 parents and specific combining ability of 28 crosses of cucumber for nine quantitative traits in 8 × 8 half-diallel mating design excluding reciprocals. The result revealed that the magnitude of σ^2s were higher than the σ^2g, predictability ratio (PR) was found to be less than 0.5 and average degree of dominance (ADD) was found to be > 1 for all the traits, indicating predominance of non-additive gene action and scope of heterosis breeding in improvement of different traits. The estimates of gca effects of parents showed that DC-1 was good general combiner for earliness, days to first fruit set, days to first fruit harvest and fruit diameter. For fruit length and average fruit weight, Kalyanpur Green was good general combiner. Pusa Uday showed the highest significant gca effect for number of fruits per plant and total yield per plant and second highest significant gca for average fruit weight. Majority of cross combinations recorded high sca effects and *per se* performance due to low × low, low × high or high × low parental gca status. The hybrid Pusa Uday × DC-1 exhibited high significant sca effects for days to first female flower opening, days to first fruit set, days to first fruit harvest, average fruit weight, number of fruits per plant and total yield per plant followed by Pusa Uday × Kalyanpur Green, Punjab Naveen × DC-1 for total yield per plant, hence can be further exploited for commercial cultivation after multi-location testing.

Key words: Cucumber, combining ability, gca, sca, predictability ratio.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the most important cucurbit crops in the world (FAO, 5) relished mostly as salad. It is the fourth most widely grown vegetable in the world after tomato, cabbage and onion (Tatlioglu, 18). It is believed to be originated in India (Sebastian *et al.*, 13). In India, cucumber is grown commercially throughout the country in areas extending from higher altitude to plains including river beds. The fruits and seeds possess cooling properties. The fruits are also used as an astringent, antipyretic and are considered good for people suffering from constipation, jaundice and indigestion. India being native place of cucumber possesses wide genetic variability for vegetative and fruit traits. Breeder often faces the problem of selecting parents and crosses for breeding high yielding varieties of crop plant. As in other crops, the selection of suitable parents and cross combinations is necessary for genetic improvement in cucumber. Combining ability is one of important genetic parameters for breeding improved cultivars. The variances of general combining ability (gca) and specific combining ability (sca) are related to the type of gene action involved. The variance of gca includes the additive nature of the total variance, whereas sca includes the non-additive nature of the total variance, arising largely from dominance and epistatic deviations (Malik *et al*., 9). The knowledge on the relative importance of the additive (gca) and non-additive (sca) gene actions within a breeding population is significant because it determines the breeding method for genetic improvement (Sincik, 17).

For the development of superior hybrids, estimates of general combining ability of parents and specific combining ability of the crosses help in proper selection of parents for hybridization (Dogra and Kanwar, 4). The present investigation was therefore, undertaken to identify the best combiners among the existing inbreds and the crosses as well as gene action of different quantitative traits in 8 × 8 half-diallel set to facilitate the formulation of a sound breeding programme in cucumber.

MATERIALS AND METHODS

The experiment was carried out at experiment farm of the Division of Vegetable Science, ICAR-IARI, New Delhi during March-June, 2013. Eight genetically diverse inbreds of cucumber, *viz*., P_1 (DC-77), P_2 (DC-70), P_3 (DC-83), P_4 (Pusa Uday), P_5 (Punjab Naveen), P_6 (DC-1), P_7 (CHC-1) and P_8 (Kalyanpur Green) were crossed in half diallel

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mating design. The 28 F_1 hybrids along with eight parents were evaluated in a randomised block design with three replications. Two to three seeds were sown on the side of the channel in a well prepared hill, with a spacing of 1.5 m between channels and 60 cm between hills. Each treatment comprised of ten hills. Two plants were allowed to grow in each hill and finally one plant was kept for taking final observations. Recommended agronomic package of practices were followed throughout the growing season. Five plants were randomly selected for taking observations after discarding the border plants at both the ends. Data were recorded on days to first female flower anthesis, days to first fruit set, days to first fruit harvest, number of fruits per plant, fruit length (cm), fruit diameter (cm), average fruit weight (g), vine length (cm) and total yield per plant (g). The combining ability estimates were calculated according to Method 2, Model I of Griffing (7). Relative importance of gca and sca was estimated by the predictability ratio $2\sigma^2g/2\ \sigma^2g + \sigma^2s$ (Baker, 1) for fixed effect model where, $2\sigma^2g$ and σ^2s is additive and non-additive component of variance, respectively. Average degree of dominance was estimated by the formula $\sqrt{\ \sigma^2s/2\ \sigma^2g}$.

RESULTS AND DISCUSSION

The analysis of variance showed significant difference among the genotypes studied for all the traits except for fruit width. Similar results were reported by Singh *et al.* (15). The mean sum of squares due to gca and sca were highly significant for all the traits except fruit width for sca, indicating preponderance of dominant gene action (Kumar *et al*., 8) (Table 1). The variances due to sca (σ^2s) were greater than variance due to gca (σ^2g) for all the parameters which indicated the importance of non-additive gene action and scope for heterosis breeding for improvement in cucumber. Similar findings were also noted by Chirani *et al.* (2), and Singh *et al*. (16). The predictability ratio also showed relevant result, it was less than 0.5 for all the characters indicating predominant role of non-additive component of variance. Similarly, average degree of dominance was also found to be >1 for all the traits, suggesting the predominant role of dominance variance. Our findings are in conformity with the findings of Munshi *et al*. (10).

The potentiality of any line to be used as a parent in hybridization depends on its *per se* performance and the performance of F_1 hybrid derived from it and its own gca effect. The data presented in Table 2 clearly reveals that none of the parent was good general combiner for all the traits. However, the estimates of gca effects of parents showed that parent P_6 (DC-1) was good general combiner for earliness (-3.71), days to first fruit set (-3.61), days to first fruit harvest (-3.64) and fruit diameter (0.21), followed by P_7 (CHC-1). P_8 (Kalyanpur Green) was considered to be good general combiner for fruit length (1.28) and average fruit weight (23.01). P_4 (Pusa Uday) showed the highest significant gca effect for number of fruits (0.86) and second highest significant gca for average fruit weight (20.57). For total yield, P_4 (Pusa Uday) (443.18) showed maximum significant gca effect followed by P_6 (DC-1) (241.68). P_2 (DC-70) recorded significant sca effect for vine length (19.57). As good general combiners these parents could be exploited in hybridization to produce desirable recombinants. Our findings were in conformity with the findings of Golabadi *et al.* (6).

The sca signifies the predominance of non additive gene action for the expression of any trait. However, high sca effects may not arise only in the crosses involving high × high combination, but it also arises in those crosses involving low × high

Table 1. Analysis of variance for combining ability for different traits in cucumber.

Source of variation	df	Days to first female flower appearance	Days to first fruit set	Days to first fruit pickings	Fruit length (cm)	Fruit width (cm)	Average fruit wt. (g)	No of fruits/ plant	Total yield/ plant (g)
Due to GCA	7	38.90**	34.88**	34.87**	17.33**	0.40**	9061.87**	7.40**	586519.25**
Due to SCA	28	2.92**	3.32**	3.34**	4.15**	0.13	1316.16**	3.63**	144547.07**
Error	70	0.20	0.18	0.20	1.50	0.10	252.85	0.65	463.72
σ^2g		0.02	0.02	0.01	0.04	0.01	7.37	0.02	40.50
σ^2s		0.17	0.15	0.16	0.41	0.03	69.22	0.17	380.57
PR		0.08	0.21	0.11	0.16	0.40	0.17	0.19	0.17
ADD		2.05	1.9	2.85	2.28	1.23	2.16	2.06	2.17

**&*Significance at 1 and 5% level of probability, respectively.

Predictability ratio (PR) = $2\ \sigma^2g/\ 2\ \sigma^2g + \sigma^2s$; Average degree of dominance (ADD) = $\sqrt{\sigma^2s}\ /\ 2\ \sigma^2g$

Table 2. Estimates of general combining ability effects of parent genotypes in cucumber for various traits.

Parent	Days to first female flower opening		Days to first fruit set		Days to first fruit harvest		Fruit length (cm)		Fruit dia. (cm)		Average fruit wt. (g)		No. of fruits / plant		Total yield /plant (g)	
	Effect	Mean	Effect	Mean	Effect	Mean	Effect	Mean	Effect	Mean	Effect	Mean	Effect	Mean	Effect	Mean
DC-77	2.27**	59.02	1.95**	62.03	1.92**	67.03	-0.55*	12.78	-0.09	3.25	-14.89**	169.55	-0.87**	5.24	-213.95**	807.67
DC-70	1.78**	58.01	1.68**	61.02	1.66**	66.03	0.46	13.60	-0.12*	2.98	-9.68**	154.31	-0.09	6.38	-179.72**	775.63
DC-83	0.99**	56.04	1.00**	59.02	0.98**	64.02	-1.05**	11.32	0.07	3.30	-21.88**	153.28	-0.22	5.53	-198.78**	816.00
P. Uday	0.62**	57.04	0.59**	60.04	0.57**	65.03	-0.02	13.26	0.05	3.32	20.57**	255.58	0.86**	7.10	443.18**	1473.33
P. Naveen	-0.97**	53.04	-1.03**	56.04	-0.95**	61.06	-0.53*	13.24	-0.05	3.83	-3.84	197.19	0.24	6.55	119.12**	1032.33
DC-1	-3.71**	49.05	-3.61**	52.05	-3.64**	57.05	-0.25	14.06	0.21**	3.42	16.20**	241.20	0.18	6.56	241.68**	1200.00
CHC-1	-1.57**	52.33	-1.33**	55.34	-1.36**	60.31	0.66**	15.57	0.05	3.33	-9.49**	183.36	-0.27	5.90	-133.95**	787.66
K. Green	0.58**	55.08	0.76**	58.08	0.83**	63.06	1.28**	16.88	-0.12*	3.30	23.01**	251.98	0.17	6.43	-77.58**	973.67
SE (gi)	0.13		0.12		0.13		0.20		0.05		2.71		0.13		6.37	

** & *Significant at 0.01 and 0.05, respectively.

or high × low or low × low. The results showed that none of the hybrids were having higher sca effect for all the traits. Considering this, top three crosses exhibiting high sca effects were selected for each traits and magnitude of gca of respective parents was presented as either low or high (Table 3). In the present study, majority of the crosses exhibited high sca effects as a result of either low × low, low × high or high × low and high × high gca, indicating a genetic interaction of the dominance × dominance, dominance × additive or additive × dominance type. With regard to specific combining ability effects, the cross Pusa Uday × DC-1 (high × high) was found to show superior sca effects for days to first female flower opening (-3.84), days to first fruit set (-3.71), days to first fruit harvest (-3.68), number of fruits per plant (2.30) and total yield (553.48). Average fruit weight (45.26) and fruit length (2.04) was observed highest in the cross DC-70× DC-83 (low × low). Even both negative combiners (poor parents) have yielded crosses with high sca effects. This indicated that negative combiners are also capable of giving high sca effects. The cross DC-70 × DC-1 (low × high) showed highest sca effect for fruit diameter (0.48) and vine length (38.34). Twenty hybrids out of 28, exhibited positive significant sca effects for total yield per plant, indicating the presence of dominance and epistatic (non-additive) interaction. Similar results were reported by Reddy *et al*. (11). The number of fruits per plant was the only trait that had a high relationship to total plant yield. The importance of non-additive gene action for number of fruits per plant was also reported by Pati *et al*. (10), Kumar *et al.* (8) and Dogra (3).

It is apparent that most hybrids showing high sca effects involved atleast one good general combiners. It implies that there is a strong tendency of transmission of specific genetic architecture for higher gain from parents to its offspring. Such crosses are likely to produce desirable transgressive seggregants if additive genetic system is present in good general combiner. It is also possible that the cross which is showing high sca effect may have parents with high gca effects, in which case both additive and non-additive gene actions can be utilized. However, only few crosses confirmed to these observations. The high × low or low × high crosses, besides exhibiting the favourable additive gca effects of the parent, complement the epistatic effects present in the cross, which would finally result in higher sca effects (Santhakumar and Salimath, 14).

The result showed that the relative importance of gca and sca (predictability ratio) was <0.5 and average degree of dominance was >1 for all the traits

Table 3. Ranking of best five crosses for *per se* performance and all desirable crosses for significant sca effect with respect to eight quantitative traits.

Trait	Crosses with *per se* performance	Crosses with significant sca effects	GCA effect of parent	
			P1	P2
Days to first female flower opening	Pusa Uday × DC-1 (46.00)	Pusa Uday × DC-1 (-3.84)	Low	High
	Punjab Naveen × DC-1 (47.00)	DC-77 × CHC-1 (-2.63)	Low	High
	DC-1 × CHC-1 (48.00)	DC-83 × Kalyanpur Green (-1.50)	Low	Low
	DC-77 × DC-1 (50.00)	DC-77 × DC-1 (-1.48)	Low	High
	DC-1 × Kalyanpur Green (50.00)	DC-83 × CHC-1 (-1.35)	Low	High
Days to first fruit set	Pusa Uday × DC-1 (49.00)	Pusa Uday × DC-1 (-3.71)	Low	High
	Punjab Naveen × DC-1 (50.01)	DC-77 × CHC-1 (-2.75)	Low	High
	DC-1 × CHC-1 (51.00)	DC-77 × Punjab Naveen (-2.47)	Low	High
	DC-77 × DC-1 (52.33)	DC-77 × DC-1 (-1.74)	Low	High
	DC-70 × DC-1 (52.87)	DC-83 × Kalyanpur Green (-1.47)	Low	Low
Days to first fruit harvest	Pusa Uday × DC-1 (54.00)	Pusa Uday × DC-1 (-3.68)	High	Low
	Punjab Naveen × DC-1 (55.02)	DC-77 × CHC-1 (-2.72)	Low	High
	DC-1 × CHC-1 (56.00)	DC-77 × Punjab Naveen (-2.58)	Low	High
	DC-77 × DC-1 (57.32)	DC-77 × DC-1 (-1.72)	Low	High
	DC-70 × DC-1 (57.83)	DC-83 × Kalyanpur Green (-1.55)	Low	Low
Fruit length (cm)	DC-70 × Kalyanpur Green (16.63)	DC-70 × DC-83 (2.04)	Low	Low
	DC-70 × CHC-1 (16.52)	DC-7 × CHC-1 (1.72)	Low	High
	Pusa Uday × Kalyanpur Green (16.17)	DC-83 × Pusa Uday (1.68)	Low	Low
	Punjab Naveen × CHC-1 (15.29)	Pusa Uday × Kalyanpur Green (1.23)	Low	High
Fruit dia. (cm)	DC-70 × DC-1 (4.01)	DC-70 × DC-1 (0.48)	Low	High
	Pusa Uday × DC-1 (3.86)			
Av. fruit weight (g)	Pusa Uday × DC-1 (287.19)	DC-70 × DC-83 (45.26)	Low	Low
	DC- × Kalyanpur Green (259.61)	Pusa Uday × DC-1 (40.43)	High	High
	Pusa Uday × Kalyanpur Green (258.44)	DC-77 × DC-83 (34.06)	Low	Low
	DC-77 × Kalyanpur Green (236.84)	DC-83 × Punjab Naveen (28.50)	Low	Low
	CHC-1 × Kalyanpur Green (236.61)	DC-77 × DC-70 (17.75)	Low	Low
No. of fruits per plant	Pusa Uday × DC-1 (10.86)	Pusa Uday × DC-1 (2.30)	High	Low
	Pusa Uday × Punjab Naveen (10.03)	Pusa Uday × Punjab Naveen (1.41)	High	Low
	DC-70 × Pusa Uday (8.78)	DC-77 × DC-83 (1.39)	Low	Low
	CHC-1 × Kalyanpur Green (8.68)	DC-83 × Kalyanpur Green (1.11)	Low	Low
	Pusa Uday × CHC-1 (8.59)	DC-77 × Kalyanpur Green (0.97)	Low	Low
Total yield per plant (g)	Pusa Uday × DC-1 (2750)	Pusa Uday × DC-1 (553.48)	High	High
	Pusa Uday × Kalyanpur Green (2400)	Pusa Uday × Kalyanpur Green (522.75)	High	Low
	Pusa Uday × Punjab Naveen (2300)	Punajb Naveen × DC-1 (327.55)	High	High
	Punjab Naveen × DC-1 (2200)	Pusa Uday × CHC-1 (279.12)	High	High
	Pusa Uday × CHC-1 (2100)	DC-77 × DC-1 (260.62)	Low	High

studied which indicated the predominant role of non additive component of variance for the improvement of these traits. Parent P_1 (Pusa Uday) and P_6 (DC-1) were best general combiner for yield and its contributing traits and can be utilized in hybridization programme for developing high yielding hybrids. The specific combination $P_4 \times P_6$ (Pusa Uday × DC-1) was identified as best hybrid for days to first female flower opening, days to first fruit set, days to first fruit harvest, number of fruits per plant and total yield per

plant, and second highest significant sca for average fruit weight followed by Pusa Uday × Kalyanpur Green, and Punjab Naveen × DC-1 for total yield per plant. The result indicated the preponderance of over dominance and non-additive genetic variance for all the quantitative traits taken in the study and they can be efficiently improved through heterosis breeding.

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Received : January, 2016; Revised : November, 2016; Accepted : February, 2017