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Short communication

Combining ability and its relationship with gene action in slicing cucumber

Jagesh Kumar[**], A.D. Munshi[*], Ravinder Kumar, A.K. Sureja and R.K. Sharma[***]
Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi 110 012

ABSTRACT

A study was conducted on the combining ability analysis in a 6 x 6 half-diallel cross of cucumber (*Cucumis sativus* L.) excluding reciprocals. The 15 F_1 hybrids along with six parental lines were grown in randomized block design with three replications. The mean square due to gca and sca were highly significant for almost all the characters indicating the importance of both additive and non-additive genetic components for the characters under study. The predictability ratio and average degree of dominance was observed to be less than 0.5 and more than 1 for important yield contributing characters, *viz.* earliness, number of fruits per plant and total yield per plant suggesting the importance of non-additive components of variance for improvements of these characters. The parents P_1, P_2, P_5 and P_6 were observed to be good combiners for a number of characters, including yield per plant. The crosses, P_1 x P_5, P_2 x P_5 and P_2 x P_6 were most promising combinations for earliness and other desirable characters including yield per plant. The results indicated the importance of heterosis breeding for effective utilization of non-additive genetic variance in cucumber.

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

India being native place of cucumber (*Cucumis sativus* L.) possesses high genetic variability for vegetative and fruit characters. Low fruiting ability and yield suppression due to its inherent fruiting habits are the major factors limiting fruit yield in slicing and processing cucumber (Lower *et al.*, 5). Development of high yielding varieties mainly depends upon genetically superior parents, coupled with suitable breeding methodology. Combining ability analysis is one of the powerful tools available which give the estimates of combining ability effects and aids in selecting desirable parents and crosses for further exploitation. Such studies in cucumber are very few. Therefore the present investigation was undertaken to identify the best combiners among the existing germplasm as well as to study the gene action of different quantitative characters in 6 × 6 half-diallel set for formulation of a sound breeding programme in cucumber.

The experiment was carried out at Indian Agricultural Research Institute during two summer seasons. Six genetically diverse inbreds of cucumber *viz*, CRC-8 (P_1), CHC-2 (P_2), G-338 (P_3), CH-20 (P_4), Pusa Uday (P_5) and DC-1 (P_6) were crossed in 6 × 6 half-diallel (excluding reciprocal) mating scheme (Hayman, 4). The resulting 15 F_1 hybrids along with 6 parental lines were evaluated in a randomized block design with three replications. The seeds were sown in rows of 1.5 m with 0.50 m spacing between the plants. All the recommended package of practices was followed to grow a successful crop. Out of 12 plants, 10 were marked for taking observations. Observations on individual plant basis were recorded on eight quantitative characters, *viz.*, days to first female flower opening, node number of first female flower, days to first fruit harvest, fruit weight (g), number of fruits per plant, fruit length (cm), fruit diameter (cm) and total yield per plant (g). The combining ability estimates were calculated according to Method-2, Model 1 (Griffing, 2). For the gene action, relative importance of general combining ability (gca) and specific combining ability (sca) was estimated by predictability ratio $2\sigma^2g/2\sigma^2g \pm \sigma^2s$ (Baker, 1) for fixed effect model, where σ^2g is the additive component of variance and σ^2s is the non-additive component of variance. Average degree of dominance was estimated by using formula $\sigma^2s/2\sigma^2g$.

The mean square due to gca and sca were highly significant for all the characters indicating the importance of both additive and non-additive genetic components for the characters under study (Table 1). Sca components of variance was higher than gca components of variance for five traits, *viz.*, days to first female flower opening, node number of first female flower, days to first fruit harvest, number of fruits per plant and total yield per plant while gca components of variance was higher than sca components of variance for three traits, *viz.*, fruit weight, fruit length and fruit diameter which indicated the predominance of both and non-additive gene action for the characters studied. The relevant

*Corresponding author's E-mail: anilabhm@yahoo.co.in
**Division of Crop Improvement, Central Potato Research Institute, Shimla
***Division of Genetics, Indian Agricultural Research Institute, New Delhi 110 012

Table 1. Analysis of variance for combining ability for eight quantitative characters in cucumber.

Source	d.f.	Days to 1st female flower opening	Node No. of 1st female flower	Days to first fruit harvest	Fruit weight (g)	No. of fruits per plant	Fruit length (cm)	Fruit dia. (cm)	Total yield per plant (g)
gca	5	36.97**	12.08**	51.70**	276.12**	6.92**	7.39**	1.31**	670790.35**
sca	15	12.09**	3.12**	14.66**	30.68**	1.56**	0.91**	0.21**	254584.35**
Error	40	0.55	0.02	0.17	1.82	0.06	0.24	0.03	1739.17
$\sigma^2 g$		3.11	1.12	4.63	34.46	0.67	0.83	0.11	52025.75
$\sigma^2 s$		11.54	3.10	14.49	32.51	1.62	0.67	0.18	252845.18
PR		0.35	0.42	0.39	0.68	0.46	0.71	0.61	0.14
Add		1.81	1.36	1.68	0.82	1.21	0.41	0.90	2.43

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

*, ** Significant at 5 and 1% levels

results regarding relative importance of gca and sca (predictability ratio) observed to be <0.5 for days to first female flower opening, node number of first female flower, days to first fruit harvest, number of fruits per plant and total yield per plant, thus reflecting the predominant role of non-additive components of variance for improvement of these characters. Average degree of dominance which was found to be >1 for these characters further confirmed the results. Predictability ratio and average degree of dominance was observed to be >0.5 and <1 for fruit weight, fruit length and fruit diameter, indicating the predominance of additive gene action for improvement of these characters. Among the six parental lines, the parent P_1 showed highest gca for days to first female flower opening (-1.98), node number of first female flower (-0.69), days to first fruit harvest (-1.97); P_6 for fruit weight (13.82), number of fruits per plant (0.46), fruit length (1.20); P_5 for fruit diameter (0.31) and total yield per plant (328.41) (Table 2). In most of the cases it was observed that *per se* performance of parents bear direct reflection of their respective gca effects, *i.e.* parents showing highest gca effects for a character, were also observed to be good performer with respect to that particular character. The results are in conformity with the findings of Munshi *et al.* (7), Yudhvir and Sharma (15), and Sarkar and Sirohi (11) in cucumber.

The number of crosses having significant sca effects were 10 for days to first female flower opening, 8 for node number of first female flower, 8 for days to first fruit harvest, 8 for fruit weight, 6 for number of fruits per plant, 9 for fruit length, 7 for fruit diameter and 7 for total yield per plant. The crosses showing highest significant sca effects for various characters in order of merit were $P_1 \times P_5$ for days to first female flower opening and total yield per plant; $P_5 \times P_6$ for node number of first female flower; $P_2 \times P_5$ for days to first fruit harvest, number of fruits per plant and fruit length; $P_1 \times P_6$ for fruit weight and $P_2 \times P_6$ for fruit diameter. In most of the cases, these 5 hybrids which showed best *per se* performance also possessed desirable significant sca effects (Table 3). This indicated the *per se* performance of hybrids had a direct relation with respective sca effects. A comparison of the sca effects of the crosses and gca effects of the parents involved indicated that in most of the cases gca effects were reflected in the sca effects of the cross combination. It is apparent that in almost all the hybrids which showed the best sca effects, the parental lines involved were at least one of the four outstanding parental lines, *viz.*, CRC-8 (P_1), CHC-2 (P_2), Pusa Uday (P_5) and DC-1 (P_6), also had high gca effects for one or more characters contributing towards yield. This indicated that there was strong tendency of transmission of higher gain from the parents to the offspring. The present findings corroborated the earlier work of Munshi *et al.* (6,7), Navazio and Simon (10), Gulamuddin and Ahmed (3), Sarkar and Sirohi (12), Shushir *et al.* (13), and Verma *et al*. (14) in cucumber; Munshi and Verma (9) in muskmelon and Munshi and Sirohi (8) in bittergourd.

The results indicated the importance of heterosis breeding for effective utilization of non-additive genetic variance which had a predominant role for the improvement of five most yield attributing traits, *viz.*, the days to first female flower opening, node number of first female flower, days to first fruit harvest, number of fruits per plant and total yield per plant. The other three characters, *viz.*, fruit weight, fruit length and fruit diameter where additive gene action is predominant can be improved through selection. The combination $P_1 \times P_5$ (CRC-8 × Pusa

Table 2. Estimates of general combining ability (gca) effects of parents for eight quantitative characters in cucumber.

Genotype	Days to 1st female flower opening		Node number of 1st female flower		Days to1st fruit harvest		Fruit weight (g)		No. of fruits per plant		Fruit length (cm)		Fruit diameter (cm)		Total yield per plant (g)	
	Mean	Effects	Mean	Effects	Mean	Effects	Mean	Effects	Mean	Effects	Mean	Effects	Mean	Effects	Mean	Effects
CRC-8	48.33	-1.98**	4.60	-0.69**	60.20	-1.97**	120.83	-5.77**	8.20	0.14**	14.61	0.25	4.74	0.05	943.78	-98.25**
CHC-2	50.31	-0.52**	4.03	-0.42**	62.33	-0.48**	116.30	-7.54**	7.80	-0.33**	12.70	-0.33**	4.71	-0.06	860.53	-54.42**
G-338	50.20	0.71**	5.07	0.23**	63.57	0.72**	129.57	-9.42**	7.60	-0.80**	13.23	-0.84**	4.64	-0.12*	672.97	-171.66**
CH-20	52.44	1.16**	4.81	0.13**	63.51	1.25**	142.80	-2.89*	7.07	-0.43**	14.34	-0.74**	4.77	-0.10	1128.80	-74.60**
Pusa-Uday	51.60	0.27*	4.94	0.06**	64.56	0.38**	152.13	11.81**	6.62	0.46*	14.60	0.46*	5.24	0.31**	1513.80	328.41**
DC-1	52.71	0.41**	5.11	0.18**	62.43	0.10	159.80	13.82**	5.64	0.31**	16.43	1.20**	4.45	0.17	1265.30	267.52**
SE (gi)		0.13		0.01		0.14		1.37		0.08		0.16		0.06		8.78

*, ** Significant at 5 and 1% levels

Uday) which exhibited highest sca effects for days to first female flower opening and total yield per plant may be exploited for commercial cultivation.

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Table 3. Ranking of best crosses for *per*-se performance and desirable crosses for significant sca effects with respect to eight quantitative traits in cucumber.

Character	Crosses with *per-se* performance	Crosses with significant sca effects
Days to first female flower opening	1 × 5 (47.10)	1 × 5 (-3.07)
	1 × 6 (47.76)	1 × 6 (-2.97)
	2 × 5 (50.01)	2 × 5 (-2.61)
	2 × 6 (50.09)	3 × 5 (-2.53)
	3 × 5 (51.40)	2 × 6 (-2.50)
Node number of first female flower	2 × 5 (3.50)	1 × 5 (-0.58)
	2 × 6 (3.60)	1 × 6 (-0.54)
	1 × 5 (3.80)	2 × 5 (-0.39)
	1 × 6 (3.86)	2 × 6 (-0.33)
	3 × 5 (4.42)	3 × 5 (-0.24)
Days to first fruit harvest	2 × 5 (56.47)	2 × 5 (-2.82)
	2 × 6 (56.53)	2 × 6 (-2.64)
	1 × 5 (57.93)	1 × 5 (-2.60)
	3 × 5 (58.03)	3 × 5 (-2.49)
	1 × 6 (59.27)	1 × 6(-2.25)
Fruit weight (g)	1 × 6 (192.17)	1 × 6 (25.80)
	1 × 5 (187.07)	2 × 5 (22.95)
	2 × 6 (187.01)	1 × 5 (22.70)
	2 × 5 (185.53)	2 × 6 (22.41)
	3 × 5 (177.87)	3 × 5 (16.56)
No. of fruits per plant	1 × 5 (10.27)	2 × 5 (1.68)
	2 × 5 (9.77)	1 × 5 (1.64)
	2 × 6 (9.67)	2 × 6 (1.42)
	1 × 6 (9.30)	5 × 6 (1.18)
	5 × 6 (7.77)	1 × 6 (1.12)
Fruit length (cm)	2 × 6 (21.13)	2 × 5 (2.91)
	2 × 5 (19.43)	1 × 5 (2.67)
	1 × 5 (19.27)	2 × 6 (2.37)
	1 × 6 (18.50)	4 × 5 (1.18)
	4 ×5 (16.80)	1 × 6 (1.15)
Fruit diameter (cm)	2 × 6 (6.18)	2 × 6 (0.68)
	1 × 6 (5.77)	1 × 6 (0.63)
	2 × 5 (5.40)	2 × 5 (0.51)
	1 × 5 (5.33)	1 × 5 (0.49)
	3 × 4 (4.77)	3 × 4 (0.40)
Total yield per plant (g)	1 × 5 (2192.28)	1 × 5 (420.38)
	2 × 5 (2067.85)	2 × 5 (363.06)
	1 × 6 (1767.08)	1 × 6 (380.94)
	2 × 6 (1692.13)	2 × 6 (345.62)
	2 × 3 (1156.68)	2 × 4 (331.66)

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