Combining Ability Studies in Cucumber (*Cucumis sativus* L.) under Salinity Condition

Jagesh Kumar[1]*, AD Munshi[1], Ravinder Kumar[1] and Amish K Sureja[2]

[1] *Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi-110 012, India*

[2] *Department of Vegetable Crops, College of Horticulture and Forestry, CAU, Pashighat-791 102, Arunachal Pradeh, India*

A field study with diallel analysis (excluding reciprocals) in cucumber using cross combinations of salinity-tolerant and -sensitive inbreds indicated that the mean square due to gca and sca were significant in desirable direction for all the characters. The higher sca values than gca and, PR and ADD values <0.5 and >1, respectively indicates the predominance of non-additive gene effects in the expression of characters and accordingly hybrids development was rewarded. The potential cucumber hybrid CRC-8 x Pusa Uday and CHC-2 x Pusa Uday were found superior for earliness, yield and its attributing traits based on high sca effects and could be exploited in saline areas of our country.

Key Words: *Cucumis sativus*, **Salinity, Combining ability, Gca, Sca**

Introduction

Cucumber is one of the most important cucurbits grown throughout the country for its tender fruits. Low fruiting ability and yield suppression are due to its inherent habits. Development of high yielding varieties mainly depends upon the extent of genetic variability and superiority of parents, coupled with suitable breeding methodology. Combining ability analysis is one of the powerful breeding tools available which give the estimates of general combining ability (gca) for selecting desirable parents and specific combining ability (sca) for hybrids selection which are necessary for devising an effective and efficient breeding methods. Therefore, selection of suitable parents with high gca is most crucial and critical aspect of any breeding programme for hybrids development (Sprague and Tatum, 1942).

In India, 8.5 m ha areas are affected by salinity and around 27 per cent of cultivable land in the state of Punjab, Haryana, Uttar Pradesh, Gujarat, Rajasthan, West Bengal, Maharashtra, Orissa, Andhra Pradesh, Karnataka and Tamil Nadu comes under salinity. India possesses vast genetic variability for vegetative and fruit characters of cucumber due to being its native place. Unfortunately, cucumber can not tolerates salinity. Therefore, cucumber production under saline soil requires salinity tolerant varieties. In this regard, present study was undertaken to select better combiner parents among saline-tolerant and -sensitive inbreds of cucumber and consequently hybrid development from them to exploit the hybrids in salt affected areas of our country.

Materials and Methods

The present study was carried out at research farm of Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi during 2006-07. Six cucumber inbreds namely P_1 (CRC-8), P_2 (CHC-2), P_3 (G-338), P_4 (CH-20), P_5 (Pusa Uday) and P_6 (DC-1) were used for experimentation after 5 generation of selfing. Among these inbreds, three parents namely P_1, P_2 and P_3 had salinity tolerance upto $4dSm^{-1}$ whereas P_4, P_5 and P_6 were sensitive to salinity (Kumar, 2007).

The salinity-tolerant and -sensitive inbred lines were crossed in 6 x 6 half-diallel fashion [n(n-1)/2] (Hayman, 1954) to obtain 15 F_1 hybrids. All the hybrids and parents (inbreds) were grown in Randomized Block Design with three replications. The crops were sown at the spacing of 1.5 m between rows and at 50 cm between plants. All the recommended package of practices was followed to grow a successful crop. Out of 10 plants per hybrid in each replication, 8 plants were marked for observations and 2 border plants were rejected to minimize the error. Observations on individual plant basis were recorded for seven quantitative characters *viz.* days to first female flower anthesis, days to first fruit harvest, fruit weight (g), number of fruits per plant, fruit length (cm), fruit diameter (cm) and fruits yield per plant (g). The combining ability analysis was estimated according to Method-2, Model 1 of Griffing (1956) in which parents (inbreds) and hybrids are included without reciprocals using SPAR1 programme developed by IASRI, New Delhi. For Standard error of an estimate was calculated by square root of variance of that

* *Author for correspondence: Cell and Molecular Biology Laboratory, Division of Crop Improvement, Central Potato Research Institute, Shimla- 171 001 (H.P.) E-mail: jageshtiwari@gmail.com*

estimate. Critical difference was calculated as a product of standard error and 't' value for error degree of freedom at 5% and 1% level of significance. Genetic component of variance i.e. $\sigma^2 g = [(Mg-Ms)/n+2]$, $\sigma^2 s = Ms-Me$ and $\sigma^2 e = Me$ were estimated where, $\sigma^2 g$ and $\sigma^2 s$ are variance due to gca and sca, respectively; Mg, Ms and Me are mean sum of square due to gca, sca and error; and n is number of parents used i.e. six. The relative importance of gca and sca effects was determined by the Predictability Ratio (PR) $[2\sigma^2 g/(2\sigma^2 g+\sigma^2 s)]$ and the Average Degree of Dominance (ADD) $[\sigma^2 s/2\sigma^2 g]$, where $\sigma^2 g$ and $\sigma^2 s$ also denote the additive and non-additive components of variance, respectively (Baker,1978). If the PR value is <0.5 and ADD value is >1, it indicates the predominance of non-additive components of variance. While if the PR value is >0.5 and ADD value is <1, it indicate the predominance of additive components of variance.

Results and Discussion

The mean square due to gca and sca were highly significant for all the characters indicated importance of both additive and non-additive gene effects in the expression of the characters (Table 1). Estimates of gca effects of the parents (inbreds) and sca effects of the hybrids are presented in Table 2 and Table 3, respectively. Table 2 reveals that sca components of variance were higher than gca components of variance for days to first female flower anthesis, days to first fruit harvest, number of fruits per plant and fruit production per plant, in addition the PR and ADD values were also estimated <0.5 and >1, respectively. The above traits indicating the preponderance of non-additive variance of gene action. Hence, heterosis breeding is rewarded for the improvement of days to first female flower opening, days to first fruit harvest, number of fruits per plant and fruit production per plant in cucumber. While gca components of variance were higher than sca components of variance for fruit weight, fruit length and fruit diameter, besides the PR and ADD values were also estimated >0.5 and <1, respectively for these traits which indicates the predominance of additive variance of gene action. These differences may be due to the difference in the genetic materials studied. Therefore, simple selection procedure is rewarded for the improvement of fruit weight, fruit length and fruit diameter in cucumber.

The significant gca value in desirable direction was estimated in the cucumber parents (inbreds) and showed them as the better combiner parents namely P_1 for days to first female flower anthesis (-1.98) and days to first fruit harvest (-1.97), P_5 for number of fruits per plant (0.46), fruit diameter (0.31), and fruit production per plant (382.41) and P_6 for fruit weight (13.82) and fruit length (1.20) for breeding cucumber in Table 2. Since

Table 1. Analysis of variance for combining ability for seven characters in 6 × 6 half-diallele cross of cucumber

Source	d. f.	Days to 1st female flower anthesis	Days to first fruit harvest	Fruit weight (g)	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit production per plant (g)
Gca	5	3.11 **	5.01 **	528.39 **	1.27**	7.39**	1.31**	97723.29 **
Sca	15	12.05 **	10.16 **	92.74 **	1.68**	0.91**	0.21**	255584.35 **
Error	40	0.15	0.17	18.05	0.06	0.24	0.03	2739.17
$\sigma^2 g$		1.12	0.64	54.46	0.05	0.83	0.14	19732.63
$\sigma^2 s$		11.90	9.99	74.69	1.62	0.67	0.18	252845.18
PR		0.23	0.15	0.59	0.06	0.71	0.60	0.14
Add		5.31	7.80	0.68	16.2	0.41	0.64	6.40

$\sigma^2 g = [(Mg-Ms)/n+2]$, $\sigma^2 s = Ms-Me$ and $\sigma^2 e = Me$; Predictability ratio (PR) = $2\sigma^2 g/2\sigma^2 g + \sigma^2 s$; Average degree of dominance (ADD) = $\sigma^2 s/2\sigma^2 g$;
*Significant at 5% level, **Significant at 1% level

Table 2. Estimates of general combining ability (GCA) of the parents for different characters in 6 × 6 half-diallele cross of cucumber

Inbred lines	Days to 1st female flower anthesis	Days to 1st fruit harvest	Fruit weight (g)	Number of fruits	Fruit length (cm) per plant	Fruit diameter (cm)	Fruit production per plant (g)
P1	-1.98**	-1.97**	-5.77**	0.14**	0.25	0.05	-98.25**
P2	-0.52**	-0.48**	-7.54**	-0.33**	-0.33**	-0.06	-54.42**
P3	0.71**	0.72**	-9.42**	-0.80**	-0.84**	-0.12*	-171.66**
P4	1.16**	1.25**	-2.89*	-0.43**	-0.74**	-0.10	-74.60**
P5	0.27*	0.38**	11.81**	0.46*	0.46*	0.31**	328.41**
P6	0.41**	0.10	13.82**	0.31**	1.20**	0.17	267.52**
S.E. (gi)	0.13	0.14	1.37	0.08	0.16	0.06	8.78

the parents (inbreds) P_1, P_2 and P_3 had salinity tolerance and high yield components attributes as well, they could be used to breed high yielding cucumber hybrids for salt affected areas of our country.

Table 3 shows the estimates of sca effects of 15 F_1 cucumber hybrids obtained through cross combination of better combiner salinity tolerant parent *viz.*, P_1, P_2 and P_3 and salinity sensitive parent *viz.*, P_5, P_6 and P_4 for earliness, yields and its components. Table 3 demonstrates that the significant sca value was estimated in the 10 hybrids for days to first female flower anthesis, among which the hybrid P_1 x P_5 (-3.07) showed maximum negative sca effect followed by P_1 x P_6 (-2.97). Among the 9 highly significant hybrids for days to first fruit harvest, the hybrid P_2 x P_5 (-2.82) was estimated maximum negative sca effects value followed by P_2 x P_6 (-2.64). Thus, the cucumber inbreds-hybrids P_1 x P_5 and P_2 x P_5 were found to be superior for earliness characters. Highly positive significant sca effects were exhibited by 8 hybrids for fruit weight among which the hybrid P_1 x P_6 showed maximum (25.80) sca effects followed by P_2 x P_5 (22.95). For number of fruits per plant, among 6 positively significant hybrids, maximum highly significant sca effects was observed in cross P_2 x P_5 (1.68) followed by P_1 x P_5 (1.64). Analysis of sca effects for fruit length revealed that 9 hybrids showed highly significant values, in which maximum positively highly significant sca effects recorded in P_2 x P_5 (2.91), followed by P_1 x P_5 (2.67). Fruit diameter was observed significant in 7 hybrids, among which P_2 x P_6 (0.68) revealed maximum sca effect for followed by P_1 x P_6 (0.63).

A perusal of Table 2 reveals that fruit production per plant was found positively significant sca effects in 7 hybrids, among which maximum sca effects was observed in P_1 x P_5 (420.38) followed by P_3 x P_5 (399.86) and P_1 x P_6 (380.94), and minimum positive sca effect was noted in P_2 x P_4 (302.80). These results were very much similar to the finding of Shushir *et al.* (2005) and Sreevani (2005) who observed the high gca effects for parents and high sca effects in hybrids coupled with non-additive component of variance in cucumber. Yudhvir and Sharma (2006) and Munshi *et al.* (2006) also opined the pre-dominance of non-additive genetic variance and low narrow sense heritability in cucumber for the days to first fruit harvest, number of fruits per plant and yield per plant and suggested the heterosis breeding for the improvement of these traits.

The saline-tolerant and -sensitive inbreds with its high gca values and higher genetic base -due to diverse source from different parts of the states in India- produced hybrids with higher sca effects for faster and higher magnitude of success. The advance inbred lines -produced through 5 generations of selfing to attain a level of homozygosity- were used for hybrids production. The gca effect of parent is primarily a function of additive and additive × additive gene effect and it determines the breeding value of the parent. Besides, gca effects are more stable due to polygenic fixable components of genetic variation and therefore, it is of more use for breeders (Griffing 1956). Though, cucumber is cross-pollinated crop in which hybrid development is possible through crossing of inbred lines.

Table 3. Estimates of specific combining ability (SCA) for different characters in 6 × 6 half-diallele cross of cucumber

Hybrids	Days to 1^{st} female flower anthesis	Days to 1^{st} fruit harvest	Fruit weight (g)	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit production per plant (g)
P_1 x P_2	0.88	0.16	1.97	0.09	-0.68	0.33*	-137.05
P_1 x P_3	0.67	-0.09**	4.13	0.03	0.10	0.42*	-146.75
P_1 x P_4	-2.05**	-1.87**	9.51*	-0.33	-0.24	0.23	12.79
P_1 × P_5	-3.07**	-2.60**	22.70**	1.64**	2.67**	0.49**	420.38**
P_1 x P_6	-2.97**	-2.25**	25.80**	1.12**	1.09*	0.63*	380.94**
P_2 x P_3	-0.11	0.34	1.15	-0.25	1.15*	-0.04	331.66**
P_2 x P_4	-1.21**	-0.93*	9.32*	0.02	-0.54	-0.08	302.80**
P_2 x P_5	-2.61**	-2.82**	22.95**	1.68**	2.91**	0.51**	363.06**
P_2 x P_6	-2.50**	-2.64**	22.41**	1.42**	2.37**	0.68**	345.62**
P_3 x P_4	-0.44	0.46	4.37	0.41	1.19*	0.40*	-69.61
P_3 x P_5	-2.33**	-2.49**	16.56**	1.08**	1.15*	0.29	399.86**
P_3 x P_6	-0.09	-0.41	1.79	-0.63	-0.05	0.06	14.11
P_4 x P_5	-0.68*	1.31	-4.33	-0.71	1.18*	-0.06	-87.23
P_4 x P_6	-0.95*	1.63	0.59	0.03	0.31	0.25	-73.14
P_5 x P_6	-1.17*	-0.12**	14.72**	1.18**	1.02*	0.13	29.21
S.E. (sij)	0.34	0.37	3.77	0.22	0.45	0.16	24.10

Thus, results demonstrate that the significance of gca and sca effects of parents (inbreds) and hybrids, respectively in favorable direction for earliness, yield and its components in cucumber. Accordingly inbred-hybrids P_1 x P_5 for days to first male flower anthesis and fruit production per plant, P_2 x P_5 for days to first fruit harvest, number of fruits per plant and fruit length and fruit diameter and P_5 x P_6 for fruit weight were found to be suitable for further exploitation in salinity affected areas of our country.

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