IJPS INTERNATIONAL JOURNAL OF PLANT SCIENCES
Volume 7 | Issue 2 | July, 2012 | 248-252

RESEARCH ARTICLE

Study on combining ability in cucumber (*Cucumis sativus* L.)

■ S.K. SINGH, S.V. SINGH AND J.P. SRIVASTAVA

SUMMARY

The F_1 and F_2 progenies of a 8x8 parent diallel cross (excluding reciprocals) of cucumber (*Cucumis sativus* L.) were analyzed for combining ability in respect of ten attributes. Analysis of variance for combining ability revealed highly significant GCA and SCA variances for all the characters studied in F_1 and F_2 generations except fruit length in F_2 generation indicating the importance of both additive and non-additive gene action for inheritance of these attributes. However, the estimated values of GCA variance were lower than the SCA variance for all the traits in both F_1 and F_2 generations indicating the predominance of non-additive genetic variance. The parent C 99-12 was best general combiner for yield/vine, days to first male flower, fruit length, fruit weight and vine length in both the generations. The cross combinations EC 43342 x C 99-10, EC 43342 x C 98-6 and PCUC 15-1 x C 98-6 were observed as good general combiners for yield/vine in both F_1 and F_2 progenies. Biparental mating followed by recurrent selection may be utilized to exploit both additive and non-additive gene actions and to obtain transgressive segregants in advanced generations for characters governed by such type of gene action.

Key Words : Combining ability, Gene action, Diallel analysis, Cucumber

How to cite this article : Singh, S.K., Singh, S.V. and Shivastava, J.P. (2012). Study on combining ability in cucumber (*Cucumis sativus* L.). *Internat. J. Plant Sci.*, **7** (2) : 248-252.

Article chronicle : Received : 06.01.2012; **Revised :** 10.04.2012; **Accepted :** 22.04.2012

Cucumber (*Cucumis sativus* L.) is an important crop of cucurbitaceae family. Its cultivation is most popular in north and north-east region of India; *i.e.*, Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. It has an important place in human diet in the form of green vegetables and salad as well as in the form of medicine. It is a monoecious crop. Therefore, a very high degree of cross pollination takes place. The diversity in this crop is also quite meagre. As in other crops the selection of suitable parents and cross combinations are necessary for genetic improvement. The knowledge on the gene action for expression of various quantitative characters is very essential in deciding the breeding methods for genetic improvement. Combining ability leads to identification of parents and cross combinations with high GCA and SCA effects, respectively for crop improvement program. It also helps getting idea about the nature of gene action for a particular character. In a heterosis breeding program the breeder is often confronted with problems in choosing desirable parents. Diallel analysis provides information about the components of genetic variation and helps the breeder in the selection of desirable parents for hybridization and in deciding a suitable breeding procedure for the genetic improvement of various quantitative traits. The present study aims to identify best parent and cross combinations as well as to know the nature of gene action for various attributes.

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MATERIALS AND METHODS

Eight genotypes of cucumber; namely, PCUC 15, EC 43342, PCUC 15-1, CHC 2, BIHAR 1, C 99-12, C-98-6 and C 99-10 were used to make all possible crosses excluding reciprocals. The experiment material consisting 8 parents, 28 F_1s and 28 F_2s was sown in randomized block design with three replications at Department of Vegetable Science, C.S. Azad

University of Agriculture and Technology, Kanpur during *Kharif* 2002. All the parents and F_1s were sown in a single row while F_2s were sown in two rows in each replication. The length of row was kept 6.0 m while row to row and plant to plant distance was maintained at 3.0 m and 5.0 m, respectively. All the recommended agronomic practices were adopted to ensure a good s crop. The data were recorded on five selected plants in each parents and F_1s as well as ten plants in F_2s for 10 characters; *viz.,* days to first male flower, days to first female flower, node number of first male flower, node number of first female flower, fruit length (cm), fruit diameter (cm), fruit weight (g), number of fruit/vine, vine length (cm) and yield/vine (g).The combining ability analysis was worked out by the procedure suggested by Griffing's (1956b) method 2,model 1.

RESULTS AND DISCUSSION

The general combining ability has been equated with additive gene action and specific combining ability with non-additive gene action. Analysis of variance for combining ability (Table 1) revealed highly significant GCA and SCA variances for all the characters studied in F_1 and F_2 generations except fruit length in F_2 generation indicating the importance of both additive and non-additive gene action for inheritance of these attributes. However, the estimated values of GCA variance were lower than the SCA variances for all the traits in both F_1 and F_2 generations which indicated the predominance of non-additive genetic variance. The value of degree of dominance (δ^2GCA /δ^2SCA) was less than unity for all the characters in both F_1 and F_2 generations indicating non-additive gene action for these traits. Wang *et al*. (1980), Vecchia (1982), Owens (1983), Prudek (1984), Prudek and Wolf (1985) and Ananthan and Pappiah (1997) have also reported similar results in cucumber.

The parents observed as good general combiner on the basis of significant and desirable GCA effects in both F_1 and F_2 generations (Table 2) were C 99-12 for days to first male flower; C 98-6 and PCUC 15-1 for days to first female flower; C 98-6 for node number of first male flower; EC 43342 for node

Table 1 : Analysis of variance for combining ability and related statistics for 10 characters in a 8x8 parent diallel cross of cucumber

Characters	Generation	Source of variation					
		GCA (d.f.7)	SCA (d.f.28)	Error (d.f.70)	δ^2 GCA	δ^2 SCA	δ^2 GCA/δ^2 SCA
Days to first male flower	F_1	27.73**	16.52**	0.42	2.23	15.89	0.14
	F_2	17.88**	20.01**	0.78	1.71	19.23	0.09
Days to first female flower	F_1	32.09**	19.27**	0.67	3.14	18.30	0.17
	F_2	11.33**	18.77**	1.35	0.99	17.42	0.06
Node no. of first male flower	F_1	0.61**	0.57**	0.05	0.05	0.53	0.11
	F_2	0.64**	0.54**	0.04	0.06	0.50	0.12
Node no. of first female flower	F_1	1.62**	1.92**	0.29	0.13	1.66	0.08
	F_2	2.27**	2.96**	0.17	0.21	2.80	0.08
Fruit length (cm)	F_1	7.39**	7.78**	0.28	0.71	7.55	0.09
	F_2	5.29*	4.68*	0.19	0.51	4.49	0.11
Fruit diameter (cm)	F_1	0.48**	0.38**	0.05	0.04	0.33	0.12
	F_2	0.18**	0.29**	0.05	0.01	0.24	0.04
Fruit weight (cm)	F_1	6307.25**	4448.56**	13.16	629.40	4435.30	0.14
	F_2	888.26**	1188.96**	13.26	87.50	1175.69	0.07
No. of fruit/vine	F_1	1.66**	1.91**	0.11	0.15	1.80	0.08
	F_2	0.50**	1.09**	0.10	0.04	0.99	0.04
Vine length (cm)	F_1	378.00**	347.47**	17.05	36.09	331.45	0.11
	F_2	265.61**	395.35**	13.43	25.22	381.92	0.07
Yield/vine (g)	F_1	369455.47**	189537.94**	2339.85	3671.15	187913.46	0.02
	F_2	49688.70**	71799.00**	791.89	4889.68	7100.71	0.69

* and ** indicate significance of values at P=0.05 and 0.01, respectively

number of first female flower; C 99-12 and PCUC 15 for fruit length; PCUC 15-12 for fruit diameter; PCUC 15, CHC-2 and C 99-12 for fruit weight; EC 43342 for number of fruit/vine; C 99-12 for vine length and CHC-2 and C 99-12 for yield/vine. The parent C 99-12 was best general combiner for yield/vine, days to first male flower, fruit length, fruit weight and vine length, while CHC 2 was good general combiner for fruit weight and yield/vine in both the generations. These parents may be utilized extensively in crossing programmes for genetic improvement of yield/vine.

Specific combining ability effects representing dominance and epistatic components of genetic variability, would contribute much for improvement of cross pollinated crops where commercial exploitation of heterosis is feasible.

None of the cross combinations was observed superior for all the characters on the basis of SCA effects in both the generations (Table 3). On the basis of significant and desirable SCA effects, the cross combinations; *viz.,* EC 43342 x C 99-10, PCUC 15-1 x C 99-12, PCUC 15-1 x BIHAR 1, BIHAR 1 x C 98-6 and CHC 2 x C 99-10 for days to first male flower; PCUC 15-1 x C 99-12, CHC 2 x C 99-10, CHC 2 x BIHAR 1, EC 43342 x CHC 2 and BIHAR 1 x C 99-12 for days to first female flower; PCUC 15 x CHC 2 and EC 43342 x BIHAR 1 for node number of first male flower; PCUC 15 x C 98-6 for node number of first female flower; BIHAR 1 x C 98-6 and PCUC 15-1 x BIHAR 1 for fruit length; BIHAR 1 x C 98-6 for fruit diameter; EC 43342 x C 99-10, PCUC 15-1 x BIHAR 1, PCUC 15 x C 99-10, CHC 2 x C 98-6 and BIHAR 1 x C 98-6 for fruit weight; PCUC 15-1 x C 98-6 and PCUC 15 x C 99-12 for number of fruit/vine; PCUC 15-1 x C 99-10, PCUC 15-1 x BIHAR 1, EC 43342 x BIHAR 1, EC 43342 x C 99-10 and PCUC 15 x C 99-12 for vine length were selected as good specific combinations in both F_1 and F_2 generations. Among 28 cross combinations, three crosses; namely, EC 43342 x C 99-10, EC43342 x C 98-6 and PCUC 15-1 x C 98-6 were observed as good specific combiners for yield/vine in both the generations. The crosses isolated for yield performance

Table 2 : Estimates of general combining ability effects of parents in a 8x8 parent diallel cross for 10 characters of cucumber

Parents	Generation	Days to first male flower	Days to first female flower	Node no. of first male flower	Node no. of first female flower	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	No. of fruit/vine	Vine length (cm)	Yield/vine (g)
PCUC 15	F_1	2.78**	3.56**	0.21**	0.63**	0.95**	0.29**	33.09**	-0.05	4.31**	208.56**
	F_2	-0.50**	0.01	0.04	-0.82**	1.25**	0.13*	3.21**	0.03	-10.18**	-28.54**
EC 43342	F_1	0.61**	-0.69*	0.20**	0.35*	-0.65**	-0.15*	-18.35**	0.22*	7.70**	-92.69**
	F_2	2.65**	1.31**	0.11	0.35**	-0.25*	0.05	-8.38**	0.35**	-1.02	-25.67**
PCUC15-1	F_1	0.09	-0.71*	0.10	-0.04	0.08	0.12	7.55**	0.70**	5.27**	133.32**
	F_2	-0.76**	-1.06**	-0.26**	-0.10	-0.37**	0.10	-4.12**	-0.37**	-3.32**	-19.33
CHC 2	F_1	-0.29	0.80**	-0.45**	-0.04	0.91**	0.20**	29.48**	0.34**	-4.11**	226.50**
	F_2	-1.76**	-1.21**	-0.01	0.35**	-0.09	-0.10	7.57**	0.04	-1.18	74.37**
BIHAR 1	F_1	-1.60**	-1.02**	-0.04	-0.55**	-0.74**	-0.10	-24.72**	-0.02	-2.49**	-130.02**
	F_2	0.70**	1.40**	0.31**	0.43**	0.49	0.12	1.35	0.04	6.11**	-2.03
C 99-12	F_1	-0.77**	-0.13	-0.16**	-0.12	1.07**	0.18**	18.85**	-0.32**	4.43**	43.10**
	F_2	-0.92**	-0.63	-0.18**	-0.13	0.57**	0.08	17.08**	-0.18	3.74**	132.89**
C 98-6	F_1	-1.87**	-2.56**	0.30**	0.25	-0.70**	-0.26**	-18.66**	-0.34**	-8.52**	-154.99**
	F_2	0.43**	-0.69*	0.35**	0.45**	-0.56**	-0.19**	-4.23**	-0.11	3.24**	-42.69**
C 99-10	F_1	1.03**	0.73*	-0.15**	-0.48**	-0.93**	-0.26**	-27.24**	-0.54**	-6.60**	-273.77**
	F_2	0.16	0.80*	-0.35**	-0.52**	-1.03**	-0.18**	-12.48**	0.20*	2.63*	-88.99**
SE(gi)±	F_1	0.23	0.29	0.07	0.15	0.14	0.07	1.08	0.10	1.18	0.01
	F_2	0.26	0.34	0.06	0.12	0.13	0.07	1.08	0.10	1.08	8.32
SE(gi-gj)±	F_1	0.35	0.44	0.10	0.23	0.21	0.10	1.63	0.14	1.79	0.02
	F_2	0.39	0.52	0.09	0.18	0.19	0.11	1.63	0.14	1.64	12.59

* and ** indicate significance of values at P=0.05 and 0.05, respectively

besides, they performed for other traits *viz.,* EC 43342 x C 99-10 for days to first male flower, fruit weight and vine length and PCUC 15-1 x C 98-6 for node number of first female flower in both the progenies.

It was observed for most of the characters a close association between mean performance and general combining ability effects of the parents. However, the parents with high GCA having high mean value did not exhibited high SCA effects for all attributes which suggested that only general combiner on the basis of mean performance may be reliable but not good specific combiner. The parents involved in these crosses were high x high, high x low, low x high and low x low combiners. The crosses involving both parents with high GCA effects (high x high) indicated additive gene action which is fixable in nature and could be exploited through pedigree selection for further improvement of the respective trait. The cross combinations showing high SCA effects and involving both parents as low general combiner (low x low) indicated the presence of epistasis or non-additive gene action in controlling the respective traits. This suggested that these crosses may be utilized through heterosis breeding for further improvement of the respective character. The crosses

Table 3 : Estimate of SCA effects of top cross combinations for 10 characters in cucumber

Characters	Cross combinations	SCA effects		GCA effects			
				F_1		F_2	
		F_1	F_2	P_1	P_2	P_1	P_2
Days to first male flower	EC 43342 x C 99-10	-6.68**	-3.10**	High	High	High	Low
	PCUC 15-1 x C 99-12	-6.24**	-6.47**	Low	Low	Low	Low
	PCUC 15-1 x BIHAR 1	-4.69**	-3.56**	Low	Low	Low	Low
	BIHAR 1 x C 98-6	-4.60**	-4.88**	Low	High	Low	Low
	CHC 2 x C 99-10	-1.81**	-4.49**	Low	High	Low	Low
Days to first female flower	PCUC 15-1 x C 99-12	-7.37**	-7.09**	Low	Low	Low	Low
	CHC 2 x C 99-10	-2.91**	-4.52**	High	High	Low	High
	CHC 2 x BIHAR 1	-1.99**	-6.07**	High	Low	Low	High
	EC 43342 x CHC 2	-1.88**	-6.32**	Low	High	High	Low
	BIHAR 1 x C 99-12	-1.79**	-7.19**	Low	Low	High	Low
Node no. of first male flower	PCUC 15 x CHC 2	0.84**	0.35**	Low	Low	Low	Low
	EC 43342 x BIHAR 1	0.41**	0.61**	High	Low	Low	High
Node no. of first female flower	PCUC 15 x C 98-6	1.00**	1.73**	High	Low	Low	High
Fruit length (cm)	BIHAR 1 x C 98-6	2.00**	1.30**	Low	Low	Low	Low
	PCUC 15-1 x BIHAR 1	1.43**	1.24**	Low	Low	Low	Low
Fruit diameter (cm)	BIHAR 1 x C 98-6	0.43**	0.43**	Low	Low	Low	Low
Fruit weight (g)	EC 43342 x C 99-10	55.65**	10.28**	Low	Low	Low	Low
	PCUC 15-1 x BIHAR 1	27.97**	38.26**	High	Low	Low	Low
	PCUC 15 x C 99-10	27.76**	2.75**	High	Low	Low	Low
	CHC 2 x C 98-6	20.97**	0.22**	High	Low	High	Low
	BIHAR 1 x C 98-6	13.78**	7.64**	Low	Low	Low	Low
No. of fruit/vine	PCUC 15-1 x C 98-6	2.44**	2.58**	Low	Low	Low	Low
	PCUC 15 x C 99-12	0.85**	1.38**	Low	Low	Low	Low
Vine length (cm)	PCUC 15-1 x C 99-10	23.15**	14.71**	High	Low	Low	High
	PCUC 15-1 x BIHAR 1	22.04**	14.43**	High	Low	Low	High
	EC 43342 x BIHAR 1	19.49**	8.19**	High	Low	Low	High
	EC 43342 x C 99-10	13.65**	10.01**	High	Low	Low	High
	PCUC 15 x C 99-12	11.38**	8.99**	High	High	Low	High
Yield/vine (g)	EC 43342 x C 99-10	385.21**	152.52**	Low	Low	Low	Low
	EC 43342 x C 98-6	278.09**	52.21**	Low	Low	Low	Low
	PCUC 15 x C 98-6	198.68**	305.93**	High	Low	Low	Low

* and ** indicate significance of values at P=0.05 and 0.01, respectively

representing high SCA effect and involving at least one parent with high GCA effect (high x low) indicated the involvement of additive dominance gene interaction for the expression of respective trait. The presence of both additive and non-additive genetic variability suggested the utilization of certain genotype and cross to evolve new cucumber genotypes. Biparental mating followed by recurrent selection may be utilized for faster rate of improvement in characters governed by such type of gene action.

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I J PS INTERNATIONAL JOURNAL OF PLANT SCIENCES
Volume 7 | Issue 2 | July, 2012 | 253-258

RESEARCH ARTICLE

Influence of phosphorus enriched biogas spent slurry (BSS) on growth and yield of sunflower (*Helianthus annuus*)

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SUMMARY

A field experiment was conducted during 2006-2007 at Main Agricultural Research Station (MARS), Dharwad, to study the influence biogas spent slurry enriched with phosphorus using rock phosphate and phosphate solubilizing bacterial cultures in black clayey soil. Significantly highest was plant height recorded for the treatment 100 per cent recommended dose of fertilizers and normal BSS (124.07cm) followed by 75 per cent RDF and 25 per cent P-enriched BSS. The stem girth and head diameter were found to be significantly different for the P-enriched BSS, where PSB-D1 performed better than TNAU-2. The yield attributes *viz*., head weight, thousand seed weight and grain yield were significant in the same treatment enriched with PSB-D1. A matching trend was observed with respect to shoot N and P concentration. Similarly, the population of rhizosphere microflora *viz*., bacteria, fungi, actinomycetes, free living nitrogen fixers and phosphate solubilizers were found to be highest at flowering stage and thereafter decreased at harvest.

Key Words : Sunflower, BSS, Enrichment, P-solubilizers, Yield

How to cite this article : Shankarappa, T.H., Gurumurthy, S.B., Patil, S.V. and Lokesh, M.S. (2012). Influence of phosphorus enriched biogas spent slurry (BSS) on growth and yield of sunflower (*Helianthus annuus*). *Internat. J. Plant Sci.*, **7** (2) : 253-258.

Article chronicle : Received : 25.01.2012; **Revised :** 17.04.2012; **Accepted :** 26.04.2012

The addition of organic matter to the soil had long been recognized as an essential component in maintenance of soil health for sustainable crop production. Maintenance of soil fertility, release of nutrients to the plants over the growing season, improvement of water holding capacity, cation exchange capacity and resistance to soil erosion are some of the properties of organic matter in soil. Biogas spent slurry (BSS), a product obtained from biogas plants, is one among the various organic inputs used as fertilizer in crop production (Shankarappa and Geeta, 2001; Geeta *et al.,* 2004). BSS contain both macro and micro nutrients in appreciable quantities that promote plant growth and also improve physical, chemical and biological properties of soil, which in turn contribute to increased productivity (Shyam and Sreenivasa, 1998).

The nutrient status of various organic inputs may be deficient in major nutrient, phosphorus. To overcome this, several workers have tried to enrich P in FYM (Bajpai and Sundara Rao, 1971), in compost (Rasal *et al*., 2002), in BSS (Shankarappa and Geeta, 2001; Geeta *et al.,* 2002) and other organic amendments. The performance of BSS in crop production had been documented for few crops. The manurial value of BSS composted with mango leaves, wheat straw and rock phosphate was evaluated on wheat crop (Pathak *et al.,* 1992). The application of BSS along with inoculation of nitrogen fixers enhanced growth and yield of maize (Sreenivasa and Geeta, 2000). Application of BSS with *Azospirillum* inoculation had reduced the fertilizer nitrogen requirement by 25 per cent in potato

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