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Studies on combining ability in cucumber

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ABSTRACT

Thirty six F_1 hybrids were developed from nine diverse parental cucumber lines, through half diallel mating system. The hybrids along with their parents were evaluated for their combining ability for ten important quantitative traits. The parent P_3 (CHC-1) was the best general combiner for days to first fruit harvest, whereas, parent P_1 (Pusa Uday) was the best general combiner for yield per plant and its contributing traits like average fruit weight & diameter and number of fruits per plant. The hybrid $P_6 \times P_7$ (Poona Khira × Sel. 97-7) exhibited significant s.c.a effects for earliness (days to first female flower anthesis, node number of first female flower and days to first fruit harvest) while the highest s.c.a effect for yield per plant were exhibited by F_1 crosses $P_2 \times P_4$ (DC-1 × Himangi), followed by $P_1 \times P_9$ (Pusa Uday × Pant Khira). The specific combining ability component of variance (σ^2s) was higher than general combining ability component of variance (σ^2g) for all the characters, which indicated the importance of non-additive gene action for improvement. The predictability ratio was observed to be < 0.5 for all the traits except node number of first female flower, which further confirmed the predominant role of non-additive component of variance for improvement of these traits.

Key words: Cucumber,combining ability, predictability ratio.

INTRODUCTION

India being the native place of cucumber (*Cucumis sativus* L.) possesses wide range of genetic variability for qualitative and quantitative characters. In spite of this, very little effort has been made for its genetic improvement through exploitation of hybrid vigour. Hybrids offer opportunities for improvement in production, earliness, uniformity, quality and resistance to pests and diseases. The *per se* performance of parents may not always serve as an index of their genetic nicking ability (Allard, 1) or in other words high performing parents do not necessarily give rise to good hybrid. Heterosis is rather a function of specific cross combination, so analysis of combining ability helps to determine the feasibility of its utilization and identification of best combiners. It also helps in the identification of superior hybrid combinations, which may be utilized for commercial exploitation of heterosis. Therefore, the present study was carried out to determine the general combining ability (g.c.a) and specific combining ability (s.c.a) of nine parents and their 36 F_1 hybrids in cucumber.

MATERIALS AND METHODS

The present study was carried out at the Research Farm of Division of Vegetable Science, IARI, New Delhi, during the spring-summer and *kharif* seasons for two years. Nine genetically diverse cucumber inbred lines or varieties, *viz*., Pusa Uday (P_1), DC-1 (P_2), CHC-1 (P_3), Himangi (P_4), Poinsette (P_5), Poona Khira (P_6), Sel. 97-7 (P_7), CHC-2 (P_8) and Pant Khira (P_9) were crossed in a half-diallel mating scheme during spring-summer season. The 36 F_1 hybrids along with nine parents were evaluated in a randomized block design with three replications during *kharif* season. The crop was sown in rows of 2.5 m apart with 45 cm spacing between the plants. All the recommended agronomic practices along with plant protection measures were followed to raise a successful crop under irrigated conditions. Out of 10 plants, five were randomly selected in each treatment. Observations on individual plant basis were recorded on ten important quantitative traits, *viz*., days to first male flower anthesis, days to first female flower anthesis, node number of first female flower, days to first fruit harvest, fruit length (cm), fruit diameter (cm), average fruit weight (g), number of fruits per plant, vine length (cm) and yield per plant (kg). The combining ability analysis for different characters was worked out according to Method 2, Model 1 of Griffing (7), where parents and F_1s were included but not the reciprocals. Relative importance of general combining ability and specific combining ability was estimated by the predictability ratio 2 σ^2g/ (2 σ^2g + σ^2s) (Baker, 3) for fixed effect model, where σ^2g is the additive component of variance and σ^2s is the non-additive component of variance.

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RESULTS AND DISCUSSION

Combining ability analysis of nine parents and their 36 F_1 hybrids showed significant g.c.a. and s.c.a. effects for all the characters studied (Table 1). This indicated that both additive and non-additive gene action influenced the characters under study. The s.c.a. component of variance (s^2s) was higher than g.c.a. component of variance (s^2g) for all the characters, which indicated the importance of non-additive gene action for the improvement of these characters. The predictability ratio was observed to be < 0.5 for all the characters studied except node number of first female flower, which further confirmed the predominant role of non-additive component of variance for the improvement of these characters.

The results of general combining ability (Table 2) revealed that among nine parental lines, the parent P_2 (DC-1) exhibited highest negative g.c.a effect in desirable direction for days to first male flower anthesis, followed by P_3 (CHC-1). The parent P_3 (CHC-1) exhibited highest negative g.c.a effect in desirable direction for days to first female flower anthesis, node number of first female flower and days to first fruit harvest, followed by P_2 (DC-1). The parent P_7 (Sel. 97-7) exhibited the highest g.c.a. effect for fruit length, followed by P_1 (Pusa Uday). The parent P_1 (Pusa Uday) showed the highest g.c.a. effect for fruit diameter and average fruit weight, followed by P_9 (Pant Khira). The parent P_4 (Himangi) exhibited highest negative g.c.a. effect for vine length, followed by P_3 (CHC-1). The parent P_1 (Pusa Uday) showed highest positive g.c.a. effect for number of fruits per plant and yield per plant, followed by parent P_2 (DC-1). In most of the cases it was observed that *per se* performance of parents bears direct reflection of their respective g.c.a effects, *i.e.* parents showing highest g.c.a effect for a character were also observed to be good performer with respect to that particular character. The present results are in conformity with the findings of Batakurki *et al*. (4), Brar *et al*. (5), Chirani *et al*. (6), Kumar *et al*. (8), Sarkar and Sirohi (9), and Singh *et al*. (10) in cucumber.

The estimates of s.c.a. effects are presented in Table 3a and 3b. Out of 36 F_1 hybrids taken for present study, significant s.c.a. effects in favourable direction were observed in 21 hybrids for days to first male flower anthesis, 23 for days to first female flower anthesis, 13 for node number of first female flower, 21 for days to first fruit harvest, 23 for fruit length, 20 for fruit diameter, 22 for average fruit weight, 15 for number of fruits per plant, 9 for vine length and 20 for yield per plant. The F_1 crosses showing the highest significant desirable s.c.a. effects for various characters in order of merit were $P_6 \times P_7$, $P_1 \times P_2$ and $P_1 \times P_3$ for days to first male flower anthesis; $P_6 \times P_7$, $P_1 \times P_4$ and $P_5 \times P_6$ for days to first female flower anthesis; $P_6 \times P_7$, $P_6 \times P_9$ and $P_1 \times P_5$ for node number of first female flower; $P_6 \times P_7$, $P_1 \times P_4$ and $P_3 \times P_9$ for days to first fruit harvest; $P_2 \times P_4$, $P_1 \times P_8$ and $P_6 \times P_7$ for fruit length; $P_4 \times P_8$, $P_3 \times P_9$ and $P_3 \times P_5$ for fruit diameter; $P_4 \times P_8$, $P_1 \times P_8$ and $P_2 \times P_4$ for average fruit weight; $P_2 \times P_4$, $P_1 \times P_9$ and $P_2 \times P_3$ for number

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

Character	Source of variation of g.c.a			Source of variation of s.c.a			Error		s^2g	s^2s	PR
	D.F.	M.S.S.	F	D.F.	M.S.S.	F	D.F.	M.S.S.			
Days to first male flower anthesis	8	7.46**	120.34	35	2.24**	36.13	88	0.062	0.673	2.179	0.38
Days to first female flower anthesis	8	16.86**	257.24	35	3.92**	59.88	88	0.065	1.528	3.862	0.44
Node number of first female flower	8	2.39**	57.52	35	0.42**	10.34	88	0.041	0.214	0.388	0.52
Days to first fruit harvest	8	19.75**	217.09	35	3.90**	42.94	88	0.091	1.788	3.817	0.48
Fruit length (cm)	8	3.56**	188.21	35	3.31**	174.77	88	0.018	0.323	3.293	0.16
Fruit diameter (cm)	8	0.46**	114.76	35	0.27**	68.18	88	0.0040	0.042	0.272	0.23
Average fruit weight (g)	8	1125.70**	85. 98	35	871.87**	66.59	88	13.09	101.147	858.78	0.19
No. of fruits per plant	8	2.76**	68.50	35	0.96**	23.83	88	0.040	0.248	0.923	0.34
Vine length (cm)	8	493.92**	38.18	35	114.76**	8.87	88	12.93	43.726	101.835	0.46
Yield per plant (kg)	8	0.18**	44.63	35	0.11**	27.10	88	0.0041	0.016	0.107	0.23

* Significant at 5% level; ** Significant at 1% level; Predictability ratio (PR) = $2\sigma^2g/(2\sigma^2g + \sigma^2s)$

Table 2. Estimate of g.c.a. effects of cucumber parent genotypes.

Parent	DFMFA	DFFFA	NNFFF	DFFH	FL (cm)	FD (cm)	AFW (g)	NF/P	VL (cm)	Y/P (kg)
P_1 (Pusa Uday)	0.633**	0.708**	0.082	0.958**	0.587**	0.302**	13.673**	0.623**	12.997**	0.216**
P_2 (DC-1)	-1.046**	-1.595**	-0.354**	-1.660**	0.227**	-0.054*	0.219	0.611**	6.451**	0.134**
P_3 (CHC-1)	-0.919**	-1.729**	-0.694**	-1.963**	-0.905**	-0.279**	-13.842**	-0.541**	-4.306**	-0.186**
P_4 (Himangi)	-0.682**	-0.595**	-0.245**	-0.478**	-0.529**	-0.120**	-11.327**	-0.092	-4.761**	-0.090**
P_5 (Poinsette)	0.081	0.320**	0.179*	0.437**	-0.166**	0.165**	2.067	-0.371**	-1.367	-0.070**
P_6 (Poona Khira)	-0.034	0.223*	0.119	0.249**	0.243**	0.051*	6.704**	-0.347**	-3.70**	-0.030
P_7 (Sel. 97-7)	1.475**	1.968**	0.858**	2.073**	0.753**	0.032	5.916**	-0.607*	0.178	-0.092**
P_8 (CHC-2)	-0.155	-0.547**	-0.348**	-0.805**	-0.566**	-0.289**	-12.236**	0.538**	8.943**	0.014
P_9 (Pant Khira)	0.645**	1.247**	0.403**	1.189**	0.355**	0.192**	8.825**	0.187*	3.451**	0.105**
S.E. (gi)	0.070	0.072	0.057	0.085	0.039	0.018	1.028	0.057	1.02	0.018
S.E. (gi - gj)	0.106	0.109	0.086	0.128	0.058	0.027	1.542	0.085	1.53	0.027
C.D. at 5%	0.16	0.16	0.13	0.19	0.089	0.04	2.37	0.13	2.35	0.04
C.D. at 1%	0.23	0.24	0.19	0.28	0.13	0.06	3.44	0.19	3.42	0.06

*, **Significant at 5 and 1% levels.
DFMFA = Days to first male flower anthesis; DFFFA = Days to first female flower anthesis; NNFFF = Node number of first female flower; DFFH = Days to first fruit harvest; FL = Fruit length, FD = Fruit diameter; AFW = Average fruit weight; NF/P = Number of fruits/ plant; VL = Vine length; Y/P = Yield/ plant.

Table 3a. Estimates of s.c.a. effect of F_1 hybrids for different quantitative traits.

Cross	DFMFA	DFFFA	NNFFF	DFFH	FL (cm)
$P_1 \times P_2$	-1.998**	-1.514**	-0.651**	-1.251**	0.438**
$P_1 \times P_3$	-1.725**	-1.247**	0.022	-1.148**	-0.544**
$P_1 \times P_4$	-1.495**	-2.247**	-0.693**	-2.299**	0.927**
$P_1 \times P_5$	-1.325**	-1.496**	-0.718**	-1.215**	-0.190
$P_1 \times P_6$	2.057**	1.801**	0.143	1.107**	0.768**
$P_1 \times P_7$	1.415**	0.056	-0.130	0.282	-0.055**
$P_1 \times P_8$	1.045**	2.504**	0.810**	2.028**	2.317**
$P_1 \times P_9$	-0.888**	-0.490*	-0.342	-0.966**	0.750**
$P_2 \times P_3$	-0.713**	-1.078**	-0.275	-1.196**	1.970**
$P_2 \times P_4$	-0.016	0.722**	0.543**	0.919**	4.394**
$P_2 \times P_5$	-0.713**	-0.993**	-0.015	-1.330**	1.264**
$P_2 \times P_6$	-0.931**	-1.496**	-0.687**	-1.875**	-1.671**
$P_2 \times P_7$	-0.973**	-1.841**	-0.493**	-1.233**	-2.388**
$P_2 \times P_8$	-0.276	-1.126**	-0.487**	-1.154**	-0.509**
$P_2 \times P_9$	-0.543*	-1.320**	0.495**	-0.948**	1.010**
$P_3 \times P_4$	-0.143	-0.078	-0.184	0.155	-0.135
$P_3 \times P_5$	-1.640**	-1.259**	-0.408*	-1.627**	-0.571**
$P_3 \times P_6$	-0.525*	0.038	-0.081	0.495	1.394**
$P_3 \times P_7$	1.566**	1.892**	-0.021	1.737**	-0.156
$P_3 \times P_8$	0.396	-0.126	-0.148	-0.118	0.256*
$P_3 \times P_9$	-0.337	-1.853**	-0.499**	-1.978**	-0.032
$P_4 \times P_5$	-0.476*	-0.726**	0.676**	-1.045**	0.999**
$P_4 \times P_6$	-0.161	-0.296	0.337	-0.724**	0.311*
$P_4 \times P_7$	1.530**	1.292**	0.131	0.852**	1.194**
$P_4 \times P_8$	-0.907**	-1.193**	-0.663**	-0.536	1.939**
$P_4 \times P_9$	-0.907**	-1.320**	0.185	-0.930**	0.419**
$P_5 \times P_6$	-1.392**	-2.144**	-0.487**	-1.772**	1.168**
$P_5 \times P_7$	0.833**	0.310	0.173	0.404	1.365**
$P_5 \times P_8$	0.596**	0.825**	-0.021	0.549*	-1.410**
$P_5 \times P_9$	0.863**	1.298**	-0.639**	1.288**	0.249*
$P_6 \times P_7$	-3.785**	-5.259**	-1.433**	-5.742**	2.146**
$P_6 \times P_8$	-0.822**	-0.478*	0.107	-0.663*	1.174**
$P_6 \times P_9$	0.778**	1.662**	-0.778**	1.276**	0.874**
$P_7 \times P_8$	-0.998**	-0.490*	0.167	-0.221	-0.349**
$P_7 \times P_9$	-0.731**	-1.550**	-0.318	-1.081**	0.724**
$P_8 \times P_9$	-0.834**	-0.768**	-0.245	-0.802**	-0.358**
S.E. S_{ii}	0.201	0.207	0.164	0.244	0.111
S.E. $S_{ii} - S_{jj}$	0.280	0.288	0.230	0.340	0.155
S.E. S_{ij}	0.227	0.234	0.186	0.275	0.125
S.E. $S_{ij} - S_{ik}$	0.335	0.345	0.274	0.406	0.185
S.E. $S_{ij} - S_{kl}$	0.318	0.327	0.260	0.385	0.176

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*, **Significant at 5 and 1% levels; DFMFA = Days to first male flower anthesis; DFFFA = Days to first female flower anthesis; NNFFF = Node number of first female flower; DFFH = Days to first fruit harvest; FL = Fruit length.

Table 3b. Estimates of s.c.a. effects of F_1 hybrids for different quantitative traits.

Cross	FD (cm)	AFW (g)	NF/P	VL (cm)	Y/P (kg)
$P_1 \times P_2$	0.217**	12.382**	-0.075	5.248	0.072
$P_1 \times P_3$	0.494**	5.442	0.543**	6.339	0.121*
$P_1 \times P_4$	0.063	12.927**	-0.372*	1.794	-0.008
$P_1 \times P_5$	0.004	-2.467	-0.293	-3.600	-0.081
$P_1 \times P_6$	0.039	2.897	0.216	5.067	0.062
$P_1 \times P_7$	-0.173**	-4.982	0.210	-12.812**	0.004
$P_1 \times P_8$	0.262**	31.503**	-0.069	9.976**	0.225**
$P_1 \times P_9$	-0.026	11.109**	1.482**	11.915**	0.420**
$P_2 \times P_3$	0.461**	28.897**	1.222**	13.885**	0.420**
$P_2 \times P_4$	-0.227**	31.382**	1.973**	23.339**	0.625**
$P_2 \times P_5$	-0.226**	5.655	0.719**	-5.388	0.175**
$P_2 \times P_6$	0.242**	-12.315**	1.095**	-2.721	0.118*
$P_2 \times P_7$	-0.166**	-28.194**	-1.845**	-16.933**	-0.530**
$P_2 \times P_8$	0.359**	3.291	0.276	7.855*	0.061
$P_2 \times P_9$	0.507**	23.230**	0.628**	-8.873**	0.290**
$P_3 \times P_4$	-0.330**	-1.891	-0.408*	-10.903**	-0.092
$P_3 \times P_5$	0.678**	4.382	0.470*	-4.297	0.111
$P_3 \times P_6$	0.286**	23.745**	-0.754**	-5.630	-0.049
$P_3 \times P_7$	0.578**	19.200**	0.507**	-0.842	0.200**
$P_3 \times P_8$	-0.820**	-15.982**	-0.772**	-10.721**	-0.236**
$P_3 \times P_9$	0.755**	12.958**	0.313	-4.448	0.112
$P_4 \times P_5$	0.363**	27.200**	0.022	10.491**	0.116*
$P_4 \times P_6$	0.118*	10.230**	-1.336**	-9.842**	-0.224**
$P_4 \times P_7$	-0.023	18.685**	-0.875**	-9.388**	-0.133*
$P_4 \times P_8$	0.888**	48.836**	-0.087	4.067	0.308**
$P_4 \times P_9$	0.486**	22.109**	1.198**	10.673**	0.387**
$P_5 \times P_6$	0.392**	21.503**	0.876**	8.430*	0.322**
$P_5 \times P_7$	0.331**	28.958**	0.204	-0.782	0.204**
$P_5 \times P_8$	0.109	-11.558**	-0.008	-9.661**	-0.069
$P_5 \times P_9$	-0.619**	-11.285**	-1.657**	-15.388**	-0.420**
$P_6 \times P_7$	0.029	25.321**	1.046**	2.552	0.374**
$P_6 \times P_8$	0.330**	21.139**	-0.033	12.006**	0.138
$P_6 \times P_9$	-0.064	9.079**	0.385*	0.612	0.120*
$P_7 \times P_8$	-0.044	-12.073**	1.095**	10.461**	0.133*
$P_7 \times P_9$	0.131*	8.200**	0.646**	-4.267	0.242**
$P_8 \times P_9$	0.522**	10.018**	0.234	4.855	0.113
S.E. Sii	0.051	2.927	0.162	2.909	0.051
S.E. $S_{ii} - S_{jj}$	0.071	4.082	0.226	4.057	0.072
S.E. S_{ij}	0.058	3.309	0.183	3.289	0.058
S.E. $S_{ij} - S_{ik}$	0.085	4.879	0.271	4.849	0.086
S.E. $S_{ij} - S_{kl}$	0.081	4.628	0.257	4.600	0.081

*, **Significant at 5 and 1% levels; FD = Fruit diameter; AFW = Average fruit weight; NF/P = Number of fruits/plant; VL= Vine length; Y/P = Yield/plant

of fruits per plant; $P_2 \times P_7$, $P_5 \times P_9$ and $P_1 \times P_7$ for vine length and $P_2 \times P_4$, $P_1 \times P_9$ and $P_2 \times P_3$ for yield per plant. The two top performing hybrids for yield per plant showed significantly higher s.c.a. effects for yield contributing characters which culminated into higher total yield.

A comparison of s.c.a. effects of the crosses and g.c.a. effects of the parents involved indicated that in most of the cases, g.c.a. effects were reflected in the s.c.a. effects of the cross combination. The F_1 hybrids showed promising results when at least one of the parental lines exhibiting high g.c.a. effect for yield and its component traits were involved in the crosses. This indicated that there was strong tendency of transmitting the higher gain from parents to offspring. The results are in conformity with the findings of Batakurki *et al.* (4), Brar *et al.* (5), Chirani *et al.* (6), Kumar *et al.* (8), Sarkar and Sirohi (9) and Singh *et al.* (10).

In the present investigation, 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 yield and its contributing characters. The crosses, which showed high s.c.a. effects can be best utilized in heterosis breeding. The F_1 hybrid $P_2 \times P_4$ (DC-1 × Himangi), which exhibited highest significant s.c.a. for fruit length, number of fruits per plant, yield per plant and the third highest s.c.a. effect for average fruit weight and hybrid $P_1 \times P_9$ (Pusa Uday × Pant Khira), which exhibited second highest significant s.c.a. effect for number of fruits per plant and yield per plant may be exploited for commercial F_1 hybrid production.

REFERENCES

1. Allard, R.W. 1960. *Principles of Plant Breeding*, John Wiley and Sons, Inc., New York, 485 p.
2. Bairagi, S.K., Singh, D.K. and Ram, H.H. 2001. Diallel analysis of combining ability in cucumber (*Cucumis sativus* L.). *Prog. Hort.* **33**: 178-83.

3. Baker, R.J. 1978. Issues in diallel analysis. *Crop. Sci.* **18**: 533-36.
4. Batakurki, I., Mulge, R., Aradiguddi, M.K. and Ghasti, V.D. 2011. Heterosis and combining ability studies for growth and quality parameters in cucumber (*Cucumis sativus* L.). *Green Farming*, **2**: 521-23.
5. Brar, P.S., Singh, G., Singh, M. and Batth, G.S. 2011. Combining ability for yield and its attributing traits in cucumber. *Crop Improv.* **38**: 189-90.
6. Chirani, J.O., Peyvast, G., Lahiji, H.S., Rabiei, B. and Khodaparast, S.A. 2011. General yield and specific combining ability and heterosis of some cucumber lines in partial diallel design. *Iranian J. Hort. Sci.* **42**: 53-64.
7. Griffing, J.B. 1956. Concepts of general and specific combining ability in relation to diallel crossing system. *Australian J. Biol. Sci.* **9**: 663-93.
8. Kumar, J., Munshi A.D., Kumar, R., Sureja A.K. and Sharma, R.K. 2013. Combining ability and its relationship with gene action in slicing cucumber. *Indian J. Hort.* **70**: 135-38.
9. Sarkar, M. and Sirohi, P.S. 2010. Combining ability analysis for yield and its contributing characters in cucumber. *Indian J. Hort.* **67**: 525-30.
10. Singh, S.K., Singh, S.V. and Srivastava, J.P. 2012. Study on combining ability in cucumber (*Cucumis sativus* L.). *Intl J. Plant Sci.* (*Muzaffarnagar*), **7**: 248-52.

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