Combining ability analysis for yield and its contributing characters in cucumber

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ABSTRACT

Combining ability was studied in cucumber in a 10 × 10 diallel cross excluding reciprocals for ten important quantitative characters including total yield per plant, maturity and fruit characters. The mean square due to gca and sca were highly significant for all the characters studied which revealed that both additive and non-additive gene actions were important in the inheritance of these characters. Hence, for the improvement of these traits, both selection and heterosis methods of breeding can be adopted. The estimated components of variance for sca were larger than those of gca. This indicated that the superior performance of F_1 hybrids showing high sca was largely due to epistasis interaction. Among 10 parental lines, the parent P_1 (DC-1) showed highest gca for fruit weight, fruit length and total yield per plant and parent P_3 (DC-2) exhibited maximum favourable gca for node number of first female flower and number of fruits per plant. In order of merit, the hybrid $P_7 \times P_8$ (PCUC-28 × VRC-11-1), $P_1 \times P_7$ (DC-1 × PCUC-28) and $P_4 \times P_6$ (CH-20 × Himangi) were found to be the top performing hybrids over top parent for total yield per plant. These F_1 hybrids showed highly significant sca effects for yield and its important contributing characters. The results of this study suggests that for improvement of a desirable character, the selected parental line should be of high gca value and their F_1s should express high specific combining ability.

Key words: Cucumber, diallel cross, combining ability, yield.

INTRODUCTION

The cucumber (*Cucumis sativus* L.) is one of the most important vegetable of Cucurbitaceae family. It is grown throughout the world in sub-tropical and tropical climates. Its tender fruits are consumed in several ways and are in great demand throughout the world. It possesses very wide range of genetic variability that may be exploited for its improvement. Being a cross-pollinated crop, it has ample scope for the utilization of hybrid vigour. Combining ability of the parents serve as a useful guide in the selection of parents for a hybridization programme, either to exploit for heterosis or to combine favourable fixable genes. The present study was, therefore, undertaken in a group of 10 genetically diverse cucumber lines to obtain information regarding the estimates of general and specific combining abilities.

MATERIALS AND METHODS

Ten pure lines of cucumber, namely, P_1 (DC-1), P_2 (CHC-1), P_3 (DC-2), P_4 (CH-20), P_5 (CHC-2), P_6 (Himangi), P_7 (PCUC-28), P_8 (VRC-11-1), P_9 (Poona Khira) and P_{10} (DARL-81) were crossed in a half-diallel fashion. The 45 F_1s thus obtained along with 10 parents were grown in the randomized block design with three replications. The crop was grown in rows at 2 m apart with spacing of 0.60 m between the plants. All the recommended practices for irrigated conditions were followed to raise the crop. Ten plants in each replication per treatment were randomly selected at maturity for ten important characters namely; vine length, days to first male flower opening, days to first female flower opening, node number of first female flower opening, days to first fruit harvest, fruit weight, fruit diameter, fruit length, number of fruits per plant and total yield per plant. The combining ability estimates (gca and sca) were calculated according to the Model 1 and Method 2 of Griffing (2).

RESULTS AND DISCUSSION

The results of the analysis of variance for general and specific combining ability are presented in Table 1. It revealed that the mean squares were highly significant for both the general and specific combining ability for all the ten characters studied. Estimates of gca effects of parents and estimates of sca effects of F_1 hybrids are presented in Tables 2 and 3, respectively. Combining ability analysis of the 10 parents and their 45 F_1 hybrids showed significant gca and sca effects for all the characters studied. This indicated the importance of both additive and non-additive gene action for the characters under study. Among 10 parental lines, the parent P_1 (DC-1) showed highest gca for fruit weight, fruit length and total yield per plant. Parent P_3 (DC-2) exhibited maximum favourable gca for node number of first female flower and number of fruits per plant.

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Table 1. Analysis of variance for combining ability.

Character	Source of variation of gca			Source of variation of sca			Error	
	D.F.	M.S.S.	F	D.F.	M.S.S.	F	D.F.	M.S.S.
Vine length (m)	9	0.102**	22.574	45	0.016**	3.611	108	0.005
Days to first male flower opening	9	23.325**	128.255	45	6.379**	35.073	108	0.182
Days to first female flower opening	9	42.362**	207.657	45	6.781**	33.240	108	0.204
Node number of first female flower	9	1.084**	19.177	45	0.371**	6.569	108	0.057
Days to first fruit harvest	9	44.970*	121.583	45	6.490**	17.548	108	0.370
Fruit weight (g)	9	2672.152**	69.567	45	981.587**	25.554	108	38.411
Fruit diameter (cm)	9	0.355**	17.890	45	0.186**	9.351	108	0.020
Fruit length (cm)	9	4.991**	16.323	45	2.488**	8.137	108	0.306
Number of fruits per plant	9	14.070**	52.509	45	2.842**	10.612	108	0.268
Total yield per plant (g)	9	744574.920**	86.537	45	189572.227**	22.033	108	8604.145

*,**Significant at 5 and 1% levels of significance.

The parent P_7 (PCUC-28) exhibited highest gca for fruit diameter. The parent P_9 (Poona Khira) exhibited maximum negative gca for days to first male flower opening. The parent P_6 (Himangi) recorded highest negative gca in desirable direction for days to first female flower opening and days to first fruit harvest. The parent P_5 (CHC-2) exhibited maximum negative gca in favourable direction for vine length. On the analysis of parental lines, it was seen that DC-2 (P_3) gave the highest yield of 1510.33 g followed by PCUC-28 (P_7) with 1440.30 g and DC-1 (P_1) with 1063.47 g per vine. These parents have shown high gca with respect to yield and yield contributing characters. These results suggest that while selecting the parental lines for obtaining F_1 hybrids, it will be useful to choose those lines that have high gca with respect to yield and yield contributing characters. The results are in conformity with the findings of Dogra *et al.* (1), Singh *et al.* (3), and Verma *et al.* (4) in cucumber

Among 45 F_1 hybrids, significant sca effects in desirable direction were manifested by 8 for vine length, 22 for days to first male flower opening, 19 for days to first female flower opening, 10 for node number of first female flower, 17 for days to first fruit harvest, 16 for fruit weight, 12 for fruit diameter, 15 for fruit length, 15 for number of fruits per plant and 18 for total yield per plant. The hybrids, which showed highest sca effects in favourable direction for different characters were $P_3 \times P_{10}$ (DC-2 × DARL-81) for vine length, $P_1 \times P_4$ (DC-1 × CH-20) for days to first male flower opening, $P_1 \times P_{10}$ (DC-1 × DARL-81) for days to first male flower opening and for node number of first female flower, $P_1 \times P_2$ (DC-1 × CHC-1) for days to first fruit harvest, $P_3 \times P_8$ (DC-2 × VRC-11-1) for fruit weight, $P_4 \times P_9$ (CH-20 × Poona Khira) for fruit diameter, $P_7 \times P_8$ (PCUC-28 × VRC-11-1) for fruit length and $P_3 \times P_4$ (DC-2 × CH-20) for number of fruits per plant . In order of merit, the hybrid $P_7 \times P_8$ (PCUC-28 × VRC-11-1), $P_1 \times P_7$ (DC-1 × PCUC-28) and $P_4 \times P_6$ (CH-20 × Himangi) were found to be the top performing hybrids over top parent for total yield per plant. These F_1 hybrids also showed highly significant sca effects for yield and its contributing characters. The results are in conformity with the findings reported by Verma *et al.* (4), who reported high sca effects for yield and other traits for the cucumber cross combinations.

In the present study, the mean square due to gca and sca were highly significant for all the characters studied which revealed that both additive and non-additive gene actions were important in the inheritance of these characters. Hence, for the improvement of these traits, both selection and heterosis methods of breeding can be adopted. The response to selection is expected to be the best in crosses involving parents having high gca effects. The selected parental lines having better performance can be crossed in suitable combinations to exploit heterosis. The crosses which showed high sca effects can be best utilized in heterosis breeding.

Table 2. Estimate of gca effects of some cucumber parents.

Parent	Vine length (m)	Days to first male flower opening	Days to first female flower opening	Node number of first female flower	Days to first fruit harvest	Fruit weight (g)	Fruit diameter (cm)	Fruit length (cm)	Number of fruits per plant	Total yield per plant (g)
P_1 (DC-1)	0.04*	-1.60**	-0.96**	0.43**	-1.51**	27.39**	-0.13**	1.09**	1.13**	369.36**
P_2 (CHC-1)	0.05**	0.25*	0.98**	0.21**	1.31**	-3.05	-0.29**	0.20	-0.71**	-116.86**
P_3 (DC-2)	-0.04*	-0.79**	-1.08**	-0.41**	-0.34*	1.81	0.01	-0.61*	1.65**	298.87**
P_4 (CH-20)	0.00	-0.30*	-0.67**	-0.08	-0.36*	-6.27**	0.14**	-0.21	0.16	-20.63
P_5 (CHC-2)	-0.13**	0.56**	-0.63**	-0.36**	-0.72**	-17.27**	0.07*	-0.28	0.27	-85.31
P_6 (Himangi)	-0.08**	-1.27**	-2.05**	-0.01	-2.25**	-18.11**	-0.09*	-1.07**	-0.26	-160.58**
P_7 (PCUC-28)	0.17**	0.49**	-0.21	-0.02	-0.69**	18.56**	0.28**	0.85**	1.17**	338.76**
P_8 (VRC-11-1)	0.08**	1.92**	3.83**	-0.33**	3.85**	8.26**	0.12**	0.34*	-0.62**	-43.74
P_9 (Poona Khira)	-0.11**	-1.63**	-1.67**	0.37**	-1.64**	-12.69**	0.14**	-0.16	-1.09**	-282.08**
P_{10} (DARL-81)	0.02	2.37**	2.48**	0.19**	2.53**	1.37	-0.13**	-0.16	-1.71**	-298.25**
SE (gi)	0.017	0.118	0.122	0.063	0.167	1.697	0.032	0.152	0.141	25.40
SE (gi-gj)	0.028	0.173	0.184	0.095	0.249	2.530	0.055	0.226	0.212	37.86

*,**Significant at 5 and 1% levels of significance.

Table 3. Estimates of sca effects of F_1 hybrids in cucumber.

Cross	Vine length (cm)	Days to first male flower opening	Days to first female flower opening	Node number of first female flower	Days to first fruit harvest
P1 × P2	0.17	-3.10**	-3.34**	-0.15	-4.99**
P1 × P3	-0.13*	-1.66**	-0.94*	0.07	-1.35**
P1 × P4	-0.18**	-4.12**	-3.48**	0.14	-2.34**
P1 × P5	0.02	-2.24**	-2.16**	1.22**	0.06
P1 × P6	0.28*	0.29	2.70**	-0.82**	3.49**
P1 × P7	-0.01	2.69**	3.72**	0.08	2.90**
P1 × P8	0.05	-0.60	0.82	0.19	0.52*
P1 × P9	0.03	-1.65**	-0.68	0.86**	-0.36
P1 × P10	-0.11	-3.58**	-4.53**	-1.03**	-2.89**
P2 × P3	0.02	1.69**	1.29**	-0.31	-0.12
P2 × P4	0.11	1.73**	2.67**	0.16	3.10**
P2 × P5	0.05	1.47**	0.43	-0.56*	4.46**
P2 × P6	-0.14*	-2.10**	-2.94**	0.50	-2.31**
P2 × P7	-0.22**	-0.49	-0.25	-0.40	1.80**
P2 × P8	-0.07	1.31**	-1.09**	-0.29	-0.08
P2 × P9	-0.03	-1.03**	0.97*	-0.19	-0.26
P2 × P10	0.11	-0.27	-0.78*	-0.51*	-0.09
P3 × P4	0.05	1.31**	0.84*	-0.52*	1.26**
P3 × P5	0.13*	-2.89**	-3.17**	-0.14	-2.41**
P3 × P6	-0.02	3.54**	2.72**	0.41	3.29**
P3 × P7	0.02	2.81**	0.98*	0.52*	0.80**
P3 × P8	0.04	-2.95**	-3.46**	-0.27	-2.98**
P3 × P9	0.07	-0.50	-0.84*	0.13	1.31**
P3 × P10	-0.29**	-1.30**	-2.41**	-0.29	-2.62**
P4 × P5	0.13*	0.92*	2.29**	-0.07	0.97**
P4 × P6	-0.03	-3.25**	-4.09**	-0.12	-4.76**
P4 × P7	0.33**	0.99**	1.40**	0.09	1.48**
P4 × P8	-0.11	-0.54	0.49	0.50*	0.07
P4 × P9	0.02	-1.19**	-2.47**	0.77**	-0.28
P4 × P10	-0.16**	-1.22**	-2.82**	-1.02**	-1.94**
P5 × P6	0.15*	-0.41	0.47	-0.34	0.80**
P5 × P7	-0.07	2.73**	-0.07	-0.03	0.37
P5 × P8	-0.14*	-1.30**	-3.01**	0.18	-2.77**
P5 × P9	0.03	-1.95**	1.29**	-0.22	-0.38
P5 × P10	0.02	-1.55**	0.84*	-0.64**	-0.98**
P6 × P7	-0.19**	-2.54**	-1.95**	-0.27	-1.79**
P6 × P8	0.10	2.00**	0.71	-0.56*	1.24**
P6 × P9	-0.07	-0.52	0.81*	-0.26	-0.45*
P6 × P10	-0.03	-1.85**	-2.94**	-0.59**	-3.41**
P7 × P8	0.01	-5.10**	-3.63**	-0.66**	-4.29**
P7 × P9	0.14*	-1.18**	-0.53	0.81**	-0.41
P7 × P10	0.00	0.32	1.52**	0.82**	-0.14
P8 × P9	-0.02	0.39	1.56**	-0.07	1.82**
P8 × P10	0.05	-0.81*	0.98*	0.43	0.99**
P9 × P10	0.01	1.64**	-2.52**	0.43	-2.73**
Sii	0.05	0.35	0.37	0.19	0.50
Sii-Sjj	0.08	0.49	0.52	0.27	0.70
Sij	0.06	0.39	0.42	0.22	0.56
Sij-Sik	0.09	0.58	0.61	0.32	0.82
Sij-Skl	0.08	0.55	0.58	0.31	0.79

*,**Significant at 5 and 1% levels of significance.

Table 3. Contd…

Cross	Fruit weight (g)	Fruit diameter (cm)	Fruit length (cm)	Number of fruits per plant	Total yield per plant (g)
P1 × P2	16.42**	-0.09	1.45**	2.74**	562.89**
P1 × P3	-35.44**	-0.03	-0.07	-0.27	-249.98**
P1 × P4	-0.69	-0.02	0.78	-1.19*	-218.68**
P1 × P5	29.97**	0.27**	-2.48**	2.41**	638.67**
P1 × P6	56.14**	0.16	1.97**	1.98**	638.67**
P1 × P7	14.47*	-0.53**	0.56	-0.41	704.38**
P1 × P8	-18.55**	-0.48**	-0.60	-1.23*	73.27**
P1 × P9	35.46**	-0.08	1.53**	2.15**	571.74**
P1 × P10	-18.66**	0.09	-0.77	-0.15	-143.41**
P2 × P3	13.34*	-0.11	1.23*	0.06	44.69
P2 × P4	-5.25	-0.32*	-0.92	0.50	-16.41
P2 × P5	14.09*	0.20	1.98**	-0.55	-24.99
P2 × P6	4.92	0.23	-0.93	-0.03	-24.42
P2 × P7	39.92**	-0.05	-0.53	1.66**	586.94**
P2 × P8	-23.11**	0.33**	0.79	-1.96**	-426.49**
P2 × P9	-0.50	-0.05	-0.80	-0.87	-125.19**
P2 × P10	-32.89**	0.40**	-0.55	0.89	-38.98
P3 × P4	4.89	-0.29*	-0.63	3.04**	470.92**
P3 × P5	4.22	-0.25*	0.56	1.05*	130.60**
P3 × P6	1.72	-0.46**	-0.61	-2.91**	-486.09**
P3 × P7	51.06**	0.80**	2.06**	1.57**	521.86**
P3 × P8	56.36**	-0.11	-0.56	1.31**	673.40**
P3 × P9	-27.03**	-0.26*	-0.86	0.13	-216.53**
P3 × P10	-42.75**	-0.34**	0.27	-0.67	-489.05**
P4 × P5	-11.03	0.64**	2.03**	-0.40	-112.10**
P4 × P6	54.47**	0.26*	0.15	1.62**	698.14**
P4 × P7	26.81**	0.29*	0.35	2.10**	432.03**
P4 × P8	-11.55	0.73**	2.32**	-2.84**	-524.23**
P4 × P9	-13.94	0.84**	-0.43	-0.14	-84.00**
P4 × P10	-33.00	-0.14	0.29	-1.5**	-349.18**
P5 × P6	-34.14**	-0.01	1.68**	3.03**	695.32**
P5 × P7	-0.86	-0.10	1.18**	-2.29**	-393.15**
P5 × P8	-25.55**	-0.13	-0.63	-2.14**	-445.72**
P5 × P9	-14.61*	0.03	1.34**	-0.07	-80.51**
P5 × P10	13.00*	-0.30*	0.84	0.86	-25.03
P6 × P7	-60.03**	0.38**	1.43**	-1.19*	-639.58**
P6 × P8	-28.05**	-0.39**	1.39**	-0.95*	-310.45**
P6 × P9	-18.78**	-0.33**	-1.40**	-1.73**	-221.44**
P6 × P10	18.84**	0.20	0.72	0.07	131.10**
P7 × P8	35.28**	0.65**	2.60**	2.40**	758.71**
P7 × P9	-37.11**	0.55**	1.32**	-0.74	-380.12**
P7 × P10	-19.50**	-0.72**	-2.90**	-0.64	-260.57**
P8 × P9	-25.14**	-0.33**	-0.77**	1.99**	132.42**
P8 × P10	29.14**	-0.23	-1.19**	2.32**	533.96**
P9 × P10	15.09**	0.18	-0.41	-0.55	33.53
Sii	5.118	0.114	0.456	0.427	23.697
Sii-Sjj	7.156	0.161	0.638	0.597	33.139
Sij	5.70	0.126	0.508	0.476	26.436
Sij-Sik	8.391	0.190	0.748	0.701	38.859
Sij-Skl	8.001	0.182	0.713	0.667	37.050

*,**Significant at 5 and 1% levels significance.

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