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Heterosis and Combining Ability in Cucumber (*Cucumis sativus* L.)

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The present study on heterosis and combining ability for fruit yield and its components was carried out in a set of 27 F_1 hybrids of cucumber obtained from a Line x Tester method involving twelve diverse parents at Navsari Agricultural University, Navsari 2009. The ratio of the genetic variance was less than unity, which indicated the predominance of the non-additive gene action in all the traits. The analysis revealed that none of the parents was found good general combiners for all the traits consistently, however parents CCP-9, Gujarat local and SPP-44 were good combiner for fruit yield and its contributing traits. The hybrids Pilibhit Local x K-90 followed by Sheetal x SPP-44 and Sheetal x CC-9 have exhibited higher heterobeltiosis for fruit yield and its components characters. These crosses involved poor x poor and poor x good combiner parents. Further improvement in fruit yield could be possible through the hybridization and selection in transgressive segregants.

Keys words: Heterosis, combining ability, gene action, *Cucumis sativus* L., line x tester

Cucumber (*Cucumis sativus* L.) is one of the most important and popular cucurbitaceous vegetable crops grown extensively throughout the tropical and subtropical region of the world. According to De Candle (1967) India is consider as a centre of origin of cucumber. It is grown commonly throughout India and popularly known as Kakari (Gujarati). The fruits are edible and very much used as salad and used during summer as a cooling food. Fruit is demulcent while seeds are cooling, tonic, diuretic and anthelintic when leaves along with cumin seeds administered (Vashista, 1974). High degree of cross-pollination, wide range of genetic variability in vegetative and fruit characters exist in this crop. Concerted efforts towards its improvement and developing new varieties are lacking and only a few improved varieties have been developed. Thus, it necessitates development of high yielding, better quality varieties through efficient breeding programmes. The success of any breeding procedure is determined by useful gene combination organized in the form of high combining inbreds and heterosis in their crosses. The line x tester analysis was adopted in the present study on cucumber to gather information on the magnitude of heterosis, general and specific combining abilities and various types of gene effects involved for different quantitative characters.

Material and Methods

An experiment was conducted during *Kharif* 2009 at the Experimental farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari. The experimental materials comprised of 3 lines (females) namely; Sheetal (L1), Gujarat Local (L2) and Pilibhit Local (L3) and nine testers (males) namely; SPP-44 (T1), K-90 (T2), CV-5 (T3), SPP-93 (T4), CC-9 (T5), SPP-63 (T6), DC-2 (T7), PCUC-8 (T8) and PCUC-28 (T9) and Gujarat Local-1 as an standard check. The complete set of 27 F_1s and 12 parents were grown in randomized block design (RBD) with replications. Row to row and plant to plant spacing were maintained at 3 m and 2 m, respectively. All the recommended agronomic package of practices was followed to grow a healthy crop. In each replication, 5 plants and F_1s were marked for observation. Observations were recorded on nine important characters, *viz*. node number on which first male flower appeared, node number on which first female flower appeared, average fruit length (cm), average fruit diameter (cm), number of lateral branches per vine, number of fruits per vine, length of vine and fruit yield per vine (kg). Combining ability analysis was done by using Model I and Method II of Griffing (1956). Heterosis was calculated as the percentage of F_1 performance in the favorable direction of its better parent as suggested by Hayes *et al*. (1955).

Results and Discussion

The mean sum of square due to gca and sca were highly significant for all nine characters except node number on which first male flower appeared, node number on which first female flower appeared, number of lateral branches and fruit diameter for gca variance (Table 1). It indicated that both additive and non-additive gene action were involved in the

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

Source of variation	NFM	NFF	NLB	FL	FD	AFW	VL	NFP	FYV
σ_2 gca	-0.019	0.010	0.036	1.361**	-0.018	37.698*	38.966*	1.942**	0.139**
σ_2 sca	0.164**	0.481**	0.575**	1.912**	0.490*	267.515**	103.94**	4.985**	0.191**
σ_2 gca σ_2 sca	-1.158	0.020	0.062	0.711	-0.036	0.140	0.384	0.389	0..727

NFM = Node number on which first male flower appeared**, NFF=** Node number **=** on which first female flower appeared**, NLB =** Number of lateral branches per vine , **F =**Fruit length (cm), **FD NFP** Fruit diameter (cm), **AFW =** Average fruit weight (g), **VL =** Vine length (cm), **=** Number of fruit per vine**, FYV =** Fruit yield per vine **(**kg).

expression of these traits. Similar results have been reported by Prajapati (2008) and Prasad and Singh, (1992) in cucumber. The estimates of sca variance (σ_2 sca) was higher than gca variance (σ_2 gca). The ratio of gca/sca variance (σ_2 gca/σ_2 sca) being lesser than unity for all the nine traits revealed preponderance of non additive gene effects in the inheritance of fruit yield and its components traits. The present findings are in congruence with the reports of Solanki and Shah (1990), Ananthan and Pappiah (1997), Sarkar and Sirohi (2006) in cucumber.

The estimates of gca effects (Table 2) revealed that the none of the parents exhibited good gca for all the characters so it was difficult to pick good combiners for all the characters together because the combining ability effects were not consistent for all the yield components, possibly because of negative association among of the characters (Solanki and Shah, 1990). This shows that genes for different desirable characters would have to be combined from different sources (Nehe *et al*. 2007). Among the twelve parents, CC-9, Gujarat local and SSP-44 were good general combiner for fruit yield

Table 2. Estimation of general combining ability (gca) effects of parents for different characters in Cucumber

Parents	NFM	NFF	NLB	FL	FD	AFW	VL	NFP	FYV
Females									
Sheetal	-0.059	0.178	0.185	-0.851**	-0.014	-3.655	-1.020	0.265	0.126
Gujarat local	-0.013	-0.290*	0.222	1.280**	0.271*	10.264**	8.640**	1.562**	0.381**
Pilibhit local	0.072	0.112	-0.407**	-0.429*	-0.257*	-6.609**	-7.619**	-1.827**	-0.507*
SPP-44	-0.337*	-0.807**	0.519*	3.065**	0.600**	19.394**	-6.453	2.006**	0.380**
K-90	0.049	0.313	0.074	1.052**	-0.006	5.816	-10.283*	-0.772	0.211
CV-5	-0.193	0.309	-0.593**	-1.224**	-0.397*	-12.984**	6.594	-1.216**	-0.107
SPP-93	0.250	0.050	0.407	-0.189	-0.102	-4.551	-8.819	0.106	-0.112
CC-9	-0.177	-0.843**	0.630*	1.442**	0.372	10.849**	1.440	2.784**	0.506**
SPP-63	0.230	0.105	-0.481*	-2.157**	-0.255	-0.173	3.263	-0.994*	-0.229
DC-2	0.114	0.535*	0.185	-1.746**	-0.080	-11.64**	5.228	-0.549	-0.334**
PCUC-8	0.280*	0.572*	-0.815**	-1.319**	-0.360	-3.720	-5.383	-2.372**	-0.462**
PCUC-28	-0.215	-0.190	0.074*	1.076**	0.227	-2.970	10.414**	1.006*	0.147

per vine. These parents also showed significant general combining ability effects in desirable direction for various characters, CC-9 for node number on which first female flower appeared**,** days to 50 per cent flowering (female), fruit length, average fruit weight and number of fruit per vine, while Gujarat local for node number on which first female flower appeared, fruit length, fruit diameter, average fruit weight, vine length and number of fruit per vine and SSP-44 for node number on which first male flower appeared**,** node number on which first female flower appeared **,** number of lateral branches per vine, fruit length, fruit diameter, average fruit weight and number of fruit per vine**.** These parents were superior for most of the traits, an inter mating population involving all possible crosses among themselves subjected to biparental mating in early generation will be expected to offer the maximum promise in breeding for yield and earliness. Similar results reported by Nehe *et al*. (2007) in cucumber and Niyaria and Bhalala (2001) in ridge gourd.

The estimates of specific combining ability effects were found negatively significant in cross combinations Pilibhit Local x K-90 (-0.83) and Gujarat Local x DC-2 (-0.50) for Node number on which first male flower appeared, Pilibhit Local x K-90 (-1.17), Gujarat Local x SPP-93 (-1.14) and Gujarat Local x PCUC-28 (-0.87) for node number on which first female flower appeared. The highest significantly positive specific combining ability effect in Gujarat Local x PCUC-28 (1.22) for number of lateral branches per vine, Pilibhit Local x K-90 (2.55) for Fruit length, Pilibhit Local x K-90 (1.30) for Fruit diameter, Pilibhit Local x K-90 (25.92) for average fruit weight, Pilibhit Local x SPP-63 (21.99) for vine length, Pilibhit Local x K-90 (4.38) for number of fruits per vine. Hybrids *viz*., Pilibhit Local x K-90, Sheetal x SPP-44 and Sheetal x CC-9 produced the highest sca effect for the fruit yield per vine (Table 3). Thus, sca effect of these three crosses indicates the inclusion of atleast one good combining parent in producing superior hybrids. However, a former cross involved both of the parents with poor combining abilities. This suggests that high sca effect of any cross combination does not necessarily

Table 3. Estimation of specific combining ability (sca) effects of hybrids for various characters in cucumber

Crosses	NFM	NFF	NLB	FL	FD	AFW	VL	NFP	FYV
Sheetal x SPP-44	-0.22	-0.69	0.91*	-0.13	0.74*	19.01**	5.77	2.50**	0.40*
Sheetal x K-90	0.33	0.16	-0.40	-0.77	-0.47	-4.43	-12.20	-0.71	-0.43*
Sheetal x CV-5	0.32	-0.13	0.25	-0.05	0.21	10.13	-6.20	-0.93	-0.08
Sheetal x SPP-93	-0.19	0.83*	-1.07*	-0.28	-0.79*	-18.86**	4.61	-0.25	-0.09
Sheetal x CC-9	-0.53*	0.96*	0.37	1.23*	1.23**	15.99**	-3.48	0.73	0.57*
Sheetal x SPP-63	0.24	0.18	-0.18	0.51	-0.24	11.05	-6.83	-0.15	0.07
Sheetal x DC-2	0.11	0.13	1.14**	0.41	0.89*	-0.13	6.32	-0.93	0.079
Sheetal x PCUC-8	-0.25	-0.51	0.14	-0.16	-0.19	0.04	5.62	1.55	0.30
Sheetal x PCUC-28	0.03	0.56	-0.74	-0.75	-0.27	-21.17**	6.37	-1.82*	-0.40
Gujarat Local x SPP-44	-0.31	-0.34	0.44	2.06**	0.23	2.80	-5.67	0.88	0.23
Gujarat Local x K-90	0.50*	1.00*	-0.44	-1.78**	-0.82*	-21.48**	6.21	-3.67**	-0.38
Gujarat Local x CV-5	-0.33	0.53	-0.44	-0.17	-0.43	-23.08**	-14.85	-0.22	-0.20
Gujarat Local x SPP-93	0.50*	-1.14**	0.88*	1.06	1.06**	18.44**	3.45	3.11**	-0.50*
Gujarat Local x CC-9	0.30	-0.30	0.33	0.80	0.46	9.28	13.02	0.43	-0.01
Gujarat Local x SPP-63	0.20	0.20	-0.88*	-1.37*	-0.41	-9.09	-15.16	0.21	-0.11
Gujarat Local x DC-2	-0.50*	0.51	-0.88*	-1.19*	-0.77*	4.84	7.86	-0.89	0.09
Gujarat Local x PCUC-8	0.07	0.41	-0.22	-0.65	-0.02	-0.20	6.31	-1.40	-0.41*
Gujarat Local x PCUC-28	-0.43	-0.87*	1.22**	1.25*	0.70*	18.50**	-1.18	1.54	0.30
Pilibhit Local x SPP-44	0.53*	1.04*	-0.92*	-1.92**	-0.78*	-10.19	-0.10	-3.39	-0.64**
Pilibhit Local x K-90	-0.83**	-1.17**	0.85*	2.55**	1.30**	25.92**	5.99	4.38**	0.82**
Pilibhit Local x CV-5	0.07	-0.39	0.18	0.22	0.22	12.95*	21.06*	1.16	0.28
Pilibhit Local x SPP-93	-0.31	0.30	0.18	-0.77	-0.27	0.42	-8.07	-2.86**	-0.40*
Pilibhit Local x CC-9	0.08	0.83*	-0.70	-2.03**	-0.77*	-25.28**	-9.54	-1.17	-0.19
Pilibhit Local x SPP-63	-0.44	-0.38	1.07*	0.86	0.65	-1.95	21.99**	-0.06	0.10
Pilibhit Local x DC-2	0.38	-0.64	-0.25	0.78	-0.12	-4.70	-14.19	1.82*	-0.17
Pilibhit Local x PCUC-8	0.18	0.09	0.07	0.82	0.22	0.16	-11.94	-0.15	0.10
Pilibhit Local x PCUC-28	0.40	0.31	-0.48	-0.50	-0.43	2.67	-5.19	0.27	0.09

depend on the gca effects of the parental lines involved. This superiority of sca effects may be due to complementary type of gene action or involvement of non allelic interaction of fixable and non fixable genetic variance (Patel and Desai, 2008 and Purohit, 2007).

The hybrids varied in magnitude and direction of heterosis for most of the characters (Table 4). The significant heterobeltiosis observed for node number on which first male flower appeared in cross combination viz., Gujarat Local x PCUC-28 (-32.43) and Gujarat Local x SPP-44 (29.25), node number

Table 4. The better performing F_1 over better parent for different characters in cucumber

Characters	No. of crosses with significant heterosis	Three best cross combination with heterosis value (%)
Node number on which first male flower appeared	2	Gujarat Local x PCUC-28 (-32.43) ,Gujarat Local x SPP-44 (29.25)
Node number on which first female flower appeared	7	Gujarat Local x SPP-44 (-30.06), Gujarat Local x CC-9 (-29.94), Gujarat Local x SPP-93 (-29.72)
Number of lateral branches per vine	3	Sheetal x DC-2 (41.67), Sheetal x SPP-44 (33.33), Gujarat Local x SPP-93 (30.77)
Fruit length	5	Sheetal x SPP-44 (22.35), Pilibhit Local x K-90 (15.89), Pilibhit Local x SPP-44 (11.61)
Fruit diameter	6	Sheetal x SPP-44 (35.94), Sheetal x CC-9 (23.08), Gujarat Local x SPP-93 (22.07)
Average fruit weight	7	Pilibhit Local x K-90 (22.68), Gujarat Local x SPP-44(18.83), Sheetal x CC-9 (18.61)
Vine length	5	Pilibhit Local x SPP-63 (21.35), Pilibhit Local x CV-5 (20.46), Gujarat Local x CC-9 (18.33)
Number of fruit per vine	8	Sheetal x SPP-44 (66.67), Sheetal x CC-9 (75.00), Pilibhit Local x K-90 (33.33)
Fruit yield per vine	7	Pilibhit Local x K-90 (57.96), Sheetal x SPP-44 (56.60), Sheetal x CC-9 (53.89)

on which first female flower appeared in Gujarat Local x SPP-44 (-30.06), Gujarat Local x CC-9 (-29.94), Gujarat Local x SPP-93 (-29.72), Sheetal x SPP-44 (-28.85), Sheetal x CC-9 (-26.79), Gujarat Local x PCUC-28 (-24.57) and Pilibhit Local x K-90 (-20.87). In general, heterosis for node number on which first male flower appeared and node number on which first female flower appeared should be in negative direction, in order to develop early cultivars therefore, Gujarat Local x SPP-44 can be used in future crop improvment programme for development for early fruit bearing hybrids. These findings are in

consonance with Prajapati, (2008), Patel and Desai (2008). The character that contribute to vegetative growth such as number of lateral branches per vine expressed highest magnitude of heterosis in cross combinations *viz*., Sheetal x DC-2 (41.67), Sheetal x SPP-44 (33.33) and Gujarat Local x SPP-93 (30.77**)**. Cross combinations *viz*., Pilibhit Local x SPP-63 (21.35), Pilibhit Local x CV-5 (20.46) and Gujarat Local x CC-9 (18.33) expressed positively significant heterosis for vine length. Above findings are in accordance with the results reported by Prajapati, (2008) and Prasad and Singh (1992).

A desirable degree of vegetative growth is essential for realizing high fruit yield. Regarding the fruit length, five crosses expressed positively significant heterosis over heterobeltiosis in cross combination Pilibhit Local x SPP-63 (21.35), Pilibhit Local x CV-5 (20.46) and Gujarat Local x CC-9 (18.33). However, the cross combinations namely Sheetal x SPP-44 (35.94), Sheetal x CC-9 (23.08) and Gujarat Local x SPP-93 (22.07) have recorded higher heterosis for fruit diameter. For average fruit weight the crosses *viz*., Pilibhit Local x K-90 (22.68), Gujarat Local x SPP-44(18.83) and Sheetal x CC-9 (18.61) showed higher heterosis. These reports are similarly Randhawa and Singh (1990) and Rao *et al*. (2000).

Fruit characters directly played important role in the enhancement of the yield. Cross combinations *viz*., Sheetal x SPP-44 (66.67), Sheetal x CC-9 (75.00) and Pilibhit Local x K-90 (33.33) exhibited the highest heterobeltiosis for the number of fruit per vine. The results are in close conformity with findings of Prajapati, (2008) and Prasad and Singh (1992). Number of fruit per vine had direct correlation with fruit yield per vine (Ananthan and Pappiah, 1997). The extent of heterosis for fruit yield per vine varied greatly. The highest value of heterosis was observed in Pilibhit Local x K-90 (57.96) followed by Sheetal x SPP-44 (56.60) and Sheetal x CC-9 (53.89). These crosses showing desirable heterosis for fruit yield per vine in addition to most of the yield contributing characters studied. Thus, total yield could be the result of combinational heterosis (Das and Rai, 1972). Similar results were reported by Prajapati, (2008), Bairagi, *et al*. (2002) and Hormuzidi and More (1989).

Considering the overall performance in respect of fruit yield per vine, most promising three hybrids *viz*., Pilibhit Local x K-90, Sheetal x SPP-44 and Sheetal x CC-9 exhibited high heterotic effects. These crosses have higher sca effects due to involvement of poor x poor and poor x good parents. The higher sca effect observed in poor x poor general combiners cross might be due to non-additive gene effects and such could be exploited through the hybridization, which is possible in the crop due to monocieous nature of flowers. The cross involved poor x good general combiners can produce good transgressive segregants in later generation.

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