Adv. Hort. Sci., 2011 25(4): 239-244

Selecting parents for developing superior hybrids in cucumber (*Cucumis sativus* L.)

B.S. Dogra*, M.S.Kanwar**

* *Regional Horticultural and Forestry Research Station, Dr Y S Parmar University of Horticulture and Forestry, Bhota-176041, Hamirpur (HP), India.*

** *High Mountain Arid Agriculture Research Institute (SKUAST-K), Leh, 194101 Jammu and Kashmir, India.*

Key words: Cucumber, *Cucumis sativus*, gca, hybrids, sca.

Abstract: Estimates of general combining ability of parents and specific combining ability of the crosses help to select desidered parents for hybridization and development of superior hybrids. Crosses among eight parents were attempted in a half-diallel fashion. The material comprising eight parents, 28 F_1s and one check (Pusa Sanyog) was sown at two locations in Randomized Block Design with three replications. The highest estimates of general combining ability (gca) were exhibited by G_2 and Gyn_1 for most of the characters at both the locations. In general, there was close agreement between gca effects and per se performance, but in some cases it did not hold good, which may be due to a higher degree of gene action involved. The superior cross combinations which recorded high specific combining ability (sca) estimates and per se performance for yield and number of fruits were K-90 x G_2 and K-90 x Gyn_1 and hence may be exploited for the development of F_1 hybrid (s) after testing their performance at multi-locations for two to three years.

1. Introduction

Cucumber (*Cucumis sativus* L.), a member of the Cucurbitaceae family, is grown as a summer and rainy season crop in the low and mid hills of the northwestern Himalaya from April to August and fruits are available from June to October to the plains of northern India. The crop raised in the hills, being of high quality and off-season, brings good returns to the growers.

F_1 hybrids in cucumber, as in many vegetable crops, have several well known advantages over open-pollinated varieties (Dogra and Kanwar, 2011) and hence provide a scope for the breeder to find more appropriate combinations to develop superior hybrids. F_1 hybrids are early, vigorous, high yielding, tolerant to diseases and insect-pests and more efficient in the use of water and fertilizers. Currently, farmers are purchasing hybrid seeds from private firms who charge exorbitant prices for seed. To tide over the situation, there is a need to develop F_1 hybrids and make their seed available to farmers at a reasonable price. For the development of superior hybrids, estimates of general combining ability of parents and specific combining ability of the crosses help to properly select parents for hybridization. Moreover, use of gynoecious lines for developing cucumber hybrids makes the production of F_1 seed more cost effective. Furthermore, there is urgent need to develop stable hybrids adapted to a wide range of climatic conditions.

Received for publication 1 June 2011
Accepted for publication 21 October 2011

2. Materials and Methods

The present investigations were carried out at two locations: Experimental Farm Nauni (L1) and Experimental Farm Chambaghat (L2) of the Department of Vegetable Crops, Dr Y S Parmar University of Horticulture and Forestry, Solan (Himachal Pradesh), India, which are 1276 m a.m.s.l. and 1300 m a.m.s.l., respectively. Both locations fall in the mid-hill sub-temperate zone of the state of Himachal Pradesh; Nauni lies at latitude and longitude of 30^0 52'N and 77° 11' and Chambaghat, 30° 55' N and 77° 06'. All the parents except two gynoecious lines were of monoecious type. Crosses among eight parents were attempted in a half-diallel fashion. The material comprising eight parents, 28 F_1s and one check (Pusa Sanyog) was sown in Randomized Block Design with three replications. Spacing was 1.25x1.00 m. Data were recorded on randomly selected plants for yield and horticultural characters at both the locations. Griffing's (1956) method II model I was used to derive general and specific combining ability estimates. The analysis of variance for combining ability was based on following mathematical model:

$$P_{ijk} = m + g_{ii} + g_{jj} + s_{ij} + b_k + e_{ijk}$$

where,

P_{ijk} = phenotypes of the hybrids between i^{th} and j^{th} parents in k^{th} plots
m = population mean
g_{ii} = GCA effects of i^{th} parent
g_{jj} = GCA effects of j^{th} parent
s_{ij} = SCA of the crosses between i^{th} and j^{th} parents
b_k = block effects
e_{ijk} = environmental effect associated with ijk^{th} observation

3. Results and Discussion

Analysis of variance (Table 1) for combining ability revealed that the importance of gca (σ^2g) was more than sca (σ^2s), indicating the preponderance of additive gene action for days to first female flower appearance (DFFFA) at location 1 and days to marketable maturity (DMM) at both locations. However, in all the other traits, the sca component was higher in magnitude than gca's, indicating the preponderance of non-additive gene effects. However, mean sum of squares for gca and sca were highly significant for all the characters except TSS, suggesting the importance of both additive and non-additive genetic variance in agreement with the findings of Om *et al*. (1978). Similar trends at both the locations proved that the conclusions on gene actions are authentic.

The parents G_2, Gyn_1 and Poinsette had negative estimates for DFFFA and node at which first female flower appears (NFFF) at both the locations (Table 2) showing earliness in fruit bearing and were good general combiners for these characters. Among F_1's, the sca effects were significantly negative in 12 and 15 crosses, respectively, for these two traits at L1 (Table 3) whereas significantly negative in 15 crosses for each of these two traits at L2 (Table 4). The crosses LC-11 x Gyn_1 (poor x high) and EC 173934 x LC-40 (poor x poor), respectively, had the highest sca effect at L1 and the crosses LC-11 x LC-40 (poor x poor) and EC 173934 x LC-40 (poor x poor), respectively, had the highest sca effects at L2 for these traits. The parents G_2 and Gyn_1 (L1) and G_2, Gyn_1 and Poinsette (L2) with significantly high gca estimates (with negative value) were good general combiners for DMM. Crosses LC-11 x Gyn_1, EC 173934 x LC-40, K-90 x G_2 and K-90 x EC 173934 had high sca estimates at both the locations for DMM. El-Shawaf and Baker (1978), Om *et al.* (1978), and Wang and Wang (1980) also reported greater additive genetic variance for DMM. The parents G_2 and Gyn_1 may be used in the hybridisation programme for developing early hybrids adapted to a wide range of climate. LC-11 x Gyn_1 and EC 173934 x LC-40 may be exploited as early hybrids after further multi-locational testing. These crosses may also be exploited to produce transgressive segregants in advanced generations.

With regard to fruit length, the parents Gyn_1, LC-11 and K-90 were good general combiners as is evident from their high gca estimates at both locations. Fourteen crosses exhibited significant sca effects. The sca effects were high in crosses Poinsette x LC-40 and G_2 x Poinstte involving poor x poor general combiners. K-90, K-75 and EC 173934 had the highest gca with respect to fruit width and hence were good general combiners. The sca effect was maximum in G_2 x Gyn_1 involving poor x poor general combining parental lines (at L1) and in G_2 x K-75 involving poor x high general combining parental lines (at L2). In India, slicing cucumbers are preferred, therefore lengthy fruits are desirable. Kupper and Staub (1988) and Hormuzdi and More (1989) reported contrasting results for fruit length and width due to different experimental material and environment.

Table 1 - Analysis of variance for combining ability for different characters in F_1 cucumber

Source of variation	Df	Character: Days to first female flower appearance	Node of first female flower	Days to marketable maturity	Fruit length	Fruit width	TSS	Flesh to seed cavity ratio	Fruit weight	No. of fruits per plant	Yield per plant	Internodal length
Location 1 - Nauni												
Gca	7	678.818 *	27.997 *	705.436 *	6.425 *	1.087 *	0.005	0.001 *	3787.657 *	9.898 *	0.735 *	9.512 *
Sca	28	42.264 *	3.049 *	45.029 *	3.237 *	0.243 *	0.021	0.0015 *	693.149 *	1.159 *	0.193 *	2.183 *
Error	70	0.557	0.228	0.562	0.004	0.002	0.0013	0.00004	62.357	0.112	0.0013	0.272
σ2g		67.826	2.777	70.487	0.642	0.108	0.0004	0.0001	372.53	0.979	0.073	0.924
σ2s		41.707	2.821	44.467	3.0233	0.240	0.020	0.002	630.79	1.047	0.191	1.911
σ2g/ σ2s		1.626	0.984	1.585	0.199	0.451	0.021	0.068	0.591	0.934	0.383	0.483
Location 2 - Chambaghat												
Gca	7	390.457 *	35.726 *	577.811 *	7.820 *	0.993 *	0.012 *	0.0016 *	3515.486 *	14.247 *	0.786 *	7.800 *
Sca	28	67.477 *	4.551 *	37.300 *	3.895 *	0.268 *	0.028 *	0.0009 *	612.551 *	1.582 *	0.181 *	1.510 *
Error	70	0.431	0.205	0.442	0.089	0.023	0.006	0.000035	49.232	0.148	0.0096	0.358
σ2g		39.003	3.552	57.737	0.773	0.097	0.0006	0.000159	346.630	1.409	0.078	0.744
σ2s		67.046	4.346	36.859	3.806	0.245	0.022	0.00088	563.320	1.434	0.171	1.153
σ2g/ σ2s		0.582	0.817	1.566	0.203	0.395	0.029	0.081	0.615	0.983	0.452	0.646

* Significant at 5% level of significance.

The best general combiners for TSS at both locations in order of merit were EC 173934 and LC-40. Among 28 specific combinations, 16 (at L1) and 14 (at L2) crosses exhibited positive sca effects being maximum in K-90 x Poinsette and Poinsette x K-75 at L1 and LC-40 x Gyn_1, K-90 x Poinsette and K-75 x LC-40 at L2. For flesh to seed cavity ratio (FSR), the best general combiners were Poinsette, EC 173934 and Gyn_1, irrespective of locations. Cross combination K-90 x K-75 at L1 and Poinsette x EC 173934 at L2 had maximum sca among seven significant and positive specific combinations. In contradiction to the present results, importance of additive gene action for FSR has been reported (Dogra, 1995).

The parents LC-11, K-90 and K-75 depicted high *per se* performance with respect to fruit weight at both locations as is evident from their high gca effect (Table 2). These parents had maximum concentration of favourable genes for increasing fruit weight. Eleven (at L1) and 12 (at L2) specific cross combinations had significantly positive sca effects (Tables 3 and 4), being maximum in K-90 x LC-11 (high x high) and K-90 x EC 173934 (high x poor). Non-additive gene action for fruit weight was also obtained by Ghaderi and Lower (1979) in consonance with the present findings. However, Gyn_1 and G_2 were identified as good general combiners for number of fruits per plant. The top specific combinations in order of merit were K-90 x G_2, K-90 x Gyn_1 and K-75 x Gyn_1 involving medium high, medium x high and poor x high general combiners, respectively. The situation holds good for both the locations with respect to number of fruits. Importance of non additive gene action for number of fruits per plant was also reported (Om *et al.*, 1978; Ghaderi and Lower, 1979; Dogra, 1995). However, the present results with regard to fruit weight and number of fruits are in disagreement with El Hafeez *et al.* (1997). This may be due to differences in the parental material used for making diallel crosses.

For yield per plant, K-90 was the best general combiner in addition to Gyn_1 and G_2 irrespective of location (Table 2). The sca effects (Tables 3 and 4) were high for K-90 x G_2 (high x high), K-90 x Gyn_1 (high x high) and LC-11 x Gyn_1 (poor x high). The present results on yield per plant were similar to earlier findings of Om *et al*. (1978), Ghaderi and Lower (1979), Wang and Wang (1980) and Doligibh and Sidorova (1983) but in contradiction to the work of Gu *et al.* (2004). Parents such as G_2, Gyn_1 and LC-40 had negative gca effects and were considered good general combiners for internodal length. Nine (at L1) and 10 (at L2) specific combinations had significant negative values with the maximum in K-90 x Poinsette and Poinsette x EC 173934, poor x poor general combiners at each location.

As is evident from the data in Tables 2, 3 and 4, environmental effect was observed as non-significant on geno-

Table 2 - Estimates of general combining ability of parents for different characters in cucumber

Source of variation	Character										
	Days to first female flower appearance	Node of first female flower	Days to market-able maturity	Fruit length	Fruit width	TSS	Flesh to seed cavity ratio	Fruit weight	No. of fruits per plant	Yield per plant	Internodal length
Location 1											
K-90	0.000	0.367*	-0.550*	0.361*	0.364*	-0.016*	-0.0002	20.083*	0.017	0.276*	0.021
G2	-12.133*	-2.567*	-12.217*	-1.404*	-0.041*	0.004	0.004*	-25.250*	1.317*	0.302*	-1.856*
Poinsette	-2.433*	-0.767*	-2.0183*	-0.105	-0.531*	-0.031	0.014*	-4.917*	-0.217*	-0.055*	1.048*
EC173934	8.167*	1.633*	8.517*	-0.390*	0.191*	0.037*	0.011*	7.417*	-0.617*	-0.346*	0.144
K-75	0.733*	0.733*	1.017*	-0.050*	0.320*	-0.004	0.017*	10.083*	-0.017	0.024*	1.084*
LC-11	6.600*	0.633*	6.583*	0.388*	0.136*	-0.022	0.007*	32.750*	-0.783*	-0.089*	0.604*
LC-40	9.800*	2.067*	9.950*	-0.225*	-0.008*	0.029*	0.005*	-8.417*	-1.283*	-0.379*	-0.593*
Gyn1	-10.733*	-2.100*	-11.117*	1.425*	-0.433*	0.002	0.008*	-16.917*	1.583*	0.268*	-0.453
SE (gi)	0.221	0.141	0.222	0.019	0.013	0.011	0.0019	2.336	0.099	0.011	0.154
CD0.05 (gi)	0.441	0.281	0.443	0.037	0.026	0.021	0.0038	4.658	0.197	0.022	0.307
Location 2											
K-90	0.075	0.258*	-0.267*	0.208*	0.269*	-0.021	-0.013*	20.492*	0.508*	0.301*	0.116
G2	-10.092*	-2.908*	-11.600*	-1.355*	0.016	-0.015	-0.016*	-23.341*	1.842*	0.285*	-1.828*
Poinsette	-1.158*	-0.375*	-1.133*	-0.285*	-0.574*	-0.008	0.018*	-7.141*	-0.325*	-0.053*	0.693*
EC173934	7.642*	1.192*	7.867*	-0.592*	0.196*	0.065*	0.014*	-5.342*	-0.858*	-0.384*	0.489*
K-75	2.908*	0.792*	1.100*	-0.025	0.309*	-0.013	-0.010*	8.825*	-0.258*	0.058*	0.869*
LC-11	2.875*	1.325*	6.300*	0.495*	0.083*	-0.028*	-0.0001	30.825*	-1.092*	-0.125*	0.513
LC-40	5.675*	2.358*	7.900*	-0.148*	0.083*	0.045*	-0.0007	-5.342*	-1.358*	-0.363*	-0.364*
Gyn1	-7.925*	-2.642*	-10.167*	1.702*	-0.381*	-0.026*	0.009*	-18.375*	1.542*	0.279*	-0.488*
SE (gi)	0.194	0.134	0.197	0.088	0.044	0.023	0.0018	2.076	0.114	0.029	0.177
CD0.05 (gi)	0.387	0.267	0.393	0.175	0.088	0.046	0.0036	4.139	0.227	0.058	0.353

* Significant at 5% level of significance.

Table 3 - Estimates of specific combining ability of F_1 for different characters in cucumber at Nauni (L1)

Crosses	Characters										
	Days to first female flower appearance	Node of first female flower	Days to marketa-ble maturity	Fruit length	Fruit width	TSS	Flesh to seed cavity ratio	Fruit weight	No. of fruits per plant	Yield per plant	Inter-nodal length
K-90x G2	-7.422*	-1.059*	-7.252*	-2.481*	-0.411*	-0.082*	0.122*	-13.259*	2.685*	1.023*	-0.627*
K-90x Poinsette	-4.789*	-0.526*	-4.618*	-0.440*	0.086*	0.275*	-0.046*	-38.593*	0.848*	-0.324*	-2.530*
K-90x EC173934	-7.056*	-1.259*	-7.612*	-0.445*	-0.573*	-0.073*	-0.040*	40.574*	-0.752*	-0.059*	-1.894*
K-90x K-75	10.378*	1.974*	9.484*	1.382*	0.451*	0.011	0.012*	-35.259*	-0.352*	-0.543*	0.466
K-90x LC-11	9.178*	-0.259	9.948*	-0.406*	0.516*	-0.061*	-0.031*	55.407*	-0.252	-0.309*	2.246*
K-90x LC-40	-5.356*	-1.693*	-5.085*	1.324*	-0.794*	0.006	0.006*	-1.759	-0.085	-0.303*	2.043
K-90x Gyn1	-4.489*	-0.526*	-5.352*	-1.343*	-0.182*	-0.051*	-0.013*	-23.259*	2.382*	0.509*	-0.030
G2 xPoinsette	2.011*	1.074*	3.715*	2.334*	-0.393*	0.002*	-0.045*	0.074	-0.119	-0.316*	0.680*
G2 x EC173934	3.411*	0.007	3.348*	1.819*	0.482*	-0.032	-0.029	-4.093	-1.052*	-0.398*	0.883*
G2x K-75	0.178	-1.093*	0.515	2.113*	0.306*	0.112*	-0.009*	21.074*	1.348*	0.494*	1.143*
G2 x LC-11	-3.356*	0.674*	-4.052*	-1.142*	-0.367*	0.043	-0.014*	24.074*	0.115	0.268*	-0.044
G2 x LC-40	9.444*	0.574*	9.248*	0.638*	-0.240*	0.160*	0.003	-26.426*	-1.385*	-0.659*	0.453
G2 x Gyn1	-0.356*	0.741*	0.982*	1.421*	0.756*	0.093*	-0.023*	-14.593*	0.082	-0.140*	1.013*
Poinsette x EC173934	1.044*	-1.126*	1.315*	2.070*	0.192*	0.085*	0.080*	5.574	0.482*	0.065*	-2.387*
Poinsettex K-75	-0.522*	0.107	-1.185*	2.002*	0.343*	0.223*	-0.039*	16.407*	-0.118	0.201*	2.006*
Poinsettex LC-11	-5.056*	-1.126*	-5.418*	-0.325*	-0.527*	-0.023*	-0.035*	10.407*	0.648*	0.478*	1.419*
Poinsettex LC-40	-4.922*	-1.226*	-5.452*	2.622*	0.654*	-0.256*	0.032*	-28.426*	0.481*	0.088*	-1.517*
Poinsettex Gyn1	14.944*	0.941*	15.615*	-1.995*	0.126*	0.120*	0.032*	18.407*	-0.385*	0.260*	1.109*
EC173934x K-75	-1.456*	1.041*	-2.885*	0.033	-0.276*	-0.205*	0.0006	-7.759*	-0.718*	-0.314*	1.009*
EC173934x LC-11	-0.322*	-2.526*	-0.785*	1.161	0.139*	-0.074*	0.044*	9.574*	0.048	0.189*	0.489*
EC173934x LC-40	-9.189*	-3.293*	-8.818*	1.174*	-0.525*	-0.107*	-0.002	-5.926	1.548*	0.446*	0.353
EC173934x Gyn1	9.678*	3.541*	8.915*	-0.092*	-0.059*	0.036*	-0.018*	-14.093*	-1.985*	-0.602*	0.179
K-75x LC-11	3.778*	0.374	3.715*	1.238*	0.436*	0.020	-0.014	-36.259*	0.448*	-0.258*	-2.084*
K-75x LC-40	4.244*	-2.059*	4.682*	0.901*	-0.677*	0.134*	-0.013*	-0.093	-0.052	-0.028*	-1.954*
K-75x Gyn1	-6.556*	-0.893*	-6.585*	-1.116	-0.379*	-0.213*	-0.020*	13.407*	1.415*	0.538*	0.006
LC-11x LC-40	4.044*	4.041*	4.115*	0.496*	-0.593*	-0.005	-0.003	22.241*	-0.285	0.049*	1.259*
LC-11x Gyn1	-9.422*	-1.459*	-9.818*	-0.454*	-0.158*	0.128*	-0.030*	25.741*	0.181	0.518*	-0.614*
LC-40x Gyn1	3.378*	-0.226	2.482*	-1.707*	0.173*	0.211	-0.019*	-16.426*	-1.318*	-0.352*	-2.084*
SE (ij)±	0.676	0.433	0.680	0.058	0.044	0.032	0.0057	7.160	0.303	0.033	0.472
CD0.05	1.994	0.883	1.356	0.116	0.088	0.064	0.011	14.280	0604	0.066	0.941

*Significant at 5% level of significance.

Table 4 - Estimates of specific combining ability of F_1 for different characters in cucumber at Chambaghat (L2)

Crosses	Characters										
	Days to first female flower appearance	Node of first female flower	Days to marketable maturity	Fruit length	Fruit width	TSS	Flesh to seed cavity ratio	Fruit weight	No. of fruits per plant	Yield per plant	Inter-nodal length
K-90x G2	-7.826*	-0.915*	-7.207*	-2.255*	-0.745*	-0.095*	0.009*	-8.641*	3.696*	1.058*	-1.097*
K-90x Poinsette	-3.759*	0.885*	-3.674*	-0.025	0.012	0.265*	-0.390*	-28.174*	-0.137	-0.361*	-0.917*
K-90x EC173934	-6.893*	-2.015*	-6.674*	-0.152*	-0.625*	-0.142*	-0.028*	43.359*	-1.270*	-0.140*	-1.580*
K-90x K-75	9.174*	1.719*	11.426*	1.081	0.295*	0.070	0.042*	-27.474*	-0.537*	-0.565*	1.140*
K-90x LC-11	11.207*	-0.148	7.893*	-0.172	0.088	-0.049	-0.014*	33.859*	-0.370*	-0.252*	2.263*
K-90x LC-40	-1.593*	-1.515*	-3.374*	1.705*	-0.412*	-0.022	-0.004	-1.641	-0.437*	-0.288*	-0.193
K-90x Gyn1	-7.659*	-1.182*	-5.974*	-1.578*	-0.082*	-0.050	-0.007*	-19.674*	1.663*	0.431*	-0.737*
G2 xPoinsette	3.741*	1.385*	4.659*	2.838*	-0.502*	-0.009	-0.036*	-17.674*	-0.470*	-0.255*	0.027
G2 x EC173934	0.607*	0.819*	2.326*	2.845*	0.428*	0.018	-0.022*	-14.474*	-1.937*	-0.434*	1.363*
G2x K-75	-5.659*	-1.448*	-2.907*	2.278*	0.782*	0.196*	-0.001	23.026*	0.796*	0.334*	-0.583*
G2 x LC-11	-1.293*	0.352	-3.774*	-1.275*	-0.392*	0.045	-0.008*	24.359*	-0.704*	0.184*	-0.327
G2 x LC-40	18.574*	1.319*	7.293*	0.702*	0.008	-0.095*	0.023*	-12.807*	-1.437*	-0.515*	0.717*
G2 x Gyn1	-0.826*	0.652*	2.026*	1.018*	0.738*	0.143*	-0.014*	-7.507*	-0.670*	-0.087	0.807*
Poinsette x EC173934	2.674*	-1.048*	2.859*	0.908*	0.318*	0.145*	0.077*	14.326*	0.896*	0.147*	-1.957*
Poinsettex K-75	-3.593*	-0.315	-1.374*	-1.792*	0.072	0.190*	-0.042*	30.159*	0.296	0.255*	1.330*
Poinsettex LC-11	-2.893*	0.485*	-6.574*	-0.478*	-0.302*	0.005	-0.012*	11.493*	0.796*	0.492*	1.587*
Poinsettex LC-40	-0.693*	-1.548*	-2.841*	2.665*	1.065*	-0.170*	0.029*	-29.007*	0.729*	0.066	-1.903*
Poinsettex Gyn1	11.574*	1.118*	13.893*	-2.252*	-0.372*	0.069	0.015*	9.959*	-0.170	0.344*	0.753*
EC173934x K-75	-1.726*	3.452*	-0.041	-0.085	-0.165*	-0.250*	0.002	-3.307	-0.170	-0.247*	-0.200
EC173934x LC-11	4.307*	-2.082	0.759*	1.095*	0.195*	-0.069	0.042*	19.693*	0.330*	0.236*	-0.343
EC173934x LC-40	-6.159*	-4.115*	-8.507*	1.105*	-0.205*	-0.175*	-0.004	-19.141*	1.263*	0.340*	1.600*
EC173934x Gyn1	2.774*	0.219	4.893*	-0.412*	-0.109*	-0.070*	-0.014*	-18.841*	-1.970*	-0.618*	1.423*
K-75x LC-11	5.707*	-1.015*	4.193*	1.062*	0.582*	-0.157*	-0.014*	-41.141*	0.396*	-0.309*	-0.857*
K-75x LC-40	4.907*	-3.715*	4.259*	0.938*	-0.885*	0.203*	-0.017*	-6.041	-0.004	-0.131*	-1.613*
K-75x Gyn1	8.507*	-1.048*	-5.674*	-1.578*	-0.255*	-0.242*	-0.020*	10.326*	1.429*	0.307*	0.077
LC-11x LC-40	-22.726*	3.085*	6.393*	0.618*	-0.825*	-0.015	-0.014*	23.026*	0.163	0.025*	0.077
LC-11x Gyn1	-5.793*	-2.248*	-7.541*	-0.865*	0.238*	0.123*	-0.030*	28.326*	-0.404*	0.574*	-1.467*
LC-40x Gyn1	2.074*	5.052*	1.859*	-2.322*	0.105	0.317*	-0.023*	-12.174*	-1.137*	-0.302*	-1.322*
SE (ij)±	0.595	0.411	0.603	0.271	0.134	0.070	0.0054	6.362	0.349	0.089	0.542
CD0.05	1.186	0.819	1.202	0.540	0.267	0139	0.011	12.685	0.696	0.177	1.081

*Significant at 5% level of significance.

types and hybrid combinations for most of the characters. The results are similar at both locations with developed hybrid combinations and hence hybrids K-90 x G_2 and K-90 x Gyn_1 can be exploited in similar types of climates.

K-90, G_2 and Gyn_1 may be used in hybridisation for developing high yielding hybrids with higher number of fruits per vine, long fruits and high TSS on the basis of results from location 1, whereas G_2 and Gyn_1 are promising for developing high yielding hybrids with higher number of fruits per vine and short inter-nodal length on the basis of results from location 2. It can be concluded that G_2 and Gyn_1 may be used in hybridisation for developing high yielding hybrids with more fruits per vine and wider adaptability. The crosses K-90 x G_2 and K-90 x Gyn_1 can be released as hybrids after further testing.

References

DOGRA B.S., 1995 - Heterosis *and combining ability studies in cucumber (*Cucumis sativus *L.)* - M.Sc. Thesis, Dr Y S Parmar University of Horticulture and Forestry, Solan, India, pp. 591.

DOGRA B.S., KANWAR M.S., 2011 - *Exploiting heterosis for yield and horticultural traits in cucumber (*Cucumis sativus *L.)*. - Indian J. Plant Genet. Resour., 24(3): 332-339.

DOLIGIBH S.T., SIDOROVA A.M., 1983 - *Combining ability of induced mutants and partially dioecious forms of cucumber*. - Genetika, 19(8): 1292-1300.

EL HAFEEZ A.A., EL SAYED S.F., GHARIB A.A., 1997 - *Genetic analysis of cucumber yield and its components by diallel crossing.* - Egyptian J. Hort. Sci., 24(2): 141-159.

EL-SHAWAF I.I.S., BAKER L.R., 1978 - *Inheritance of yield in parthenocarpic hybrid pickling cucumber (abstract)*. - Hort. Science, 13(3): 355.

GHADERI L.R., LOWER R.L., 1979 - *Heterosis and inbreeding depression for yield in populations derived from six crosses of cucumber*. - J. Amer. Soc. Hort. Sci., 104(4): 564-567.

GRIFFING J.B., 1956 - *Concept of general and specific combining ability in relation to diallel crossing system.* - Aust. J. Biol. Sci., 9: 463-494.

GU X.F., ZHANG S.P., XU C.Q., 2004 - *Analysis of combining ability of early yield and total yield character of cucumber cultivated in open field in spring*. - China Vegetables, 6: 13-15.

HORMUZDI S.G., MORE T.A., 1989 - *Studies on combining ability in cucumber (*Cucumis sativus *L.).* - Indian J.Genet., 49(2): 161-165.

KUPPER R.S., STAUB J.E., 1988 - *Combining ability between lines of* Cucumis sativus *L. and* Cucumis sativus *var. hardwickii (R.) Alef.* - Euphytica, 38: 197-210.

OM Y.H., CHOI K.S., LEE C.H., CHOI C.I., 1978 - *Diallel analysis of several characters in cucumber* (*Cucumis sativus* L.). - Korean J. Breeding, 10(1): 44-50.

WANG Y.J., WANG Y.S., 1980 - *Preliminary analysis of combining ability in autumn cucumber.* - Scientia Agricultura Sinica, 3: 52-57.