Diallel Analyses for Yield and Vegetative Characteristics in Cucumber (*Cucumis sativus* L.) Under Low Temperature Conditions

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Abstract

Diallel analyses was used to evaluate five different inbred lines of cucumber (*Cucumis sativus* L.) and their F_1 progenies for several characteristics related to vegetative, flowering and yield and it s components under low temperature conditions.

Five different inbred lines of cucumber were entered into full diallel crosses. The inbred lines (1- PI 267742, 2- PI 436672, 3- PI 344348, 4- PI 135345, 5- Biet Alpha) were crossed in a full diallel to produce 10 F_1 single crosses and 10 reciprocal crosses, in order to evaluate their suitability as parents in hybrid combinations. The crosses were carried out in 1997 and their F_{1r} progenies and parents were compared in a randomized complete block design (RCB) with three replications.

Characters were evaluated under low temperature conditions in an open field at the El-Bossily farm during winter season of 1998 where the maximum and minimum temperatures were 18C° and 6C°, respectively during the growing season. Analysis of variance was carried out in F_1 crosses and reciprocals and was subjected to analysis of variance of randomized complete block to estimate general (GCA) and specific (SCA) combining ability effects following Grifting (1956), method 1, model II. The results showed that there were significant difference among parents and crosses for all characters studied. For most characters, the best mean performance of parental lines and GCA were observed in P_1.

INTRODUCTION

The planning of any breeding program for the improvement of a crop depends on the nature and magnitude of genetic and non-heritable variation. Combining ability analysis gives very useful information with regard to selection of parents based on the performance of their hybrids for the development of hybrids synthetics and composites. Moreover, this analysis indicates the nature and magnitude of gene action involved in the expression of quantitative traits. In this paper, results are reported for the combining ability through diallel analysis of five cucumber-inbred lines for 11 characters including yield.

Darwish (1992) demonstrated that the genetic difference among genotypes obtained from four inbred cucumber lines (1909, Marbosan, Biet Alpha and Chinese long) were significant for main stem length. Moreover, there was a highly significant difference among parents and hybrids in cucumber for anthesis of first female flower (Gharib, 1991). For number of female flowers per plant, Solanki and Seth (1980) observed a considerable phenotypic variability among some varieties of cucumbers El-Mahdy et al. (1992) mentioned in their studies on five lines and cultivars that they were genetically diverse for total number of fruits and fruit weight.

General combining ability (GCA) and specific combining ability (SCA) effects have been found to be significant for cucumber yield (Wang and Wang, 1980; Solanki and Seth, 1980). Fredrick and Staub (1989) showed that lines WI 2963 and 4H 261 (a *hardwickii* line) had the highest GCA as male and female parents respectively for total yield in cucumber. GCA and SCA were significant for main stem length, flowering time and number of female flowers in cucumber (Darwish, 1992). Abd El-Hafez et al. (1997)

mentioned that GCA and SCA effects were highly significant for flowering characters and yield and its components between five inbred lines in cucumber.

The aim of this study was to evaluate the genetic system of some inbred lines and their F_1 populations of cucumber plants under low temperature conditions. This was in order both to reduce the risk of environmental stresses and to reduce costly hybrid seed imports.

MATERIAL AND METHODS

Five different inbred lines of cucumber (*Cucumis sativus* L.) were used as parents in a diallel cross. These inbred lines were: 1- PI 267742, 2- PI 436672, 3- PI 344348, 4- PI 135345 and 5- Biet Alpha. Table 1 shows the origin of cucumber accessions used in the study.

These inbred lines were selfed for three generations. After ensuring the purity of each line, crossing was made in all possible combinations of a complete diallel including reciprocals, giving a total of 20 crosses.

In the winter season of 1998/1999, all populations were sown in the open field of El-Bossily Experimental site to evaluate these generations under low temperature conditions. A randomized complete block design with three replicates was used. Data were recorded on an individual plant basis. The following data were recorded on 15 plants for parents and F_1s:

Traits	**Methodology**
Main stem length (cm):	This character was studied at the age of 65 days from seeding.
Leaf area (m^2):	Was measured twice in 50 and 75 days after sowing date using LI-3000 Portable area meter (standard technique No. 5).
Total dry weight/ plant (g):	Was measured twice after 50 and 75 days after sowing date by calculated average dry weight.
Female flower anthesis:	Counted in days after the date of seeding.
Number of female flowers / plant:	Was counted all over the growing season.
Non-viable pollen grains %:	This character was recorded as mentioned by khana and Chaudhary (1970) and De-Halac (1986) and was calculated from the equation: *Non-stainable pollen grains % = (No. of non-viable pollen / total number of pollen) x 100*
Fruit set %:	Was calculated from the equation: *Fruit set % = (No. of fruits / pistillate No. of flowers) x 100*
Total fruit weight (kg):	Uniform and malformed fruits were weighed as total fruit weight.
Total number of fruits:	Uniform and malformed fruits were counted as Total number of fruits.
Marketable fruit weight (kg):	Uniform fruits were weighed as marketable fruit weight.
Marketable No. of fruits:	Uniform fruits were counted as marketable number of fruits.

All fruits were picked from each plant at every picking time, were weighed and counted to calculate weight and number of fruits per plant. The harvesting was done between 50 to 90 days from sowing date.

The means for the F_1 crosses were subjected to analyses of variance of a randomized complete block design to estimate General Combining Ability (GCA) and Specefic Combining Ability (SCA) following Griffings (1956) method I model II. Statistical analyses were carried out in F_1 crosses and reciprocals F_1r and was subjected to the model proposed by Hayman (1953) and Jinks (1954). Table 2 shows meteorological

data during the cucumber crop period at El-Bossily site in the winter season of 1998. Mean values of air and soil temperature at 8 a.m. (15-cm depth) and relative humidity were provided by air thermometer (maximum and minimum) and soil thermometer and hygrometer, respectively.

RESULTS AND DISCUSSION

Mean Performance of Parental Lines, F_1 Crosses and F_1 Reciprocal

Data presented in Table 3, 4 and 5 show the mean performance of the parental lines, their F_1 and F_1r, respectively for studied characters at El-Bossily site during winter season. Parental lines showed narrowest range (165.00-314.33 cm) than F_1s (135.0-343.3 cm) and (194.33-349.33) among F_1r for plant height. The same trend was observed in leaf area after 50 and 75 days from sowing date respectively. These data were in accordance with results obtained by Gharib (1991) who found that the hybrids in cucumber showed wider range than the parents for stem length. On the contrast, Bite (1978) proved that hybrids did not differ from their parents in length of the main shoot in cucumber.

For flowering characters, parental ranges were 50.67 to 77.33 days for anthesis of the first female flower, 20.67 to 34 for number of female flower and 35.69 to 54.85% for pollen non-viability %. Corresponding ranges among F_1 were 45.00 to 77.33, 21.33 to 32.00 and 26.18 to 49.06, respectively. For F_1r ranges, they were 45.33 to 73.67, 25.00 to 32.67 and 27.15 to 51.32, respectively. Thus, F_1 and F_1r showed also wider ranges for the three characters than parents range. Solanki and Seth (1980), Gharib (1991), Darwish (1992) and El-Mahdy et al. (1992) mentioned that highly significant differences among parents and hybrids for anthesis of the first female flower and number of female flower in cucumber, and the hybrids showed wider range than the parents.

Mean performance of parents and their hybrids, the hybrids showed higher means only for total yield per plant on weight basis (total and marketable fruit weight). Mean yield per plant on weight basis was 1.018 kg in parents but 1.285 and 1.344 kg in the F_1 and F_1r respectively. Meanwhile, mean number of fruits per plant (total and marketable number of fruits) and percentage of fruit set were 13.78 and 54.15 % respectively. Besides, the upper limits of the ranges for the hybrids were extremely higher than the upper limits of the parents and also, the lower limits of the ranges for the hybrids were extremely lower than the lower limits of the parents. These data were in agreement with Gharib (1991), Darwish (1992) and El-Mahdy et al. (1992) who mentioned that there were highly significant differences among parents and hybrids for total and marketable yield on weight and number basis. Moreover, the hybrids showed wider ranges than the parents and as well as, the hybrids recorded higher means than the parents.

Estimates of General (GCA) and Specific (SCA) Combining Ability

Data presented in Table 6 show the estimates of General combining ability (GCA) effect for each of five cucumber parents at El-Bossily site during winter season. A significant GCA effect with respect to earliness (negative effect) was observed by P_1 and for lateness (positive effect) by P_2, P_3, P_4 and P_5. In addition, significant GCA effects were shown by the parent P_1 for higher number of female flowers per plant. The P_1 have shown highly significant negative GCA for percentage of pollen non-viability effect than the P_2, P_3, and P_4. The positive values for GCA effects for parental lines under such character in question denote undesirable (higher pollen non-viability) average performance however, negative values denote the desirable of less non-viable pollen grains and may be of great value. Therefore, the parent P_1 possessed favorable genes for lower percentage of pollen non-viability and suggested that improvement in decreased pollen non-viability achieved by using this parent could be of great importance. The GCA effect for P_1 was significant and positive for both yield and its components. This indicated that P_1 is the best combine for increasing total and marketable yield.

Estimates of specific combining ability (SCA) effect for F_1 crosses among five cucumber parents at El-Bossily site during winter season are shown in Table (7). The

cross P_1xP_4 displayed the earliest date for the first female flower and also the highest negative effect. On the other hand, this hybrid revealed significant positive effect for higher number of female flowers per plant. Cross combination P_1xP_4 generally exhibited higher specific effects for lowering the percentage of pollen non-viability suggesting that a considerable non-allelic gene effect was found in this cross combination. In addition, this cross-showed the highest SCA effect for total yield per plant. In general, the highest yielding cross P_1xP_4 showed significant SCA effects for all characters.

The present results were in agreement with those reported by Gharib (1991); Darwish (1992) and Yaccop et al. (1993) in cucumber, on main stem length; Gharib (1991); Darwish (1992) and El-Mahdy et al. (1992) in cucumber on first female flower anthesis; Darwish (1992) on the number of female flower; Solanki and Seth (1980); Gharib (1991); Darwish (1992); Yaccop et al. (1993) on yield and its components in cucumber.

CONCLUSION

The results showed that the best mean performance and GCA were observed in P_1. This parent could be improved and used in producing a low temperature tolerance variety. Cucumber production could be increased under favourable conditions.

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Tables

Table 1. Origin of used cucumber accessions.

Parents	Accession No.	Origin	Provenance
P_1	PI 267742	Hong Kong	Holland
P_2	PI 436672	China	U.S.A
P_3	PI 344348	Turkey	U.S.A
P_4	PI 135345	Afghanistan	U.S.A
P_5	Beit Alpha	U.S.A (Asgrow Co.)	U.S.A

Table 2. Meteorological data at EL-Bossily site during 1998/1999-winter season.

Date	Mean temp. C°		Soil temp. C°	R.H. %
From-To	Max.	Min.		
01-10 Nov. 1998	17	13	22	79.85
11-21 Nov.1998	15	13	23	93.22
22-30 Nov.1998	18	12	20	69.59
01-10 Dec.1998	13	9	19	80.17
11-21 Dec.1998	13	10	19	97.33
22-31 Dec.1998	11	7	15	79.17
01-10 Jan.1999	11	7	15	87.26
11-21 Jan.1999	9	7	19	97.33
22-31 Jan.1999	11	6	13	72.83

Table 3. Mean performance of five cucumber parental lines at El-Bossily site during 1998-1999-winter season.

Plant Characters	Parents					LSD(.05)
	P1	P2	P3	P4	P5	
Plant height (cm)	314.33	281.00	200.33	165.00	196.33	14.13
Leaf area (50) days (m^2)	0.75	0.66	0.54	0.39	0.44	0.26
Leaf area (75) days (m^2)	0.98	0.93	0.80	0.58	0.67	0.04
Dry weight (50) days (g)	52.56	45.62	41.17	30.22	41.64	7.80
Dry weight (75) days (g)	70.63	64.41	59.71	43.32	48.28	2.06
Anthesis of first female flower	50.67	57.67	62.67	73.67	77.33	4.43
Number of female flowers	34.00	23.00	27.33	27.33	20.67	4.64
Pollen non-viability %	35.69	44.81	50.69	53.61	54.85	4.50
Fruit set %	68.96	70.30	47.72	36.28	47.51	11.68
Total fruit weight/plant (kg)	1.87	1.13	0.91	0.52	0.66	0.19
Total number of fruits /plant	23.39	16.17	12.43	7.45	9.50	2.57
Marketable fruit weight/plant (kg)	1.12	0.57	0.41	3.35	0.30	0.10
Marketable number of fruits /plant	14.00	16.17	5.59	3.35	0.30	1.75

P1: PI 267742 P2: PI 436672 P3: PI 344348 P4: PI 135345 P5: Biet Alfa

Table 4. Mean performance of 10 F_1 crosses at EL-Bossily site during 1998/1999-winter season.

Plant Characters	Crosses										LSD(.05)
	P_1XP2	**P_1XP3**	**P_1XP4**	**P_1XP5**	**P_2XP3**	**P_2XP4**	**P_2XP5**	**P_3XP4**	**P_3XP5**	**P_4XP5**	
Plant height (cm)	293.67	297.6	343.3	291.00	299.0	181.00	196.67	247.33	284.00	135.00	14.13
Leaf area (50) days (m^2)	0.71	0.47	0.56	0.79	0.44	0.32	0.37	0.65	0.63	0.39	0.26
Leaf area (75) days (m^2)	0.80	0.86	1.12	0.84	0.90	0.42	0.54	0.83	0.87	0.55	0.04
Dry weight (50) days (g)	47.00	48.49	54.34	47.48	46.65	30.77	38.88	49.19	45.71	30.54	7.80
Dry weight (75) days (g)	67.45	67.51	75.46	70.63	65.29	57.58	57.83	68.35	64.38	40.23	2.06
Anthesis of first female flower	53.67	49.00	45.00	53.67	49.67	75.00	68.33	53.33	56.33	77.33	4.43
Number of female flowers	25.67	28.33	31.33	28.00	28.00	21.33	28.00	32.00	28.67	32.00	4.64
Pollen non-viability %	35.08	36.41	26.18	31.30	31.63	43.63	38.22	48.90	52.01	49.06	4.50
Fruit set %	76.12	78.10	84.72	69.56	59.30	57.29	47.09	59.72	45.02	47.51	11.68
Total fruit weight/plant (kg)	1.55	1.75	2.12	1.53	1.22	0.86	0.92	1.42	0.96	0.52	0.19
Total number of fruits /plant	19.33	21.83	26.45	19.12	16.21	12.21	13.17	18.87	12.76	7.33	2.57
Marketable fruit weight/plant (kg)	0.93	1.05	1.27	0.92	0.61	0.43	0.46	0.64	0.43	0.23	0.10
Marketable number of fruits /plant	11.60	13.10	15.87	11.47	8.10	6.11	6.58	6.26	4.32	3.30	1.75

P1: PI 267742 P2: PI 436672 P3: PI 344348 P4: PI 135345 P5: Biet Alfa

Table 5. Mean performance of F_1 reciprocal at EL-Bossily site during 1998/1999 - winter season.

Plant Characters	**Crosses**										**LSD(.05)**
	P_2XP1	**P_3XP1**	**P_4XP1**	**P_5XP1**	**P_3XP2**	**P_4XP2**	**P_5XP2**	**P_4XP3**	**P_5XP3**	**P_5XP4**	
Plant height (cm)	283.67	318.33	349.33	320.00	230.67	165.67	205.67	295.00	217.00	194.33	14.13
Leaf area (50) days (m^2)	0.72	0.69	0.81	0.78	0.72	0.31	0.50	0.48	0.52	0.40	0.26
Leaf area (75) days (m^2)	0.82	1.00	1.15	1.07	1.01	0.52	0.66	0.59	0.73	10.42	0.04
Dry weight (50) days (g)	56.37	52.04	54.44	47.65	48.50	40.65	46.71	46.33	47.46	34.33	7.80
Dry weight (75) days (g)	68.57	71.65	74.58	70.18	67.47	51.28	66.73	60.36	67.45	45.44	2.06
Anthesis of first female flower	50.67	45.67	45.33	45.33	58.33	66.33	66.33	55.00	55.00	73.67	4.43
Number of female flowers	27.67	30.67	32.67	28.33	32.67	25.00	30.67	29.00	29.00	28.33	4.64
Pollen non-viability %	34.54	41.78	27.15	37.90	40.76	46.72	51.32	48.37	46.26	46.72	4.50
Fruit set %	80.22	75.31	78.98	72.32	51.08	57.36	44.57	59.84	46.84	31.84	11.68
Total fruit weight/plant (Kg)	1.66	1.84	2.32	1.63	1.17	1.00	0.95	1.22	1.02	0.63	0.19
Total number of fruits /plant	22.08	23.03	25.76	20.43	15.56	14.28	12.72	17.24	13.61	9.03	2.57
Marketable fruit weight/plant (Kg)	0.99	1.11	1.39	0.98	0.58	0.50	0.48	0.55	0.46	0.28	0.10
Marketable number of fruits /plant	13.25	13.82	15.46	0.98	7.78	7.14	0.48	7.82	0.46	0.28	1.75

P1: PI 267742 P2: PI 436672 P3: PI 344348 P4: PI 135345 P5: Biet Alfa

Table 6. Estimates of general combining ability effect of each of five cucumber parents at EL-Bossily site during 1998/1999-winter season.

Plant Characters	*Parents*					*S.E(gi)*
	P1	***P2***	***P3***	***P4***	***P5***	
Plant height	*60.35**	*-10.41**	*6.75**	*-28.11**	*-28.58**	*1.75*
Leaf area (50) days	*0.17**	*0.00*	*-0.03**	*-0.07**	*-0.01**	*0.00*
Leaf area (75) days	*0.17**	*0.02**	*0.02**	*-0.05**	*-0.08**	*0.00*
Dry weight (50) days	*7.45**	*1.50**	*-0.85**	*-1.88**	*-1.64**	*0.06*
Dry weight (75) days	*10.71**	*3.09**	*-1.27**	*-4.02**	*-2.07**	*0.04*
Anthesis of first female flower	*-7.38**	*4.02**	*-7.21**	*7.49**	*8.72**	*0.17*
Number of female flowers	*3.12**	*-0.45**	*-0.51**	*0.35**	*0.35**	*0.19*
Pollen non-viability %	*-11.06**	*0.29**	*0.48**	*7.19**	*9.30**	*0.33*
Fruit set %	*17.38**	*3.42**	*-5.38**	*-2.96**	*-7.96**	*1.20*
Total fruit weight/plant	*0.60**	*-0.06**	*-0.07**	*-0.11**	*-0.27**	*0.00*
Total number of fruits /plant	*6.59**	*-0.10**	*-0.77**	*-1.28**	*-3.17**	*0.06*
Marketable fruit weight/plant	*0.43**	*-0.05**	*-0.08**	*-0.08**	*-0.18**	*0.00*
Marketable number of fruits /plant	*4.59**	*-0.10**	*-0.33**	*-0.48**	*-1.30**	*0.02*

P1: PI 267742 P2: PI 436672 P3: PI 344348 P4: PI 135345 P5: Biet Alfa
S.E(gi) = Standard error of general combining ability

Table 7. Estimates of specific combining ability effect of F_1 crosses among five cucumber parents during 1998/1999 winter season.

Plant Characteristics	Crosses										S.E.(Sij)
	P1XP2	P1XP3	P1XP4	P1XP5	P2XP3	P2XP4	P2XP5	P3XP4	P3XP5	P4XP5	
Plant height	*-13.49**	*-11.32**	*61.88**	*21.51**	*16.28**	*-40.35**	*-12.05**	*40.31**	*20.11**	*31.98**	*7.47*
Leaf area (50) days	*0.01**	*-0.09**	*0.05**	*0.09**	*0.07**	*-0.16**	*-0.10**	*0.12**	*0.08**	*-0.06**	*0.002*
Leaf area (75) days	*-0.15**	*-0.03**	*0.24**	*0.04**	*0.21**	*-0.21**	*-0.11**	*0.03**	*0.09**	*-0.11**	*0.000*
Dry weight (50) days	*-4.70**	*0.72**	*5.88**	*-1.19**	*3.98**	*-3.52**	*-0.01*	*7.54**	*6.13**	*-5.49**	*0.26*
Dry weight (75) days	*-5.81**	*0.11*	*8.31**	*1.75**	*4.54**	*-4.65**	*1.25**	*0.00*	*9.24**	*-11.08**	*0.16*
Anthesis of first female flower	*-0.82**	*5.58**	*-11.29**	*-8.19**	*0.85**	*2.81**	*-1.75**	*-2.45**	*-2.19**	*2.95**	*0.73*
Number of female flowers	*-2.95**	*-0.05*	*1.58**	*-2.25**	*4.35**	*-3.69**	*2.48**	*3.71**	*2.05**	*2.51**	*0.80*
Pollen non-viability %	*0.94*	*8.01**	*-18.28**	*-10.71**	*-12.22**	*0.44*	*-2.37**	*7.56**	*4.99**	*-3.96**	*1.41*
Fruit set %	*-0.58*	*6.76**	*9.49**	*3.58*	*-0.79*	*-1.08*	*-7.57**	*10.18**	*1.33*	*-7.34**	*5.10*
Total fruit weight/plant	*-0.15**	*0.05**	*0.51**	*0.04**	*0.11**	*-0.13**	*0.05**	*0.28**	*0.11**	*-0.27**	*0.0013*
Total number of fruits /plant	*-1.68**	*0.72**	*4.90**	*0.47**	*0.86**	*-1.26**	*0.33**	*4.21**	*1.24**	*-3.25**	*0.25*
Marketable fruit weight/plant	*-0.08**	*0.07**	*0.33**	*0.04**	*0.06**	*-0.06**	*0.03**	*0.09**	*0.04**	*-0.14**	*0.00036*
Marketable number of fruits /plant	*0.2**	*1.5**	*3.8**	*0.8**	*0.6**	*-0.6**	*0.1**	*0.1**	*-0.2**	*-2.3**	*0.08*

P1: PI 267742 P2: PI 436672 P3: PI 344348 P4: PI 135345 P5: Biet Alfa
S.E.(Sij) = Standard error of specific combining ability