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COMBINING ABILITY AND HETEROSIS IN SWEET PEPPER (*Capsicum annuum* L.)

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ABSTRACT

This investigation was carried out at the Experimental Station Farm, Faculty of Agriculture, Alexandria University at Abies region, in four successive seasons. from 1998 till 2001.

At the first season, the various characteristics of five parental cutivars of sweet pepper were evaluated by measuring their mean, coefficient of variation (C.V.) and range. Two cycles of inbreeding were performed on individual true type plants of the parental cultivars for genetic purification of their characters. Hybridizations among plants of the 5 parents were performed in one way diallel fashion without reciprocals. The data of 15 genotypes of the characters of yield-and quality-components were subjected to combining ability analyses . Mean performance and heterosis to the better parent as well as the effects of general – and specific- combining ability were counted for the important characters for the various studied genotypes of sweet pepper.

INTRODUCTION

Sweet pepper is one of the most important vegetable crops in Egypt for its high content of minerals and vitamins, especially vitamin C and A. The superiority of F_1 hybrids, comparing with the open-pollinated cultivars resulting from the heterosis phenomena, was reported by many investigators has been proved in sweet pepper (Khalil and Omran, 1982; Khalil, 1984 and 1988; Gaafar, 1993; Khereba *et al.*, 1995, and Mohamed *et al.*, 1995). The diallel crosses are performed to offer informations about types of gene action controlling studied characters. The general combining ability (GCA) relates to the additive gene effects; whereas, the specific combining ability (SCA) estimate involved both non-additive and additive gene action (Welsh, 1981 and Greenleaf, 1986). Also, results from such crosses provide valuable informations on heterosis values, reflected on the general performance of the evaluated hybrids.

The purpose of this study was to investigate and evaluate some important characters of commercial sweet pepper cultivars and their hybrid combinations and to determinate the types of gene action controlling these valuable characters and to predict also the best hybrids from such diallel matings.

MATERIALS AND METHODS

This study was carried out at the Experimental Station Farm of the Faculty of Agriculture, Alexandria University at Abies region, Alex (A.R.E.), in four seasons during years of 1998 to 2001. The five cultivars of sweet pepper named: Jupiter, California wonder 300 (TMV), California Wonder, Marconi

and Balady (Local cv.) were used in this study. The first four cultivars were produced by the companies of: S & G, sandoz seeds (Holland); Sun Seeds, sally seeds (U.S.A.); Vilmorin (France), respectively, whereas the fifth one was locally produced and bought from a commercial seed store.

Seeds of the five cultivars were sown on the first of March, 1998 and seedlings were transplanted into the open field on April 15th. The five cultivars were randomly distributed in plots within four replicates, using the plot size of three rows, 6m. long, 0.6 m. wide and 25 cm. between plants. Fertilization, irrigation and other cultural practices were conducted whenever they were needed as commonly recommended in the commercial pepper's production.

Marked variabilities were observed for the characters of vegetative growth, yield and fruit shape within plants of each cultivar, especially in Marconi and Balady ones. Also, fruits from several plants of the latter two cultivars appeared to have a pungency taste. The over-all means and the variability measurements, represented as the coefficients of variation (C.V.) and ranges were measured on 150 individual plants from each cultivar for the characters of fruits number, average fruit weight, fruit wall thickness, as well as length and width of marketable fruits. Because of such variations within the used cultivars material, the Summer and Fall seasons of 1998 were devoted to purificate characters toward their true types through two selection and selfing cycles. Selfed seeds from the homogenious plants of each cultivar for the characters of plant habit, fruit shape and pungency fruit free, were used as parents in the required crosses.

Selfed seeds of the five parental cultivars, were separately sown on September 15th, 1999 in pots; filled with a soil mixture consisting of equal parts of sand, clay and silt. All cultural practices were performed as recommended in pepper transplanting production.

Uniform healthy seedlings were transplanted on the first of November into ridges in a greenhouse. Each ridge was 100 cm wide and the plants were spaced at 50 cm. on both sides of ridges. Cultural practices were conducted as previously mentioned. At flowering stage, after emasculation and collecting pollen grains, a half-diallel cross involving the matings among the five selected parental cultivars, in all possible two-parent combinations (10 crosses), was performed, in addition to performing selfing of the parental cultivars (5 cvs.). Enough seeds from the red ripe fruits of each of the 15 genotypes were extracted, air dried, and stored for the next season.

Evaluation of the 15 genotypes was carried out in the winter season of 2000/2001 under a greenhouse. Seeds of the tested entries were sown on October 16th, 2000 in pots, which transplanted into greenhouse on December 15th.

A randomized complete blocks design (R.C.B.D.) with five replications was used. Each replicate consisted of the fifteen gynotypes; randomly distributed on both side of a ridge, 38 meters long and one meter wide, with 50 cm. of plant spacing. Each genotype was represented by a plot of 10 plants in each replicate. Fertilization, irrigation and other cultural practices were applied as usually recommended in the commercial production of sweet peppers hybrid.

Experimental Data :

Samples of 5 plants each were randomly chosen from each plot to record the characters of plant height and number of main branches, whereas the earliness of flowers was measured as days from transplanting to the first flower anthesis of the 50% of flowering plants per plot. Early green fruits yield (Kg/plot) was recorded from the first three harvests, whereas the total yield parameters (number and weight of fruits/plot) were recorded from all harvestings. Sample of ten random fruits at the green stage, from each plot, was taken to determine the following fruit characteristics: length to diameter ratio; wall thickness; average fruit weight, total soluble solids (T.S.S.) and vitamin "C" content as described in A.O.A.C., 1980.

Data were statistically analized using the R.C.B.D. design, illustrated by Al-Rawi and Khalf-Allah (1980); whereas, the differences among means were tested using Duncan's Multiple Rang Test (L.S.R.). Heterosis percentage over the better-parent, variances and effects of general and specific combining abilities were calculated, according to Mather and Jinks (1971) and Griffing (1956), respectively.

RESULTS AND DISCUSSION

Results in Table (1), reflected marked differences between the five used cultivars for the most important studied characters. Concerning fruit number per plant, the highest values were obtained from the Balady and Marconi cvs., which gave the lowest values for their average fruit weight. Generally such cultivars showed wider variabilities and ranges for the all studied characters than those of the other cultivars. Since the shape of marketable fruits can be distinguished from its length, width and their ratio; the obtained results indicated that the fruits of the cultivars: Jupiter; California wonder 300 and California wonder have a blocky bell shape, whereas the Marconi and Balady cultivars, belongs to the long wax fruit shape, that resembled to fruit of the standard cultivars Anaheim TMR23, U.S. and Long Spanish bell, Spain, respectively. Classification of the parental cvs., was performed according to Smith classification system of pepper that was modified by Greenleef (1986) and to Smith *et al.* (1987) classification.

Depending on field and personal fruit taste, it was noticed that the two practiced selection and selfing cycles on the used cultivars were found enough for purification of the following studied materials, especially for the fruits of Marconi and Balady cvs., that became pungency free. Such a pungency trait that existed in fruits of some plants of the two mentioned cultivars could be translocated from the nearby plants of some pungent cultivars by cross pollination that sometimes, reached to 36.8%, and because this trait reported to be controlled by a major dominant gene, with pollygenes acting in a cumulative manner (Ohta, 1962). Yagishita *et al.* (1990) reported that the pungency character is generally controlled by at least two pairs of genes. The two purification cycles of selection were found enough because of the natural self pollination in pepper crop; that ranged from 63.2 to 92.4% (Greenleaf, 1989). The existence of some pronounced variabilities within and

between cultivars of pepper was reported by several investigators; such as Elangovan *et al.*, (1981), Ghai and Thakur, (1987), Varalakshmi and Babu, (1991), and Ghildiyal *et al.*, (1996).

Table 1. Mean, coefficient of variation (C.V.) and range of some important characters of the used parental cultivars of sweet pepper, in the summer season of 1998.

Cultivars	Total fruits/ plant	Marketable fruit			
		Weight (g)	Wall thickness (mm)	Diameter (cm)	Length (cm)
Jupiter					
X	21.90	100.37	5.21	7.67	8.00
C.V. (%)	9.30	13.79	12.86	11.69	2.53
Range	19-26	85-140	4.0-6.5	6.0-9.5	6.5-9.9
Cal. Won. 300*					
X	21.80	84.58	4.04	5.67	7.07
C.V. (%)	18.00	8.38	13.80	15.02	12.73
Range	16-30	75-120	3.0-5.5	4.0-7.8	5.3-8.8
Cal. Won.*					
X	22.10	91.00	4.07	6.19	7.00
C.V. (%)	18.68	10.97	14.98	17.59	15.00
Range	15-30	70-120	3.0-5.5	4.5-8.5	4.9-9.0
Marconi					
X	30.10	30.06	1.64	4.27	13.60
C.V. (%)	27.04	27.04	29.60	21.03	24.18
Range	15-45	19-45	0.4-3.5	2.5-6.0	8.0-20.0
Balady					
X	38.00	23.00	2.60	4.14	8.38
C.V. (%)	49.90	31.56	37.48	33.59	25.54
Range	11-85	10.0-35.5	0.85-4.0	1.7-6.2	4.0-15.5

*: California Wonder 300
**: California Wonder

The results in Tables 2-a and 2-b showed clear and significant differences between the 15 genotypes for all studied characters, as well as the heterosis over the best parent from the all combinations of crosses.

Comparisons among means of the parental cultivars (Table 2-a), illustrated that the Jupiter cv. (P_1) gave the highest values for seven characters (main branches, early yield, total yield, fruit weight, diameter and wall thickness of fruit and vitamin C content). Insignificant differences were detected when Jupiter cv., was compared with the cultivars: Balady (P_5) for main branches, the California wonder 300 (P_2) and California wonder (P_3) for early yield, and P_2 for weight and wall thickness of fruit. The Balady cv., showed the highest significant value for the character of number of fruits/plot, following by that of Marconi one (P_4). The Balady cultivar did not show any marked differences when compared with the other cvs., for the characters of early and total yield/plot, except P_1, and for the traits T.S.S. and vitamin C

content except for the P_4. On the other hand Balady cv., (P_5), showed the lowest values of wall-fruit thickness. The cultivar Marconi showed the highest value of fruit length and the lowest average fruit weight.

Mean performances of hybrids (Table 2-b) indicated that the highest significant values for branches number were obtained from the hybrids P_1 x P_5, P_1 x P_3 and P_1 x P_4, whereas the moderate values were given by P_1 x P_2, P_2 x P_5 and P_3 x P_5. The F_1 hybrid P_1 x P_2 gave the highest early yield; whereas, most of the other entries had moderate values without any significant differences. Concerning total yield, all hybrids gave better values than their parents. The two hybrids P_1 x P_2 and P_1 x P_4 appeared have the highest significant values; whereas, no marked differences were observed among the others. The lowest values of all hybrids were obtained from the crosses between the parents 5 with P_2 and P_3, respectively. The highest values of fruits number per plot (plant), were recorded from P_4 x P_5 cross, whereas moderate values were given by the crosses P_2 x P_5 and P_1 x P_5. Hybrid P_1 x P_2 gave the highest fruit wall thickness followed by P_2 x P_3 with a significant difference. The highest entries in T.S.S. content appeared be the cultivar Marconi cv., (P_4), crosses P_4 x P_1, P_4 x P_3 and P_1 x P_3. Most entries did not show any significant differences in vitamin C content; whereas, the highest values were those of the crosses P_5 x P_2 and P_5 x P_3. As clearly noticed from the mentioned results, that hybrid' means of most characters tended to be either towards the higher parent or over the best one. These results revealed that partial dominance or over-dominance of gene action primarily, controlled most of the studied characters, which agreed with the findings of Mansour and Honma (1967), Gad (1979), Maksoud *et al.* (1980), Joshi (1988), Thakur (1990), Khereba *et al* (1995), Mohamed *et al.*(1995) and Khalil (2001). Other authors disagreed with the previous results, since they indicated that additive gene action appeared more important on the inheritance of some characters, such as; Khalil *et al.* (1989) and Setiamihardja and Knavel (1990) for fruit length; Khalil *et al.* (1989) and Gaafar (1993) for fruit' wall thickness; Gad (1974), Khalil *et al.* (1989) and Khalil (2001) for average fruit weight; Khalil *et al.* (1989) for total yield; and Khalil and Omran (1982) and Gaafar (1993) for of T.S.S. and vitamin C content.

Heterosis to the extent of 27.12% for plant height on the cross (P_1 x P_2), as 10% for number of main branches for the crosses (P_2 x P_3 and P_2 x P_4), as 55.34% for early yield on the cross (P_1 x P_2), as 82.60% for total yield (P_2 x P_3), 55.59% for fruits' number/plot or plant on the cross (P_1 x P_4), as 3.85% for average fruit weight on the cross (P_1 x P_2), as 0.67% for fruit wall thickness on the cross (P_1 x P_2), as 9.93% for T.S.S. on the cross (P_1 x P_3) and as 25.90% for vitamin C content on the cross P_2 x P_5 were recorded over their respective better parents. For most characters, it could be observed that the hybrids having the highest heterosis values did not give the highest means. Such an observation could be due to the relatively high additive effects than non-additive effect involved in these traits.

Table 2-a: Mean performance of sweet pepper parents (cvs.) for the characteristics of some vegetative, yield components- and fruit quality

Parents*	Plant height (cm)	No. of main branches	Days to 1st flower	Early yield kg/plot**	Total yield kg/plot	Total fruits no./plot	Marketable fruit						
							Average fruit wt. (g)	Fruit length (L) (cm)	Fruit diameter (D) (cm)	Length/ diameter (L / D)	Wall thick-ness (mm)	T.S.S content mg/100 ml juice	Vit. C mg/100 ml juice
P_1	60.24 g	3.00 ab	74.00 bc	6.36 b-d	32.75 bc	250.00 h	130.0 ab	9.09 g-l	9.00 a	1.1 e	4.49 a	5.64 b-d	125.08 a-d
P_2	64.16 fg	2.00 e	66.00 c	5.58 b-e	20.23 eg	220.80 h	119.0 bc	9.17 f-l	7.34 c	1.25 e	4.35 ab	5.66 b-d	119.98 b-d
P_3	65.32 f	2.00 e	76.00 ab	5.99 b-e	19.35fg	169.60 i	114.0 c	9.77 e-f	8.16 b	1.19 e	3.97 c	5.64 b-d	117.74 b-d
P_4	109.04 b	2.00 e	85.00 a	4.70 c-e	14.06 g	403.60 e	56.0 ef	14.57 a	2.71 g	5.92 a	2.57 f	7.22 a	95.52 d
P_5	99.50 c	3.00 ab	80.00 ab	4.33 de	17.99 fg	611.60 c	29.0 g	8.17 j	3.55 f	2.30 cd	1.56 h	4.92 d	110.41 b-d

* Parents 1-5 = Jupiter, California wonder 300, California wonder, Marconi and Balady cvs. , respectively.

** Plot size = 10 plants.

Mean followed by different letters are significantly different within a column for the 15 investigated entries, presented in Table 2-a and 2-b, don't significantly differ using Duncan's Multiple Range Test at 0.05 level.

Table 2-b. Mean performance of F_1 and heterosis (H%) over the better parent for the characteristics of some vegetative, yield components and qulity in sweet pepper, in the winter season of 2000.

Crosses	Plant height (cm)		No. of main branches		Days to first flower		Early yield (kg / plot)*		Total yield (kg / plot)		Marketable fruit											
											Total fruit no. (fruits/ plot)		Average fruit wt. (g)		Length/ diameter (L/D)		Wall thickness (mm)		T.S.S. content (%)		Vit. C (mg/100ml juice)	
	X	H%	X	H%	X	H%	X	H%	X	H%	X	H%	X	H%	X	H%	X	H%	X	H%	X	H%
**P_1x P_2	81.56 d	27.12	2.84 bc	-5.33	55.0 d	-16.67	9.88 a	55.34	48.36 a	47.66	358.8 f	42.38	135.0 a	3.85	1.12 e	-10.40	4.52 a	0.67	5.08 cd	-10.24	102.18 cd	-18.31
P_1x P_3	70.60 e	8.08	2.88 a-c	-4.00	76.2 b	2.97	6.47 b-d	1.73	35.88 bc	9.55	301.6 g	19.68	119.0 bc	-8.46	1.11 e	-6.72	3.80 c	-15.37	6.20 a-c	9.93	119.98 b-d	-4.07
P_1x P_4	96.40 c	-11.59	2.88 a-c	-4.00	83.0 b	12.16	7.69 b	20.91	47.06 a	43.69	628.0 c	55.59	75.0 d	-42.30	2.30 cd	-61.15	3.01 d	-32.96	6.48 a-c	-10.25	129.96 a-c	3.90
P_1x P_5	96.24 c	-3.28	3.12 a	4.00	73.2 c	-1.08	5.63 b-e	-11.47	32.99 bc	0.73	644.0 bc	5.29	51.0 ef	-60.76	2.01 d	-12.61	2.60 f	-42.09	5.74 b-d	1.77	126.64 a-c	1.25
P_2x P_3	77.96 d	19.35	2.20 e	10.00	78.0 b	18.18	5.90 b-d	-1.50	36.94 b	82.60	321.2 g	45.47	115.0 bc	-3.36	1.22 e	-2.40	4.12 bc	-5.29	5.56 b-d	-1.76	124.40 a-d	3.68
P_2x P_4	96.12 c	-11.85	2.20 e	10.00	75.0 a-c	13.64	6.70 bc	20.07	33.03 bc	63.27	533.6 d	32.21	62.0 de	-47.89	2.35 cd	-60.30	3.24 d	-25.52	6.08 b-d	-15.79	100.18 cd	-16.50
P_2x P_5	96.60 c	-3.30	2.68 c-d	-10.67	73.4 b-c	11.21	5.03 c-e	-9.85	27.81 c-e	37.46	668.4 b	9.28	42.0 fg	-64.70	2.17 d	-5.65	2.68 ef	-38.39	5.26 cd	-7.07	151.06 a	25.90
P_3x P_4	96.04 c	-11.92	2.16 e	8.00	80.0 ab	5.26	6.18 b-e	3.17	30.38 bc	57.00	508.8 d	26.06	60.0 e	-47.36	2.57 c	-56.59	2.96 de	-25.44	6.16 a-c	-14.68	102.20 cd	-13.19
P_3x P_5	96.28 c	-2.23	2.80 b-d	-6.67	76.0 a-b	0.00	4.37 de	-27.04	22.22 d-f	14.83	542.4 d	-11.31	41.0 fg	-64.03	2.03 d	-11.74	2.35 fg	-40.81	5.74 b-d	1.77	137.74 ab	16.98
P_4x P_5	117.28 a	7.56	2.60 d	-13.33	81.0 a-b	1.25	4.04 e	-14.04	29.50 b-d	63.97	840.0 a	37.34	35.0 g	-37.50	3.90 b	-34.12	2.10 g	-18.29	6.04 bd	-16.34	109.96 bd	-0.41

* Plot size = 10 plants.

** P_1 to P_5 = The parental cvs., of Jupiter, California wonder 300, California wonder, Marconi and Balady, respectively.

Means followed by different letters are significantly different within each column for the 15 investigated entries, using Duncan's Multiple Range Test at 0.05 level.

The estimates of σ^2_{sca} showed higher values than those of the σ^2_{gca} in only four traits (Table 3); early yield, total yield/plot, total number of fruits and vitamin C content. These results indicated the important of both additive and non-additive gene effects for most of the studied characters (Peter and Singh, 1974 and Vijayalakshmi *et al.*, 1989). The relative proportion variances of general- to specifics - combining ability ($2\sigma^2_{gca}/\sigma^2_{sca}$), reveals that, plant height, main branches, day to first flower, average fruit weight, length to fruit diameter, fruit wall thickness and T.S.S. content were predominantly governed by additive gene action, whereas the non-additive gene action was found to be more important for the other economical characters, such as total yield/plot ($2\sigma^2_{gca}/\sigma^2_{sca} = 22.79$).

The results presented in Table 4, concerning the estimates of general combining ability (GCA) effects of the parental cultivars, generally illustrated that Jupiter cv could be a good combiner for most of the desirable characters, but not for fruits/plant and T.S.S. content, whereas Balady cv., may be better for fruits per plant and vitamin C content. Since non of the tested limited parental cultivars appeared to have desirable GCA effects for all characters, earlier top cross test using great number cultivars with a common tester having a broad genetic base would be preferable, to select parental cultivars having relatively the highest GCA effects for most traits, than conducting such diallel crosses among few of commercial cutivars (Peter and Singh, 1974 and Srivastava and Bajpai,1977).

A perusal of specific combining ability (SCA) for characters (Table 5) indicated that the best crosses having highest significant values are: $P_1 \times P_2$, $P_1 \times P_5$ and $P_3 \times P_5$ for plant height; $P_1 \times P_2$ and $P_1 \times P_4$ for early yield/plot; $P_1 \times P_4$, $P_1 \times P_2$ and $P_2 \times P_3$ for total yield/plot; $P_4 \times P_5$, $P_1 \times P_4$ and $P_2 \times P_4$ for fruits' number/plot; $P_1 \times P_2$, $P_4 \times P_5$ and $P_2 \times P_3$ for average fruit weight; $P_1 \times P_2$ and $P_4 \times P_5$ for fruit' wall thickness; $P_1 \times P_3$, $P_1 \times P_5$ and $P_3 \times P_5$ for T.S.S. content; $P_2 \times P_5$, $P_1 \times P_4$ and $P_3 \times P_5$ for vitamin C content, with insignificant differences between such crosses for each character. These results are in agreement with those of Gad (1974), Maksoud *et al.* (1980), Richard and John (1983), Hassan *et al.* (1986), Meshram and Mukewar (1986), Joshi (1988), Khalil (1988), Khereba *et al.* (1995), Mohamed *et al.* (1995) and Khalil (2001); who reached also to some
particular single crosses that appeared superior for some of the interesting pepper characters.

Finally, it may concluded from results of this investigations that, the cultivars Balady (P_5) and Jupiter (P_1) were found to be the best general combiners for total fruits' number and total yield, respectively, since they possessed the highest gca values.The best hybrid combinations of all appeared to be Marconi x Balady ($P_4 \times P_5$) and Jupiter x Marconi ($P_1 \times P_3$) for total fruits' number, and $P_1 \times P_3$ for total yield, because they gave the highest estimates for sac effects.

Table 3. Estimates of total variance components of the studied characters on five parental cultivars in 5 x 5 diallel crosses system in one direction in sweet pepper.

Variance components	Plant height (cm)	No. of main branches	Days to 1st flower	Early yield (Kg/plot)	Total yield (Kg/plot)	Marketable fruit					
						Total fruit no. (fruits/plot)	Average fruit wt. (g)	L/D ratio	Wall thickness (mm)	T.S.S. content (%)	Vit. C mg/100 ml juice
σ^2_{gca}	116.27	0.07	113.76	0.45	7.55	10266.74	610.46	0.64	0.41	0.12	8.67
σ^2_{sca}	62.87	0.02	20.77	1.26	86.05	17191.56	238.12	0.15	0.05	0.01	168.30
σ^2_e	1.63	0.01	5.59	0.24	4.28	85.39	14.26	0.01	0.01	0.08	46.04

σ^2_{gca} = variance of general combining ability.
σ^2_{sca} = variance of specific combining ability.
σ^2_e = variance of environmental.

Table 4. General combining ability effects of five parents (cvs.) in 5 x 5 diallel crosses system in one direction in sweet pepper.

Parents	Plant height (cm)	No. of main branches	Days to 1st flower	Early yield (kg/ plot)	Total yield (kg/plot)	Marketable fruit					
						Total fruit no.(fruits/ plot)	Average fruit wt. (g)	Length/ diameter (L / D)	Wall thickness (mm)	T.S.S. content mg/100ml juice	Vit. C mg/ 100 ml juice
Jupiter	-9.208	0.339	-2.520	1.012	7.310	-52.194	23.794	-0.605	0.513	-0.024	2.816
Cal. Won. 300*	-7.025	-0.203	5.663	0.454	1.138	-68.309	16.937	-0.489	0.561	-0.235	1.224
Cal. Won.**	-8.174	-0.186	1.366	-0.114	-2.074	-112.651	12.794	-0.495	0.262	-0.009	1.512
Marconi	13.455	-0.215	5.223	-0.184	-2.074	73.691	-18.491	1.311	-0.411	0.600	-10.839
Balady	10.952	0.265	1.594	-1.168	-4.301	159.463	-35.034	0.277	0.925	0.332	5.287
L.S.D.$_{0.05}$	1.366	0.070	2.528	0.524	2.212	9.878	4.038	0.098	0.088	0.296	7.254

*: California Wonder 300
**: California Wonder

Table 5. Specific combining ability effects for some characters in 10 F_1 hybrids from 5 x 5 diallel crosses system in one direction in sweet pepper.

Crosses	Plant height (cm)	No. of main branches	Days to 1st flower	Early yield (kg/plot)	Total yield (kg/plot)	Marketable fruit: Total fruit no. (fruits/plot)	Average fruit wt. (g)	Length/diameter (L/D)	Wall thickness (mm)	T.S.S. content (%)	Vit. C (mg/100ml juice
$P_1 \times P_2$	9.504	0.147	-12.324	2.434	10.139	12.343	15.362	0.078	0.223	-0.486	-20.061
$P_1 \times P_3$	-0.308	0.170	1.848	-0.411	0.869	-0.514	3.505	0.076	-0.192	0.408	-2.548
$P_1 \times P_4$	3.864	0.198	4.790	1.476	12.056	139.543	-9.210	-0.535	-0.312	0.080	19.779
$P_1 \times P_5$	6.207	-0.042	-1.381	-0.197	0.213	69.771	-16.667	0.208	-0.204	0.292	0.335
$P_2 \times P_3$	4.870	0.032	6.790	-0.029	8.101	35.200	6.362	0.077	0.074	-0.020	3.460
$P_2 \times P_4$	1.401	0.061	-0.067	0.450	4.192	61.257	-15.352	-0.605	-0.131	-0.109	-8.407
$P_2 \times P_5$	4.384	0.061	1.962	-0.237	1.201	110.286	-18.810	0.251	-0.179	0.003	26.345
$P_3 \times P_4$	2.470	0.004	-2.095	0.495	4.762	80.800	-13.210	-0.382	-0.111	-0.313	-6.675
$P_3 \times P_5$	6.212	0.164	-2.467	-0.338	-1.180	28.629	-15.667	0.118	-0.209	0.257	12.737
$P_4 \times P_5$	4.584	-0.008	-0.724	-0.589	6.107	139.886	9.619	0.190	0.218	-0.052	-2.690
$L.S.D._{0.05}$											
Same parent	3.346	0.170	6.194	1.282	5.418	24.198	9.880	0.238	0.216	0.724	17.768
Different parent	3.050	0.156	5.654	1.170	4.946	22.090	9.028	0.218	0.198	0.660	16.220

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القدرة على التآلف وقوة الهجين فى الفلفل الرومى

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اجريت هذه الدراسة بمحطة البحوث الزراعية التابعة لكلية الزراعة جامعة الاسكندرية بمنطقة أبيس ، خلال أربعة مواسم من ١٩٩٨ حتى ٢٠٠١. تناولت الدراسة انتاج نباتات ممثلة للتراكيب الوراثية لخمسة أصناف من الفلفل الرومى وهى جوبيتر ، كاليفورنيا وندر ٣٠٠ ، كاليفورنيا وندر ، ماركونى ، البلدى. وذلك لتقييم السلوك العام للأصناف الأبوية والهجن الناتجة منها ، وتقدير كل من القدرة العامة والخاصة على التآلف وقياس قوة الهجين وذلك لأهم صفات النمو الخضرى والمحصولى للـ ١٥ عشيرة. وبدات الدرلسة بتقدير الاختلافات الموجودة للصفات الهامة للخمسة أصناف التجارية ، ثم أجريت دورتان من الانتخاب والتلقيح الذاتى لتنقية تلك الصفات لتوافق أصنافها. في الموسم الثالث تم اجراء كل التهجينات الممكنة بين نباتات الخمسة أصناف فى اتجاه واحد مع اجراء التلقيح الذاتى لكل صنف. وفى نهاية الموسم ، جمعت بذور كل تركيب وراثى على حده. فى الموسم الرابع ، زرعت بذور العشرة هجن بالاضافة للخمسة أصناف أبوية وذلك باستخدام تصميم القطاعات العشوائية الكاملة بأربع مكررات. ولقد قدر متوسط سلوك كل عشيرة بالنسبة لصفات النمو الخضرى والمحصولى وصفات الجودة للثمار الخضراء. كما تم تقدير قوة الهجين للعشرة هجن بالمقارنة بأفضل الآباء لكل هجين ، وكذلك حلل التباين وقدرت تأثيرات القدرة العامة والخاصة على التآلف للصفات المدروسة.

تبين من الدراسه أهمية كل من التفاعل الاضافى واللاضافى فى توريث جميع الصفات المدروسة، كما تبين تفوق التفاعل الجينى اللاضافى فى تحديد سلوك كل من صفات عدد الثمار/النبات والمحصول المبكر والكلى ومحتوى الثمار الكلى من فيتامين ج. أوضحت النتائج كذلك أن أكثر الأصناف تميزا فى القدرة العامة على التآلف ، وتصلح كمختبر عام لصفات عدد الثمار/النبات ومحتواها من فيتامين ج، هو الصنف البلدى ، أما الصنف جوبيتر فيصلح كمختبر عام لمعظم الصفات ، ومنها متوسط وزن الثمره والمحصول المبكر والكلى. من القدرة الخاصة على التآلف ، تبين أن أفضل الهجن المدروسة لمعظم الصفات الاقتصادية هو الجين الناتج من جوبيتر X كاليفورنيا وندر ٣٠٠ ، حيث أعطى أعلى القيم لكل من المحصول المبكر والكلى ومتوسط وزن الثمرة وسمك جدار الثمرة.