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GENETICS ANALYSIS, COMBINING ABILITY AND HETEROSIS OF SOME YIELD AND YIELD COMPONENT TRAITS IN SUMMER SQUASH (C*UCURBITA PEPO* L.)

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ABSTRACT: This study was carried out from 2020 to 2022 at Kaha vegetable Research Farm, Horticulture Research Institute, Kaliobia Governorate under unheated plastic house to produce some F_1 seeds. Six parental genotypes and their fifteen hybrids were evaluated in open field in the two summer successive seasons 2021 and 2022. Significant differences among genotypes were observed in mean performance for all studied characters. Highly significant differences for general and specific combining abilities were found for all studied characters. Estimates of general combining ability effects showed that the line 220-2 (P3) was the best combiner for most studied characters *i.e.* days to female flower anthesis, average fruit weight, fruit length, fruit diameter and total yield/plant followed by the lines 202-2 (P1) and 264 (P4). Certain crosses had high SCA effect values for certain traits. For specific combining ability effects, the best crosses were P1×P3, P1×P6, P1×P2 and P2×P3 since they showed significant SCA effect values for number of days to anthesis of first female flower, early yield /plant and total yield / plant. For heterosis effects all crosses indicated desirable positive MP heterosis ranged from 23.80 (P2×P5) to 147.83 % (P3×P4) and all crosses indicated desirable positive HP heterosis ranged from 18.18 (P2×P5) to 137.50 % (P3×P4) except the cross (P1×P4) for early yield / plant. For total yield/ plant all crosses indicated desirable positive MP and HP heterosis except three crosses *i.e.* P2×P5, P4×P6 and P5×P6. MP heterosis ranged from 39.28 (P1×P4) to 152.11 % (P2×P4) and HP heterosis ranged from 32.79 (P1×P4) to 127.31 % (P2×P4). The presence of desirable heterosis in yield and its components encourage using F_1 hybrids in commercial production.

Key words: Summer squash, heterosis, combining ability, genotypes.

INTRODUCTION

Summer squash (*Cucurbita pepo* L.), is a warm season crop belongs to family *Cucurbitaceae* and it's an important vegetable crop grown in Egypt. The cultivated area of squash, in Egypt, in 2020/2021 according to statistics of the Ministry of Agriculture, reached about 48169 feddans around year for the all season and its production reached, nearly 399948 tons with an average of 8.303 ton/fed. (Bulletin of The Agriculture Statistics part (2) Summer and Nile crops, 2020-2021) Commercial development of squash hybrids have been increasing owing to the superior of hybrids due to the expression of heterosis effects for vegetative growth, yield and yield components (Firpo *et al.*, 1998; Ahmed *et al*,. 2003 and Lopez-Anido *et al.*, 2004). Furthermore, El-Adl *et al.*, 2014, Habiba *et al.*, 2015 and Soliman 2018) estimated heterosis for some economical characters and high yield in summer squash. They detected heterosis over mid-parents and over its better parents for all traits.

Al-Ballat (2008) and Soliman (2018) reported that heterosis over the mid-parents was highly significant with negative values for number of days to first female flower.

El-Gendy (1999) and Marie *et al.*, (2012) found that heterosis relative to mid parent and better parent were desirable and highly significant for number of days to first female flower opening, fruit length, fruit diameter and total fruit number.

Jasim and Esho (2021) reported that the performance of parents was an indication of their

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GCA effects for all studied traits, The positive GCA indicates that these parents contribute to improving these characteristics and transfer them to the added effect of genes on the yield to their crosses towards increasing the yield so that they can be used as parents in crossbreeding programs to improve the efficiency and increase of the yield components by selecting plants superior to the characteristics of the yield components, and that the values of the high GCA of parents indicates their large contribution in transferring this characteristic to hybrids because of the high contrast added to it. This result was reported earlier similar results by (El sharkawy*et al*., 2018). Hussein *et al*., (2013) reported that the ratio of GCA/SCA was more than one for most characters, indicating the importance of additive and additive x additive gene effects. Nine out of 15 crosses exhibited significant favorable SCA effects for yield and one or more important studied traits.

The objectives of the present study were to estimate the magnitude of heterosis as well as genetic components, for traits under study in a half diallel crosses, to recognize desirable parent combinations as genetic resources for improving such important traits and to identify suitable material to be used in summer squash breeding programs and enhance of hybrids production and quality of hybrids in local market.

MATERIALS AND METHODS

The present investigation was carried out during 2020 to 2022, at Kaha vegetable Research Farm, Horticulture Research Institute, Kaliobia Governorate. The genetic materials used in this study were started by six inbred lines of summer squash (*Cucurbita pepo* L.) as a parental lines in a half diallel cross mating design. These genetic materials were developed by Hussein A.H. and author (Vegetables, Medicinal and Aromatic Plant Breed. Dept. Hort. Res. Inst., Agric. Res. Center, Egypt). These inbred lines were named; Line 202-2 (P1), Line 282-2 (P2), Line 220-2 (P3), Line 264 (P4) Line 240-1 (P5) and Line-206-3 (P6).

In the summer season of 2020, the six inbred lines were planted under unheated plastic house to ensure homozygosity and seed increase of parents.

In the fall season of 2020, the six parents were planted under unheated plastic house and all possible crosses, without reciprocals, were made to produce F_1 seed.

On the 22th of February of 2021 and 2022, seed of parents and their hybrids were sown in seedling trays under unheated plastic house.

On March 15th 2021 and 2022, the seedling of parents and their hybrids were transplanted on field to evaluate in a field experiment. A randomized complete block design with three replicates was used in this study. Plants were spaced 50 cm apart in rows of 4 m long and 1 m width with 4 rows for each plot. All the agricultural practices were applied according to the recommendation of Ministry of Agriculture, Egypt.

Data were recorded on individual plants from 10 plants of each parents and F_1 hybrids for the studied traits, *viz*, days to anthesis of female and male flowers, number of fruits/plant, average fruit length (cm), average fruit diameter (cm) and average fruit weight (g), early yield/plant and total yield/plant (kg).

Statistical analysis

Means and variances were calculated for each treatment where the means were statistically compared for significant differences using New L.S.D. according to Snedecor and Cochran (1990).

The analysis of general and specific combining abilities (GCA and SCA) were calculated according to Griffing (1956) method 2 model 1.

Average degree of heterosis (ADH%) was estimated as the increase or decrease percent of F_1 performance over the mid-parent (MP) and better parent (BP) according Sinha and Khanna (1975) as follows:

Heterosis based on MP= $\frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$

Heterosis based on BP = $\frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$

Where: $\overline{MP}$, $\overline{BP}$ and $\overline{F_1}$ are the mid-parents, mean of better parent in the trait and mean of F_1 hybrids, respectively.

RESULTS AND DISCUSSION

Mean performance

Data obtained on six genotypes and their fifteen hybrids of summer squash evaluated during 2021, 2022 and combined across two seasons and their ranks are presented in Table (1). Significant differences were observed in all studied traits in 2021 and 2022 and no significant differences were observed between two seasons then combined analysis was used. For combined analysis, values for number of days to anthesis of the first female flower showed that the parental values ranged from 35.83 (P5) to 45.50 days (P6), while, their 15 F_1 hybrids ranged from 29.66 (P1 × P3), to 40.66 days (P3 × P4). Regarding number of days to anthesis of the first male flower, the parental values ranged from 24.0 (P1) to 37.16 days (P6). The 15 F_1 hybrids ranged from 22.83 (P1 × P2) to 30.50 days in (P3×P6). The parental value for average fruit weight (P1) had the highest value 65.10 g on the other hand; lowest parent in this trait was (P5) had 47.85 g. The F_1 hybrids ranged from 68.80 (P4 × P5) to 99.45 (P1 × P3). Regarding number of fruits /plant the parental value (P5) had the highest value 20.93 fruits/ plant on the other hand; lowest parent in this trait was (P2) had 11.80 fruits /plant. The F_1 hybrids ranged from 10.96 (P5 × P6) to 26.26 fruits/plant (P2 × P4). For average fruit length the parental values ranged from 10.76 (P6) to 14.95 cm (P3). Their 15 F_1 hybrids ranged from 11.15 (P1 × P2) to 16.75 cm (P1 × P3). For average fruit diameter the genotype (P5) gave the lowest mean value of 2.30 cm and the parental genotype (P3) had the highest mean value (3.35 cm). For the F_1 hybrids (P1 × P3) had the highest mean value (3.85 cm), while the hybrid (P1 × P2) had the lowest one (2.60 cm). With respect to the parental performance for early yield /plant the six parental genotypes ranged from 0.06 (P4) to 0.16 kg (P1) while, their hybrids ranged from 0.12 (P2 × P5, P3 × P5 and P4 × P5) to 0.28 kg (P1 × P2). Regarding total yield/plant, the parental values ranged from 0.60 (P6) to 0.92 kg (P1) and (P5). Their hybrids ranged from 0.81 (P4 × P5) to 1.87 Kg (P2 × P4) These findings agreed to Hatem *et al*., (2013), Badr *et al*., (2021) and Hussein (2015), who mentioned that the analysis of variance indicated that there were significant differences among the studied generations in all studied characters.

Combining ability

The analysis of variance for combining ability on various studied traits is shown in Table (2). Highly significant differences were observed for both general and specific combining ability in all studied traits. This result indicates the importance of both additive and non-additive gene effects in the inheritance of the studied characters. The same results were found by Moualla *et al.*, (2011) who found that the values of mean squares for GCA and SCA were highly significant for all traits studied, suggesting the presence of both additive and non-additive genetic variance in such traits inheritance. The estimated GCA/SCA mean squares ratio indicated that the additive genetic variance played the main role in the inheritance of days to anthesis first male flower, average fruit length, average fruit diameter and early yield the same results were found by other investigators, among them Lopez- Anido *et al*., (1998), El-Gendy, (1999) and Hussein *et al.*, (2013). On the other hand, it was found that anthesis first female flower, average fruit weight, number of fruit / plant and total yield exhibited low GCA/SCA ratio of less than unity, indicating the predominance of non- additive gene action for this traits.

To follow up the effect of GCA for the parental lines and SCA for the crosses, the estimated values are presented in Tables (3 and 4 respectively) for the various characters. Regarding GCA effects, the following parental lines showed highly significant positive effect values for different traits and could be considered as the best combiners: P1 and P3 (for average fruit weight, number of fruit /plant, average fruit length, average fruit diameter and total yield/plant); P4 (for average fruit diameter and total yield/plant) and P5 (for number of fruit/plant).

Table (1): Mean performance of the six parents and their fifteen crosses of summer squash for yield and some fruit characters, during 2021, 2022 and combined across two seasons.

Genotypes	Days to anthesis of first female flower			Days to anthesis of first male flower			Average fruit weight (g)			No. of fruits /plant		
	2021	2022	Com.	2021	2022	Com.	2021	2022	Com.	2021	2022	Com.
202-2 (P1)	36.33	36.66	36.50	25.00	23.00	24.00	64.20	66.00	65.10	15.20	17.26	16.23
282-2 (P2)	36.00	36.33	36.16	2300	25.33	24.16	61.60	60.90	61.25	11.73	11.86	11.80
220-2 (P3)	37.66	36.66	37.16	26.00	24.00	25.00	61.83	66.23	64.03	14.30	14.43	14.36
264 (P4)	38.66	37.00	37.83	28.33	27.33	27.83	53.50	53.40	53.45	17.03	16.13	16.58
240-1 (P5)	35.66	36.00	35.83	25.33	24.00	24.66	48.13	47.56	47.85	20.70	21.16	20.93
206-3 (P6)	45.33	45.66	45.50	36.00	38.33	37.16	49.76	52.80	51.28	12.30	13.10	12.70
P1 × P2	37.00	39.33	38.16	22.33	23.33	22.83	72.70	74.20	73.45	18.90	19.23	19.06
P1 × P3	29.00	30.33	29.66	22.66	23.66	23.16	99.10	99.80	99.45	14.43	15.70	15.06
P1 × P4	39.00	39.33	39.16	23.33	23.33	23.33	95.73	95.80	95.76	14.26	13.60	13.93
P1 × P5	37.66	39.00	38.33	24.33	26.33	25.33	84.30	85.56	84.93	17.66	17.90	17.78
P1 × P6	36.33	34.33	35.33	24.00	23.33	23.66	73.43	75.23	74.33	18.90	20.06	19.48
P2 × P3	36.66	36.33	36.50	24.33	23.66	24.00	84.10	83.30	83.70	16.10	18.60	17.35
P2 × P4	33.33	34.66	34.00	24.00	22.66	23.33	80.00	80.93	80.46	25.40	27.13	26.26
P2 × P5	35.66	37.33	36.50	23.66	24.33	24.00	73.60	72.86	73.23	11.33	12.16	11.75
P2 × P6	35.00	36.33	35.66	24.33	24.00	24.16	80.33	80.73	80.53	11.73	11.66	11.70
P3 × P4	41.33	40.00	40.66	23.00	24.00	23.50	86.13	87.06	86.60	18.70	19.16	18.93
P3 × P5	36.33	33.33	34.83	23.66	23.66	23.66	90.60	88.93	89.76	15.70	15.33	15.51
P3 × P6	36.33	33.33	34.83	30.00	31.00	30.50	94.10	99.40	96.75	1910	17.20	18.15
P4 × P5	36.33	35.33	35.83	23.33	26.33	24.83	67.93	69.66	68.80	18.13	18.03	18.08
P4 × P6	39.33	38.66	39.00	30.33	29.00	29.66	73.13	70.93	72.03	11.96	12.60	12.28
P5 × P6	40.00	39.33	39.66	28.00	27.66	27.83	79.16	79.96	79.56	10.70	11.23	10.96
N.L.S.D(0.05)	2.18	1.68	2.061	2.493	1.68	1.61	3.84	3.48	3.66	2.50	3.24	2.84

Table (1): Cont.

Genotypes	Average fruit length (cm)			Average fruit diameter (cm)			Early yield/ plant (kg)			Total yield/ plant (kg)		
	2021	2022	Com.	2021	2022	Com.	2021	2022	Com.	2021	2022	Com.
202-2 (P1)	14.80	14.60	14.70	3.20	3.16	3.18	0.15	0.16	0.16	0.92	0.92	0.92
282-2 (P2)	14.43	14.13	14.28	2.86	2.83	2.85	0.12	0.11	0.11	0.65	0.66	0.66
220-2 (P3)	15.00	14.90	14.95	3.36	3.33	3.35	0.08	0.08	0.08	0.91	0.90	0.91
264 (P4)	12.06	12.10	12.08	2.86	2.73	2.80	0.06	0.07	0.06	0.87	0.83	0.85
240-1 (P5)	11.33	11.26	11.30	2.36	2.23	2.30	0.08	0.09	0.09	0.91	0.93	0.92
206-3 (P6)	10.80	10.73	10.76	2.40	2.36	2.38	0.08	0.08	0.08	0.58	0.62	0.60
P1 × P2	11.03	11.26	11.15	2.60	2.60	2.60	0.273	0.28	0.28	1.24	1.23	1.23
P1 × P3	16.70	16.80	16.75	3.86	3.83	3.85	0.26	0.26	0.26	1.30	1.50	1.40
P1 × P4	16.30	16.56	16.43	3.83	3.66	3.75	0.13	0.14	0.13	1.24	1.22	1.23
P1 × P5	15.60	15.66	15.63	3.33	3.36	3.35	0.18	0.19	0.18	1.42	1.44	1.43
P1 × P6	14.50	14.80	14.65	2.76	2.70	2.73	0.20	0.19	0.20	1.32	1.38	1.35
P2 × P3	14.73	14.36	14.55	2.93	2.86	2.90	0.13	0.14	0.14	1.29	1.43	1.36
P2 × P4	15.60	15.60	15.60	3.33	3.30	3.31	0.13	0.13	0.13	1.86	1.88	1.87
P2 × P5	11.83	11.96	11.90	2.66	2.56	2.61	0.12	0.13	0.12	0.80	0.84	0.82
P2 × P6	14.93	15.03	14.98	3.16	3.23	3.20	0.13	0.14	0.14	0.90	0.90	0.90
P3 × P4	16.23	16.30	16.26	3.76	3.63	3.70	0.18	0.19	0.18	1.51	1.53	1.52
P3 × P5	16.13	16.16	16.15	3.60	3.46	3.53	0.12	0.12	0.12	1.33	1.34	1.33
P3 × P6	16.10	16.53	16.31	3.70	3.86	3.78	0.15	0.17	0.16	1.63	1.70	1.66
P4 × P5	12.20	12.16	12.18	2.76	2.73	2.75	0.11	0.12	0.12	1.30	1.28	1.29
P4 × P6	11.96	11.93	11.95	3.00	2.86	2.93	0.14	0.15	0.14	0.80	0.83	0.81
P5 × P6	11.96	11.93	11.95	3.16	3.10	3.13	0.15	0.17	0.16	0.82	0.86	0.84
N.L.S.D(0.05)	0.37	0.41	0.38	0.22	0.20	0.21	0.019	0.016	0.017	0.082	0.160	0.125

Com. = combined

Table (2): Mean squares for combining ability (GCA and SCA) for some characters in summer squash during season 2022

Characters / Source of variation	Days to anthesis of first female flower		Days to anthesis of first male flower		Average fruit weight		No. of fruits /plant	
	MS	F	MS	F	MS	F	MF	F
GCA	29.13	27.95**	103.1	98.72**	536.70	120.48**	27.23	7.03**
SCA	29.57	28.38**	18.64	17.85**	693.55	155.69**	51.80	13.38**
GCA/SCA	0.98		5.53		0.77		0.525	

**Significant at 0.01 level of probability.

Table (2): Cont.

Characters / Source of variation	Average fruit length		Average fruit diameter		Early yield/ plant		Total yield/ plant	
	MS	**F**	**MS**	**F**	**MS**	**F**	**MF**	**F**
GCA	21.23	337.88**	1.12	72.46**	0.012	129.30**	0.277	29.51**
SCA	9.80	156.03**	0.52	33.77**	0.008	75.81**	0.410	43.55**
GCA/SCA	2.16		2.14		1.70		0.67	

**Significant at 0.01 level of probability

Table (3): General combining ability effects (g_i) of parental lines for studied characters of summer squash during season 2022.

Parents	Days to anthesis of first female flower	Days to anthesis of first male flower	Average fruit weight	No. of fruits /plant	Average fruit length	Average fruit diameter	Early yield/ plant	Total yield/ plant
202-2 (P1)	-1.04**	-5.04**	12.06**	2.44**	2.25**	0.38**	0.131**	0.20**
282-2 (P2)	-0.67**	-4.04**	-6.23**	-0.75	-0.67**	-0.47**	0.005*	-0.18**
220-2 (P3)	-4.41**	-2.04**	22.7**	0.12	4.38**	1.06**	-0.004	0.46**
264 (P4)	1.33**	0.20	-7.21**	3.1**	-0.57**	0.07*	-0.062**	0.12**
240-1 (P5)	-0.79**	-1.16**	-14.36**	0.92*	-2.94**	-0.67**	-0.05**	-0.17**
206-3 (P6)	5.58**	12.08**	-6.96**	-5.83**	-2.45**	-0.37**	-0.02**	-0.43**
S.E(gi)	0.23	0.32	0.68	0.63	0.08	0.04	0.003	0.03

*Significant at 0.05 level of probability.
**Significant at 0.01 level of probability.

Table (4): Specific combining ability effects (s_i) of crosses for studied characters of summer squash during season 2022.

Crosses[Z]	Days to anthesis of first female flower	Days to anthesis of first male flower	Average fruit weight	No. of fruits /plant	Average fruit length	Average fruit diameter	Early yield/ plant	Total yield/ plant
P1×P2	8.95**	2.17*	-10.56**	6.93**	-9.91**	-1.32**	0.27**	0.20**
P1×P3	-14.30**	1.17	37.31**	-4.55**	1.64**	0.84**	0.21**	0.39**
P1×P4	6.95**	-2.07*	55.22**	-13.82**	5.89**	1.34**	-0.08**	-0.12
P1×P5	8.07**	8.31**	31.67**	1.25*	5.56**	1.18**	0.03**	0.82**
P1×P6	-12.30**	-13.94**	-6.73**	14.51**	2.49**	-1.12**	0.02**	0.91**
P2×P3	3.32**	-0.82	6.10**	7.34**	-2.73**	-1.20**	-0.02**	0.54**
P2×P4	-7.43**	-5.07**	28.90**	29.96**	5.91**	1.10**	0.02**	2.25**
P2×P5	2.70**	1.30	11.85**	-12.76**	-2.61**	-0.37**	-0.02**	-0.60**
P2×P6	-6.68**	-12.95**	28.06**	-7.50**	6.11**	1.33**	0.0007	-0.15*
P3×P4	12.32**	-3.07**	18.387**	5.19**	2.96**	0.56**	0.18**	0.54**
P3×P5	-5.55**	-2.69**	31.13**	-4.14**	4.94**	0.79**	-0.04**	0.27**
P3×P6	-11.92**	6.05**	55.13**	8.22**	5.56**	1.69**	0.08**	1.60**
P4×P5	-5.30**	3.05**	3.24*	0.99*	-2.11**	-0.40**	0.03**	0.43**
P4×P6	-1.67*	-2.20**	-0.35	-8.55**	-3.28**	-0.30**	0.08**	-0.66**
P5×P6	2.44**	-4.82**	33.89**	-10.47**	-0.91**	1.13**	0.12**	-0.27**
SE(Sij)	0.90	0.90	1.87	0.55	0.22	0.11	0.008	0.086

Z; 202-2 (P1), 282-2 (P2), 220-2 (P3). 264 (P4), 240-1 (P5) and 206-3 (P6).*Significant at 0.05 level of probability.
**Significant at 0.01 level of probability.

On the other hand, the following lines P1, P2, P3 and P5 showed significant negative effects for number of days to first female and male flower anthesis. These lines could be considered as good combiners for breeding to these characters. The production of superior hybrids was realized when high GCA parents was used as reported by Al-Hmdany and Allelah (2011) and Soliman (2018).

For specific combining ability effects of the crosses, the best combinations were: P1×P3, P1×P6, P3×P6, P2×P4, P2×P6 ,P3×P5, P4×P5 and P4×P6 (for number of days to anthesis of first female flower) ; P1×P6, P2×P6, P2×P4, P5×P6, P3×P4, P4×P6, P3×P5 and P1×P4 (for number of days to anthesis of first male flower) these combinations exhibited significant desirable (negative) SCA effects for days to flowering, indicating the possibility to combine both high yield and earliness. These results confirm the conclusions of Hallauer and Miranda (1989), who stated that combining ability of inbred lines is the ultimate factor determining future usefulness of the lines for hybrids, and was a general concept considered collectively for classifying an inbred line relative to its cross performance.

Crosses P1×P4, P3×P6, P1×P3, P5×P6, P1×P5 ,P3×P5, P2×P4, P2×P6, P3×P4 ,P2×P3, P2×P5 and P4×P5 (for average fruit weight); P2×P4, P1×P6, P3×P6, P2×P3, P1×P2 ,P3×P4, P1×P5, and P4×P5 (for number of fruit/plant); P2×P6, P1×P4, P3×P6, P1×P5, P2×P4, P3×P5, P3×P4, P1×P6 and P1×P3 (for average fruit length); P3×P6, P1×P4, P2×P6, P1×P5, P5×P6 ,P2×P4, P1×P3, P3×P4, and P4×P5 (for average fruit diameter); P1×P3, P3×P4, P5×P6, P1×P5, P2×P4, P3×P6, P1×P2, P1×P6,. P4×P6 and P4×P5 (for early yield/ plant) and P2×P4, P3×P6, P1×P6, P1×P5, P2×P3, P3×P4, P4×P5 ,P3×P5, P1×P3, and P1×P2 (for total yield/ plant. The ten cross combinations, which exhibited significant positive SCA effects for total yield / plant, also combined significant /highly significant desirable SCA effects for one or more important studied traits. These results confirm the conclusions of Hussien *et al*., (2013).

Average degree of heterosis

Mid-parent (MP) and better parent (BP) heterosis of all studied traits are presented in Table (5). Desirable negative MP heterosis for the earliness (days to anthesis of first female flower) was observed in seven F_1 crosses, four F_1 crosses exhibited desirable significant negative BP values, *i.e*. P1×P6, P3×P5, P3×P6 and P1×P3 with (-6.35, -7.40, -9.07 and -17.26% respectively). The similar results were obtained by El-Hadi and El-Gendy (2004) who reported that significant negative value (-10.7%) for the number of days to first pistillate flower at the best parent was detected. Also, Hatem *et al*., (2013) reported that nine crosses gave high significant negative heterosis values from the MP.

Desirable negative MP heterosis for the earliness (days to anthesis of first male flower) was observed in seven F_1 crosses, only one F_1 cross exhibited desirable significant negative BP values, *i.e.* P2×P4 with (-10.50%).

These results are in agreement with those of Obiadalla-Ali (2006), Tamil *et al*., (2012) and El- Adl *et al*., (2014).

All crosses indicated desirable positive MP and BP heterosis for average fruit weight ranged from 16.9 (P1×P2) to 67.01 % (P3×P6) and ranged from 12.42 (P1×P2) to 51.45% (P5×P6) for MP and BP respectively.

These results disagree with Hatem *et al*., (2013) who reported that none of the studied crosses showed dominance or over dominance for the heavy fruit. All crosses showed insignificant or significant negative heterosis values from the MP indicating incomplete dominance or dominance toward the small fruited parent. On the other hand, These results agree with Hussein (2015) who reported that average fruit weight the most important yield component, had significant positive heterosis was up to 49.4 % over mid-parent and 32.5% over better parent.

Six crosses indicated desirable positive MP heterosis for number of fruits /plant *i.e*. P2×P4, P2×P3, P1×P6, P1×P2, P3×P4 and P3×P6 with 93.78, 41.44, 32.16, 32.04, 25.40 and 24.93% respectively). Two crosses indicated desirable positive BP heterosis for number of fruits /plant *i.e.* P2×P4 and, P2×P3 with (68.19 and 28.89% respectively).

Table (5): Relative heterosis (MP) and heteobeltiosis (BP) for studied characters of summer squash during season 2022.

Crosses[Z]	Days to anthesis of first female flower		Days to anthesis of first male flower		Average fruit weight		No. of fruits /plant	
	MP %	BP %	MP %	BP %	MP %	BP %	MP %	BP %
P1×P2	7.76**	8.26**	-3.44	1.44	16.90**	12.42**	32.04**	11.43
P1×P3	-17.27**	-17.26**	0.70	2.89	50.90**	50.68**	-0.95	-9.04
P1×P4	6.78**	7.29**	-7.28*	1.44	60.46**	45.15**	-18.56	-21.20*
P1×P5	7.34**	8.33**	12.05**	14.49**	50.68**	29.64**	-6.85	-15.40*
P1×P6	-16.60**	-6.35**	-23.91**	1.44	26.65**	13.98**	32.16**	16.26
P2×P3	-0.45	0.009	-4.05	-1.39	31.04**	25.77**	41.44**	28.89*
P2×P4	-5.45*	-4.58	-13.92**	-10.50**	41.65**	34.88**	93.78**	68.19**
P2×P5	3.22	3.70	-1.35	1.39	34.35**	21.44**	-26.33**	-42.50**
P2×P6	-11.38**	0.009	-24.60**	-5.25	42.01**	34.55**	-6.54	-10.94
P3×P4	8.59**	9.11**	-6.49*	0	45.55**	31.46**	25.40*	18.82
P3×P5	-8.26**	-7.40**	-1.39	-1.39	56.29**	34.27**	-13.85	-27.53**
P3×P6	-19.02**	-9.07**	-0.53	29.16**	67.01**	50.08**	24.93*	19.19
P4×P5	-3.19	-1.85	2.59	9.72**	37.99**	30.46**	-3.30	-14.77
P4×P6	-6.45**	4.50	-11.67**	6.11*	33.58**	32.83**	-13.79	-21.88*
P5×P6	-3.67	9.25**	-11.23**	15.27**	59.34**	51.45**	-34.43**	-46.91**

Z; 202-2 (P1), 282-2 (P2), 220-2 (P3). 264 (P4), 240-1 (P5) and206-3 (P6).
*Significant at the 0.05 level of probability according to T test.
** Significant at the 0.01 level of probability according to T test.

Table (5): Cont.

Crosses[Z]	Average fruit length		Average fruit diameter		Early yield/ plant		Total yield/ Plant	
	MP %	BP %	MP %	BP %	MP %	BP %	MP %	BP %
P1×P2	-21.57**	-22.83**	-13.33**	-17.72**	107.23**	79.16**	55.46**	34.06**
P1×P3	13.90**	12.75**	17.95**	15.11**	116.44**	64.58**	64.66**	63.77**
P1×P4	24.09**	13.47**	24.29**	16.03**	23.94**	-8.33	39.28**	32.97**
P1×P5	21.13**	7.30**	24.69**	6.54*	46.15**	18.75**	54.84**	54.84**
P1×P6	16.84**	1.37	-2.41	-14.55**	57.33**	22.92**	78.49**	50.36**
P2×P3	-1.03	-3.58*	-7.03**	-13.91**	51.72**	33.33**	82.16**	58.89**
P2×P4	18.93**	10.40**	18.56**	16.61**	46.43**	24.24**	152.11**	127.31**
P2×P5	-5.77**	-15.31**	1.31	-9.30*	23.80**	18.18**	5.00	-9.68
P2×P6	20.91**	6.39**	24.36**	14.25**	46.67**	33.33**	39.53**	36.36**
P3×P4	20.74**	9.39**	19.78**	9.11**	147.83**	137.50**	76.24**	70.37**
P3×P5	23.57**	8.50**	24.55**	4.10	35.85**	33.33**	45.75**	44.44**
P3×P6	29.00**	10.96**	35.67**	16.12**	104.00**	97.67**	121.74**	88.89**
P4×P5	4.14*	0.55	10.07*	0.12	45.10**	37.04**	45.01**	37.99**
P4×P6	4.52*	-1.38	12.41**	5.00	87.50**	74.42**	13.70	0.00
P5×P6	8.48**	5.98**	34.78**	31.35**	85.45**	88.89**	10.45	-7.17

Z; 202-2 (P1), 282-2 (P2), 220-2 (P3). 264 (P4), 240-1 (P5) and206-3 (P6).
*Significant at the 0.05 level of probability according to T test.
** Significant at the 0.01 level of probability according to T test.

For average fruit length all crosses except three crosses indicated desirable positive MP heterosis for this trait. Nine crosses indicated desirable positive BP heterosis for average fruit length *i.e.* P1×P4, P1×P3, P3×P6, P2×P4, P3×P4, P3×P5, P1×P5, P2×P6 and P5×P6 with (13.47, 12.75, 10.96, 10.40, 9.39, 8.50, 7.30, 6.39 and 5.98 % respectively).

For average fruit diameter all crosses except three crosses *i.e.* P1×P2, P1×P6 and P2×P5 indicated desirable positive MP heterosis for this trait. Eight crosses indicated desirable positive BP heterosis for average fruit diameter i.e. P5×P6, P2×P4, P3×P6, P1×P4, P1×P3, P2×P6, P3×P4 and P1×P5 with (31.35, 16.61, 16.12, 16.03, 15.11, 14.25, 9.11 and 6.54 % respectively).

For early yield/ plant all crosses indicated desirable positive MP heterosis ranged from 23.80 (P2×P5) to 147.83 % (P3×P4).

All crosses indicated desirable positive BP heterosis ranged from 18.18 (P2×P5) to 137.50 % (P3×P4) except the cross (P1×P4).

For total yield/ plant all crosses indicated desirable positive MP and BP heterosis except three crosses i.e. P2×P5, P4×P6 and P5×P6. MP heterosis ranged from 39.28 (P1×P4) to 152.11% (P2×P4) and BP heterosis ranged from 32.79 (P1×P4) to 127.31 % (P2×P4).

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التحليل الوراثى والقدرة على التآلف وقوة الهجين للمحصول ومكوناته فى الكوسة

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الملخص العربى

أجريت هذة الدراسة فى مزرعة بحوث الخضر بقها- معهد بحوث البساتين بمحافظة القليوبية تحت نظام الصوب البلاستيكية الغير مدفأة والارض المكشوفة متتالين لانتاج هجن الكوسة ثم تم تقييم ست اباء مرباة داخليا و خمسة عشر هجين ناتج منها خلال موسمين متتاليين فى الحقل المكشوف فى الفترة من ٢٠٢٠ حتى ٢٠٢٢ وتم التهجين بنظام الهجن الدائرية بدون استخدام الهجن العكسية منها لتقدير القدرة العامة و الخاصة على الائتلاف وقوة الهجين بالنسبة لمتوسط الابين و الأب الاعلى للصفات المدروسة ، أستخدمت ست أباء من الكوسة متباينة فيما بينها وراثيا وهى:- ٢٢٢-٢ (الاب الاول)، ٢٨٢- ٢(الاب اللثانى)، ٢٢٠-٢(الاب الثالث)،٢٦٤ (الاب الرابع)، ٢٤٠-١ (الاب الخامس)،٢٦٠-٣ (الاب السادس). وقد اوضحت النتائج وجود اختلافات معنوية فى متوسطات كل الصفات المدروسة. اوضحت النتائج معنوية تباين عالية لكل من القدرة العامة و الخاصة على الائتلاف فى كل الصفات المدروسة. وكان الاب الثالث٢٢٠-٢ أفضل الاباء من حيث القدرة العامة على التألف فى معظم الصفات المدروسة مثل عدد الايام اللازمة لتفتح اول زهرة مؤنثة، متوسط وزن الثمرة، طول وقطر الثمرة والمحصول الكلى يليه الاب الأول ٢٢٢-٢ ثم الأب الرابع ٢٦٤.

كما أظهرت نتائج القدرة الخاصة على التألف ان افضل الهجن كانت كالتالى :-

الهجين (الاب الاول × الاب الثالث) ، الهجين (الأب الأول × الاب السادس)، الهجين (الاب الأول × الاب الثانى)، الهجين (الأب الثانى × الاب الثالث) حيث اظهروا قدرة تالف خاصة عالية لصفات عدد الايام اللأزمة لتفتح اول زهرة مؤنثة و المحصول المبكر والكلى للنبات. اظهرت النتائج أن هناك قوة هجين لمتوسط الأباء لصفة المحصول المبكر للنبات تراوحت مابين ٢٣,٨٠ فى الهجين (الاب الثانى × الاب الخامس) الى ١٤٧,٨٣ % فى الهجين (الاب الثالث × الاب الرابع) كما اظهرت كل الهجن المدروسة فيما عدا الهجبن (الاب الأول × الاب الرابع) قوة هجين بالنسبة الاب الاعلى لنفس الصفة تراوحت مابين ١٨,١٨ فى الهجين(الاب الثانى × الاب الخامس) الى ١٣٧,٥٠ % فى الهجين (الاب الثالث × الاب الرابع). كما أظهرت كل الهجن المدروسة قوة هجين بالنسبة لمتوسط الابين والأب الأعلى لصفة المحصول الكلى للنبات فيما عدا ثلاث هجن هى الهجين (الاب الثانى × الاب الخامس) ، (الهجين الاب لرابع × الاب السادس) والهجين (الاب الخامس× الاب السادس). تراوحت قوة الهجين بالنسبة لمتوسط الأبين مابين ٣٩,٢٨ فى الهجين الاب الأول × الاب الرابع الى ١٥٢,١١٪ فى الهجين(الاب الثانى × الاب الرابع) كما تراوحت قوة الهجين على بالنسبة للأب الأعلى من ٣٢,٧٩ فى الهجين (الاب الأول × الاب الرابع) الى ١٢٧,٣١ % فى الهجين (الاب الثانى × الاب الرابع) فى صفة المحصول الكلى للنبات

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