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Combining Ability Effect of Some Squash (*Cucurbita Pepo* L.) Genotypes at Different Planting Times under Greenhouse Conditions

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ABSTRACT

This investigation was conducted at the plastic greenhouses at Qaha Res Farm, Horticultural Research Institute, Qalyubia Governorate, Egypt, to estimate GCA and SCA effects of 7 parents and 21 cross combinations resulting from diallel (Method 2) during the growing winter season of 2020 / 2021 in two different planting time. Also, mean squares due to parents, crosses and par. vs. cross were highly significant for all features in each planting time, except the parents vs. crosses for fruit length, fruit diameter, and no. of fruits per plant at first planting time under various greenhouse conditions. Variance due to GCA were much higher than those of SCA for all studied traits at two planting dates revealing the predominance of additive genetic effect in the inheritance of these traits, except fruit length. P2, P3, P5 and P7 seemed to be the best GCA combiner for most of fruit, yield and its attributed traits under all environments, respectively. For most of studied traits, the following crosses; P1 X P4, P4 X P5, P4 X P6, P1 X P5, P3 X P7, P3 x P5, P4 X P6 and P5 X P6, had the highest values of SCA effects, respectively. From the previous results, it could be recommended to use the mentioned hybrids to improve winter squash productivity and fruit quality attributed under greenhouse condition.

KEYWORDS: Planting time, combining ability and gene action.

1. INTRODUCTION

Squash (*Cucurbita pepo* L.) is one of the most important vegetable crops of the *Cucurbitaceae* family. It is one of the leading vegetable crops worldwide in 2022 (FAO, 2022). Its diploid chromosome number is (2n=40), and it is a cross-pollinated plant.

Squash is rich in niacin and amino acids and contains many minerals that are beneficial to humans. Also contain vitamin C and vitamin A. Local varieties suffer from genetic deterioration and low production rates. Therefore, recent studies have focused on developing new hybrids from this crop under greenhouse condition in the winter season to maximize of yield production for its high nutritional value especially in seeds and fruits Soliman (2022) and Hamdan and Al-Zubaae (2023).

In Egypt, squash is sowing in open fields and/or under unheated greenhouse conditions. Cultivated area of squash in Egypt reaches 428,175 feddans, producing 6,751,856 tons with an average productivity of 15.7 tons per feddan (FAOSTAT 2022). In Egypt the season of 2021/2022, the number of greenhouses that cultivated squash reached 693 (304729 m^2), producing 1639 tons, with an average productivity ranging between 5.31 and 6.63 kg-/m^2, according to the statistics of the Ministry of Agriculture and Land Reclamation.

Large genetic diversity for fruit shape, size and color are available in landraces with limited attempts made to exploitation this variability in crop adjustment programs (Mohsin *et al*., 2017). The strategy of Egyptian government initiates 100 faddans of greenhouses in Egypt till 2030, so the productions of local in Egypt to cultivate under greenhouse are essential.

When compared to the expenses of producing hybrid seeds from other vegetable crops, summer squash has very low hybrid seed production costs, Metwally (1985).

Imported hybrid squash varieties are highly expensive. Therefore, it is urgently necessary to produce local hybrid seeds in order to lower costs for farmers and conserve hard currency.

According to Hussien (2015), Hussien and Hamed (2015), Othman (2016) and Chaudhari *et al*., (2017), commercial use of squash hybrids is growing. Additionally, hybrids may combine parental resistance to different diseases. In order to create optimum hybrids or varieties with desired features like: stem length, no. of leaves, earliness, and yield per plant, breeding for squash appears to be more intensive than ever. Quantity of fruits per plant and fruit weight determines the overall production. All of these characteristics would increase production.

This study aimed to estimate G C A and S C A effects of some squash genotypes under two different planting times under greenhouse conditions, in order to identify prospective lines and hybrids that reflect desirable characteristics for consumers.

2. MATERIALS AND METHODS

The present investigation was conducted at the unheated plastic greenhouses at Qaha Research Farm, Qalyubia Governorate, Egypt, to evaluate the performance of 7 parents and 21 cross combinations resulting from half diallel mating design and estimate general and specific combining ability during the successive growing winter season of 2020 / 2021.

2.1. Plant materials and experimental design:

Seven exotic inbred lines of squash (*Cucurbita pepo* L.) were obtained from U. S. Nat. Plant Germ. System (NPGS) of U. S., Department of Agric. Breeding program was used in half diallel mating design. The seven parents listed in Table (1). The inbred lines of squash were planted by direct seed inside the greenhouse. During flowering stage, all crosses were performed in diallel method. In addition, seeds of the seven inbred lines by making self-pollination in each inbred line. After maturing stage of fruits, the seeds were extracted, washed and stocked after drying to the next planting season. Twenty-one (F_1) straight hybrids were obtained after harvesting the matured fruits, according to Griffing's schema method of the half diallel cross mating design for the seven parents Table (2).

At the second winter season 2020, all hybrids and their parents were planted in two times 25/10/2020 and 8/11/2020 to estimate the genetic parameters. Before sowing and after germination all agricultural managements were done.

2.2. Experimental design

RCBD (Randomized Complete Block Design) were used with three replicates; each replicate had 10 plants from the same hybrid. At the time of planting, the parents and hybrids were planted in greenhouse. The cultivation took place in two different times in two different greenhouses with a total number of 87 repetitions in each greenhouse. The experiment unit was 15.0 m tall, 1.2 m width and 0.50 cm apart between plants.

Table 1. Names, pedigree, type and origin of included lines

Study code	Genotype name	Source	Origin	Code in Gene Bank
P1	10575	NPGS	USA	PI 182202
P2	Black Magic	NPGS	USA	PI 599994
P3	Eskandarani	ARC	EGYPT	-
P4	Kabak	NPGS	USA	PI 167136
P5	Dolmalik	NPGS	USA	PI 171622
P6	Sakiz	NPGS	USA	PI 174183
P7	Dolma	NPGS	USA	PI 175710

Table 2. Schema of the diallel design according to Griffing's schema method (II), model (I) for the seven parents.

Parents	1	2	3	4	5	6	7
1		C:1*2	C:1*3	C:1*4	C:1*5	C:1*6	C:1*7
2			C:2*3	C:2*4	C:2*5	C:2*6	C:2*7
3				C:3*4	C:3*5	C:3*6	C:3*7
4					C:4*5	C:4*6	C:4*7
5						C:5*6	C:5*7
6							C:6*7
7							

2.3. Evaluated characters

The following traits were calculated for each of the 28 genotypes' individual plants:

2.3.1. Fruit characters

Fruit length (cm): This character measured as the average length in centimeters (cm) for randomly selected fruits that picked from the selected plants every picking by using a caliper.

Average fruit diameter (cm): This characteristic was expressed as the typical fruit diameter, expressed in centimeters (cm), taken at random from the chosen plants.

Average fruit weight (g): By dividing the entire yield per plant by the total number of fruits, this attribute was determined.

Total soluble solids (T. S. S. %): This character estimated by hand refractometer in the fruits juice as percentage (%), for fruits T.S.S content, according to Sharaf (2020).

Fruit chlorophyll content: Data were recorded in epicarp by using dig. chlorophyll meter (SPAD–501).

Total sugars (F.W.) were assessed according to Lemoine *et al.*, (2010).

2.3.2. Yield and its attributed characters

The picking for fruits was every alternative day, and data registered as follow:

No. of fruits per plant: Every picking during the pick season was recorded for the chosen plants' amount group of fruit.

Fruit set (%): This attribute was determined by dividing the no. of fruits produced by each plant by the total number of female flowers present at the time of harvest.

Yield per plant (kg): Total yield was calculated by recording fruit weight per plant in the selected plants during the picking period.

2.4. Statistical Analysis

ANOVA for all traits for each sowing time inside each greenhouse conditions was done according to Gomez and Gomez (1984). G. c. a. and S. c. a. were estimated according to half diallel mating design method (II), proposed by Griffing's (1956) GCA/SCA variance ratio to estimate gene action was calculated according to Baker (1978).

3. RESULTS AND DISCUSSION

3.1. Analysis of variance

3.1.1. Fruit traits

ANOVA for fruit traits *viz.*, fruit length, fruit diameter, fruit weight, total soluble solids (T.S.S. %), fruit chlorophyll content and total sugar at two sowing dates under environmental conditions are presented in Table (3 and 4).

Var. due to genotypes, par., crosses and par. vs. crosses were highly significant for all fruit features in each sowing dates under greenhouse conditions, except par. *vs.* crosses for fruit length and fruit diameter traits at T_1, T_2 planting times under different greenhouse conditions. These results expressed that the wide range diversity and variability between the genotypes used in the present investigation.

Var. for GCA ability was found highly significant for all studied traits at two planting times. These results indicate that additive gene action was important for inheritance of these traits.

Mean squares for SCA ability were found high significant for all studied traits. These results indicate that non-add. gene effect was important for controlling of these traits.

Table 3. ANOVA of half diallel mating design, general and specific C. Ability for fruit traits in squash plants.

S.O.V.	D.F.	Mean Squares (MS)					
		Fruit Len. (cm)		Fruit Diameter (cm)		Fruit Weight (g)	
		First sowing	Second sowing	First sowing	Second sowing	First sowing	Second sowing
Rep/L	**2**	0.05	0.04	0.01	0.02	12.96	1.42
Genotypes	**27**	6.28**	6.25**	0.44**	0.34**	523.39**	513.45**
Parents (P)	**6**	10.72**	11.33**	0.96**	0.51**	159.37**	183.71**
Crosses (C)	**20**	5.24**	5.04**	0.32**	0.31**	630.46**	612.14**
Par. vs. Cr.	**1**	0.34	0.15	0.01	0.01	566.1**	518.01**
Error	**54**	0.39	0.14	0.04	0.03	4.94	5.67
GCA	**6**	1.17**	1.7**	0.35**	0.24**	175.1**	172.91**
SCA	**21**	2.36**	2.19**	0.09**	0.08**	174.28**	166.36**
Error	**54**	0.13	0.05	0.01	0.01	1.65	1.89
GCA/SCA		0.5	0.77	4	3.17	1.2	1.03

Where, * and ** sign. and highly sign. at 0.05 and 0.01 levels of probability, respectively.

Table 4. Analysis of variance and mean squares of half diallel mating design, general and specific combining ability for fruit traits in squash plants.

S.O.V.	D.F.	Mean Squares (MS)					
		(T.S.S %)		Fruit Chlorophyll Content		Total sugars (% f.w.)	
		T1	T2	T1	T2	T1	T2
Rep/L	**2**	0.07	0.01	0.92	0.01	0.03	0.02
Genotypes	**27**	6.33**	6.27**	1372.1**	1366.47**	1.78**	1.88**
Parents (P)	**6**	9.03**	8.77**	2064.27**	2079.43**	2.26**	2.63**
Crosses (C)	**20**	4.66**	4.58**	1232.11**	1219.8**	1.52**	1.63**
Par. vs. Cr.	**1**	22.56**	25.21**	19.12**	22.2**	4.08**	2.49**
Error	**54**	0.05	0.04	0.33	0.34	0.04	0.03
GCA	**6**	3.89**	3.62**	1277.48**	1280.76**	1.01**	1.17**
SCA	**21**	1.59**	1.65**	223.05**	219.7**	0.47**	0.47**
Error	**54**	0.02	0.01	0.12	0.11	0.01	0.01
GCA/SCA		2.45	2.19	5.73	5.83	2.13	2.48

Where, * and ** significant and highly significant at 0.05 and 0.01 levels of probability, respectively.

GCA/SCA ratio was more than one indicating the importance of additive gene effect in the inheritance of these traits larger than the non-add. gene effects, except fruit length where the ratio was less than one and this ratio leads to the suggestion that non-add. gene effects were higher in magnitude than the additive effects. These data were agreed with Gad-Allah (2019), Soliman (2022) and Hamdan and Al-Zubaae (2023).

3.1.2. Total yield per plant and its component traits

Ana. of var. for fruit yield and its attributed traits such as number of fruits per plant, fruit set percentage (%) and total yield per plant at different sowing dates under greenhouse conditions are presented in Table (5). Results found that, Var. due to genotypes, par., crosses and par. *vs.* crosses were high significant for all fruit traits in each planting dates under greenhouse conditions, except par. *vs.* crosses for no. of fruits per plant at first planting time under different greenhouse conditions. Such results indicated that the wide variability between the all genotypes used in the present investigation.

Mean squares for (GCA) were found highly significant for all studied traits at two planting times. These results indicate that add. genetic effect was important for inheritance of these features.

Var. due to GCA were much higher than those of SCA for all studied traits at T_1, T_2 sowing dates at different greenhouse conditions revealing the predominance of add. genetic effect in the inheritance of these traits.

GCA /SCA ratio was more than one indicating the importance of add. gene effect in the controlling of these traits larger than the non-additive gene effects. These data were agreed with Gad- Allah (2019), El-Gazzar, *et al.* (2020), Soliman (2022) and Hamdan and Al-Zubaae (2023).

Table 5. Analysis of variance and mean squares of half diallel mating design, general and specific combining ability for yield and its component traits in squash plants.

S.O.V.	D.F.	Mean Squares (MS)					
		Number of fruits per plant		Fruit set (%)		Yield per plant (kg)	
		S1	S2	S1	S2	S1	S2
Rep/L	**2**	22.54	12.94	6.98	6.19	0.28	0.11
Genotypes	**27**	900.04**	912.94**	216.98**	181.00**	9.39**	9.60**
Parents (P)	**6**	1193.98**	1307.71**	177.65**	173.56**	5.81**	5.89**
Crosses (C)	**20**	856.14**	834.94**	232.91**	180.18**	10.63**	10.79**
Par. vs. Cr.	**1**	14.29	104.14**	134.50**	242.10**	6.15**	8.22**
Error	**54**	10.12	7.16	7.50	2.89	0.08	0.07
GCA	**6**	860.43**	865.1**	128.02**	81.86**	7.97**	7.71**
SCA	**21**	139.89**	144.09**	56.42**	54.18**	1.75**	1.91**
Error	**54**	3.37	2.39	2.50	0.96	0.03	0.02
GCA/SCA		6.15	6.05	2.27	1.51	4.56	4.03

Where, * and ** sign. and highly sign. at 0.05 and 0.01 levels of probability, respectively.

3.2. General and Specific combining abilities

3.2.1. G. C. A.: were estimated for parental inbred lines as follows:

3.2.1.1.Fruit traits

Fruit length (cm): Results for fruit length (cm) expressed that the lines P2, P3 and P7 reported highly positive significant GCA effect in desired direction at both planting times in different climatic environment. Indicating could be as better combiners for developing high yield in squash plants. While, the parents P4 and P5 showed high significant negative GCA effect (Table 6). The other parents were poor combiners.

Fruit diameter (cm): Data showed that the P5 exhibited highly significant positive GCA effect

Table 6. Estimation of general combining ability (GCA) effects of the seven parents for fruit traits in squash plant.

Parents	Fruit Length (cm)		Fruit Diameter (cm)		Fruit Weight (g)	
	First sowing	Second sowing	First sowing	Second sowing	First sowing	Second sowing
P1	-0.13	-0.05	-0.04	-0.08*	-6.27**	-5.51**
P2	0.35**	0.44**	-0.03	-0.07*	-0.95*	-1.1*
P3	0.31**	0.35**	-0.23**	-0.18**	-3.82**	-4.33**
P4	-0.22	-0.23**	-0.19**	-0.13**	-1.98**	-1.83**
P5	-0.51**	-0.6**	0.35**	0.31**	3.48**	2.91**
P6	-0.22	-0.39**	0.02	0.08*	5.11**	5.37**
P7	0.43**	0.48**	0.12**	0.06	4.44**	4.5**
L.S.D gi 0.05	0.22	0.13	0.07	0.07	0.79	0.85
L.S.D gi 0.01	0.3	0.17	0.1	0.09	1.05	1.13
L.S.D gi-gj 0.05	0.34	0.2	0.11	0.1	1.21	1.3
L.S.D gi-gj 0.01	0.45	0.27	0.15	0.13	1.61	1.72

Where, * and ** significant and highly significant at 0.05 and 0.01 levels of probability, respectively.

(ĝi) at early, late sowing in greenhouse conditions. While, P3 gave significant negative GCA effect under all environment (Table 6). Therefore, these parents seemed to be the best GCA for this trait. However, others parents were weak combiners.

Fruit weight (g): As for fruit weight (g), results showed that the parental lines P6 and P7 registered high significant positive general combining ability effect in desired direction under two different planting time in greenhouse conditions. While, the parents P1, P3 and P4 showed significant or high significant negative GCA effect under all environment, respectively (Table 6).

Total soluble content: Results for this character indicated that, the parent (P1) expressed highly positive significant values of GCA effect at early, late sowing dates in two different greenhouses, recording 1.32** and 1.28**, respectively (Table 7). Therefore, this parent seemed to be the best general combiner for this trait at first and second sowing dates, respectively. These data were in true with El-sharkawy *et al.*, (2018), Marxmathi *et al.*, (2018b), Gad-Allah (2019) and Singh *et al.*, (2019), El- Shoura and Diab (2022) and Hamdan and Al-Zubaae (2023).

Fruit Chlorophyll Content: Data for this character showed that the (P2) exhibit highly significant positive GCA effect (ĝi) at early and late planting time, respectively. While, the parent P7 showed significant negative GCA effect under all different environment (Table 7). Therefore, (P2) was the best combiner for this trait under first and second sowing dates, recording 24.79** and24.71**, respectively. However, other parents were weak combiners.

Total sugars (% f.w.):

Results for this trait indicated that (P1) expressed highly significant positive desirable GCA effect (ĝi) at first and second planting time, recording 0.73** and 0.76** respectively. While, the parent P3 showed significant negative GCA effect under all different environment (Table 7). Therefore, the parent (P1) seemed to be the best general combiner for this trait under first and second sowing dates, respectively. However, other parents were weak combiners.

3.2.1.2. Yield and its attributed traits:

No. of fruits per plant: Data in Table (8) regarding with this character showed that the parental lines P3, P5, P6 and P7 exhibited highly positive significant GCA effect for number of fruits per plant under both planting times in two different greenhouses. Indicating that, these inbred lines could be considered as good combiners for improving high yield character. On the contrary, the parents P1 and P4 registered high significant negative GCA effect for the studied

Table 7. Estimation of general combining ability (GCA) effects of the seven parents for fruit traits in squash plants.

Parents	Total soluble solids (T.S.S %)		Fruit Chlorophyll Content		Total sugars (% f.w.)	
	First sowing	Second sowing	First sowing	Second sowing	First sowing	Second sowing
P1	1.32**	1.28**	-1.78**	-1.81**	0.73**	0.76**
P2	0.01	0.01	24.79**	24.71**	0.02	0.03
P3	-0.65**	-0.62**	2.78**	3.12**	-0.23**	-0.34**
P4	-0.63**	-0.61**	-5.77**	-5.88**	-0.21**	-0.18**
P5	-0.13**	-0.14**	-0.47**	-0.42**	-0.09*	-0.06
P6	0.02	0.03	-8.94**	-9.15**	-0.02	0.02
P7	0.06	0.05	-10.62**	-10.57**	-0.19**	-0.23**
L.S.D gi 0.05	0.08	0.07	0.2	0.21	0.07	0.06
L.S.D gi 0.01	0.11	0.09	0.27	0.28	0.1	0.08
L.S.D gi-gj 0.05	0.13	0.11	0.31	0.32	0.11	0.1
L.S.D gi-gj 0.01	0.17	0.14	0.41	0.42	0.15	0.13

Where, * and ** significant and highly significant at 0.05 and 0.01 levels of probability, respectively

Table 8. Estimation of general combining ability (GCA) effects of the seven parents for yield and its component traits in squash plants.

Parents	Number of fruits per plant		Fruit set (%)		Total fruit yield per plant (kg)	
	First sowing	Second sowing	First sowing	Second sowing	First sowing	Second sowing
P1	-17.43**	-18.05**	-7.46**	-6.03**	-1.69**	-1.67**
P2	0.61	-0.02	1.40**	1.42**	-0.04	-0.11*
P3	6.76**	6.43**	3.53**	2.74**	0.41**	0.27**
P4	-9.39**	-8.31**	-0.82	0.26	-0.83**	-0.74**
P5	7.57**	6.65**	2.42**	1.21**	0.79**	0.74**
P6	3.98**	4.69**	2.50**	2.09**	0.51**	0.62**
P7	7.90**	8.61**	-1.57**	-1.69**	0.84**	0.89**
L.S.D gi 0.05	1.13	0.95	0.98	0.61	0.10	0.09
L.S.D gi 0.01	1.51	1.27	1.30	0.81	0.13	0.13
L.S.D gi-gj 0.05	1.73	1.46	1.49	0.93	0.15	0.14
L.S.D gi-gj 0.01	2.3	1.94	1.98	1.23	0.20	0.19

Where, * and ** significant and highly significant at 0.05 and 0.01 levels of probability, respectively.

character. These parents were weak combiners for this trait.

Fruit set percentage (%): Results for this trait revealed that the parental lines P3, P5 and P6 showed high significant positive GCA effect in two different sowing dates. While, P1, P4 and P7 exhibited significant or high significant negative GCA effects under all different environment (Table 8). The inbred line P3 had the greatest GCA effects recording (3.53** and 2.74**), followed by P6 line, recording (2.50** and 2.09**) at both planting times in two greenhouses, respectively.

Total fruit yield per plant (kg): Data concerned in table (8) indicated that the parental lines P3, P5, P6 and P7 showed highly significant positive GCA effects for the studied character at both sowing date in 2 different greenhouse conditions. Indicating that, these lines could be considered as good combiners for high yield trait. While, the parents P1, P2 and P4showed significant or high significant GCA effect for the studied character under all environments. These results were in harmony with El-sharkawy *et al.*, (2018), Marxmathi *et al.*, (2018b), Gad Allah (2019) and Singh *et al.*, (2019), El- Shoura and Diab (2022) and Hamdan and Al-Zubaae (2023).

3.2.2. Specific combining ability (SCA):

Specific combining ability effects were estimated for straight crosses as follows:

3.2.2.1. Fruit traits

Fruit length (cm): It is worth noting that the eight hybrids revealed highly positive significant SCA effects *viz.*, P4 X P5 (2.13** and 2.12**) and P5 X P7 (1.59** and 1.57**) under 2 sowing dates, respectively (Table 9). On the other hand, eight crosses exhibited highly negative significant SCA effect at all different environments. The rest of hybrids did not show any significant effects.

Fruit diameter (cm): Three hybrids exhibit significant or high significant positive (Ŝij) effects, *viz.*, P4 X P6 (0.71** and 0.45**), P1 X P4 (0.33** and 0.24**) and P5 X P7 recording (0.36** and 0.47**) at early and late planting time, respectively. While, three hybrids gave significant negative SCA effect at two different sowing dates in different greenhouse conditions. The other hybrids did not show any significant effects. (Table 9).

Table 9. Estimation of specific combining ability (SCA) effects of the straight hybrids for fruit traits in squash plants.

Crosses	Fruit Length (cm)		Fruit Diameter (cm)		Fruit Weight (g)	
	S1	S2	S1	S2	S1	S2
P1 x P2	-2.19**	-2.15**	-0.23*	-0.12*	-15.58**	-14.24**
P1 x P3	-0.58**	-0.56**	0.03	-0.01	-3.98**	-3.24*
P1 x P4	1.15**	1.06**	0.33**	0.24*	15.05**	15.96**
P1 x P5	-1.19**	-1.6**	-0.38**	-0.13*	-21.05**	-24.28**
P1 x P6	0.02	-0.28	0.05	0.04	-12.88**	-12.24**
P1 x P7	0.12	0.11	-0.22*	-0.24*	-2.88*	-0.7
P2 x P3	0.31	0.35	-0.17*	-0.29**	-4.54**	-5.95**
P2 x P4	-1.5**	-1.73**	0.16	0.06	4.79**	1.12
P2 x P5	-0.77*	-0.49*	-0.09	-0.2	-2.84*	-6.2**
P2 x P6	0.7*	0.5*	-0.08	-0.17	10.33**	11.58**
P2 x P7	1.32**	1.12**	0.21	0.24*	12.3**	14.25**
P3 x P4	-1.76**	-1.7**	0.05	-0.06	-13.81**	-10.33**
P3 x P5	1.31**	1.54**	-0.03	-0.29**	9.53**	9.93**
P3 x P6	-1.29**	-1.21**	-0.16	0.4**	8.9**	6.8**
P3 x P7	1.03**	1.08**	-0.23*	-0.14	14.9**	11.78**
P4 x P5	2.13**	2.12**	-0.2	-0.38**	0.69	2.43
P4 x P6	-0.56	-0.22	0.71**	0.45**	5.96**	7.31**
P4 x P7	-0.94**	-0.83**	0.04	0.17	-7.67**	-6.85**
P5 x P6	2.6**	1.95**	-0.17	0.09	13.53**	13.16**
P5 x P7	1.59**	1.57**	0.36**	0.47**	10.27**	9.44**
P6 x P7	-0.64	-0.68**	0.13	-0.13	10.44**	10.38**
L.S.D sij 0.05	0.65	0.38	0.21	0.19	2.3	2.47
L.S.D sij 0.01	0.87	0.51	0.29	0.26	3.06	3.28
L.S.D sij-Sik 0.05	0.97	0.57	0.32	0.29	3.42	3.67
L.S.D sij-Sik 0.01	1.29	0.75	0.42	0.38	4.55	4.88

Where, * and ** significant and highly significant at 0.05 and 0.01 levels of probability, respectively

Fruit weight (g): Concerning this trait, ten hybrids indicated highly significant positive SCA effects *viz.*, P1 X P4 (15.05** and 15.95**), P2 X P6 (10.33** and 11.58**), P2 X P7 (12.3** and 14.25**), P3 X P7 (14.9** and 11.73**) and P5 X P6 (13.53** and 13.16**) at 1st and 2nd planting dates in greenhouse conditions, respectively. (Table 9). On the contrary, eight hybrids revealed significant or high significant negative SCA effects under different greenhouse conditions. The rest of hybrids did not show any significant effects.

Total soluble solids (T.S.S %): As for T.S.S. (%), four cross combinations showed high significant positive (Ŝij) effect under two sowing dates. The most desirable SCA effects for T. S. S. (%) were recorded for the crosses P1 X P5 (2.29** and 2.33**), P1 x P6 (1.65** and 1.6**), and P4 x P7 (0.86** and 0.97**) at two planting times, respectively (Table 10). In addition to, fourteen hybrids showed significant negative SCA effects at all different greenhouse environments. The rest of hybrids did not show any significant effects. These data were in agreement with Tamiselvi *et al.*, (2015), Othman (2016), Mohsin *et al*., (2017), El-shoura and Abed (2018), Hatwal *et al.*, (2018), Marxmathi *et al.*, (2018b), El- Shoura and Diab (2022) and Hamdan and Al-Zubaae (2023).

Fruit Chlorophyll Content: Regarding with this character, ten hybrids indicated significant or high significant positive SCA effects. It is worth noting that the cross P2 x P5 would be of prime importance for squash breeder since they had the most desirable positive SCA effects (47.23** and 46.79**) for fruit chlorophyll content at two planting time, respectively (Table 10). On the contrary, nine hybrids revealed significant or high significant negative SCA effects at 2 sowing dates. The rest of hybrids did not show any significant effects.

Total sugars (% f.w.): Concerning total sugars, five, crosses expressed positive and highly significant SCA effects at early and late sowing data, respectively. However, the highest significant positive SCA effects for this trait were detected for the cross P1 x P5 recording 1.17**, 1.40** at first and second sowing respectively, Table (10). On the other side, eight hybrids reported significant or high significant negative SCA effects, the highest values were in the hybrids P1 X P3 under all different environments. The rest of hybrids did not show any significant effects.

3.2.2.2. Yield and its attributed traits:

Number of fruits per plant: Seven hybrids indicated significant or high significant positive SCA effects, the highest significant positive SCA effects were in the hybrid P3 X P7 recording (24.15** and 22.98**) at first and second planting times, respectively (Table 11). While, ten hybrids reported significant or high significant negative SCA effect at all different conditions. The other of hybrids did not show any significant effects.

Fruit set percentage (%): As fruit set (%), seven hybrids showed highly significant positive SCA effects, However, the highest significant positive SCA effects for this trait were detected for the cross P3 x P7 recording 13.35**, 11.63** at early and late sowing, respectively (Table 11). While, five crosses showed significant or high significant negative SCA effects under all planting times. The rest of hybrids did not show any significant effects.

Total fruit yield per plant (g): Regarding with fruit yield per plant (g), eight cross combinations reported significant or high significant positive SCA effects. Meantime, the highest significant SCA effects were detected in the hybrid P3 X P7 (2.99* and 2.74**) at two different sowing dates at two greenhouse circumstance (Table 11). The other of hybrids did not show any significant effects. These results were in harmony with Shamil Y .H. Al-Hamdany (2011), Othman (2016), Mohsin *et al*., (2017), El-shoura and Abed (2018), Hatwal *et al*., (2018), Marxmathi *et al.*, (2018b), El-sharkawy *et al.*, (2018) El- Shoura and Diab (2022) and Hamdan and Al-Zubaae (2023).

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Table 10. Estimation of specific combining ability (SCA) effects of the straight hybrids for fruit traits in squash plants.

Crosses	Total soluble solids (T.S.S %)		Fruit Chlorophyll Content		Total sugars (% f.w.)	
	T1	T2	T1	T2	T1	T2
P1 x P2	-1.81**	-1.88**	-16.36**	-16.06**	-0.52**	-0.89**
P1 x P3	-1.68**	-1.51**	9.91**	9.53**	-1.01**	-1.05**
P1 x P4	-1.04**	-1.02**	-0.14	-0.17	-0.16	-0.4**
P1 x P5	2.29**	2.33**	-1.97**	-2.26**	1.17**	1.42**
P1 x P6	1.65**	1.6**	2.93**	3.06**	0.71**	0.75**
P1 x P7	-1.23**	-1.42**	1.42**	1.65**	-0.45**	-0.44**
P2 x P3	-0.07	-0.15	6.07**	5.75**	-0.11	0.18
P2 x P4	-0.82**	-0.89**	-2.68**	-2.89**	-0.86**	-0.85**
P2 x P5	-0.76**	-0.7**	47.23**	46.79**	0.02	0.16
P2 x P6	-0.94**	-0.91**	-24.04**	-23.92**	-0.15	-0.1
P2 x P7	-0.95**	-0.96**	-27.42**	-27.57**	-0.88**	-0.87**
P3 x P4	0.7**	0.68**	-7.67**	-7.76**	0.49**	0.57**
P3 x P5	0.2	0.1	-11.17**	-9.79**	-0.2	-0.23*
P3 x P6	-0.31*	-0.3**	5.87**	5.64**	-0.5**	-0.04
P3 x P7	-0.29*	-0.25*	2.82**	2.73**	0.07	0.09
P4 x P5	0.01	-0.01	0.25	0.28	0.58**	0.2*
P4 x P6	-0.74**	-0.85**	1.31**	1.01**	-0.62**	-0.42**
P4 x P7	0.86**	0.97**	5.44**	5.56**	0.31**	0.4**
P5 x P6	-0.37**	-0.36**	-4.58**	-4.42**	-0.21	-0.26**
P5 x P7	-0.48**	-0.58**	-2.46**	-2.7**	0.13	0.14
P6 x P7	-0.52**	-0.51**	9.47**	9.29**	-0.47**	-0.43**
L.S.D sij 0.05	0.24	0.2	0.59	0.6	0.21	0.19
L.S.D sij 0.01	0.32	0.27	0.79	0.8	0.28	0.25
L.S.D sij-Sik 0.05	0.36	0.3	0.88	0.9	0.32	0.27
L.S.D sij-Sik 0.01	0.47	0.4	1.17	1.19	0.42	0.37

Where, * and ** significant and highly significant at 0.05 and 0.01 levels of probability, respectively.

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Table 11. Estimation of specific combining ability (SCA) effects of the straight hybrids for yield and its attributed traits in squash plants.

Crosses	Number of fruits per plant		Fruit set (%)		Total fruit yield per plant (kg)	
	S1	S2	S1	S2	S1	S2
P1 x P2	4.96**	2.76 **	3.29*	-2.05*	-0.13	-0.29*
P1 x P3	-12.85**	-14.35**	-12.35**	-13.30**	-0.98**	-1.06**
P1 x P4	17.3**	21.72**	5.01**	5.85**	1.94**	2.36**
P1 x P5	-12**	-6.91**	-8.97**	-2.51**	-1.52**	-1.42**
P1 x P6	0.26	-5.94**	-0.78	-8.02**	-0.42**	-0.95**
P1 x P7	-8.33**	-6.87**	0.78	1.83*	-0.76**	-0.64**
P2 x P3	-7.56**	-5.72**	-2.58	-0.38	-0.67**	-0.83**
P2 x P4	4.93**	8.69**	1.28	0.54	0.54**	0.66**
P2 x P5	-6.37**	-6.61**	-5.26**	-3.85**	-0.77**	-0.96**
P2 x P6	-8.44**	-6.65**	-3.64*	-0.26	-0.26	0.04
P2 x P7	1.96	0.09	4.72**	6.12**	0.79**	0.87**
P3 x P4	-16.56**	-14.76**	-11.65**	-8.45**	-1.71**	-1.53**
P3 x P5	22.48**	21.61**	9.37**	7.99**	2.28**	2.30**
P3 x P6	-12.26**	-12.76**	-1.84	0.69	-0.69**	-0.75**
P3 x P7	24.15**	22.98**	13.35**	11.63**	2.99**	2.74**
P4 x P5	5.63**	2.35	7.03**	2.27*	0.31*	0.13
P4 x P6	10.89**	12.65**	5.55**	4.90**	1.11**	1.37**
P4 x P7	-0.04	1.39	-0.55	5.84**	-0.46**	-0.36*
P5 x P6	8.59**	7.69**	10.60**	8.61**	1.60**	1.53**
P5 x P7	-7.01**	-4.91**	0.33	-0.15	-0.08	0.13
P6 x P7	-4.74**	-2.94*	1.66	3.28**	0.19	0.46**
L.S.D sij 0.05	3.3	2.77	2.84	1.76	0.29	0.28
L.S.D sij 0.01	4.38	3.69	3.78	2.34	0.38	0.37
L.S.D sij-Sik 0.05	4.9	4.12	4.22	2.62	0.43	0.41
L.S.D sij-Sik 0.01	6.51	5.48	5.61	3.48	0.57	0.55

Where, * and ** significant and highly significant at 0.05 and 0.01 levels of probability, respectively.

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الملخص العربى

تقييم القدرة على التألف والفعل الجيني لبعض التراكيب الوراثية المختلفة من القرع (الكوسة) تحت ميعادين للزراعة تحت ظروف البيوت المحمية

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تم إجراء الدراسة الحالية في البيوت البلاستيكية غير المدفأة وذلك بمزرعة بحوث قها، معهد بحوث البساتين، محافظة القليوبية، مصر، بهدف تقدير تاثيرات القدرة العامة والخاصة على التألف والفعل الجيني المتحكم في توارث بعض الصفات الهامة لـ ٧ آباء و ٢١ هجين فردي ناتج من تصميم التهجين النصف تبادلي وذلك خلال موسم النمو الشتوي ٢٠٢٠/٢٠٢١ تحت موعدين مختلفين للزراعة هما ٢٠٢٠/١٠/٢٥ و ٢٠٢٠/١١/٨ وذلك تحت ظروف مختلفة داخل البيوت المحمية. كما أن التباين الراجع الي التراكيب الوراثية والآباء والهجن وتفاعل الآباء في الهجن كانت ذات معنوية عالية لجميع الصفات وذلك في كل موعد زراعة تحت ظروف الزراعة داخل الصوب، وذلك باستثناء التفاعل بين الآباء مقابل الهجن بالنسبه لصفة طول الثمرة وقطر الثمرة وعدد الثمار/النبات وذلك في ميعاد الزراعة الأول تحت ظروف مختلفة داخل الصوب الزراعية. وكان تباين القدرة العامة علي التألف أعلى بكثير من تباين القدرة الخاصة علي التألف وذلك بالنسبة لجميع الصفات المدروسة تحت مواعيد زراعية مختلفة (T١ و T٢) تحت ظروف مختلفة من الزراعة داخل الصوب، مما يدل على سيادة التباين الوراثي الإضافي في وراثة هذه الصفات، باستثناء صفة طول الثمرة. وأظهرت النتائج أن الآباء P٢ وP٣ وP٥ وP٧ ذات قدرة عامه علي التألف عالية بالنسبة لمعظم صفات المحصول والجودة والصفات المنسوبة إليها وذلك تحت جميع البيئات على التوالي. كما لوحظ أن أفضل التوليفات (الهجن) بالنسبه لمعظم الصفات المدروسة هي؛ P1 X P4، P4 X P5، P4 X P6، P1 X P5، P3 X P7، P3 x P5، P4 X P٦ وP5 X P٦، والتي كانت لها أعلى قيم لتأثيرات القدرة الخاصة علي التألف وذلك في ميعادين مختلفين للزراعة داخل الصوب، على التوالي . وبناء علي النتائج السابقة يمكن التوصية باستخدام هذه الآباء والهجن في التعزيز الوراثي لبرامج تربية الكوسة الشتوية تحت ظروف البيوت المحمية مما يؤدي إلى زيادة صفات الإنتاج والجودة.

الكلمات المفتاحية: الكوسة، ميعاد الزراعة، القدرة عل التألف والفعل الجيني.