



Genetic Study of Some Fruit Economic Traits and Chemical Components Health Properties in Squash Varieties and Their Hybrids

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Abstract

A half diallel of F₁ hybrids involving 4 parental varieties of squash were used to evaluate two heterosis types for growth traits, chemical contents, yield and yield attributes. Amounts of heterosis showed highly significant values for all studied traits over mid-parents and most studied traits over better-parent. The results showed that all hybrids exhibited highly significant heterobeltiosis values in desirable direction for the earliness traits. The higher moisture contents were established in all hybrid peels while, only half studied hybrids exhibited the highest carbohydrate content in peels. The seeds of all hybrids and peels of most one had higher amounts of oils and proteins compare with parents. The cross of P₂ × P₃ exhibited the highest performance in yield and oils% of seeds and peels as well as it was over the grand means of most other traits, the highest relative heterosis for each early yield/plant, fruit diameter, total soluble solid%, weight of fruit and fruit yield per plant. Generally, the maximum significant heterobeltiosis (145.48%) was recorded for T₉ followed by T₄ (76.03%), T₈ (69.16%), T₅ (35.87%), T₇ (34.45%), T₁ (29.22%), T₂ (-25.61%) and T₃ (-23.71%). The oils and proteins contents of the *Cucurbita pepo* seeds in all parents and hybrids were found to be higher than peels. The hybridization in squash is very useful to produce hybrid vigor over the mid-parents & the better parent and give a high level in chemical components of some health properties in squash fruits and their peels in hybrids.

Keywords: Squash, Hybrids, Fruit economic traits, Chemical components, Seeds, Peels.

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1. Introduction

Cucurbitaceae (Gourd family) is a medium sized and taxonomically highly specialized family of mainly climbing plants. Cucurbitaceae is an enormous family which is mainly tropical or subtropical in habitat distribution, with a few species reaching out into temperate climate [1]. The summer squash is the edible undeveloped fruits of *Cucurbita pepo*, L. which contain numerous different varieties belonging to Cucurbitaceae or the gourd family. Squash is one of other crops that can be simply and easily cultivated because it has short-season yield and can grow in temperate and subtropical regions [2]. The Egyptian people called it as Kosa [3]. Summer squash varieties differ in most or some of their traits, especially the edible part (fruits) of the plant. Therefore, plant breeders found a great contrast between all groups of different varieties [4]. The family Cucurbitaceae includes an enormous gathering of plants which are pharmaceutically important. Cucurbits are a group of sound nourishments. Cucumbers are utilized as a significant consuming less calories nourishment. It offers an incredible wellspring of nutrients A, K & C, just as an amazing entirety of potassium.

Cucurbitaceae which incorporates vegetables like squashes, melons, cucumbers and luffas [5]. This family have huge medicinal & pharmaceutical properties, for example, hostile to HIV; anxiolytic; against pyretic; hostile to diarrheal; carminative; cancer prevention agent; hostile to diabetic; antibacterial; diuretic; anthelmintic; against tuberculosis & laxative. It to boot used as an abortifacient; diuretic & cardio tonic head. They also appear solid calming, antitussive, cytotoxic, and expectorant properties [6]. *Cucurbita pepo* is customarily utilized in numerous nations to treat a few illnesses e.g., as an anti-inflammatory, antiviral, pain relieving urinary disarranges, antiulcer, anti-diabetic and antioxidant. *Cucurbita pepo* (squash) is developed for its natural product & consumable seeds. It has sweet and chewable white seeds coated in a husk. The advantage of Squash seed treatment is highlighted by its tonic effect on the bladder and sphincter unwinding and its seeds have appeared in the immunosuppression movement of single-core blood cells in the laboratory [7] and anti-bacterial properties [8].

Generally, Squash has been considered as an important source to health since it contains different naturally dynamic components such as polysaccharides; para-aminobenzoic corrosive; settled oils; sterols; proteins & peptides [9] and [10]. Morphological studies and the effect of peels as natural antioxidants studied in some squash cultivars and discussed in genetic studies and in case of processing cake [11-13]. Half-diallel mating design could be used for estimation of general (GCA) & specific (SCA) combining abilities. So, diallel crosses & non-additive) of tested traits [14-17]. Many authors studied Heterosis in most vegetable crops to increase productivity and quality among them [16-21]. Also, [18], [22-23] and [37] carried out genetically studies on squash and pumpkin in two different locations of Egypt and the Northern Border Region of Saudi Arabia. Main objectives of this study were to quantify heterosis over mid-parents and better parent and chemical components of some health properties in squash fruits & their peels.

2. Materials and Methods

2.1. Source of plant species

The investigation was conducted in a private farm at Burj Al-Arab region, (N 30°50'56" E 29°36'42"), Alexandria *Abdein et al., 2023*

governorate, Egypt (It is located about 45 kilometers southwest of Alexandria and some seven kilometers from the Mediterranean coast) at 2022 and 2023 seasons. The used materials in this experiment included four squash varieties (*Cucurbita pepo*, L.), i.e., variety one name Eskandarani (P₁); variety two name Siyah Kabuk (P₂); variety three name Erbil Garden (P₃) & variety four name Zucchini Alberallo Di Sarzana (P₄).

2.2. Breeding strategies

These four parental varieties were grown in greenhouse during the summer season in 2022. At flowering stage, the pollen grains from the completely open flowers of the male parent were applied on the stigma of female parents to produce the six F₁ hybrids seed. In 2023, the F₁ hybrids and their parents were planted in a Randomized Complete Block Design (RCBD) with three replicates. It represented by six plots of F₁ hybrids and four plots of parents spaced 50 cm with 0.7 m between rows; therefore, the plot area was 3.5 m². The culture practices; i.e., irrigation, fertilization and the pest control were applied as recommended for summer squash. Data were recorded for 5 fruit economic traits: chlorophyll content in fruits (T₁); date of first female flower (T₂); first picking date (T₃); early yield per-plant (T₄); fruit length (T₅); fruit diameter (T₆); Total Soluble Solid% (T₇) and weight of fruit (T₈) and fruit yield per plant (T₉). Chemical components of some health properties in squash fruits and their peels were Moisture%, Carbohydrate%, Oils% and Proteins%.

2.3. Statistical analysis

For all studied traits, differences among means were tested for significance. The analysis of variance was as outlined by [24-27]. Both types of heterosis (MP) & heterobeltiosis (BP) were estimated as deviation of F₁ mean over the mid-parents (MP) & better parent (BP) in each cross, respectively and expressed as percentages [27] as follow:

- Mid-parent heterosis (M P) = $[(F_1 - M P) / M P] \times 100$ (relative heterosis).
- Better parent heterosis (B P) = $[(F_1 - B P) / B P] \times 100$ (heterobeltiosis).

The following analysis was carried out for each harvesting time & fresh stage (two days age): fruits was randomly chosen. The Moisture%, Carbohydrate%, Oils% and Proteins% content of the samples determined according to the standard methods described in [26].

3. Results and discussion

3.1. The performance of genotypes

The results of four parental varieties & 6 F₁ hybrids of the studied fruit economic traits were selection because it very useful in plant healthy in Photosynthesis the early yield and earliness fruits bay in high prices are presented in Table 1. It is clear that both P₃ and P₄ were the highest parents for chlorophyll in fruits (T₁) with no significant differences between them. On the contrary, the parental genotype (P₂) was the significantly lowest parent for each of T₁, F₁ and T₉ than the mean average of these traits. P₁ exhibited the highest fruit yield (2.696 kg/plant) followed by P₃ (2.348 kg/plant) which was the highest earliness than others parents. This result would be confirmed by days to first female flower T₂ (36.44 to 43.88days), revealing that P₄ was a very late variety and P₃ variety followed by P₂ were early maturing varieties.

Table 1: The mean performances for fruit economic traits

Genotypes	Fruit economic traits								
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉
P ₁	31.14	41.34	43.30	1.065	13.04	3.08	3.32	115.92	2.696
P ₂	26.69	38.24	40.81	1.108	4.69	7.38	5.61	128.85	2.133
P ₃	34.16	36.44	38.15	0.847	10.78	2.68	3.45	93.55	2.348
P ₄	32.67	43.88	45.53	1.187	8.74	6.34	2.52	139.96	2.254
P ₁ × P ₂	40.24	28.45	31.13	1.779	9.39	5.79	6.33	196.19	4.957
P ₁ × P ₃	42.84	30.12	32.24	1.083	13.93	3.22	4.45	121.50	4.284
P ₁ × P ₄	37.86	33.61	35.68	1.889	13.63	3.09	3.63	207.76	5.636
P ₂ × P ₃	36.73	28.97	31.83	1.929	9.66	5.65	7.54	217.97	5.764
P ₂ × P ₄	37.42	32.94	35.86	2.089	9.30	5.75	6.39	222.46	4.684
P ₃ × P ₄	38.82	31.36	33.28	1.755	14.65	4.62	3.65	193.89	4.799
LSD _{0.05}	1.715	0.886	0.722	0.063	0.361	0.265	0.175	3.634	0.225
LSD _{0.01}	2.280	1.178	0.960	0.084	0.480	0.353	0.232	4.833	0.299

*,** Probability levels of Significant at 0.05 and 0.01, respectively.
 *T1–T9: See the Material and Method section.

Table 2: Mid-parents heterosis (H_{M.P.}%) for fruit economic traits

Hybrids	Economic traits								
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉
P ₁ × P ₂	39.17**	-28.51**	-25.97**	63.83**	5.94**	10.57**	41.77**	60.31**	105.31**
P ₁ × P ₃	31.23**	-22.55**	-20.83**	13.34**	16.92**	11.73**	31.38**	16.01**	69.86**
P ₁ × P ₄	16.30**	-21.12**	-19.66**	67.78**	25.13**	-34.55**	24.27**	62.38**	127.74**
P ₂ × P ₃	20.75**	-22.41**	-19.37**	97.37**	24.89**	12.28**	66.41**	96.02**	157.28**
P ₂ × P ₄	23.37**	-19.79**	-16.94**	82.10**	38.48**	-16.22**	57.37**	65.51**	113.55**
P ₃ × P ₄	13.96**	-21.91**	-20.46**	72.62**	50.13**	2.33	22.24**	66.07**	108.57**
LSD _{0.05}	6.95	5.87	7.82	6.89	2.38	2.59	6.58	8.27	42.04
LSD _{0.01}	9.97	7.80	9.76	9.29	3.78	4.91	11.48	13.01	53.94

*,** Probability levels of Significant at 0.05 and 0.01, respectively.

Table 3: Better parent heterosis (H_{B.P.}%) for fruit economic traits

Hybrids	Economic traits								
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉
P ₁ × P ₂	29.22**	-25.61**	-23.71**	60.64**	-27.97**	-21.63**	12.84**	52.26**	83.87**
P ₁ × P ₃	25.44**	-17.35**	-15.49**	1.74	6.80**	4.49	28.81**	4.81**	58.91**
P ₁ × P ₄	11.46**	-18.70**	-17.59**	59.13**	4.47**	-51.37**	9.29**	48.44**	109.08**
P ₂ × P ₃	7.55**	-20.50**	-16.56**	74.10**	-10.39**	-23.45**	34.45**	69.16**	145.48**
P ₂ × P ₄	10.15**	-13.87**	-12.14**	76.03**	6.43**	-22.12**	14.03**	58.94**	107.81**
P ₃ × P ₄	13.65**	-13.94**	-12.78**	47.87**	35.87**	-27.19**	5.69*	38.53**	104.39**
LSD _{0.05}	3.46	3.25	7.26	12.22	3.29	4.53	4.98	3.28	12.73
LSD _{0.01}	4.59	4.38	9.34	21.14	4.11	8.36	8.02	4.48	23.63

*,** Probability levels of significant at 0.05 & 0.01, respectively.

Table 4: Chemical components of seeds and peels in squash genotypes

Genotypes	Chemical components							
	Moisture%		Carbohydrate%		Oils%		Proteins%	
	Seeds	Peels	Seeds	Peels	Seeds	Peels	Seeds	Peels
P ₁	16.55 ± 0.501	65.05 ± 0.167	59.64 ± 1.876	51.21 ± 1.375	32.45 ± 0.011	4.65 ± 0.012	20.70 ± 0.312	1.33 ± 0.032
P ₂	13.41 ± 0.413	61.16 ± 0.178	52.92 ± 1.652	59.43 ± 1.455	34.63 ± 0.014	5.22 ± 0.011	21.34 ± 0.353	1.58 ± 0.046
P ₃	18.11 ± 0.507	66.32 ± 0.195	58.44 ± 2.073	63.15 ± 1.467	37.16 ± 0.012	5.02 ± 0.011	18.79 ± 0.423	1.26 ± 0.033
P ₄	20.29 ± 0.625	74.46 ± 0.206	61.74 ± 1.954	58.73 ± 1.274	41.22 ± 0.011	5.52 ± 0.013	22.12 ± 0.363	1.42 ± 0.144
P ₁ × P ₂	21.56 ± 0.634	82.17 ± 0.234	67.86 ± 2.223	68.17 ± 2.216	50.36 ± 1.110	7.32 ± 1.124	26.03 ± 0.465	1.88 ± 0.546
P ₁ × P ₃	24.39 ± 0.654	85.06 ± 0.253	79.35 ± 2.335	73.28 ± 1.985	53.24 ± 1.011	8.02 ± 1.013	25.16 ± 0.473	2.17 ± 0.342
P ₁ × P ₄	23.58 ± 0.703	87.33 ± 0.261	83.64 ± 2.457	75.59 ± 2.479	57.64 ± 1.117	7.71 ± 1.112	28.23 ± 0.527	2.28 ± 0.149
P ₂ × P ₃	26.32 ± 0.729	88.26 ± 0.288	80.26 ± 2.624	81.17 ± 1.765	62.34 ± 1.103	8.11 ± 1.116	24.76 ± 0.468	1.57 ± 0.745
P ₂ × P ₄	29.52 ± 0.745	90.15 ± 0.305	75.38 ± 2.536	78.43 ± 1.843	58.61 ± 1.114	7.84 ± 1.111	27.64 ± 0.443	2.08 ± 0.448
P ₃ × P ₄	31.69 ± 0.766	91.06 ± 0.269	86.15 ± 2.277	82.55 ± 2.321	55.87 ± 1.018	7.69 ± 1.015	28.14 ± 0.485	1.54 ± 0.345

On the other hand, the early F₁ crosses can be obtained when the hybridization involves any one of the earliness parents or both two parental genotypes as P₂ and P₃ in this work in relation to all the studied earliness traits. The parental variety P₄ was lowest variety for T₇. It was also noted from same table that differences between lower and higher mean averages were always important indicating that there are genetic differences b/w four parental genotypes. In general, these results suggested that there is a wide range of difference between parental varieties for all studies traits. Also, results show significant differences between F₁ hybrid for the traits and indicated that the highest F₁ hybrid of the T₁ content was P₁ × P₃ with an average of 42.84. The data indicated that highest hybrid F₁ (undesirable) for T₂ is (P₁ × P₄) was an average of 33.61 days. Conversely, the hybrid P₁ × P₂ has lowest (desirable) value for T₃, On average 31.13 days. It can be considered that F₁ hybrids for three earliness characters ranged from 28.45 to 33.61 days; 31.13 to 35.86 days and 1.083 to 2.089 kg for T₂; T₃ and T₄, respectively.

It can be considered that the yield of F₁ hybrids ranged from 4.284 kg / plant (P₁ × P₃) to 5,764 kg / plant (P₂ × P₃). On the other hand, (P₁ × P₂) was equal to or greater than the mean of all studied traits except for the length of the fruit whose highest value appeared in (P₃ × P₄). It is also evident that some F₁ hybrids of fruit economic traits have outgrown the best parent. Therefore, it is expected that there will be quite hybrid vigor values against the middle parents & the better parent. The results indicated that the F₁ hybrid ranged from 9.30 to 14.65 cm; 3.09 to 5.79 cm; 121.50 to 222.46 g; and 4.284 to 5.764 kg for length (T₅), diameter (T₆), weight (T₈) and yield for fruit (T₉), respectively. Hybrid was close to each other for the most studied traits. It is also evident that some of the F₁ hybrids for yield & yield component traits have surpassed the better parent. While it is expected that there will be quite heterosis values versus the mid-parents.

3.2. Types of Heterosis

It's known that the phenomenon of heterosis is of a common occurrence in all plants including squash. However, the estimated amounts of heterosis depend on the lines which would be crossed together to produce F₁ hybrids.

3.2.1. Relative Heterosis (Heterosis for mid-parents)

Heterosis for mid-parents was estimated (H_{M.P.}%) for fruit economic traits and the results are presented in Table 2. The results indicated that the mean of the F₁ hybrid significantly exceeded the average parents in all studied traits. All crosses showed highly significant and + values for all studied fruit economic traits. These results indicated that hybrid vigor of F₁ hybrids ranged: 13.96 to 39.17% for the chlorophyll content. These results were consistent with results obtained by [18-19-20]. All hybrids showed highly significant and negative or positive heterotic values in the desirable direction for T₂, T₃ and T₄ traits. The results showed that mid-parents heterosis percentages were found to be ranged for F₁ hybrids from -19.79% (P₂ × P₄) to -28.51 (P₁ × P₂) for T₃; -16.94% (P₂ × P₄) to -25.97 (P₁ × P₂) for T₃ and 13.34 (P₁ × P₃) to 97.37% (P₂ × P₃) for T₄. Results were in agreement with the results obtained by [12-19-24-28-29]. The results indicated that MP heterosis were ranged from 5.94 to 50.13% for T₅; -34.55 to 12.28% for T₆; 22.24 to 66.41% for T₇; 16.01 to 96.02% for T₈ and 69.86 to 157.28% for T₉. Generally, all the six F₁ hybrids exhibited positive or negative highly significances estimate in desirable direction for all studied traits. These results were in agreement with the results obtained by [12-18-19-20].

3.2.2. Heterobeltiosis (Heterosis for better parent)

H_{B.P.} % for fruit economic traits (Table 3) showed highly significantly positive values for T₁ and heterotic effect for most F₁ hybrids and ranged from 7.55 to 29.22% for this trait (T₁). Results were in agreement with [18-19-12]. All crosses showed highly significantly (desirable) negative H_{B.P.}% values for T₂ and T₃ and also, were found to be 1.74

to 76.03% for T₄. In general, all ranged from -13.87% to -25.61% for T₂; 12.14% to -23.71 for T₃ and hybrids exhibited negative highly significant (desirable) heterosis values versus the better parent for the earliness traits except P₁ × P₃ without any significant for T₄. Results were in agreement with the results cleared by [12-18-19-20]. Results obtained that the values of heterosis over the better parent for F₁ hybrids were ranged from -27.97 to 35.87% for T₅; -51.37 to 4.49% for T₆; 5.69 to 34.45% for T₇; 4.81 to 69.16% for T₈ and 58.91 to 145.48% for T₉. Results were in agreement with the results obtained by [12-18-20].

3.3. Chemical components of some health properties in squash

The squash fruits and their peel contain some nutritional compounds for human nutrition such as a moderate amount of mineral salts, eaten as some immature fruit rich in fiber and vitamins or consumed by ripe seeds that are a good source of fats and proteins. Chemical components of seeds and peels in squash genotypes and the results were presented in Table 4. Both seeds and peels of hybrid P₃ × P₄ contained the highest percentage of Moisture and Carbohydrate (31.69 ± 0.766 & 86.15 ± 2.277, respectively in seeds and 91.06 ± 0.269 & 82.55 ± 2.321, respectively in the peels) compared to all other hybrids. The hybrids (P₂ × P₃) and (P₁ × P₄) contained the highest percentage of oil and proteins in seeds (62.34 ± 1.103 and 28.23 ± 0.527, respectively) and peels (8.11 ± 1.116 and 2.28 ± 0.149, respectively). These results were agreed with previous studies [18-29]. The oils and proteins contents of the *Cucurbita pepo* seeds in all parents and hybrids were found to be higher than peels, these results reported by [30-36]. The Moisture and Carbohydrate contents of both seeds and peels were lower in the parent P₂ (61.16% and 13.41% for moisture) and the parent P₁ (51.21% and 59.64% for carbohydrate), respectively. The oils and protein contents of peels were lower than seeds of all parents and the parent P₁ (4.65% and 32.45%) and the parent P₃ (1.26% and 18.79%) has the lowest content, respectively. These results were agreed with previous studies [31-37].

4. Conclusions

The results revealed that both heterosis and heterobeltiosis were highly significant for most studied traits. In general, all hybrids exhibited highly significances heterobeltiosis values in desirable direction for the earliness traits. The higher moisture contents were established in all hybrid peels and only half studied hybrids exhibited the highest carbohydrate content in peels. The seeds of all hybrids and peels of most one had higher amounts of oils & proteins compare with parents. P₂ × P₃ exhibited the highest performance in yield and oils% of both seeds and peels as well as over the grand means of most other traits, the highest relative heterosis for each of T₄, T₆, T₇, T₈ and T₉ and heterobeltiosis for each of T₇, T₈ and T₉. Generally, maximum significances heterobeltiosis (true heterosis) in desirable direction (145.48%) were recorded for T₉ followed by T₄ (76.03%), T₈ (69.16%), T₅ (35.87%), T₇ (34.45), T₁ (29.22%), T₂ (-25.61%) and T₃ (-23.71%).

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