HETEROSIS AND NATURE OF GENE ACTION FOR EARLINESS AND YIELD COMPONENTS IN SUMMER SQUASH *(Cucurbita pepo L.)*

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Abstract: One Egyptian and three exotic parental genotypes of Summer squash were self pollinated for one generation and crossed in half diallel design to study heterosis and nature of gene action for earliness, vegetative and yield components traits. Mean squares of genotypes were found to be highly significant for all studied traits, providing evidence for presence of considerable amount of genetic variation among studied genotypes. The results showed that the majority of crosses exhibited significant heterosis estimates over mid and best parents for all studied traits. The results revealed that the general combining ability (GCA) and specific combining ability (SCA) mean squares were highly significant for all studied traits. The results indicated that the magnitude of additive genetic variance ($\sigma^2 A$) were positive and lower than those of non additive ($\sigma^2 D$) one for all of studied traits, indicating that non additive gene action played a major role in the inheritance of summer squash.. The broad sense heritability estimates (H^2_b %) were more than 85% and larger than their corresponding narrow sense heritability (H^2_n %) for all studied traits. However, estimates of narrow sense heritability were 27.25% for earliness and ranged from 4.02% to 13.46% for sex ratio (SR) and number of branches per plant, respectively. Respecting to yield components, the estimates of narrow sense heritability ranged from 8.92 % to 18.39% for number of total fruit yield per plant and average fruit weight per plant (g), respectively. The results showed that Eskandarany (P_1) was excellent general combiners for earliness and yield components traits. The cross combination ($P_2 x P_3$) showed desirable SCA effects and significant heterosis values for earliness. While, the cross ($P_1 x P_3$) exhibited desirable SCA effects for vegetative and early yield components. However, the cross combinations ($P_1 x P_3$), ($P_1 x P_4$), ($P_2 x P_3$) and ($P_2 x P_4$) revealed significant SCA effects for total yield components. These promising crosses could be used for constitution of summer squash hybrids.

Key words: heterosis, nature, gene action, earliness, yield, summer squash.

Introduction

Summer squash (*Cucurbita pepo L.*) is one of the most important vegetable crops in Egypt. Yield is the most important characters of squash cultivars and hybrids. Great efforts have been directed to improve yield production and quality proprieties in summer squash. In this trend, heterosis and combining ability provides

important information for improving economic traits in squash.

In this respect, different heterotic effects were obtained by many authors for economic traits in squash. El-Gazar, (1981); Kash and El-Diasty (1989); Kasrawi (1994); Ghai *et a*l (1998); El-Gendy (1999); Khalaf Allah *et al*., (2001); Abd El-Maksoud *et al* (2003); Gabr, (2003); Sadek (2003); Abd El-Hady and El-Gendy (2004); El-Sherbeny *et al*., (2005); Abd El-Hadi *et al*., (2006) found desirable heterotic values over mid and best parents for earliness, vegetable and yield components traits.

The roles of GCA and SCA in the inheritance of summer squash were studied by several authors. Korzeniewska and Niemirowicz (1993) obtained high GCA values for yield components, while, significant SCA value was only noted for fruit weight. Abd El-Hady *et al*., (2005) noticed that the estimates of GCA were larger than those of SCA for earliness and vegetative traits, reflecting the importance of additive gene action in the expression of these traits. Moreover, Abd El-Hady and El-Gendy (2004) found that the estimates of GCA and SCA were significant for earliness and yield components, suggesting the importance of additive and non additive gene action in the inheritance of these traits.

Therefore, the objective of this research was to study heterosis and the types of gene action controlling the inheritance of economical traits of summer squash.

Materials And Methods

The present investigation was carried out at Sohag Faculty of Agriculture Experimental Farm, South Valley University, during the three summer seasons of 2003, 2004 and 2005 where, the soil was sandy calcareous (surface layer contains transported Nile sediments over desert soil).

Four different squash cultivars (*Cucurbita pepo L.*) represented a wide range of variability in their economic traits, were used in this study. These cultivars were: Eskandrany (P_1, Egypt), Giado (P_2, Italy), Zucchino Mezza Lung Bianco (P_3, Germany) and Zucchino 544-00S (P_4, Italy).

In the summer season of 2003, the seeds of four parental genotypes were planted and the selfing was undertaken to produce the four inbred lines.

In the following summer season (2004), the four inbred lines seeds (S_1) were sown on June, 1 and crossed according to a half diallel mating design to produce six F_1 hybrids.

In the summer season of 2005, parents (four inbred lines seeds) and their six F_1 hybrids were sown on

June, 3 in a randomized complete block design with three replications. Each replicate contains 10 plots**.** Each plot was one ridge 5.0 m. long and 1.0 m. wide. Hills were spaced at 0.5 m. apart. All agricultural practices were applied as recommended for squash production.

Data were recorded for the following traits: earliness trait [days to the first female flower (D1[st] FF)], vegetative traits [six ratio (SR) which estimated as number of female flower/number of total flower, Plant height (PH) and number of branches per plant (No. B/P), early yield traits, estimated as the yield of the first three pickings for each genotypes and these include; [number of fruits per plant (No. F/P), average fruit weight per plant (AFW/P g), and average fruit weight per feddan (AFW/F ton)] and total yield traits and these include; [number of total fruit per plant (No. TF/P), and average total fruit weight yield per feddan (ATFWY/F ton)]

Data were subjected to the analysis of variance in order to test the significance of the differences among the 10 genotypes including the four inbred lines and their 6 F_1 hybrids according to Cochran and Cox (1957).

Sum of squares for genotypes was partitioned according to Griffing`s (1956) as method 2 model 1 into sources of variations due to GCA and SCA.

The variances of GCA ($\sigma^2 g$) and SCA ($\sigma^2 s$) were obtained on the basis of the expected mean squares for all studied straits. Additive ($\sigma^2 A$) and non-additive ($\sigma^2 D$) genetic variances were estimated according to Matzinger and Kempthorne (1956) as follow:

$$\sigma^2 A \quad = \quad 2\,\sigma^2 g$$
$$\sigma^2 D \quad = \quad \sigma^2 s$$

Estimates of heterosis % were calculated according to Singh and Khanna (1975) as following equations: Mid-parent heterosis (%) = ($\overline{F}_1$-M.P./M.P.)X100 where

$$M.P. = (\overline{P}_i - \overline{P}_j)/2$$

Best-parent heterosis (%) = ($\overline{F}_1$-B.P./B.P.)X100

Estimates of heritability in both broad and narrow sense were calculated according to the following equations:

$$h^2_b\% = [(\sigma^2 A + \sigma^2 D) / (\sigma^2 A + \sigma^2 D + \sigma^2 e)] \times 100$$

$$h^2_n\% = [(\sigma^2 A) / (\sigma^2 A + \sigma^2 D + \sigma^2 e)] \times 100$$

Results and Discussion

Genotypic variations

The analyses of variance for all studied traits for all genotypes (parents and F1 hybrids) are presented in Table 1. There were highly significant differences among the studies genotypes for all studied traits.

Mean squares of genotypes (Table 1) were found to be highly significant for all studied traits. This provides evidence for presence of considerable amount of genetic variation among studied genotypes. These results are in harmony with those previously obtained by Korzeniewska and Niemirowicz (1993), Abd El-Maksoud *et al* (2003), Abd El-Hady *et al* (2005 and 2006).

Estimates of heterosis

Estimates of heterosis over mid parents for all studied traits are shown in Table 2. Earliness is an important aim in summer squash, thus, the negative heterosis value for number of days to first female flowering is desirable in breeding program. In this direction, all of crosses flowered highly significant earlier than their mid parents with negative heterosis values ranging from –5.76% to –9.28%.

Respecting to vegetative traits, all crosses exhibited significant positive heterosis values relative to mid parents and ranged from (27.17% to 107.52%), (18.09% to 60.78%) and (21.50% to 168.18%) for six ratio, plant height and No. of branch / plant, respectively. Regarding to early yield components significant positive heterosis values were also obtained from all crosses and ranged from (14.29% to 54.55%), (141.71% to 806.67%) and (43.28% to 71.79%) for number of fruits/plant, average fruit weight/plant and average fruit weight/fed. Concerning total fruit yield all crosses were also significantly better yielding than their mid parents and ranged from (32.73% to 236.36%) and (75.98% to 154.89%) for number of total fruit yield/plant and average total fruit weight yield/fed., respectively.

Estimates of heterosis over best parents for all studied traits are presented in Table 3. In this direction, all crosses were significant flowered earlier than their best parents with negative heterosis values ranging from –2.27% to –8.33%. Respecting to vegetative traits, all crosses exhibited significant positive heterosis values relative to best parents for six ratio (21.42% to 86.82%), plant height (15.63% to 51.85%), number of branch/plant (20.37% to 103.45%). Regarding to early yield traits, significant positive heterosis values were also obtained from all crosses for number of fruits/plant (9.09% to 54.55%), average fruit weight/plant (48.45% to 806.67%), average fruit weight/fed., (24.39% to 63.41%). For total yield traits all crosses were significantly better yielding than their best parents and ranged from (59.53% to108.59%) and (59.53% to108.59%) for number of total fruit yield/plant and average total fruit weight yield/fed., respectively. In general, these results indicate that all crosses were significantly earlier

and high yielding than their mid or better parents, suggesting the important role of non-additive gene action in the inheritance of studied traits. These results are in agreement with those reported by El-Gazar (1981); Kash and El-Diasty (1989); Gabr (2003); Sadek (2003); Abd El-Hadi and El-Gendy (2004); Abd El-Hadi *et al* (2005 and 2006); El-Sherbeny *et al*., (2005).

Combining ability analysis

Mean squares of general and specific combining ability for all studied traits are given in Table 4. The results exhibited that mean squares of general combining ability (GCA) and specific combining ability (SCA) were highly significant for all studied traits. These results indicate that both GCA and SCA were important in the inheritance of these traits. However, the magnitudes of SCA were larger than those of GCA for all studied traits except the number of days to first female flowering (D1st FF). These results are in agreement with those reported by El-Gendy (1999) ; Khalaf Allah *et al*., (2001); Sadek (2003); Abd El-Hadi *et al.,* (2004); Abd El-Hadi and El-Gendi (2004)**.** On the other hand, Abd El-Hadi *et al*., (2005) and El-Sherbeny *et al*., (2005) reported that mean squares of GCA were more important than those of SCA for earliness, vegetative and yield component traits.

GCA effects (gi)

Estimated of general combining ability effects (gi) of each parent for all studied traits are presented in Table 5. Eskandarany (P$_1$) was the best general combiner for all studied traits except sex ratio. Zuchino Mezza Lung Biano (P$_3$) was good general combiner for average fruit weight per plant. Moreover, Zuchino Mezza Lung Biano (P$_3$) and Zucchino 544- 00S (P$_4$) were the best general combiners for six ratio. Consequently, Eskandarany (P$_1$) which exhibited useful general combining ability effects could be utilized in breeding programs to improve earliness and yield components.

SCA effects (S$_{ij}$)

Estimated specific combining ability effects (S$_{ij}$) of each cross combination for all studied traits are found in Table 6. The results revealed that the cross combination (P$_2$xP$_3$), which resulting from crossing (poor x poor) general combiners, showed desirable negative significant SCA effects for earliness. With respect to vegetative traits, four, three and two out of six crosses exhibited positive SCA effects for SR (%), PH (cm) and No.B/P., respectively. As for early yield, two, six and three out of the six crosses showed significant positive SCA effect values for No.F/P, AFW/P (g), and AFW/F (ton), respectively. Concerning to total yield, four, six and six out of

the six hybrids were the best yielding crosses for No.TFY/P, and ATFWY/F (ton), respectively.

It could be noticed that the excellent cross combinations were obtained from crossing (good x good), (good x poor) and (poor x poor) general combiners. Therefore, it is not necessary that parents having estimates of high GCA effects would also give high estimates of SCA effects in their respective cross combinations. It is interesting to note that the promising crosses which showed desirable SCA effects exhibited as previously mentioned high heterosis values for these studied traits. These promising crosses could be used for squash hybrids and segregating generations for transgressive segregants.

Gene action

Estimates of all types of gene action for all studied traits are presented in Table 7. The results indicated that the magnitude of additive genetic variance (σ^2A) were positive and lower than those of non additive (σ^2D) one for all of studied traits. This finding could be verified by the ratio (σ^2D/ σ^2A)$^{1/2}$ which was more than one, indicating that non additive gene action played a major role in the inheritance of these studied traits. Similar results were obtained by El-Gendy (1999); Sadek (2003); El-Sherbeny *et al*., (2005). Contrarily, Abd El-Hadi *et al* (2005) and noticed that additive genetic variances were important than those

of non additive ones in the expression of vegetative and earliness traits.

Estimates of heritability

The results in Table 7 showed that broad sense heritability estimates (H^2_b %) were more than 85% and larger than their corresponding of narrow sense heritability (H^2_n %). The estimates of narrow sense heritability were 27.25% for earliness. For vegetative traits, the estimates of narrow sense heritability ranged from 4.02% to 13.46% for sex ratio and number of branches per plant, respectively. Respecting to early and total yield components, the estimates of narrow sense heritability ranged from 8.92 % to 18.39% for No.TFY/P and AFW/P, respectively. These results were in agreement with those obtained by Khalaf Allah *et al*., (2001); Sadek (2003); Abd El-Hadi and El-Gendy (2004); El-Sherbeny *et al*., (2005). The estimate of narrow sense heritability presented additional evidence about the important of non additive gene action for earliness and yield components.

Conclusion

From the data presented in this study it could be concluded that the cross combinations (P_1xP_3), (P_1xP_4), (P_2xP_3) and (P_2xP_4) showed desirable SCA effects and significant heterosis values for most studied traits. This finding reflects

the presence of considerable heterosis values and suggested that non additive gene effects played the major role in the inheritance of these traits. These promising crosses could be used for developing squash hybrids.

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قوة الهجين وطبيعة فعل الجين لصفات التبكير ومكونات المحصول في قرع الكوسه.

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تم إجراء هذا البحث بمزرعه كليه الزراعه بسوهاج جامعه جنوب الوادى وذلك لدراسة قوة الهجين وطبيعة الفعل الجينى لصفات التزهير ومكونات المحصول وذلك باستخدام نظام التهجين النصف دائري بين اربعه أصناف من قرع الكوسه تشمل تركيب وراثي واحد مصري (إسكندرانى) و ثلاث تراكيب مستوردة هى (Giado وS00 -544 Zucchino من إيطاليا و Zucchino Mezza Lung Bianco من المانيا) وقد أجريت التربية الداخلية (التلقيح الذاتى) لمدة جيل واحد لجميع الأصناف للحصول على بذور السلالات النقية (S_1)

ويمكن تلخيص أهم النتائج فيما يلي:

-   أظهرت النتائج أن معظم الهجن أعطت قوة هجين عالية ومعنوية بالنسبة لمتوسط واحسن الأبوين وذلك لمعظم الصفات المدروسة.

-   كانت تقديرات القدرة العامة والخاصة علي التالف معنوية جدا لكل الصفات تحت الدراسه مما يؤكد أهمية التباين الوراثي المضيف وغير المضيف في وراثة الصفات تحت الدراسة. أوضحت النتائج أن الأب P_1 له قدرة عامة عالية علي التالف لكل الصفات قيد الدراسه.

-   كانت الهجن (P_1xP_3), (P_1xP_4), (P_2xP_3) and (P_2xP_4) ذات قدرة خاصة عالية علي التالف لصفة التزهير المبكر ومعظم صفات المحصول .

-   كانت قيمة التباين الوراثي غير المضيف أكبر من التباين الوراثي المضيف لصفة التبكير، وصفات المحصول ومكوناته.

-   كانت أعلي قيم لدرجه التوريث في المدى الواسع أكبر من 85% وكانت أعلي من قيم درجه التوريث في المدي الضيق لكل الصفاتقيد الدراسه .

-   كانت قيم درجه التوريث في المدى الضيق (27.25%) لصفة التبكير بينما كانت أقل من (20%) لصفات المحصول ومكوناته.

-   طبقا لنتائج التحليل الوراثي للصفات تحت الدراسه يمكن إستخدام هذه الهجن المبشرة في الحصول علي اعلى محصول من الكوسه .