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# SELECTION AND EVALUATION OF INBRED LINES OF SUMMER SQUASH (*Cucurbita pepo* L.)

**El-Miniawy, S. M.**
**Dept. of Horticulture, Fac. of Agric. Ain Shams Univ. Shoubra-Elkeima, Cairo, Egypt**

## ABSTRACT

This work was carried out at a private farm at Kafr Abou EL Hadeed, Giza Governorate, in the summer and fall plantings of summer squash (*Cucurbita pepo* L.) during 2002-2003, 2003-2004, and 2004-2005 seasons. Four Egyptian and Syrian summer squash cultivars (Eskandarani, Balady, Gabla, and Halap) were used. Four generations of inbreeding and selection were carried out and 8 strains of summer squash were obtained, namely E1, E2, B1, B2, G1, G2, H1, and H2. The selected lines recorded significant increment in most studied characters comparatively with their original populations, especially in number of pistillate flowers, fruit weight and early and total yield. On the other hand, most of selected lines recorded significant decrement in number of staminate flowers and sex ratio. These selected lines can be used later in a breeding program to produce new summer squash hybrids.

**Keywords:** Summer squash, *Cucurbita pepo* L., cultivars, inbreeding, inbred lines, selection.

## INTRODUCTION

Summer squash (*Cucurbita pepo* L.) is one of the most popular vegetable crops in the most Arab countries. It is known as a vegetable marrow and is called (Kosa) by the Egyptians. Among the Cucurbita crops, squash ranks the second in acreage after melon.

As hybrids have the capacity for higher yield and earliness over open-pollinated squash cultivars, there is a need to develop new hybrid squash cultivars. This breeding method is based on the principle of crossing two inbred lines. The first step is to obtain the homozygous lines by using inbreeding.

Inbreeding is the mating of closely related individuals, which results in a large number of weak types with a general decline in their vigor, fertility and fecundity. Recessive, lethal and deleterious genes which are increased in the homozygous balance after inbreeding are usually concealed in a heterozygous system. Inbreeding increases homozygosity and reduces the proportion of heterozygosity in the population and consequently reducing the vigor of plants. For inbreeding, usually selfing and sib mating are practiced (Kalloo, 1988).

However some researchers have found clear evidence of inbreeding depression in C. pepo. Some degree of inbreeding depression was observed in the second generation of C. pepo. (Abdel-al *et al*., 1973; Borghi, 1976). On the other hand many experimental results have demonstrated that cucurbits exhibit no inbreeding depression. Helmy (1985**)** found that the inbred lines gave higher measurement for the most of vegetative, flowering, fruit and yield characters. Metwally (1989**)** reported that great variations in plant vigor and fruit productivity are present in the local cultivar (Eskandarani). Seventeen inbred lines were obtained after ten generations of inbreeding and selection. The results indicated the highly significant variations for the nodal position of

the first female flower and flowering time. The obtained strains were superior to their original cultivar for early and total yield. Gwanama *et al*. (1998**)** suggested that in selecting for pumpkin yield, special attention should be given to number of fruits per plant and weight of first mature fruit of each plant. Refaei (2001) made three cycles of selection with inbreeding on EL-Eskandarani cultivar and it was reported that the selected strains were superior to the original population in the respect of most of the studied traits as sex ratio, percentage of fruit set, early and total yield/plant, average fruit weight, fruit diameter and fruit length. The vegetative traits of all inbred selected lines were less than their original population. In addition, a negative correlation was found among the studied characters. After five generations of inbred lines for summer squash, Ercan and kurum (2003) reported that the highest number of female flower and lowest number of male flower per plant and heaviest fruit were recorded for the selected inbred lines.

The aim of this study was to produce some inbred lines from four summer squash cultivars as a first step to produce promising local hybrids.

## MATERIALS AND METHODS

This work was carried out at a private farm at Kafr Abou EL Hadeed, Giza Governorate, from 2002 to 2005. Plants were grown in both early summer and fall seasons so that two generations of improvements could be done in a year.

Four summer squash cultivars were used,i.e., two Egyptain cultivars (Eskandarani and Balady) and two Syrian cultivars (Gabla and Halap).

The inbreeding and selection procedures were carried out starting with a total of 280 plants from the original population ($s_0$) of each cultivar.

The first cycle was done in summer season (February 15, 2002) and the second one in fall season (September 1, 2002). The third and the fourth ones were conducted in early summer and fall seasons of 2003. Ten plants from the $s_0$ population of each cultivar were selected and individually selfed to produce the ($s_1$) population. Ten plants from each ($s_1$) lines were planted in the second season. For each line, best plants were selected and selfed to produce the ($s_2$) population. Five plants from each ($s_2$) lines were planted in the next season. Only the best three plants from each cultivar were selected and selfed to produce the ($s_3$) population lines. Five plants from each ($s_3$) lines were planted in the next season. Only the best two plants from each cultivar were selected and selfed to produce the ($s_4$) population lines.

Earliness, dominating numbers of female flowers versus minimum numbers of male flowers and fruit characteristics were used as selection criteria. The pollination technique was carried out as described by Whitaker and Davis (1962).

Eight inbred lines, namely E1, E2, B1, B2, G1, G2, H1, and H2, as well as the original parents (Eskandarani, Balady, Gabla, and Halap) were evaluated during summer 2004 and 2005 seasons (March, 1).

**1- Experiment design:**

The experimental design was a randomized complete block design with four replications. The experimental plot contained 4 ridges of 5 meters in

length and 0.7 m in width. The soil texture was clay with a pH of 7.8 and EC of 2.81 mmohs/cm at 25˚C.

**2- Cultural practices:**

Three seeds were planted in each hill. The distance between the hills was 50 cm and the field was then irrigated. The plants were thinned to a single seedling per hill two weeks after sowing.

All replicates received similar treatments as regards to cultivation, manuring, irrigation, pest and disease control, and other agricultural practices as commonly followed in the district.

**3- Data recorded:**

1. Vegetative traits: five plants were randomly chosen from each plot and the stem length and number of leaves at the end of season, area of the fifth leaf using direct reading automatic leaf area meter (LI-COR-Portable area meter model LI – 3000), as well as fresh and dry weight per plant after 60 days of sowing were recorded.
2. Flowering characteristics: five plants from each plot were randomly labelled and the total number of staminate and pistillate flowers were counted at 3- day intervals and the number of days for opening the first pistillate flower, total number of staminate flowers, total number of pistillate flowers and sex ratio were recorded.
3. Fruit characteristics: Ten fruits in the marketable stage were picked from each plot in the seventh harvest (mid season) and length, diameter, and average weight of fruits were recorded.
4. Fruit yield: fruits were harvested at two-day intervals and early and total yield per plant were calculated. Fruits harvested during 15 days from the beginning of harvest were considered as early yield.

Data were tested by analysis of variance, and the differences among means for all traits were tested according to Waller and Duncan (1969) at the level $p< 0.05$.

Correlation coefficients (r) were calculated for pairs of some characters according to Steel and Torrie (1982) using means of all genotypes

## RESULTS AND DISCUSSION

**1- Vegetative traits:**

Results on stem length, No. of leaves/plant, leaf area and plant fresh and dry weight of 8 selected lines and their original populations ($S_0$) of four cultivars (Eskandarani, Balady, Gabla, Halap) at summer 2004 and 2005 seasons are presented in Table(1). The results indicated that there are significant differences among the most selected lines and the populations ($S_0$) in their studied traits and the inbreed lines gave higher measurements for all evaluated vegetative traits as follows:

- Lines E2, B2, G2and H2 recorded the highest stem length, leaf area and plant fresh and dry weight.
- Lines E2, B2, G1and H2 recorded the highest leaf number.

The increment in the values of vegetative traits in selected lines may be attributed to the effect of selection. The superiority of selected lines over the original populations of the four cultivars suggested the efficiency of visual selection for maintaining the genes responsible for these traits. These results

agree with those of Helmy (1985), but don't agree with those of Abdel-al *et al*. (1973) and Borghi, (1976), who reported some inbreeding depression after two generation and Refaei (2001) who found that the ($S_0$) populations of El-Eskandarani cultivar gave the highest values in the most vegetative traits compared with its inbreed lines.

**Table (1): Performance of original population ($S_0$) of four cultivars and selected ($S_4$) lines in respect to vegetative traits in the summer seasons of 2004 and 2005.**

| Characters / seasons / Genotype | Stem length (cm) | | No. of leaves / plant | | Leaf area ($cm^2$) | | Plant fresh weight (g) | | Plant dry weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ٢٠٠٤ | ٢٠٠٥ | ٢٠٠٤ | ٢٠٠٥ | ٢٠٠٤ | ٢٠٠٥ | ٢٠٠٤ | ٢٠٠٥ | ٢٠٠٤ | ٢٠٠٥ |
| Eskandarani | 98.5 a* | 96.3 a | 24.2 a | 22.1 b | 485.0b | 446.6 b | 316.8b | 321.0b | 24.2b | 23.9b |
| E1 | 99.5 a | 98.5 a | 28.8 a | 25.1 ab | 524.9a | 520.3a | 388.5a | 378.6a | 25.8ab | 26.1 b |
| E2 | 101.5 a | 99.6 a | 28.2 a | 27.4 a | 552.3a | 529.4a | 422.0a | 405.0a | 27.6 a | 28.5 a |
| | | | | | | | | | | |
| Balady | 177.6 b | 171.6 a | 37.1 ab | 34.7 a | 551.2 b | 560.9 b | 487.1 b | 480.4 b | 34.7 a | 34.3 a |
| B1 | 155.5 b | 170.4 a | 33.1 b | 29.2 b | 559.1 b | 538.3 b | 379.1 c | 475.7 b | 32.5 a | 31.6 a |
| B2 | 184.5 a | 179.0 a | 40.3 a | 37.2 a | 648.0 a | 605.6 a | 545.6 a | 539.2 a | 35.9 a | 34.5 a |
| | | | | | | | | | | |
| Gabla | 84.5 b | 87.3 a | 21.1 b | 18.7 b | 312.5 b | 331.6 b | 263.7 b | 260.4 b | 22.4 a | 22.5 a |
| G1 | 85.5 b | 85.5 a | 24.5 a | 20.9 a | 318.6 b | 349.9 b | 309.2 a | 311.2 a | 21.4 a | 20.9 a |
| G2 | 97.5 a | 91.9 a | 23.3 a | 21.9 a | 387.6 a | 409.0 a | 334.2 a | 332.6 a | 23.5 a | 22.5 a |
| | | | | | | | | | | |
| Halap | 103.3 a | 102.4 ab | 18.9 b | 16.2 b | 333.2 b | 315.5 a | 265.0 b | 258.3 b | 19.3 b | 21.2 b |
| H1 | 98.5 a | 89.6 b | 22.9 a | 21.5 a | 327.1 b | 336.6 a | 266.8 b | 261.2 b | 20.5 ab | 19.8 b |
| H2 | 103.4 a | 105.5 a | 23.8 a | 22.3 a | 406.3 a | 330.4 a | 328.8 a | 304.7 a | 22.9 a | 24.8 a |

*** Any means in each group within the same column followed by the same letter are not statistically different at the 5% (Duncan's multiple range tests)**

**2- Flowering:**

Results on number of days to first pistillate flower, number of staminate and pistillate flowers/plant and sex ratio of the released selected lines and the original populations ($S_0$) of Eskandarani, Balady, Gabla and Halap cultivars in summer seasons of 2004 and 2005 are presented in Table( 2) . The results showed that there was significant difference among most of these genotypes in all studied traits.

From these data it is clear that the selected lines had the lowest values of number of days to first pistillate flower, while the original populations ($S_0$) (Eskandarani, Balady, Gabla and Halap cultivars) had the highest values. Data on number of staminate flowers/plant indicated that the original populations ($S_0$) gave the highest values however the lowest values in this trait were obtained from the selected lines.

From the sameTable it is clear that the selected lines produced the highest number of pistillate flowers, on other hand, the lowest values were obtained from the four original populations ($S_0$) of Eskandarani, Balady, Gabla and Halap cultivars. Regarding the sex ratio trait, it is clear that plants of original population of four the cultivars Eskandarani, Balady, Gabla and Halap gave the highest values,i.e., 1.27, 2.84, 0.98 and 0.97, respectively. While the selected lines E2, B2, G1 and H2 gave the lowest values for this trait.

From the pervious explanation, it can be noticed that the selection and inbreeding exhibit increment in pistillate flowers and decrement in staminate flowers, number of days for first pistillate flower and sex ratio. The superiority of the selected lines over the original populations ($S_0$) suggested that the efficiency of visual selection for maintaining the genes responsible for more pistillate flowers. These results agree with those of Metwally (1989), Refaei (2001) and Ercan and kurum (2003).

**Table (2): Performance of original population ($S_0$) of four cultivars and selected ($S_4$) lines in respect to some flowering characters in the summer seasons of 2004 and 2005.**

| Characters | No. of days to first pistillate flowers/plant | | No. of staminate flowers / plant | | No. of pistillate flowers / plant | | Sex ratio | |
|---|---|---|---|---|---|---|---|---|
| Seasons / Genotype | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 |
| Eskandarani | 47.8 a* | 47.3 a | 17.9 a | 18.0 a | 15.0 c | 14.1 b | 1.18 a | 1.27 a |
| E1 | 46.0 ab | 44.5 ab | 17.8 a | 14.6 b | 16.4 b | 15.7 ab | 1.08 a | 0.93 b |
| E2 | 44.5 b | 42.8 b | 14.5 b | 11.3 c | 17.7 a | 17.0 a | 0.81 b | 0.66 c |
| | | | | | | | | |
| Balady | 57.6 a | 57.9 a | 30.6 a | 31.3 a | 11.5 b | 11.0 b | 2.67 a | 2.84 a |
| B1 | 56.5 a | 55.9 a | 26.0 b | 26.7 b | 11.7 b | 12.5 ab | 2.22 b | 2.13 b |
| B2 | 55.0 a | 55.0 a | 29.9 ab | 28.5 ab | 13.6 a | 13.9 a | 2.20 b | 2.05 c |
| | | | | | | | | |
| Gabla | 43.2 a | 43.8 a | 16.5 a | 16.0 a | 17.8 b | 16.3 c | 0.92 a | 0.98 a |
| G1 | 39.8 b | 38.7 b | 16.6 a | 11.3 b | 19.0 ab | 19.5 b | 0.87 a | 0.58 c |
| G2 | 39.7 b | 40.9 ab | 14.5 b | 15.0 a | 19.8 a | 21.2 a | 0.72 b | 0.77 b |
| | | | | | | | | |
| Halap | 42.7 a | 42.9 a | 17.4 a | 17.4 a | 17.9 a | 19.3 a | 0.97 a | 0.91 a |
| H1 | 35.0 b | 36.1 b | 18.5 a | 13.4 b | 18.8 a | 19.2 a | 0.98 a | 0.69 b |
| H2 | 36.7 b | 36.1 b | 16.2 a | 12.5 b | 20.0 a | 20.4 a | 0.81 b | 0.61 c |

*** Any means in each group within the same column followed by the same letter are not statistically different at the 5% (Duncan's multiple range tests)**

### 3- Fruit characters:

The results of some fruit quality characters of the released selected lines ($S_4$) and the original populations ($S_0$) of the Eskandarani, Balady, Gabla and Halap cultivars are presented in Table (3). Significant differences were found among four original cultivars and their selected lines, where the selected lines were superior to their original populations.

In conclusion the selection affected fruit character particularly fruit weight and the differences among selected lines and their original cultivars may be attributed to the differences in genetic structure. These results in agreement with those of Gwanama *et al*. (1998), Refaei (2001) and Ercan and kurum (2003**)**.

**Table (3): Performance of original population ($S_0$) of four cultivars and selected ($S_4$) lines in respect to some fruit characters in the summer seasons of 2004 and 2005.**

| Characters | Fruit length (cm) | | Fruit diameter(cm) | | Fruit weight (g) | |
|---|---|---|---|---|---|---|
| Seasons / Genotype | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 |
| Eskandarani | 13.28 a* | 13.51 a | 2.91 a | 2.34 b | 82.85 b | 82.10 b |
| E1 | 14.03 a | 14.68 a | 3.15 a | 3.11 a | 83.25 b | 83.88 b |
| E2 | 15.83 a | 15.34 a | 3.20 a | 3.04 a | 98.10 a | 98.04 a |
| | | | | | | |
| Balady | 6.62 b | 6.37 b | 3.36 b | 3.50 b | 75.55 b | 75.53 b |
| B1 | 8.45 a | 8.31 a | 3.84 a | 3.64 b | 82.10 a | 85.06 a |
| B2 | 7.81 a | 7.33 ab | 4.07 a | 3.96 a | 80.57 a | 85.43 a |
| | | | | | | |
| Gabla | 7.81 a | 7.58 a | 3.36 a | 3.33 b | 64.73 b | 64.51 b |
| G1 | 8.34 a | 8.59 a | 3.55 a | 3.51 ab | 72.94 a | 73.38 a |
| G2 | 8.25 a | 8.27 a | 3.46 a | 3.70 a | 72.94 a | 72.00 ab |
| | | | | | | |
| Halap | 8.88 a | 8.59 a | 3..37 a | 3.19 b | 65.24 b | 65.24 c |
| H1 | 9.95 a | 8.29 a | 3.23 a | 3.65 a | 63.78 b | 76.12 b |
| H2 | 9.61 a | 9.35 a | 3.42 a | 3.70 a | 80.57 a | 81.24 a |

*** Any means in each group within the same column followed by the same letter are not statistically different at the 5% (Duncan's multiple range tests)**

**4- Yield:**

Results on yield and its component for the original populations ($S_0$) of Eskandarani, Balady,Gabla and Halap cultivars and the released selected lines($S_4$) are presented Table (4).

**Table (4): Performance of original population ($S_0$) of four cultivars and selected ($S_4$) lines in respect to early and total yield in the summer seasons of 2004 and 2005.**

| Characters | Early yield /plant (g) | | Total yield /plant (Kg) | |
|---|---|---|---|---|
| Seasons / Genotype | 2005 | 2004 | 2005 | 2004 |
| Eskandarani | 834.5 c* | 849 c | 2.033 c | 2.048 b |
| E1 | 942.25 b | 907.75 b | 2.208 b | 2.173 b |
| E2 | 1359.5 a | 1357 a | 2.463 a | 2.431 a |
| | | | | |
| Balady | 323 c | 343 c | 0.996 c | 0.787 c |
| B1 | 390.25 b | 400.75 b | 1.360 b | 1.382 b |
| B2 | 525 a | 534 a | 1.615 a | 1.615 a |
| | | | | |
| Gabla | 901.75 b | 796.25 c | 1.912 c | 1.987 b |
| G1 | 821 c | 880.5 b | 2.033 b | 2.035 b |
| G2 | 982.75 a | 963.5 a | 2.167 a | 2.205 a |
| | | | | |
| Halap | 823 b | 805.5 b | 1.871 c | 1.839 b |
| H1 | 861.5 b | 875.25 b | 1.965 b | 2.183 a |
| H2 | 1036.5 a | 1062.75 a | 2.127 a | 1.156 a |

*** Any means in each group within the same column followed by the same letter are not statistically different at the 5% (Duncan's multiple range tests)**

The results showed that there were significant differences among the selected lines and their original population's cultivars. It is clear that most of the selected lines are significantly higher than the original cultivars in respect to early and total yield

It was noticed from the obtained results that the selection was efficient in improving the productivity of the developed lines and this increment may be attributed to increment in pistillate flowers and percentage of fruit set in selected lines compared with their original populations (Table 2).These results agree with those of Helmy (1985), Metwally (1989), Gwanama *et al*. (1998) and Refaei (2001).

**5- Correlation among some characters of summer squash:**

The presence of high values of correlation coefficient (r) among some characters is a great help to plant breeders in their selection programs.
Correlation coefficients were estimated among pairs of traits 6 of the 12 genotypes in the two seasons (Tables 5 and 6).

It is clear that there is a significant negative correlation between vegetative growth and yield also between yield and sex ratio. On the other hand there is a significant positive correlation between vegetative growth and sex ratio. Similar results were reported by Refaei (2001).

**Table (5): Correlation coefficient (r) among early and total yield and some characters of summer squash in the summer seasons of 2004 and 2005.**

| Characters | Early yield | | Total yield | |
|---|---|---|---|---|
| | 2004 | 2005 | 2004 | 2005 |
| Stem length | -0.806** | -0.792** | -0.820** | -0.796** |
| Leaves number | -0.636* | -0.519* | -0.930* | -0.578* |
| Leaf area | -0.386* | -0.407* | -0.317* | -0.390 |
| Sex ratio | -0.893** | -0.856** | -0.911** | -0.874** |

***,** Significant at the 5% and 1%levels, respectively.**

**Table (6): Correlation coefficient (r) among sex ratio and some vegetative characters of summer squash in the summer seasons of 2004 and 2005.**

| Characters | Sex ratio | |
|---|---|---|
| | 2004 | 2005 |
| Stem length | 0.953** | 0.915** |
| Leaves number | 0.872** | 0.777** |
| Leaf area | 0.712** | 0.712** |

***,** Significant at the 5% and 1%levels, respectively.**

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## إنتخاب وتقييم سلالات مرباة داخلياً من قرع الكوسة

**صلاح الدين محمود المنياوى**

**قسم البساتين - كلية الزراعة - جامعة عين شمس - شبرا الخيمة- القاهرة – مصر**

أجري هذا البحث في أحدى المزارع الخاصة في منطقة كفر أبو حديد - محافظة الجيزة في عروتين لزراعة قرع الكوسة هما الصيفية و الخريفية وذلك من الفترة الممتدة من صيف ٢٠٠٢ وحتى صيف ٢٠٠٥. تم استخدام أربع أصناف من قرع الكوسة المصرية والسورية هي الاسكندرانى(E) و البلدى(B) و جبلة(G) و حلب (H). أجريت أربعة أجيال من التلقيح الذاتي المترافق مع الإنتخاب وتم الحصول على ٨ سلالات مرباة داخلياً من قرع الكوسة سميت كما يلي :E1, E2, B1, B2, G1, G2, H1, H2.

أظهرت النتائج أن التربية الداخلية المترافقة مع الإنتخاب أثرت على معظم صفات النبات حيث سجلت معظم السلالات المنتخبة زيادة معنوية مقارنة مع أبائها الأصلية في معظم الصفات المدروسة خاصة في عدد الأزهار المؤنثة و متوسط وزن الثمرة والمحصول الكلي والمبكر. من جهة أخرى سجلت السلالات المنتخبة إنخفاضاً معنوياً في عدد الأزهار المذكرة والنسبة الجنسية بالاضافة الى أنخفاض عدد الايام الازمة لظهور اول زهرة مؤنثة على النبات مقارنة بأباءها الأصلية . وجد ارتباط معنوي سالب بين بعض صفات النمو الخضري والمحصول وكذلك مع النسبة الجنسية بينما كان الارتباط موجب بين النسبة الجنسية وصفات النمو الخضري. وفي الخلاصة يمكن القول أنه يمكن استخدام هذه السلالات في برنامج تربية لاحق لإنتاج هجن محلية من قرع الكوسة.