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GROWTH AND YIELD OF INBRED ZUCCHINI SQUASH (*CUCURBITA PEPO* L.) LINES DEVELOPED UNDER ADVERSE CLIMATIC CONDITIONS

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ABSTRACT :

Five pedigree-inbred lines of zucchini squash (*Cucurbita pepo* L.) were developed from the open pollinated population of the cv 'Eskandrani'. The pedigree selection focused on the enhanced formation of female flowers under adverse climatic conditions of late summer planting in Assiut. Field trial of the five lines showed that while a pronounced elevated sex ratio was expressed, the number of leaves per plant, main stem length and number of nodes below the first female flower were reduced compared with the original cultivar. All the five developed lines greatly surpassed cv 'Eskandrani' in the total fruit yield. As high yield as 200% and 300% were produced by these lines relative to cv 'Eskandrani' during the winter and summer seasons, respectively. Among the five lines, 12-127-219 gave the highest total yield in both summer and winter seasons. Line 18-136-222 was comparable to 12-127-219 only when grown in summer. However, line 18-136-222 gave significantly lager portion of the total fruit yield that was harvested early than 12-127-219 and cv 'Eskandrani' in both seasons. It is proposed that line 12-127-219 and line 18-136-222 may be introduced for improving the intensive production of summer squash in southern regions of Egypt.

INTRODUCTION:

Immature fruit of zucchini-type summer squash (*Cucurbita pepo* L.) is a popular vegetable in Egypt. It can be produced almost as year-round crop. Bush type is desirable due to its suitability for the time- and space-intensive culture and production systems. Therefore, the bush type cultivar 'Eskandrani' instead of the prostrate type 'Balady' has became extensively grown nation-wide. Varietal trials conducted in different regions of Egypt indicated similarity or sometimes superiority of cv. 'Eskandrani', in terms of earliness and total yield, to several cultivar introductions and hybrid varieties (Damarany et al., 1995; Hassan, 1988; Waly and Nassar, 1978). These results suggest an adaptability of the cultivar to the climatic conditions prevailing in Egypt.

However, low sex ratio expression associated with a varying range of prostrate growth has been observed within the open-pollinated bush type cultivar 'Eskandrani' (Mohamed, 1996, Refaei, 2001). This was accounted to 56% in the summer and 43% in the winter plantings in

Assiut.Development of an improved homogeneous version of cv. 'Eskandrani' for high sex ratio and bush growth would be needed for the current intensive production of this vegetable crop (Mohamed, 1996; Refaei, 2001). Critical inspection via bulk negative selection procedure against low sex expression at the flowering stage in the seed production field has been suggested to control this phenomenon (Mohamed, 1996). Nevertheless, the fruit yield is mainly determined by the number of the harvested immature fruits (Damarany et al., 1995, Mohamed 1996). Thus both the sex ratio and the fruit set are important traits for realizing high yield. Elevating sex ratio alone, therefore, may not substantially associate with an increased yield and earliness unless the fruit set is high. Nevertheless, superior plants cannot be judged for the number of the harvested fruits until the end of the growing season when already random mating has occurred. The mature plants at the end of the growing season also become weak to be used in developing additional pollination and mature fruits containing high quality seeds.

From these points of view and because summer squash is tolerant to inbreeding (Hassan, 1988, Metwaly, 1989), line breeding procedures may be more efficient alternative to the bulk negative selection. Individual plants exhibiting high sex ratio could be selfed and then after number of generations the elite progeny families producing larger number of immature fruits and higher yield are screened. The objective of the present study, therefore, was to evaluate the summer and the winter performance of growth and yield of five pedigree-derived lines that were selected based on high expression of female flower formation under adverse climatic conditions of the late summer planting in Assiut.

MATERIALS AND METHODS:

This study was conducted in the Agricultural Experimental Station, Assiut University. The pedigree selection program started in 1996 with a population of 3500 plants of the zucchini type summer squash cv. 'Eskandrani' (*Cucurbita pepo* L.). Plants were screened mainly for expression of high sex ratio (female:male flowers). Also, screening for light green fruits and cylindrical shape was taken into consideration. Subsequently in the S_1 and S_2 progenies, the same procedure was followed and 51 and 31 individual plants were screened within the best families. In the S_3, the most elite 5 family lines were selected. Selection in this study was conducted under the prevailing natural photoperiod at about 27° 18´ N latitude during the late summer season in four consecutive years. The seeds in each season were sown during the first weeks of May. The maximum temperature during the growing months (May to July) was usually above 35°C and the average day temperature was above 30°C.

The evaluation study of the 5 S_3 lines was carried out subsequently both in the summer and in the winter seasons. The summer planting was during the first week of April while the winter planting was on mid-September. The 5 lines (9-121-212, 12-127-219, 18-136-222, 21-146-228, 22-147-229) along with the base population of open pollinated cv 'Eskandrani' were arranged in a randomized complete-block experiment with four replicates. Plants were grown 40 cm apart on the northern side of 4.2 m long and 0.8 m wide rows. Each plot consisted of 2 rows. Fruits (120-150 g) were harvested at 2 to 4 day-intervals during the summer and the winter seasons, respectively. Regular cultural practices for the production of squash crop were followed in this study.

Growth and yield measurements were recorded on 10 guarded and randomly sampled plants. These measurements were expressed as follows: 1) number of nodes developed below the first female flower, 2) sex ratio (number of the female: male flowers), main stem length (cm) and number of leaves of the 35- and 60-day-old plants, 3) relative early yield (weight of immature fruits harvested during the first 3 harvests as a percentage of the total harvested fruits) and the total yield (weight of immature fruits in all harvests) and 4) the percentage of fruit set (the total number of harvested fruits divided on the total number of the produced female flowers and multiplied by 100). The means were separated using Duncan's multiple range test at 0.05 level of the probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION:

Significantly higher sex ratio (Table 1) and percentage of fruit set (Table 2) were expressed by the five pedigree-derived lines than those of the base open pollinated cultivar 'Eskandrani'. In contrast, all the 5 inbred lines developed lower number of nodes below the first female flower (Table 2), reduced number of leaves and shorter main stem (Table 1). Correlation coefficients between the sex ratio and each of the number of nodes below the first female flower, main stem length and the number of leaves per plant were negative (Table 3). The above mentioned results indicate a prominent role of the selection for elevated female flower expression in changing plant growth type and vigor to an opposite direction. Fruit formation can represent a sink to the plant photosynthetic assimilates and thus vegetative growth is limited in the high sex ratio expressing plants.

High positive phenotypic correlation coefficients were detected for the sex ratio, number of leaves per plant and the main stem length between the 35- and 60-day-old plants and also between summer and winter measurements (Tables 1 and 2). This may be attributed to a strong female sex expression in the five developed inbred lines. It is well documented that increased temperature and both high light intensity and long photoperiod tend to reduce female flower formation (Hassan, 1988). Selection for greater tendency to develop female flower was made, in the present study, under adverse summer conditions. It seemed that such conditions imposed a high selection pressure to differentiate a more efficient expression during the development of the 5 inbreds.

Tendency towards enhanced female flower formation exerting a strong sink for assimilates was reflected in a tendency to set higher percentage of fruits (Table 2). Consequently, significant increases of early and total yield were exhibited in both the summer and the winter plantings (Table 2). All lines significantly surpassed the original open pollinated cultivar 'Eskandrani' in the total fruit yield. The increases in the total yield over the cv 'Eskandrani' was as high as 200% and 300% during the winter and summer growing seasons, respectively. From the agronomic point of view, the reduction in the plant growth (stem length and number of leaves) of the 5 lines may not be regarded as an inbreeding depression. Rather, it seemed as a break of the dominance of the vegetative growth stage towards balancing the assimilate distribution between vegetative and reproductive organs. In an earlier study, a negative correlation between the plant growth vigor (stem length and number of leaves) and both early and total yield in cv 'Eskandrani' was detected by Mohamed (1996). The author indicated that plants developing 5-7 leaf axils before producing the first female flowers are the most suitable for intensive cultivation of the zucchini squash. It was suggested that such forms could be attained by

selection of 35-day-old plants for increasing tendency to form female flowers.

Differences were detected among the five lines in the various growth parameters and the yield and its components (Tables 1 & 2). Line 12-127-219 and 18-136-222 produced the highest fruit yield in the summer season. The former line also gave the highest fruit yield in the winter season and this can be attributed to its high percentage of fruit set (Table 2). However, both lines were not the highest among the other lines in the sex ratio. Apparently, the high yield of the two lines seemed to be affected by their ability to set higher percentage of fruits (Table 2). The importance of considering selection for both the sex ratio and the percentage of fruit set is, therefore, suggested in the present study. These two traits are the components of the number of the harvested immature fruits. Yield of immature fruits in zucchini squash is greatly affected by the number of fruits (Damarany et al., 1995). In practicing the line breeding, plants may not be screened based on the number of harvested fruits as the plants will be weak at the end of the season to make selfing and developing mature fruits containing fully developed seeds. In this context, sex ratio is useful criterion as it could be differentiated at early flowering stage.

Table (1): The sex ratio (number of female: male flowers), number of leaves and the main stem length of 35-and 60-day-old plants recorded during the summer and the winter seasons in Assiut for a population of cv 'Eskandrani' and 5 inbred lines derived from it by pedigree-selection[(a)].

Line	Summer		Winter	
	35-day-old	60-day-old	35-day-old	60-day-old
	Sex ratio (female/male flowers)			
9-121-212	1.3 c	3.0 b	1.6 d	4.3 c
12-127-219	1.6 b	2.4 c	3.0 a	3.7 d
18-136-222	1.7 ab	2.5 c	2.2 c	3.9 d
21-146-228	1.9 a	3.2 a	2.3 c	4.8 b
22-147-229	1.8 a	3.2 a	2.6 b	5.1 a
'Eskandrani'	0.4 d	0.5 d	0.7 e	0.7 e
r [(b)]	0.91 **[(d)]		0.75	
r [(c)]	0.87 *[(e)]		0.99 **	
	Leaves/plant (No.)			
9-121-212	19.0 c	41.3 b	18.5 d	42.0 b
12-127-219	18.5 cd	34.5 c	20.0 cd	33.6 d
18-136-222	19.5 c	35.8 c	19.0 cd	36.8 c
21-146-228	20.0 bc	40.8 b	20.0 c	43.5 ab
22-147-229	21.3 b	38.8 b	22.0 b	38.0 c
'Eskandrani'	25.0 a	45.5 a	24.5 a	45.0 a
r [(b)]	0.77		0.4	
r [(c)]	0.94 **		0.95 **	
	Main stem length (cm)			
9-121-212	34.0 b	55.0 b	39.0 d	67.5 c
12-127-219	25.5 a	43.8 a	25.0 a	50.5 a
18-136-222	26.0 a	44.0 a	25.0 a	50.5 a
21-146-228	33.8 b	63.5 c	34.0 c	72.5 d
22-147-229	25.8 a	44.5 a	30.0 b	59.5 b
'Eskandrani'	55.0 c	87.5 d	50.0 e	91.0 e
r [(b)]	0.98 **		0.96 **	
r [(c)]	0.95 **		0.97 **	

[a] Means followed by the same letter(s) within column are not significantly different using Duncan's Multiple Range Test at 0.05 probability level.
[b] Phenotypic correlation coefficients between 35- and 60-day-old plants within each of the summer and the winter seasons, separately.
[c] Phenotypic correlation coefficients between the summer and the winter for each of the 35- and 60-day-old plants, separately.
[d], [e] significant at 0.01 and 0.05 probability levels, respectively.

Table (2): Number of nodes below the first female flower, fruit set percentage, relative early yield and total yield recorded during the summer and the winter seasons in Assiut for a population of cv 'Eskandrani' evaluated along with 5 inbred lines derived from it by pedigree-selection [a].

Line	Growing Season			
	Summer	Winter	Summer	Winter
	Nodes to the first female flower		Fruit set (%)	
9-121-212	5.5 b	5.0 a	32.0 c	32.6 e
12-127-219	5.0 a	5.0 a	45.0 a	50.0 a
18-136-222	5.0 a	5.0 a	44.7 a	44.4 b
21-146-228	6.3 c	5.0 a	36.9 b	40.3 c
22-147-229	5.0 a	5.0 a	34.4 b	35.4 d
'Eskandrani'	12.0 d	10.0 b	31.8 c	32.0 e
r [b]	0.99 **[d]		0.96 **	
	Relative early yield (%)[c]		Total yield (Ton/feddan)	
9-121-212	43.4 a	40.3 a	14.2 b	16.2 c
12-127-219	29.3 b	28.6 b	15.2 a	19.2 a
18-136-222	41.2 a	39.9 a	15.3 a	17.6 b
21-146-228	40.7 a	42.5 a	13.1 c	14.3 d
22-147-229	42.0 a	40.5 a	14.2 b	16.0 c
'Eskandrani'	30.6 b	25.9 b	4.7 d	8.5 e
r [b]	0.95 **		0.96 **	

[a] Means followed by the same letter(s) within column are not significantly different using Duncan's Multiple Range Test at 0.05 probability level.
[b] Phenotypic correlation coefficients between the summer and the winter seasons.
[c] Early yield relative to the total yield.
[d] Significant at 0.01 probability level.

Table (3): Correlation coefficients between the sex ratio (number of female:male flowers) and each of number of leaves per plant, main stem length, number of nodes below the first female flower, fruit set percentage, relative early yield and the total fruit yield in zucchini squash grown during the summer and the winter seasons in Assiut.

Traits	Sex Ratio	
	Summer	Winter
Leaves per plant	-0.76 [a] (-0.5) [b]	-0.5 (-0.38)
Main stem length	-0.9 ** [c] (-0.74)	-0.92 ** (-0.65)
Nodes to first female flower	-0.9 ** (-0.89**)	-0.82 * [d] (-0.93 **)
Fruit set percentage	0.5 (0.17)	0.76 (0.26)
Relative early yield	0.53 (0.73)	0.32 (0.84*)
Total fruit yield	0.89 ** (0.86*)	0.86 * (0.72)

[a] Values for the 35-day-old plants
[b] Between the parentheses are the values for 60 day-old plants.
[c], [d] Significant at 0.01 and 0.05 probability levels, respectively.

Out of the present study, lines 12-127-219 and 18-136-222 represent the most balanced form among the other lines for plant growth and yield. Thus these two squash lines are proposed for the intensive production in time and space. In particular, line 18-136-222 may be preferable than 12-127-219 for the summer production due to its higher percentage of the yield that can be obtained early during the first 3 harvests.

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نمو ومحصول سلالات كوسة زوكينى مستنبطه تحت الظروف المناخية المعاكسة

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تم انتخاب خمسة سلالات من الكوسة صنف اسكندراني بطريقة النسب، لتحسين تكوين الأزهار المؤنثة وعدد الثمار المنتجة للنبات. وقد تم الانتخاب تحت ظروف مناخية معاكسة لإنتاج الأزهار المؤنثة، وعند تقييم السلالات الخمسة للإنتاج الحقلى وجد أن كل السلالات تفوقت على الصنف الاسكندراني فى النسبة الجنسية كنتيجة لزيادة إنتاج الأزهار المؤنثة وصاحب هذا انخفاض لعدد العقد تحت أول زهرة مؤنثة ونقص في عدد الأوراق علي النبات وطول الساق الرئيسي. كما تفوقت كل السلالات في إنتاجها من المحصول الثمري على الصنف الاسكندراني بما يتراوح بين ٢٠٠- ٣٠٠% خلال الموسم الصيفي والشتوي علي التوالي. أعطت السلالة ١٢-١٢٧-٢١٩ أعلي محصول في كلا الموسمين وكانت السلالة ١٨-١٣٦-٢٢٢ مساوية في محصولها للسلالة ١٢-١٢٧-٢١٩ فقط في الموسم الصيفي إلا أن محصولها المبكر كان أعلي في كل من الموسم الصيفي والشتوي.

ومن هذه الدراسة فإن السلالتين ١٨-١٣٦-٢٢٢، ١٢-١٢٧-٢١٩ قد تكونا ذات فائدة في تحسين إنتاج الكوسة في جنوب مصر .