GENETIC ANALYSIS OF SEED YIELD AND RELATED TRAITS IN SUMMER SQUASH (Cucurbita pepo L.)

El-Mahdy I. Metwally*; R.M. Khalil** and B.I. El-Sawy*
* Dept. of Hort. Faculty of Agric., Khafr El-Sheikh.
** Dept. of Hort. Faculty of Agric., Minufiya University.

التحليل الوراثى لمحصول البذرة وبعض الصفات المرتبطة فى الكوسة

المهدى ابراهيم متولى ـ رشدى مختار خليل ـ بسيونى الصاوى
كلية الزراعة ـ جامعتى طنطا والمنوفية

ملخص البحث

أجريت هذه الدراسة بهدف قياس قوة الهجين والقدرة على الائتلاف والكفاءة الوراثية لعدد من الصفات المؤثرة على انتاج البذرة فى الكوسة ٠ أستخدم فى الدراسة خمسة سلالات نتجت بالتربية الذاتية لمدة ٥ أجيال ٠

ففى عام ١٩٨٦ أجريت كل التهجينات الممكنة فى اتجاه واحد للحصول على بذور الجيل الأول (١٠ هجن) ٠ فى عام ١٩٨٧ تم تقييم ١٥ تركيب وراثى هى عبارة عن الهجن العشرة مع آبائها الخمسة بزراعتها فى تجربة مصممة بطريقة القطاعات العشوائية الكاملة بثلاثة مكررات ٠ سجلت البيانات على الثمار التامة النضج (عددها لكل نبات ـ متوسط وزن الثمرة وطولها وقطرها ـ وزن ١٠٠ بذرة) ٠

بتحليل البيانات طبقا للموديل الأول ـ الطريقة الثانية المقترحة بواسطة جريفنج ١٩٥٦ أمكن استخلاص الآتى :ـ

١ ـ ظهرت قوة الهجن بصورة معنوية لجميع الصفات التى درست عندما حسبت على أساس متوسط الأبوين ولكنها كانت غير معنوية لجميع الصفات بالمقارنة بالأب الأفضل ٠

٢ ـ كان التأثير الغير تجميعى للجينات أهم من التأثير التجميعى فى وراثة جميع الصفات عدا صفة معامل البذرة (وزن ١٠٠ بذرة) التى تتأثر بكلا النظامين بدرجة متساوية تقريبا ٠

٣ ـ الكفاءة الوراثية بمفهومها الواسع كانت مرتفعة فى جميع الصفات بلا استثناء وبمفهومها الضيق كانت منخفضة فى جميع الصفات عدا متوسط طول الثمرة ومعامل البذرة فكانت متوسطة ٠

ABSTRACT

Seed yield and related traits have been genetically analyzed by means of 5x5 partial diallel cross. The results could be summarized as follows: 1) Heterosis as estimated over the mid-parents was significant for seed yield and mature fruit characteristics. Meanwhile, heterosis when measured from the better parent was insignificant for all traits. However the absence of significance over the better parent did not imply the absence of superior F_1 hybrid. 2) Non-additive gene effects were more important than additive gene effects for all traits except that of seed index in which both of additive and non-additive gene effects were important in the inheritance of such trait. 3) Heritability estimates in broad sence were high for all traits, while as estimates in narrow sense were moderate for seed index, average fruit length and it was low for the rest of the other traits.

INTRODUCTION

Summer squash is grown in Egypt mainly to produce fresh market fruits. However in the last few years, the price of its seeds in market is highly increasing. The seed yield per feddan ranged from 250-450 kg (El-Gazar, 1977 and Metwally, 1980). The possibility of a good source of vegetable fats and oil from cucurbits seeds has been exploited very little, although an oil content in seeds of *C. pepo*, *C. maxima* and *C. moschata* averaging 45 percent has been reported (Pangalo, 1930).

Seeds of *C. pepo* according to Curtis (1946) compared favorably with peanuts in percentage of fat and protein. Use of seeds for such purposes needs maximizing the seed yield production. Exploiting of heterosis in such crop can be good solution in method much the same as in hybrid corn (Curtis, 1939). One male row for two or three female rows, and all the staminate flowers are removed from the female rows, and cross-pollination is done by insects. The costs of hybrids production are very low when compared with that of the hybrid seed production from other vegetable crops (Metwally, 1985).

As a start the estimates of genetic variance and its components are of great importance as for the improvement of squash breeding programme. If the estimates of genetic variance indicate that the additive genetic variance or general combining ability is of major importance, the most effective breeding procedure will be the intra-population selection. While, hybrid program may be the appropriate choice, if the non-additive or specific combining ability is the major component (Cockerham, 1961).

Therefore, the aim of this investigation is to determine the gene action and interaction controlling the economic traits in C. pepo. At the same time to estimate the heritability to through the light on breeding procedure to be used for improving seed yield and its related traits.

MATERIALS AND METHODS

The genetic materials used in the present study included five varieties of summer squash, i.e., All Green Bush (A.G.B.),Eskandrani, Clarella, Zucchini Dark Green (Z.D.G.) and Gray Zucchini (G.Z.) All cultivars belong to Cucurbita pepo L.

Plants from each cultivar were selfed for five generation to end with an inbred lines from each cultivar. Then the half diallel crosses were done among the five lines to produce enough F_1 seeds in the winter season of 1986-1987 under plastic House. The experiment was conducted in the Experimental Farm at the Faculty of Agriculture, Khafr El-Sheikh during the summer season of 1987. The plot size was 8 m^2. Hills were spaced at 30 cm apart with one plant per hill. The experimental design was a randomized complete block with three replications. Each replication consisted of 15 plots which included

5 parents and 10 F_1 crosses. The cultural practices were done as followed by local growers. Mature fruits of ten plants from each plot were picked after maturity and the following data were recorded; number of mature fruits/plant, average mature fruit weight, length and diameter. Then seeds were extracted from each plot (10 plants), air dried and weighed. Seeds index was calculated as a weight of 100 dried seed.

Statistical analysis:

1- The amount of heterosis was determined as follows:

a- Over the mid parents % $= \overline{F}_1 - M.P. / M.P. \times 100$

b- Over the better parent $= \overline{F}_1 - \overline{B.P.} / \overline{B.P.} \times 100.$

2- Combining ability: Estimates of combining ability effects were carried out following Griffing's Method 2, Model 1. The method 2 employing parents and crosses without reciprocals in the analysis of variance as followed according to Griffing (1956). The estimates of GCA and SCA can be expressed in terms of additive, dominance and epistatic variance according to Matzinger and Kempthorne (1956) as follows:

$$\sigma^2 g = \frac{1}{2}\sigma^2 A + \frac{1}{4}\sigma^2 AA + \frac{1}{8}\sigma^2 AAA + \ldots\ldots\ldots\ldots\ldots\ldots etc.$$

$$\sigma^2 S = \sigma^2 D + \frac{1}{2}\sigma^2 AA + \sigma^2 AD + \sigma^2 DD + \frac{3}{4}\sigma^2 AAA + \sigma^2 AAD + \sigma^2 DDD + .etc.$$

$\sigma^2 AA$ = is the variance due to additive by additive epistatic interaction. With the assumption on that there is no epistasis, the total genetic variance can be estimated as follows:

$$\sigma^2 A = 2\sigma^2 g.$$

$$\sigma^2 D = \sigma^2 S.$$

3- Heritability:

a- In broad sense h^2 (b.s.) $= 2\sigma^2 g + \sigma^2 S / 2\sigma^2 g + \sigma^2 S + \sigma^2 e.$

b- In narrow sense h^2 (n.s.) $= 2\sigma^2 g / 2\sigma^2 g + \sigma^2 S + \sigma^2 e.$

RESULTS AND DISCUSSION

Manifestation of heterosis:

Heterosis over the mid-parents was highly significant for seed yield, average mature fruit weight and length with a values of 105.4, 60.8 and 22.7%, respectively (Table 3). However, it was significant for average mature fruit diameter with a value of 12.1%, while it was insignificant for number of mature fruits per plant and seed index.

The estimates of heterosis as measured from the better parent were insignificant for all traits. The absence of heterosis over the better parent did not imply the absence of superior F_1 hybrid (Table 1).

Combining ability:

The results obtained in this study (Table 2) indicated that GCA mean squares were highly significant for all traits with the exception of number of mature fruits per plant and average mature fruit weight. These results suggest that the additive gene effects are important. The mean squares for SCA were highly significant for all traits. These suggest that the non-additive gene effects are also important in the inheritance of these attributes. Accordingly, both additive and non-additive genetic effects were important for seed yield and most other related characters.

The estimates of GCA effects ($\hat{g}i$), (Tables 4&5) showed that All Green Bush cultivar had highly significant GCA effects for seed yield, number of mature fruits per plant and average mature fruit length. Clarella cultivar had highly significant GCA effects for seed yield, seed index and average mature fruit diameter. These results indicate that both All Green Bush and Clarella cultivars

Table (1): Seed yield and mature fruit characteristics of some varieties and their crosses in summer squash.

Genotypes	Seed yield g/plot	No. of mature fruits/ plant	Seed index g/100 seeds	Mature fruit characteristics		
				Weight kg.	Length cm.	Diameter cm.
Parents:						
1.All Green Bush	183.0	1.3	6.94	1.05	36.1	8.9
2.Eskandarani	159.3	1.2	6.35	0.95	23.5	10.5
3.Clarella	328.7	1.3	11.66	1.03	23.5	11.2
4.Zucchini Dark Green	92.0	1.0	7.84	0.50	24.5	9.0
5.Gray Zucchini	211.3	1.4	5.61	1.01	26.5	9.7
Crosses:						
1 x 2	605.0	2.3	9.35	1.34	35.0	10.0
1 x 3	558.0	1.7	9.98	1.57	33.3	10.8
1 x 4	515.0	1.9	7.89	1.68	40.3	10.5
1 x 5	271.3	1.4	7.67	1.28	36.0	9.7
2 x 3	482.7	1.4	10.30	1.70	31.2	12.5
2 x 4	243.0	1.5	6.91	1.73	33.7	12.3
2 x 5	342.7	1.2	9.87	1.49	32.6	11.7
3 x 4	399.3	1.5	10.65	1.38	29.9	11.3
3 x 5	280.0	1.5	8.02	1.03	25.3	10.4
4 x 5	306.0	1.2	7.82	1.40	31.9	11.6
L.S.D. 0.05	116.3	0.51	1.83	0.41	2.79	1.49
L.S.D. 0.01	156.7	0.69	2.47	0.55	3.76	2.00

Table (2): The analysis of variance and mean squares of the partial diallel crosses for seed yield and mature fruit characteristics in summer squash.

S.O.V.	d.f.	Seed yield g/plot	No. of mature fruits/ plant	Seed index g/100 seeds	Mature fruit characteristics		
					Weight kg.	Length cm.	Diameter cm.
GCA	4	18154**	0.06	6.44**	0.027	50.66**	1.88**
SCA	10	25302**	0.11**	1.70**	0.155**	17.57**	0.93**
Error	28	1612	0.03	0.40	0.019	0.93	0.26

Table (3): Estimates of some genetic parameters for seed yield and mature fruit characteristics in summer squash.

Genetic parameter	Seed yield g/plot	No. of mature fruits/ plant	Seed index g/100 seeds	Mature fruit characteristics		
				Weight kg.	Length cm.	Diameter cm.
$\sigma^2 A$	-2042.2	-0.015	1.35	-0.037	9.45	0.271
$\sigma^2 D$	23689.8	0.083	1.30	0.136	16.64	0.667
$\sigma^2 E$	1612.3	0.030	0.40	0.020	0.93	0.264
H% (M.P.)	105.4	25.8	15.2	60.8	22.7	12.1
H% (B.P.)	22.0	11.4	-24.1	39.0	-8.9	-1.3
h^2%(b.s.)	93.6	73.5	86.9	87.2	96.6	78.0
h^2%(n.s.)	-	-	44.3	-	35.0	22.5

$\sigma^2 A$ = Additive genetic variance.

$\sigma^2 D$ = Dominant variance.

$\sigma^2 E$ = Environmental error.

h^2(b.s.)= Heritability in broad sense.

h^2(n.s.)= Heritability in narrow sense.

Table (4): Estimates of general and specific combining ability effects for seed yield, number of mature fruits/plant and seed index in summer squash.

Parent	Characters	SCA effects 2	3	4	5	gca effects
All Green Bush	Seed yield g/plot	226.7**	124.6**	185.9**	-54.30	46.30**
	No.of mature fruits	0.67**	0.08	0.37**	-0.13	0.17**
	Seed index	1.40**	0.16	-0.03	0.37	-0.28
Eskan-darani	Seed yield g/plot		95.5**	-39.9	63.3**	0.20
	No.of mature fruits		60.06	0.13	-0.17	0.01
	Seed index		0.43	-1.06	2.52**	-0.23
Clar-ella	Seed yield g/plot			61.3**	-54.4	55.2**
	No.of mature fruits			0.14	0.14	-0.003
	Seed index			0.80	-1.21	1.65**
Zucc-hini Dark Green	Seed yield g/plot				75.9**	-49.1
	No.of mature fruits				-0.07	-0.09
	Seed index				0.50	-0.26
Gray Zucc-hini	Seed yield g/plot					-52.6
	No.of mature fruits					-0.09
	Seed index					-0.88

	S.E. (g_i)	S.E. (S_{ij})
Seed yield g/plot	13.57	27.71
No.of mature fruits/plant	0.06	0.12
Seed index g/100 seeds	0.21	0.44

** is significantly different from zero at 1% level of probability

Table (5): Estimates of general and specific combining ability effects for mature fruit characteristics in summer squash.

Parent	Mature fruit characteristics	SCA effects 2	3	4	5	gca effects
All	Weight	-0.05	0.24**	0.43**	0.02	0.05
Green	Length	0.44	0.57	4.96**	1.55**	4.50**
Bush	Diameter	-0.40	0.39	0.62	-0.06	-0.76
Eskan-	Weight		0.34**	0.45**	0.20**	0.07
darani	Length		3.84**	3.72**	3.46**	-0.83
	Diameter		0.84**	1.17**	0.69	0.50**
Clar-	Weight			0.16	-0.20	0.01
ella	Length			1.78**	-2.01	-2.66
	Diameter			0.18	-0.60	0.48**
Zucc-hini	Weight				0.25**	-0.07
Dark	Length				2.00**	-0.08
Green	Diameter				1.16**	-0.05
Gray	Weight					-0.06
Zucc-	Length					-0.94
hini	Diameter					-0.17

	S.E. (g_l)	S.E. (S_{ij})
Average mature fruit weight	0.048	0.097
Average mature fruit length	0.326	0.670
Average mature fruit diameter	0.174	0.354

** is significantly different from zero at 1% level of probability.

were good general combiner for the above mentioned characters. The local cv. (Eskandrani) had highly significant GCA effects for average mature fruit diameter, while both Zucchini Dark Green and Gray Zucchini cvs. had the poorest GCA effects. These results agree with those of Shalaby (1975) on sweet melon. He reported that GCA was greater than SCA for total number of fruits per plant and average weight of first fruit. Vashistha et al. (1984), working on watermelon, found that additive effects were important for number of fruits per plant, while non-additive effects were important for fruit weight. Brar and Nandpuri (1979) working on, water melon, reported that additive component of variance was important for fruit number per plant.

The crosses (1x2), (1x3), (2x3), (2x5), (3x4) and (4x5) showed highly significant positive SCA effects for seed yield. The crosses (1x2) and (1x4) had highly significant positive SCA effects for number of mature fruits per plant, while crosses (1x2) and (2x5) had highly significant positive SCA effects for seed index. The crosses (1x3), (1x4), (2x3), (2x4) and (2x5) had highly significant positive SCA effects for average mature fruit weight. The crosses (1x4), (1x5), (2x3), (2x4), (2x5), (3x4) and (4x5) had highly significant positive SCA effects for average mature fruit length, while the crosses (2x3), (2x4) and (4x5) had highly significant positive SCA effects for average mature fruit diameter. This could indicate that All Green Bush and Clarella cultivars uniformly transmit their high performance to their F_1's.

Heritability:

Heritability in both broad and narrow sense are very important and should be recognized as a first step before starting any breeding program. In the present investigation, the estimates of heritability in broad sense were high for all traits with an estimated value of 93.6%, 73.5%, 86.9%, 87.2%, 96.6% and 78.0% for seed yield, number of mature fruits per plant, seed index, average mature fruit weight, average mature fruit length and average mature fruit diameter, respectively.

Heritability estimates in narrow sense were moderate for seed index and average mature fruit length with a value of 44.3% and 35.0% respectively. This could indicate that a major part of the total phenotypic variance is due to additive gene effects. Accordingly, phenotypic selection could be effective for these economic traits. However, heritability estimates in narrow sense were low or very low for the other traits. This could indicate that a major part of the total phenotypic variance is due to non-additive (dominace and/or over-dominance) gene effects. Accordingly, hybridization program may be the appropriate choice. Brar and Nandpuri (1979) found in watermelon that heritability estimates in broad sense was high for number of fruits per plant.

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