J. Agric. Sci. Mansoura Univ., 34 (12): 11341 - 11354, 2009

STUDIES ON SOME STRAWBERRY HYBRIDS PRODUCTION AND THEIR FIELD PERFORMANCES

Abd Ellatif, Amany A.[1]; A. E. Omran[1]; M. K. Hatem[2] and M. E. Ragab[3]

1- Potato and Vegetatively Propagated Crops Dept., Hort. Res. Institute, ARC, Giza, Egypt

2- Plant breeding Dept., Hort. Res. Institute, ARC, Giza, Egypt

3- Hort. Dept., Fac. of Agric., Ain Shams Univ., Cairo, Egypt

ABSTRACT

This study was carried out at the Barrage Horticulture Research Station, Qaluobia Governorate, and the Strawberry Improvement Center, Faculty of Agric., Ain Shams Univ. during the period from 2005 to 2009. The aim of this study was to produce and selected some local promising strawberry hybrids from the commercial cultivars through the traditional crossing method. Four potential cultivars i.e., Sweet Charlie, Diamonte, Camarosa and Vantana were used in the crossing and six hybrids were chosen and evaluated in the nursery stage and also for yield and fruit quality in two seasons. The study aimed also to determine the average degree of heterosis (ADH) regarding some horticultural characters viz., yield component, and fruit physical and chemical characteristic for the obtained hybrids. This knowledge about this sort of genetics would be helpful to the plant breeder for planning a successful breeding program. Results revealed that hybrid K102 (Kanater 102) exhibited the highest values in total yield, average fruit weight, fruit firmness and total soluble solids content as compared with its parents suggesting hybrid vigor for these traits. Hybrid K101 showed the highest values of average fruit weight, total soluble solids, ascorbic acid content and the lowest total acidity as compared with the parents. Also, K105 gave the highest values of number of fresh and dormant transplants and the lowest values of total acidity. Results indicate also that K 106 showed the highest values of total plant yield and average fruit weight as compared with the parental cultivars. Hybrids, K103 and K107 showed the highest values in fruit firmness and average fruit weight respectively as compared with the parents. Also, Sweet Charlie and Camarosa parents were the highest in early yield per plant and average fruit weight respectively. In general, the results on heterosis showed that most produced hybrids exhibited higher values than the better parent concerning most studied traits. The observed hybrid vigor for these traits encourages the production of F_1 hybrids in strawberry for commercial production.

The study concludes that six new local strawberry hybrids have been produced with high productivity and desirable eating quality than their parents.

Keywords: Strawberry, Hybrid production, Yield, Fruit quality, Heterosis.

INTRODUCTION

Strawberry is one of the most important cash crops for local consumption and export. From 1980 to 2008 a lot of strawberry cultivars were introduced and evaluated under the Egyptian conditions, some of them were promising and others did not perform. Strawberry cultivar breeding can be explained by the expansion of strawberry culture into the world areas characterized by diverse climatic condition and market demands. There is a strong demand for strawberries throughout the winter and spring season

(December to April).Early flowering cultivars are highly desirable, also eating quality is becoming more important in determining the value of a new variety.

An increase in strawberry fruit production in Egypt was observed in the last two decades. The cultivated strawberry (*Fragaria x ananassa* Duch.) is an octabloid Species which originated by natural hybridization between wild octaploid species, *F. chiloensis* and *F. virginiana*. The commercial strawberry cultivars in Egypt are introduced from USA and some other countries having similar climatic conditions. Some of these new varieties are patant and growers or exporters pay the royalties (Breeding rights) to the distributers of these varieties. Thus increase the importance of producing local hybrids or cultivars with disrable eating quality for local and export markets. Vitamin C content has been shown to be polygenic as found by Lal and Seth (1979). Moreover, Zubov and Stankevich (1982) demonstrated that significant seedling variation in fruit anthocyanin and vitamin C. contents. They also used the American selection line MDUS 3816 (NJ 459 x MDUS2927) with large round shape to improve fruit weight of Italian strawberry. Fruit firmness is needed for preserving fruit quality during the harvest and shipping, the values of this trait can be predicted from the average of parental values (Shaw *et al* 1987). In this respect, Shaw (1988) found little differences in the soluble solids and total sugars in his breeding populations. Also soluble solids and acidity are controlled by additive and dominance genes. In the study of Faedi *et al*., (1997), fruit size and firmness were negatively correlated. Simpson *et al*., (1997) released a new cv. named Sophie which can be harvested up to 14 days after *Elsana* cv. Izhar (1997) selected infra Short-day strawberry cultivar which differentiate flower buds during long day (13.5 hours). Its production peak was during winter, this is particularly appreciated in mild climate areas where protected cultivation concentrated fruit yield of good quality in the period of very high prices. The emphasis of the breeding program is to develop short-day or day- neutral varieties adapted to mild winter with high yield and good quality including fruit weight, firmness, total soluble solids, anthocyanin and vitamin C content. Ahmed (2009) and Kim *et al*., (1999) demonstrated that significant differences in number of daughter plants were obtained among strawberry cultivars in the nursery. In Spain, Refoyo and Arenas (2008) made around 120 crosses and planted around 10.000 seedlings. They selected around 200 plants and tested them for two seasons. They released 3 cultivars namely Cisco, Fun Color and Pedrone with good early and total yield and excellent quality (high total soluble solids and firmness as well as good external and internal color). Therefore, the objectives of this study were to investigate the possibility of producing some local strawberry hybrids for local consumption and export through traditional hybridization among the existed commercial cultivars in an attempt to reduce the importation of the mother plants from such patent varieties as well as reducing amounts of Royalties which should be paid yearly by the export strawberry producers to the variety distributers

MATERIALS AND METHODS

This study was carried out at Barrage Horticulture Research Station, Qaluobia Governorate, and Strawberry Improvement Center, Faculty of Agric., Ain Shams University, Shoubra El-Kheima, and its experimental farm at Ismailia during the period from 2005 to 2009. In this study four commercial strawberry cvs viz., Sweet Charlie, Diamante, Camarosa and Vantana were used as parents. Plants were planted in 15th September in four rows bed system, on beds with 120 cm width and 50 cm height at plant distances of 25 cm apart. The plot area was 12 m^2 (1.2 m x 10 m) having 160 plants and a complete block design with 3 replicates was used. The beds were covered with 40 micron clear plastic tunnels (70 cm height). Drip irrigation was used. The soil texture of the experimental site was clay with pH 8.2 and EC of 1.6 mm. All agricultural practices concerning cultivation, irrigation and pest and disease control were conducted as commonly followed for commercial production of strawberry.

Table (A): The four parental cultivars were crossed during flowering period to produce the F_1 seeds as shown

Parents	F_1 crosses
Sweet Charlie	K 101= Sweet Charlie x Diamonte
Diamonte	K 102= Sweet Charlie x Camarosa
Camarosa	K 103= Sweet Charlie x Vantana
Vantana	K 105= Diamonte x Camarosa
	K 106= Diamonte x Vantana
	K 107= Camarosa x Vantana

Hybrid seeds for each cross were extracted from ripe fruits and air dried then treated with H_2SO_4 (95%) for one minute as described by Okasha (1980). Seeds were washed with distilled water and then cultured on sterilized peat moss + vermiculite (2:1) medium in jars (500g) size and kept in growth chamber at 25 °C in addition to 16h light and 8h dark. Seedlings were transferred after 45 days to adaptation medium (2 peat moss +1 vermiculite) under low plastic tunnel for one month, then each individual hybrid seedling from the F1 hybrids was planted in 10 cm plastic cub filled with the same medium for 3 weeks. Twenty plants from each group were planted in sandy soil in Ismailia Experimental Farm, to propagate the plants. Nursery planting date was 15th May 2006. Each plant was separated 1x1m by plastic sheets (15cm height) Plants were evaluated in the nursery and data were recorded on number of fresh and frigo transplants/plant. In September 13th, 60 fresh transplants from each hybrid were dug out from the nursery and planted in the same day on four rows beds system as the above mentioned method in three replicates and evaluated for fruit production, in addition to, the four parents. Data were recorded as follows: number of leaves per plant, plant height (cm), twenty plants from each obtained hybrid (6) were left in the nursery until late December and kept in the refrigerator at -2 °C until 10th May 2007 to be propagated in the nursery and produce fresh transplants in 13th

September 2007. According to the obtained data in the first season, six promising hybrids were chosen and evaluated for yield and its components in the second season and planted on 17th September 2008.
Data were recorded as follows:-

1. Vegetative growth characters of transplants.

Representative samples of ten plants from each experimental plot were randomly chosen and the following data were recorded.

1..1. Number of fresh transplants/m^2 for fresh plantations was calculated in late August.

1.2. Number of dormant transplants for frigo plantations/m^2 and Fadden was calculated in late December

1.3. Number of leaves/plant

1.4. Plant height (cm)

2. Early and total yield:

2.1. Early yield (g/plant): It was determined as weight of all harvested fruits from each plot for the first ten harvest (December and January) and the average early yield per plant was calculated.

2.2. Total yield (g/plant): The weights of all harvested fruits all over the season from each plot were used to calculate the average total yield per plant.

3. Physical characteristics of fruits: Samples of ten fruits from each experimental plot at the 3/4 color stages were randomly chosen at February1st to determine the following characters:

3.1. Average fruit weight (g): five fruits from each experimental plot were weighed and average fruit weight was calculated.

3.2. Fruit firmness: it was determined by using a Shatillon penterometer (g/cm^2).

4. Chemical characteristics of fruits:-

They were measured in mid season (February 1st) as follows:-

4.1. Total soluble solids (TSS): The percentage of total soluble solids content was determined using the hand refractmeter.

4.2. Total titratable acidity (TA) and ascorbic acid content (mg/100g F.W.) were determined according to the methods described in A.O.A.C. (1990).

4.3. Anthocyanin (mg/100 gm f.w.) was determined as the method described by De Loose (1970).

5. Average degree of heterosis (ADH%): it was estimated for seven obtained hybrids according to Sinha and Khanna (1975**)** as follows:- Heterosis was only measured for the F_1 hybrids whose parental lines significantly differed in the trait. It was estimated, firstly, according to the mid-parental values, then it was estimated in relation to the better parent, for only the hybrids' which showed dominance toward the better parent as follows:-

Mid parent heterosis (MP) = F_1-MP /MP x 100

High parent heterosis (HP) = F_1- HP /HP x 100

6. Statistical analysis:

Data were statistically analyzed according to the analysis of variance for the complete randomized design. Duncan's multiple range test was used for the comparison between means (Waller and Duncan, 1969).

RESULTS AND DISCUSSION

I. Vegetative growth characteristics:-

1.1. Number of fresh transplant/m^2 and per feddan:

The highest numbers of fresh transplants/m^2 and per feddan were detected to K105 hybrid. On the contrary, the lowest values were obtained from Vantana and Diamonte in the two tested seasons with significant difference between them in the first season (Table 1). These results agree with those of Kim *et al*. (1999) who demonstrated that significant differences in number of daughter plants were obtained among used cultivars in the nursery. Increasing number of transplants/plant is considered the main target for the nurserymen to reduce the total cost and increase their net return from transplants business industry as mentioned by Adam *et al*. (2002) and Mohamed *et al*. (2002) who detected significant differences among some tested strawberry genotypes**.**

Table (1): Number of fresh and frigo transplants for six promising strawberry hybrids and their parents in 2006/2007 and 2007/2008 seasons.

Genotypes	No. of fresh transplants /m^2		No. of fresh transplants /feddan (1000)		Number of frigo transplants/ m^2		Number of frigo transplants/ Fedden (1000)	
F_1 Crosses	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008
K101	93.37 c	93.03 c	392.154	390.726c	199.3 b	208.3 b	837.06 b	874.86 b
K102	73.87 d	48.23 f	310.254d	202.566f	129.7 e	127.7 e	544.74 e	536.34 e
K103	111.2 b	105.2 b	467.040b	441.840b	120.0 ef	118.0 f	504.0 f	495.6 f
K105	139.40 a	133.60 a	585.480a	561.120a	228.7 a	227.3 a	960.54 a	954.66 a
K106	51.57 f	56.60 e	2166.594	237.720e	95.67 g	87.33 h	401.85 h	366.78 h
K107	62.30 e	60.53 e	261.660e	254.226e	201.0 b	120.7 f	844.45 b	506.9 f
Parental cultivar								
Sweet Charlie	89.07 c	85.77 d	374.094c	360.234d	161.7 d	165.2 d	679.14 d	693.84 d
Camarosa	44.27 g	48.20d	185.934g	202.440d	132.5 e	117.3 f	556.5 e	492.66 f
Vantana	29.07 i	34.87 g	122.094i	146.454g	64.50 h	73.0 i	275.1 i	306.6 i
Diamonte	36.58 h	37.92 g	153.636h	159.264g	108.0 f g	98.67 g	453.6 g	414.4 g

Values in same Colum followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5%level

1.2. Number of dormant transplants/m^2 and per feddan.

Results shown in Table (1) revealed that the highest number of dormant strawberry transplants per square meter and per feddan was obtained from hybrid K105. On the other hand, the lowest values were obtained from Vantana in the two tested seasons. The results are in agreement with Okasha *et al*. (2003) and Ahmed (2009).

Table (2): Number of leaves and plant length for six promising strawberry hybrids and their parents in 2006/2007 and 2007/2008 seasons.

Genotypes	Number of leaves/ plant		Plant height (cm)	
F_1 Crosses	2007/2008	2008/2009	2007/2008	2008/2009
K101	7.967a	8.967b	11.53de	18.30a
K102	6.300d	7.100d	11.07ef	15.00c
K103	6.067d	6.433e	11.63de	12.63fg
K105	6.533d	6.833de	12.07cd	13.80de
K106	8.400b	6.400e	12.57bc	16.20b
K107	9.300a	6.600de	10.67f	13.53e
Parental cultivar				
Sweet Charlie	7.700c	8.033c	13.10b	12.50g
Camarosa	8.267b	9.000b	15.57a	11.57h
Vantana	8.900a	8.667b	15.20a	14.40cd
Diamonte	9.100a	10.170a	12.13cd	11.03h

Values in same Colum followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5%level

1.3. Number of leaves/ plant:-

In Table (2) results indicate that the hybrid K101, K107, Vantana and Diamonte exhibited the highest values of number of leaves in the first season. Also, Diamonte followed by Vantana, Comarosa and K101 produced the highest values in the second season with significant difference between Diamonte and the other three genotypes in the second year. On the other hand, the lowest values were obtained from the hybrids K102, K103 and K105 in the two tested seasons in addition to K106 in the second season. The results agree with those of Okasha *et al*. (2003), who found significant differences among some strawberry genotypes in number of leaves /plant.

1.4. Plant height:

Data in Table (2) show that the highest values of plant height in the first season were obtained from Camrosa and Vantana cultivars while in the second season it was obtained from hybrid K101. On the other side, the lowest values were obtained from K102 and K107 hybrids in the first season and from Camarosa and Diamonte in the second season. Similar results were recorded by Mohamed *et al*. (2002), who found significant differences in some strawberry strains regarding to plant height**.**

2. Yield:

2.1. Early yield:

In Table (3), the highest values of early fruit yield per plant were obtained from K105 and Sweet Charlie genotypes in the first season and from Sweet Charlie in the second season. Also, the highest early fruit yields/feddans were obtained from K105 in the first season and from Sweet Charlie in the second season. The lowest early yield was obtained from K103 hybrid and Diamonte in the first and the second seasons respectively. The results confirm those of Simpson *et al*. (1997), Okasha *et al*. (2003), Adam *et al*. (2008) and Refoyo and Arenas (2008), they found differences in early yield among strawberry genotypes.

2.2. Total yield:

It is clear from Table (3) that total plant yield was the highest in hybrids K102 and K106 in the two experimental seasons as well as Sweet Charlie in the second season. The lowest values were obtained from K103 in the two tested seasons in addition to K107 in the first season.

Results indicate also that the highest total yield per feddan was obtained from K102 hybrid in the two tested season as well as K106 in the first season. The lowest total yield was obtained from K103 in the two seasons as well as K107 in the first season. The results confirm those of Izhar (1997), Ragab *et al*. (2000) and Ahmed (2009).

Table (3): Early yield and Total yield of fresh transplants for six promising strawberry hybrids and their parents in 2006/2007 and 2007/2008 seasons.

Genotypes	Early yield / plant (g)		Early yield / Feddan (ton)		Total yield /plant(g)		Total yield/ Feddan (ton)	
F_1 Crosses	2007/2008	2008/2009	2007/2008	2008/2009	2007/2008	2008/2009	2007/2008	2008/2009
K101	55.97 b	68.30 bc	2.351 cd	2.869c	310.9 d	330.2 bc	12.440 c	13.870 c
K102	53.03 b	55.10 de	2.227 de	2.314 de	488.9 a	426.8 a	19.550 a	17.930 a
K103	36.53 c	49.58 e	1.534 h	2.082 e	231.1 e	246.5 e	9.240 d	10.350 e
K105	92.27 a	67.60 c	3.875 a	2.839 c	436.9 b	337.0 bc	17.480 b	14.160 c
K106	58.30 b	68.40 bc	2.449c	2.873 c	490.1 a	405.8 a	19.470 a	17.040 b
K107	56.57 b	65.07 c	2.376cd	2.733c	245.8 e	314.3 bc	9.834 d	13.200 c
Parental cultivar								
Sweet Charlie	86.04 a	86.07 a	3.616b	3.615 a	418.3 b	435.2 a	16.530 b	18.280 b
Camarosa	46.33 bc	42.67 f	1.946fg	1.792 f	424.0 b	301.2 bc	16.960 b	12.650 cd
Vantana	50.33 bc	57.60 d	2.111bef	2.419 d	450.0b	293.4 cd	18.00 ab	12.310cde
Diamonte	45.67 bc	35.60 g	1.918 g	1.495 g	420.0 b	253.5 de	16.800 b	10.650 de

Values in same Colum followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5%level

3. Physical fruit characteristics:

3.1. Fruit weight:

Results shown in Table (4) indicate that most of the obtained hybrids produced bigger fruits than their parents. Whereas, the highest values were obtained from K101, K102, K106 and K107 but the lowest values were obtained from Sweet Charlie and Camarosa cvs in the two tested seasons in addition to Vantana in the second season. Producing such new hybrids with bigger fruit weight is needed for fresh consumption and processing in some specific markets for export and for reducing labour cost for harvest. Similar results have been obtained by Mohamed *et al.* (2002) and Ahmed (2009). They found significant differences among strawberry genotypes in fruit weight.

3.2. Fruit firmness:

Significant differences were detected among the produced hybrids and their parents in fruit firmness as shown in Table (4). Results indicate that the highest values were obtained from hybrids K102 and K103 in the two seasons, in addition to K101, Camarosa and Vantana in the first season and K105 in the second season. On the other side, K107 produced soft fruits in the two tested years. Fruit firmness is one of the most important quality parameters for local and export markets which increase shelf life and

storability as found by Shaw *et al*. (1987), moreover, crossing and selecting such firm hybrids was an important goal for the strawberry breeding program. Fruit firmness is needed for preserving fruit quality during the harvest and shipping. Similar results were recorded by Refoya and Arenas (2008). From the obtained results, fruit weight and firmness were negatively correlated in some hybrids i.e., K106 and K107 as found by Faedi *et al*. (1997) and Okasha *et al*. (2003). Others were positively correlated i.e., K101 and K102.

Table (4): Fruit weight and firmness for six promising strawberry hybrids and their parents in 2007/2008 and 2008/2009 seasons.

Genotypes	Fruit weight (g)		Firmness (g/cm^2)	
F_1 Crosses	2007/2008	2008/2009	2007/2008	2008/2009
K101	31.03 a	26.86 a	483.3 ab	450.0 c
K102	26.87 ab	22.40 abc	475.0 abc	483.3 a
K103	22.57 bc	18.33 cd	491.7 a	475.0 ab
K105	19.90 c	18.75 cd	450.0 bc	476.7 a
K106	26.07 ab	25.46 ab	441.7 c	406.7 e
K107	28.13 a	21.97 abc	300.0 e	376.7 f
Parental cultivar				
Sweet Charlie	11.71 d	11.97 e	375.0 d	341.7 g
Camarosa	13.26 d	14.97 de	461.0 abc	425.0 de
Vantana	20.67 c	20.97 de	475.0abc	456.7 bc
Diamonte	19.33 c	17.63 cd	438.3 c	441.7 cd

Values in same Colum followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5%level

4. Chemical characteristics of fruits:

4.1. Total soluble solids:

From date presented in Table (5) hybrids K101 and K102 exhibited higher significant values of T.S.S as compared with their parents in the two tested seasons. These results agree with those of Izhar (1997) and Refoya and Arenas (2008). Moreover, no significant differences were detected between the used parents and hybrids K105 and K107 in the two tested years as reported by Shaw (1988).

4.2. Total titratable acidity:

As for titratable acidity, results shown in Table (5) indicate that the highest significant values were detected to Vantana cv. On the other hand, the lowest values were obtained from hybrid K101 and K105 in the two tested seasons. Little differences were recorded among the other hybrids as reported by Shaw (1988) and Yuji *et al*. (2008).

4.3. TSS / acidity ratio:

It is clear from Table (5) that TSS/acidity ratio indicates that the highest significant values were detected to hybrid K105 in the first seasons but in the second season, the highest values were from hybrid K101. However, the lowest values were obtained from Vantana cv in the two tested**.** The current results are in agreement with those obtained by Ragab (2000) who found significant differences in this trait among Camarosa, Sweet Charlie, Chandler and Rosalinda.

Table (5): Titratable acidity, total soluble solids and TSS/acid ratio of fresh transplants for six promising strawberry hybrids and their parents in 2007/2008 and 2008/2009 seasons.

Genotypes	Titratabl acidity (mg/100g.)		T.S.S (%)		TSS / acid ratio	
F_1 Crosses	2007/2008	2008/2009	2007/2008	2008/2009	2007/2008	2008/2009
K101	0.196 cd	0.128 e	11.67 ab	12.00 a	59.54b	93.75a
K102	0.334 b	0.140 de	13.00 a	11.17 ab	38.92e	79.79b
K103	0.341 b	0.211 bc	10.67 bc	10.00bcd	31.29j	47.39f
K105	0.126 d	0.127 e	8.17 d	7.17 f	64.84a	56.46c
K106	0.226 c	0.196 bcd	7.67 d	10.83 abc	33.94h	55.26e
K107	0.253 c	0.242 b	8.66 cd	8.67 def	34.23g	35.83i
Parental cultivar						
Sweet Charlie	0.240 c	0.245 b	9.33 cd	9.67 bcde	38.88f	39.47h
Camarosa	0.219 c	0.247 b	8.59 cd	8.37 def	39.22d	33.89j
Vantana	0.478 a	0.374 a	7.87 d	8.50 def	16.46k	22.73k
Diamonte	0.184 cd	0.179 cde	8.00 d	8.00 ef	59.54c	44.69g

Values in same Colum followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5%level

4.4. Ascorbic acid content:

As for ascorbic acid content, results in Table (6) show that it increased significantly in hybrid K107 in the two tested seasons as well as hybrid K101 in the second season as compared with the parents Sweet Charlie and Diamonte. Similar results were reported by Zubov and Stankevich (1982), Okasha *et al*. (2003) and Refoyo and Arenas (2008), they found significant differences in this trait.

4-5- Anthocyanin content:

As for anthocyanin content, results shown in Table (6) indicate that significant differences were detected among the obtained hybrids and their parents whereas; the highest values were detected to Camarosa as well as K107 hybrid. On the other hand, the lowest value was detected to K101 in the two tested seasons. These results are similar to those obtained by Zubov and Stankevich (1982) and Refoyo and Arenas (2008)

Table (6): Ascorbic acid and Anthocynin of contents for six promising strawberry hybrids and their parents in 2007/2008 and 2008/2009 seasons.

Genotypes	Ascorbic acid (mg/100g f.w.)		Anthocynin (mg/100 g. f.w.)	
F_1 Crosses	2007/2008	2008/2009	2007/2008	2008/2009
K101	70.23 bc	71.37 a	58.76j	55.90i
K102	61.70 d	59.56 d	68.10i	126.80e
K103	71.61 bc	63.90 c	129.23f	126.80e
K105	72.09 b	56.23 e	92.03h	90.40g
K106	62.33 d	60.63 cd	130.87e	125.70e
K107	83.41 a	70.37 ab	162.23b	155.10c
Parental cultivar				
Sweet Charlie	62.16 d	63.87 c	56.60k	60.43h
Camarosa	70.15 bc	69.37 ab	168.57a	170.00a
Vantana	69.38 bc	72.10 a	154.30c	159.60b
Diamonte	68.18 c	67.30 b	140.03d	135.90d

Values in same Colum followed by the same letter do not significantly differ from each other according to Duncan's multiple range tests at 5%level

5. Heterosis for yield components

It is clear from results in Table (7) that from the seven obtained F_1 hybrids, significant differences were observed between the parents of 2 and 3 crosses in early yield, fruit weight per plant and total yield, respectively.

5.1. Early yield per plant.

Of the one cross whose there parents significantly different in early yield, the hybrid K102 reflected significant positive heterosis value (34.83%) based on the mid-parent value. This value suggests dominance towards the high early yield (Table 7). The results confirm those of Okasha *et al*. (2003).

Table (7): Estimation of heterosis % based on mid-parent (MP), for yield and some fruit characters in six strawberry hybrids.

Hybrids	Characters								
	Yield components		Fruit physical characters		Fruit chemical components				
	Early yield / plant	Total yield / plant	Firmness	Fruit weight	T.S.S	Titratable acidity	T.S.S / acidity	Ascorbic acids	Anthocynins
K101	-17.92**	-25.11**	13.73**	91.70**	35.64**	-17.71*	63.41**	17.63**	-2.09
K102	34.83**	12.61**	11.77*	65.96**	68.57**	40.38**	19.42	-8.07*	39.22**
K103	-22.86**	-19.95**	13.73**	37.34**	-10.87	-3.15**	-8.87	-4.57	-39.79**
K105	-31.31**	-22.05**	-47.45**	37.96**	0.76	6.51	-6.29	54.86**	64.15**
K106	-22.61**	12.12**	3.92	48.67**	-10.87	-3.57	-8.28	-6.26*	48.97**
K107	-20.58**	-47.14**	9.43*	38.46**	44.66**	2.92	14.91	6.91	-12.01**

Table (8): Estimation of heterosis %based on high parent (HP), for yield and fruit characters.

Hybrids	Characters								
	Yield component		Fruit physical characters		Fruit chemical components				
	Early yield / plant	Total yield / plant	Firmness	Fruit weight	T.S.S	Titratable acidity	T.S.S / acidity	Ascorbic acids	Anthocynins
K101	-34.95**	-27.74**	1.33	50.11**	13.39**	-23.74**	61.02**	10.20**	-28.76**
K102	-22.86**	8.64**	0.00	29.99**	16.65**	29.96**	17.67	-13.88**	1.26
K103	-38.86**	-22.77**	1.75	7.58	-17.86*	-10.12	-10.20	-10.59**	-56.20**
K105	-45.57**	24.79**	-52.98**	8.06	-7.14	-1.17	-7.66	45.08**	19.40**
K106	-38.67**	8.18**	-7.07	16.45**	-17.86*	-10.51	-9.62	-12.18**	8.36**
K107	-21.15**	-48.67**	6.65	16.73**	16.26**	-28.81**	-18.67	5.64*	-37.54**

5.2. Total yield:

Concerning total yield per plant, significant differences between the parents of two crosses were found (K102 and K106). The two hybrids K102 and K106 significantly exceeded their high parents in total yield suggesting hybrid vigor for the high yield. The obtained values were 8.64 and 8.18 % in these crosses, respectively (Table 8). The results confirm those of Okasha *et al*. (2003).

6. Fruit physical characters:-

6.1. Firmness:-

Four F_1 hybrids and their parents significantly differed in fruit firmness. The hybrids K101, K102, K103 and K107 were significantly exceeded its respective mid-parent value, suggesting dominance towards the high firmness. The ADH values for these crosses were estimated as 1.33, 0.00, 1.75 and 6.65 % based on HP, indicating complete dominance for the firm fruits (Table 7 & 8). The F_1 hybrid K106 gave insignificant ADH values based on both MP and HP values. The results confirm those of Okasha *et al*. (2003).

6.2. Average fruit weight:

Data presented in Table (7) showed that the parents of the seven obtained hybrids significantly differed in the average fruit weight. All these crosses significantly exceeded their respective MP values, suggesting dominance towards the high average fruit weight. Estimated ADH from MP ranged from 37.34 % in cross K103 to 91.70 % in cross K101. The hybrids K103 and K105 gave insignificant ADH (7.58 and 8.06 %, respectively), in relation to the high parent suggesting complete dominance. Generally none of the studied F_1 crosses exhibited dominance towards the lower parental cultivars (Table 8). The four hybrids K101, K102, K107 and K106 significantly exceeded their high parent in average fruit weight, suggesting hybrid vigor for the high average fruit weight. The results are agreed with to those obtained by Okasha *et al*. (2003) and Yuji *et al*. (2008).

7. Fruit chemical components:-

7.1. Total soluble solids (TSS):

Out of 6 F_1 hybrids, three ones viz., K101, K102 and K107 significantly exceeded the mid-parent values suggesting dominance towards the high parent. These crosses significantly exceeded their high parent in total soluble solids content, suggesting hybrid vigor for high content. The ADH obtained was 13.39, 16.65 and 16.26 % for the three crosses, respectively.

Data also showed that the cross K105 showed insignificant ADH values, based on both MP and HP.

7.2. Titratable acidity:-

Results in Tables (7 & 8) show that out of the 6 crosses whose parents differed significantly in titratable acidity, the three hybrids (K107, K105 and K106) were statistically similar to their mid-parents with insignificant heterosis values (2.92, 6.51 and -3.57 %, respectively), indicating no- dominance for this trait (Table 7). Meanwhile, the crosses K101 and K107 were significantly lower than their respective low parents, reflecting over-dominance for the low content. Estimated ADH values were -23.74 and -

28.81 %, respectively, for the two crosses (Table 8). The results confirm those of Okasha *et al*. (2003).

7.3. TSS / Acidity:-

Data of Tables (7 & 8) show that the hybrid "K101" significantly exceeded their respective high parent, reflecting over-dominance for the high ratio. Estimated ADH value was 61.02 %. Data also showed that the crosses K102, K107, K103, K105 and K106 showed insignificant ADH values based on both MP and HP. Results agree with those obtained by YujiNoguchi *et al*. (2008).

7.4. Ascorbic acid:-

Data in Tables (7 & 8) showed that significant differences between the parents of 5 crosses were found for vitamin C content in strawberry fruits. Among them, the Cross "K103" showed no- dominance for this character, since it gave insignificant heterosis value as -4.57 %, based on MP. Hybrid vigour for the high content was observed in the crosses K101 and K105; they significantly exceeded their high parent in vitamin C content. The ADH obtained was 10.20 and 45.08 % in the two crosses, respectively. These results are similar to those obtained by Ragab *et al*. (2000) and Yuji *et al*. (2008).

4.5. Anthocynin content.

From the obtained results tabulated in Tables (7 & 8), significant differences between the parents of 5 crosses were found for anthocynins content. The cross "K101" showed no-dominance for the trait, since it gave insignificant heterosis value (-2.09), based on MP. Meanwhile, the cross "K102" exceeded the mid-parent value and showed insignificant difference in relation to high parent, suggesting dominance towards the high parent. Also obtained ADH for this cross was 1.26 % (Table 8). Out of the 4 F_1 hybrids which showed dominance towards the high anthocynin content, two ones i.e., K105 and K106 showed hybrid vigour for this trait. Estimated ADH values from HP were 14.40 and 8.36 %, respectively.

REFERENCES

Ahmed, R. E. (2009). Response of some new strawberry genotypes to cultivation under plastic tunnels. M. Sc. Thesis, Fac. Agric., Ain Shams Univ., Egypt PP. 60.

Adam, D.; J. J. Luby and J. F. Hancock (2002). Breeding day neutral strawberries for northern America. Acta Hort. 567, 133-136.

Adam, W.; A. Passey and D. Simpson (2008). Developing A breeding strategy for improved performance in programmed cropping systems. VI International strawberry symposium Huelva. Spain (Abstract) No. 961.

A.O.A.C. (1990). Association of Official Agricultural Chemists. Methods of analysis, 15th edition, Washington D.C., USA.

De-Loose, R. (1970). Flower pigment composition of natural bud verities among hybrid Chinese azaleas, Rhadodendron simssi (Phanche). Journal of Horticultural Science 45: 265-266.

Faedi, W., Baruzzi, G. Dradi., R. P. Rosati, and P. Lucci (1997). Strawberry breeding in Italy. Acta Hort. 439,121-128.

Izhar, S. (1997). Infra short- day strawberry types. Acta Hort. 439:155-160.

Kim, T.; J. H. Choi; W.S. Kim; W.S. Jang; K. S. Seo; T.I. Kim; W.S. Kim; J.H. Choi; W.S. Jang and K.S. Seo (1999). Interrelation among leaf characteristics of strawberry cultivars. Korean journal of Horticultural Science and Technology. 17 (2): 111-114. (C.A. CAB Abstracts 1998-2000).

Lal, S. D. and J. N. Seth (1979). Studies on genetic variability in strawberry (*FragariaX ananassa* Duch) Progressive Horticulture 11, 49-53.

Mohamed, N.A.; R. M. Helal; Kh. A. Okasha and M.E. Ragab (2002). Production of new strawberry strains via anther culture. 1- Callus production, shoot formation and transplants production. Annals Agric .Sci., Ain Shams Univ., 47 (3), 841-858,

Okasha, H. A. (1980). The effect of light, temperature and some chemical compounds on the germination of seeds of some strawberry varieties. M. Sc. Thesis, Fac. Agric., Ain Shams Univ., Egypt PP. 183.

Okasha. Kh. A.; R. M. Helal; M. E. Ragab and S. A. Esmail (2003). Reconstitution of *Fragaria x ananasa*. 2- Hybrid yield performance and fruit physical characteristics and their heterosis. J. Agric. Sci. Mansoura Univ., 28 (7): 5589-5598.

Okasha, Kh. A.; M. E. Ragab; F. M. El- Domyati; R. M. Helal and N. A. Mohamed (2003). Production of new strawberry strains via anther culture: 2- Strains yield performances and fruits physical and chemical characteristics. Annals Agric. Sci., Ain Shams Univ., 48 (1) 269-281.

Ragab, M. E.; I. I. El-Okash and H. M. El-Sayed (2000). New promising cultivars and large crown diameter of transplants increased earliness, productivity and fruit quality of annual plastic mulched strawberry. J. Agric. Sci., Mansoura Univ., 25 (12): 8039-8052.

Refoya, A and J. M. Arenas (2008). Cultivars developed in the strawberry breeding program of Fresas Nuevo materials S.A. VI International strawberry symposium Huelva. Spain (Abstract) No. 145.

Shaw, D.V., S. R. Bringhurst and V. Voth (1987). Genetic variation for quality traits in an advanced- cycle breeding population of strawberries. J. Amer. Soc. Hort. Sci. 112:699-702.

Shaw, D.V. (1988). Genotypic variation and genotypic correlations for sugars and organic acids of strawberries.J. Amer.Soc. Hort.Sci.(113): 770-774.

Simpson, D.W., A. J. Bell and J. K. Grabham (1997). Progress in breeding strawberries for an extended season in the United Kingdom. Acta Hort. 439:133-137.

Sinha, S.K. and R. Khanna (1975). Physiological, biochemical and genetic of heterosis. Advan. Agron.27: 123-174.

Waller, R. A. and D.B. Duncan. (1969). A basic rule for the symmetric multiple comparison problem. Amer. States. Assoc. J.12: 1485-1503

Yuji, N. T. Myro and M. Morishita (2008). The possibility of the decaploid inter specific hybrids (*Fragaria X ananasa XF1 nilgerrensis*) for the utilization as parent of a new strawberry. VI. International Strawberry Symposium. Huelva. Spain (Abstract) No. 814.

Zubov, A. A. and K. V. Stankevich (1982). Combining ability of a group of strawberry varieties for quality characters of fruits (in Russia). Soviet Genetics 18: 732-739.

دراسات على إنتاج بعض هجن الفراولة وسلوكها الحقلى

أمـانى عطيـة عبـد اللطيـف[١] ، أبـو العـز عيسـى عمـران[١] ، محمـود قطـب حـاتم[٢] و محمد إمام رجب[٣]

١- قسم بحوث البطاطس والتكاثر الخضرى – معهد بحوث البساتين – مركز البحوث الزراعية.
٢- قسم تربية الخضر والطبية والعطرية – معهد بحوث البساتين – مركز البحوث الزراعية.
٣- قسم البساتين – كلية الزراعة – جامعة عين شمس.

أجريت هذه الدراسة فى محطة بحوث البساتين بالقناطر الخيرية والمزرعة التجريبية لمركز تنمية الفراولة بكلية الزراعة جامعة عين شمس بالإسماعيلية فى الفترة من ٢٠٠٥ حتى ٢٠٠٩ بهدف إنتاج وانتخاب بعض الهجن المبشرة فى الفراولة من الأصناف التجارية من خلال التهجين والانتخاب واستخدم فى هذه الدراسة أربعة أباء تجارية هى سويت شارلى، دايامونتى، كماروزا وفانتانا.

وقد تم إجراء التلقيحات بين الأصناف الأبوية فى دائرة فى إتجاه واحد وتم إنتاج ستة هجن وتم مقارنة الهجن المنتجة مع الأباء المستخدمة وقيمت فى مرحلة المشتل وأيضا تم تقييم المحصول وخصائص الجودة بالثمار لموسمين متتاليين. وقدرت قوة الهجين لبعض الصفات البستانية فى الهجن الستة المبشرة وقد أظهرت النتائج ما يلي:

تفوق الهجين K102 (قناطر ١٠٢) فى صفات المحصول الكلى ومتوسط وزن الثمرة وصلابة الثمرة ونسبة المواد الصلبة الذائبة مقارنة بالأباء كما تفوق الهجين K101 عن الأباء فى متوسط وزن الثمرة والمواد الصلبة الذائبة وحمض الأسكوربيك وأعطى أقل قيمة للحموضة الكلية بالثمار مقارنة بالأباء كما أوضحت النتائج أن الهجين K105 قد أعطى أعلى القيم لصفات عدد الشتلات الطازجة (الفرش) وعدد الشتلات الساكنة لزراعة الفراولة المبردة (الفريجو) كما أعطى نفس الهجين أقل القيم لصفة الحموضة الكلية مقارنة بالأباء. أظهرت النتائج أيضا أن الهجين K106 أعطى أعلى القيم للمحصول الكلى للنبات ومتوسط وزن الثمرة مقارنة بالأباء كما أعطى الهجين K103 والهجين K107 أعلى القيم لصفة صلابة الثمار ومتوسط وزن الثمرة على الترتيب مقارنة بالأباء بينما تفوق صنف سويت شارلى فى صفة المحصول المبكر وتفوق الصنف كماروزا فى متوسط وزن الثمرة. أظهرت نتائج قوة الهجين تفوق معظم الهجن السابقة عن الأب الأفضل فى معظم الصفات المدروسة.

بالنسبة للقياسات الوراثية للهجن المختلفة التى درست مع آبائها أظهرت الدراسة وجود درجات مختلفة من السيادة فى الصفات التى تم دراستها حيث ظهر إنعدام السيادة فى صفتى المحصول المبكر للنبات وصبغة الأنثوسيانين وظهرت السيادة التامة فى صفة الصلابة كما ظهرت قوة الهجين فى صفات المحصول الكلى ومتوسط وزن الثمرة والمواد الصلبة الذائبة الكلية والحموضة الكلية والمواد الصلبة الذائبة الكلية / الحموضة وفيتامين ج وهذا يشجع أنتاج الهجن في الفراولة لأستخدامها علي نطاق تجاري في الزراعة.

وتجمل الدراسة أنه أمكن إنتاج ستة هجن فراولة محلية تميزت بإنتاجيتها العالية وصفاتها الأكلية المتميزة عن الأباء المستخدمة.

قام بتحكيم البحث

أ.د / طه محمد السيد عمر الجزار	**كلية الزراعة – جامعة المنصورة**
أ.د / رشدى مختار خليل	**كلية الزراعة – جامعة المنوفية**