

Investigation on Yield, Fruit Quality and Plant Characteristics of Some Local, European and American Strawberry Varieties and their Hybrids

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Summary

This study was conducted in 2003-2004 and 2004-2005 growing periods. Our local cultivar “Osmanlı”, European and American cultivars: “Camarosa”, “Sweet Charlie”, “Gaviota”, “Maya”, “Paros”, “Cilady”, “Cigoulette”, “Marlate”, “Sophie”, “Ciloe”, “Diamante” and “Camarosa”, hybrids from Italian breeding program: “92/340/3”, “MT/j24/2”, “MT99/20/1”, “MT99/121/9”, “MT99/163/14”, “MT99/163/19” and “MT99/163/22”, and hybrids from Turkish breeding program: “3”, “5”, “6”, “8”, “11”, “13” and “17” were used as plant material. Average yield per plant (g/plant), fruit weight (g) and some phenological plant characteristics such as plant growth shape, plant density, plant vigour, leaf size, leaf softness, beginning of flowering time and response to Fe chlorosis of experimental strawberry genotypes were evaluated. Hybrids MT J24/2 and MT 99/163/22 were found to be very satisfactory in terms of average yield/plant, and fruit weight respectively.

Key words

strawberry, yield, fruit weight, adaptation, Fe chlorosis

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Received: May 15, 2006 | Accepted: October 6, 2006

Introduction

Strawberries (*Fragaria x ananassa* Duch.) are unique, with highly desirable taste, flavour, rich in vitamins, potassium, fiber and other secondary metabolites, also simple sugar source of energy, consumed as fresh table fruit or used in processing industry for jam and marmalades or frozen (Wang and Galletta, 2002; Perez *et al.*, 1997).

Strawberries are grown throughout the world. Although the yield/plant, size and colour of the common cultivars obtained in California are quite satisfactory, the local cultivars or types are in very big demand for their aroma and flavour (Üstün, 1996). The new octaploid strawberry cultivars are high yielding and early fruiting, but poor in aroma constituents.

Numerous breeding programs aimed at improving strawberry taste were done according to demand (Hancock, 1999). The main aspects of those breeding programs were three major components of fruit organoleptic quality: flavour, sweetness, and acidity. Consumers prefer sweet strawberries and sweetness is positively correlated with *soluble* solid contents (SSC), total soluble sugars, and fructose (Shaw, 1990). Many studies have addressed strawberry sweetness and acidity. Fruit soluble solids, titratable acidity, and organic acids at maturity are quantitatively inherited (Shaw, 1997) Consumer preference is important in determining the value of new cultivars. For this purpose, a strawberry breeding program was initiated at the University of Çukurova, Faculty of Agriculture, Department of Horticulture in 1984 (Paydaş *et al.*, 1996). In our country mostly farmers grow “Camarosa” due to yield, large fruits, and flesh firmness that is highly desirable. But it is always condemn by the consumers due to off flavour and taste. Our local cultivar Osmanli is very rich in aroma and taste whereas its average fruit size is very small (roughly 5-8 g), flesh firmness is highly undesirable due to its softness that renders it unsuitable for transportation. For these reasons we aim to develop more aromatic and tasty strawberry genotypes in our country. This breeding program has the major objective to develop new strawberry varieties especially well adapted and able to provide a high productive and qualitative standard.

In this paper, we aimed to evaluate adaptation performance especially average yield/plant, fruit weight and some phenological plant characteristics such as plant growth shape, plant density, plant vigour, leaf size, leaf softness, beginning of flowering time and response to Fe chlorosis of our local cultivar, promising hybrids from our and Italian breeding programs and some American and European cultivars.

Materials and methods

This study was conducted in 2003-2004 and 2004-2005 growing periods in Experimental and Implementation Research Area and Laboratories of Horticulture Department in Faculty of Agriculture, University of Cukurova in Mediterranean region of Turkey. In the experiment, our local cultivar “Osmanlı”, American and European cultivars “Camarosa”, “Sweet Charlie”, “Gaviota”, “Maya”, “Paros”, “Cilady”, “Cigoulette”, “Marlate”, “Sophie”, “Ciloe”, “Diamante” and “Camarosa”, hybrids from Italian breeding program: “92/340/3”, “MT/j24/2”, “MT99/20/1”, “MT99/121/9”, “MT99/163/14”, “MT99/163/19” and “MT99/163/22” and hybrids from Turkish breeding program: “3”, “5”, “6”, “8”, “11”, “13” and “17” were used as plant material. The experiment was designed as a complete randomized block with three replicate; Twenty plants were used in each replicate. Black plastic mulch and drip fertigation system were applied. Average yield per plant (g/plant), fruit weight (g) and some phenological observations such as growth shape, plant density, plant vigour, leaf size, leaf softness, beginning of flowering time and response to Fe chlorosis of those strawberry genotypes in the field were examined. Phenological characters were done using modified descriptors of Faedi *et al.*(2002), and Paydaş *et al.* (1996).

Results and discussion

The results of average yield/plant/months and total yield/plant of experimental genotypes during 2003-2004 growing period are given in Table1. The differences among the experimental genotypes of average yield/plant/month and total yield/plant were found to be statistically significant and the lowest yield was obtained in February. In this month, the highest yield was obtained from cultivars Paros (32.30 g) and hybrid number 8 (28.21 g) respectively. Whereas, no fruits were harvested from cultivars Osmanlı, Cilady, Ciloe, Sophie, Diamante and from hybrid number 92/340/3. In March, no fruits were harvested from cultivars Osmanlı, Ciloe and Sophie and the yield/plant varied from 10.95 g (“Cigoulette”) to 100.18 g (“Paros”). The lowest yield/plant was obtained from cultivar Marlate (18.98 g) whereas the highest yield was obtained from cultivar Cigoulette (90.25 g).. In May, the yield/plant varied from 10.52 g (“Paros”) to 70.67 g (hybrid number 13). No fruits were harvested from cultivar Sophie in June, while the highest yield was obtained from cultivar Sweet Charlie in the same month. According to the obtained data the highest yield was obtained from cultivar Sweet Charlie whereas the lowest yield was obtained from cultivar Sophie. Among our hybrids, hybrid number 11 was found to be very close to cultivar Sweet Charlie. Among the European cultivars

Table 1.
Average yield of experimental genotypes during 2003-2004 growing period (g/plant)

Genotypes	Months					Total
	February	March	April	May	June	
3	8.6 b	57.8 cde	38.3 c.f	13.9 g	26.6 d-g	145.2 hij
5	3.6 b	44.5 ef	53.0 bcd	47.6 bcd	29.2 def	178.0 e-h
6	6.2 b	82.9 a-d	43.4 c.f	10.7 g	41.6 bcd	184.8 d-g
8	28.2 a	61.4 b-e	55.9 bcd	43.7 cd	32.2 cde	221.5 bc
11	2.1 b	94.8 a	83.3 a	36.4 de	32.6 cde	249.2 ab
12	5.4 b	55.9 de	74.4 ab	50.3 bcd	22.5 e-g	208.6 cde
13	2.4 b	66.8 b-e	32.5 def	70.7 a	23.7 e-h	196.1 c-f
17	10.4 b	85.6 abc	53.0 bcd	59.3 abc	6.2 i	214.5 cd
92/340/3	-	15.7 gh	40.5 c-f	65.1 ab	16.0 f-i	137.3 ijk
Osmanlı	-	-	38.6 c-f	35.2 def	22.9 e-h	96.7 lm
Camarosa	5.0 b	87.4 ab	44.4 c-f	12.7 g	24.4 e-h	174.0 fgh
S. Charlie	9.2 b	64.7 b-e	23.5 ef	12.9 g	153.0 a	263.2 a
Marlate	2.8 b	10.1 h	19.0 f	50.6 bcd	12.3 ghi	94.7 lm
Cilady	-	41.8 efg	48.6 b-e	62.5 abc	47.4 bc	200.2 c-f
Gaviota	6.4 b	23.8 fgh	20.2 f	51.3 bcd	13.8 f-i	115.5 jkl
Cigoulette	4.4 b	11.0 h	90.3 a	19.6 efg	34.1 cde	159.3 ghi
Ciloe	-	-	64.3 abc	37.1 de	54.7 b	156.1 ghi
Paros	32.3 a	100.2 a	35.5 def	10.5 g	18.9 e-i	197.4 c-f
Sophie	-	-	19.6 f	60.0 abc	-	79.6 m
Maya	12.7 b	45.6 ef	17.4 f	16.9 fg	21.6 e.i	114.2 j-m
Diamante	-	20.3 fgh	30.8 def	46.0 cd	9.0 hi	106.1 klm
D%5	11.7	27.9	27.1	18.8	15.7	34.6

Table 2.
Average yield/plant of experimental genotypes during 2004-2005 growing period (g/plant)

Genotypes	Months				Total
	March	April	May	June	
3	59.4 c-g	143.3 abc	55.0 ghi	7.7 i	265.5 f-j
5	37.2 e-h	117.1 b-e	36.6 i	17.9 hi	208.8 hij
6	55.6 c-h	180.6 a	139.3 c	74.5 c-h	449.9 bc
8	47.5 d-h	105.7 b-f	108.0 c-f	26.1 ghi	287.4 d-i
11	39.2 e-h	92.1 b-g	69.1 f-i	43.7 e-i	244.2 g-j
12	62.3 c-g	133.8 a-d	60.3 f-i	26.4 ghi	282.7 e-i
13	20.2 gh	110.1 b-f	40.7 hi	-	171.0 jk
17	10.2 h	102.3 b-f	82.9 d-i	-	195.4 ij
92/340/3	39.0 e-h	77.8 dg	95.5 c-g	137.1 ab	349.4 def
Osmanlı	-	34.6 g	42.2 hi	16.8 hi	93.6 k
Camarosa	34.0 e-h	114.6 b-f	86.0 d-h	83.5 b-g	317.9 d-g
Sweet Charlie	66.0 b-f	78.9 d-g	105.8 c-f	55.1 d-i	305.8 d-h
Marlate	33.3 e-h	108.4 b-f	125.2 cd	2.2 i	269.2 f-i
Cilady	36.2 e-h	64.3 efg	60.8 f-i	52.1 e-i	213.4 hij
Gaviota	32.6 fgh	64.7 efg	88.1 d-h	87.9 b-f	273.4 f-i
Cigoulette	23.1 fgh	88.3 c-g	108.0 c-f	76.6 c-g	296.0 d-h
Ciloe	21.0 fgh	152.5 ab	105.9 c-f	96.1 b-e	375.4 cde
Paros	49.3 d-h	86.6 c-g	93.4 c-g	109.9 bcd	339.2 d-g
Maya	33.6 e-h	106.8 b-f	75.0 e-i	36.4 f-i	251.9 g-j
MT 99/121/9	78.2 a-e	65.8 efg	118.6 cde	118.6 bc	380.6 cd
MT J24/2	110.1 ab	193.4 a	187.4 b	84.8 b-f	575.7 α
MT 99/163/14	96.9 abc	52.6 fg	81.5 d-i	89.1 b-f	320.1 d-g
MT 99/163/19	61.9 c-g	72.7 d-g	243.8 a	115.4 bc	493.7 ab
MT 99/20/1	90.6 a-d	91.5 b-g	96.4 c-g	50.9 e-i	329.4 d-g
MT 99/163/22	114.0 a	103.6 b-f	128.0 cd	178.8 a	524.4 ab
D % 5	44.9	62.9	47.9	57.8	97.482

Table 3.
Average fruit weight of experimental genotypes during 2003-2004 growing period (g/plant)

Genotypes	Months				Average
	March	April	May	June	
3	5.36 g	5.00 ijk	6.33 efg	4.22 gh	5.23 jk
5	4.93 g	5.14 ijk	7.66 d-g	4.31 gh	5.51 ijk
6	7.85 d-g	6.13 f-j	9.54 a-d	5.99 c-g	7.38 e-h
8	8.54 c-g	8.68 b-g	8.08 c-f	4.90 e-h	7.55 d-g
11	9.71 c-f	5.75 g-k	6.36 efg	4.52 fgh	6.59 g-j
12	4.86 g	5.40 h-k	5.31 fg	3.97 h	4.89 k
13	7.05 efg	5.57 h-k	7.84 def	6.96 bcd	6.85 f-j
17	10.86 cde	9.20 b-e	8.38 b-e	5.42 c-h	8.46 c-f
92/340/3	15.77 a	17.34 a	10.85 abc	8.00 ab	12.99 a
Osmanlı	-	2.92 k	1.56 h	1.46 i	1.98 l
Camarosa	12.16 abc	8.37 c-h	8.92 a-e	4.85 e-h	8.58 cde
S. Charlie	8.53 c.g	4.80 jk	6.45 efg	7.12 bc	6.73 g-j
Marlate	6.71 fg	4.86 ijk	11.24 a	5.03 d-h	6.96 e-i
Cilady	11.15 cd	9.42 bcd	11.12 ab	9.64 a	10.33 b
Gaviota	12.19 abc	9.82 bc	8.94 a-e	6.44 b-f	9.35 bc
Cigoulette	11.63 bcd	7.87 c-i	6.81 d-g	5.16 c-h	7.87 c-g
Ciloe	-	8.87 b-f	9.25 a-d	5.86 c-h	7.99 c-g
Paros	15.48 ab	6.67 d-j	8.24 cde	6.74 b-e	9.28 bc
Sophie	-	6.24 e-j	4.90 g	-	5.57 ijk
Maya	8.08 d.g	5.13 ijk	6.33 efg	3.96 h	5.88 h-k
Diamante	12.20 abc	11.55 b	7.08 d-g	5.96 c-g	9.20 bcd
D % 5	3.891	3.028	2.790	1.965	1.656

Table 4.
Average fruit weight of experimental genotypes during 2004-2005 growing period (g/plant)

Genotypes	Months				Average
	March	April	May	June	
3	8.79 de	10.24 de	7.39 gh	7.73 abc	8.54 hi
5	10.19 cde	10.52 de	7.69 fgh	9.06 ab	9.36 f-i
6	14.44 a-e	12.60 b-e	9.73 c-g	8.03 ab	11.20 c-i
8	14.76 a-d	13.17 b-e	10.40 b-g	9.72 a	12.02 b,h
11	10.07 cde	9.20 ef	9.14 c-g	7.77 abc	9.05 ghi
12	7.70 e	9.31 ef	8.18 e-h	8.68 ab	8.47 i
13	9.16 de	11.09 cde	8.47 d-h	-	9.57 e-i
17	12.39 b-e	14.09 b-e	9.30 c-g	-	11.92 b-i
92/340/3	13.82 b-e	14.13 b-e	17.32 a	10.81 a	14.02 abc
Osmanlı	-	4.07 f	3.92 h	3.74 c	3.91 j
Camarosa	12.87 b-e	14.36 a-e	12.26 b-f	8.57 ab	12.02 b-h
Sweet Charlie	10.79 b-e	11.12 cde	11.03 b-g	8.43 ab	10.34 d-i
Marlate	9.35 de	11.30 cde	10.55 b-g	5.50 bc	9.18 ghi
Cilady	11.86 b-e	9.21 ef	11.84 b-g	9.49 ab	10.60 c-i
Gaviota	17.30 ab	13.68 b-e	11.65 b-g	8.64 ab	12.82 a-f
Cigoulette	14.09 b-e	14.41 a-e	11.53 b-g	9.87 a	12.48 a-g
Ciloe	12.02 b-e	13.84 b-e	11.75 b-g	9.84 a	11.87 b-i
Paros	17.43 ab	14.83 a-d	11.23 b-g	8.77 ab	13.06 a-e
Maya	9.64 de	11.20 cde	10.06 b-g	9.07 ab	9.99 e-i
MT 99/121/9	14.41 a-e	11.61 cde	10.22 b-g	9.52 ab	11.44 b-i
MT J24/2	17.11 ab	19.46 a	12.53 b-e	10.69 a	14.95 ab
MT 99/163/14	16.39 abc	13.51 b-e	14.73 ab	9.69 ab	13.58 a-d
MT 99/163/19	13.14 b-e	16.13 abc	13.21 a-d	9.70 ab	13.04 a-e
MT 99/20/1	14.75 a-d	9.71 de	11.86 b-g	8.84 ab	11.29 c-i
MT 99/163/22	21.08 a	17.49 ab	13.69 abc	10.72 a	15.75 a
D % 5	6.741	5.309	4.745	4.217	3.578

Cilady was found to be very close to “Sweet Charlie”. In terms of this trait, Italian hybrid number 92/340/3 was shown to be intermediate.

Average yield per plant per month and total yield per plant for genotypes in the experiment during the 2004-2005 growing period are given in Table 2. The differences among the experimental genotypes in terms of average yield/plant/months and total yield/plant were found to be statistically significant and the lowest yield was obtained in March. In this month, the highest yield was obtained from hybrid number MT 99/163/22 (114.01 g) and the lowest yield/plant was obtained from hybrid number 17 (10.21 g) while no fruits were harvested from Osmanlı. The highest yield was obtained in April, almost from all genotypes. In this month yield/plant varied from 34.60 g (“Osmanlı”) 193.38 g (“MT J24/2”). In May the lowest yield/plant was from hybrid number 5 (36.58 g) whereas the highest yield/plant was obtained from MT 99/163/19 (243.77 g). In June no fruits were harvested from hybrids 13 and 17; whereas in this month the yield/plant increased in some genotypes such as hybrids 92/340/3, MT 99/163/14, and MT 99/163/22 and cultivar Paros. According to the obtained data the highest yield was obtained from hybrid number MT J24/2 (575.70 g) whereas the lowest yield was obtained from cultivar Osmanlı (93.65 g). Turkish hybrid 6 was found to be very close to our hybrids and among the European cultivars cultivar Ciloe (375.37g) was found to be very close to hybrid number MT J24/2.

Similar results were obtained in terms of yield/plant of cultivar Camarosa and cultivar Osmanlı with Çağlar and Paydaş (2002) and Kafkas (2004). However, Kafkas (2004) reported that the results of yield/plant of hybrids (3, 5, 6, 8, 11, 12 and 13) were found to be higher than these experimental results. The reason for this may be due to the differences in climatic conditions of experimental years. Due to the fact that Kafkas studied the yield and other characteristics during 2001-2002 growing period and in this period the winter was very mild in comparison to the our growing period. In addition, in this study we planted the fresh runner plants of experimental genotypes approximately one month later than Kafkas (2004).

The average fruit weight of experimental genotypes and distribution according to the months are given in Table 3. As shown in Table 3 the average fruit weight was varied from 4.86 g (hybrid 12) to 15.77 g (92/340/3) in March. In the following month these values varied from 2.92 g (Osmanlı) to 17.34 g (92/340/3). In May, average fruit weight increased almost in all genotypes in comparison to April. In June, the average fruit weight of experimental genotypes decreased in comparison

to the previous month. As a result, the highest average fruit weight was obtained from hybrid 92/340/3 (12.99 g) whereas the lowest value was obtained from cultivar Osmanlı.

Average fruit weight of experimental genotypes and distribution according to the months during 2004-2005 growing period are given in Table 4. The differences among the genotypes were found to be statistically significant in all months. In March, average fruit weight varied from 4.86 g (hybrid number 12) to 15.77 g (92/340/3). The fruits of hybrid number 17 and cultivar Paros were found to be very close to 92/340/3. Average fruit weight of experimental genotypes were decreased in hybrid numbers 3, 6, 11, 13, 17 and cultivars Camarosa, Sweet Charlie, Marlate, Cilady, Gaviota, Cigoulette, Paros, Maya and Diamante while increased in others. Average fruit weight was increased in May almost for all genotypes whereas in July decreased. The highest average fruit weight of experimental genotypes was obtained from hybrid number 92/340/3 (12.99 g) while the lowest one was detected as cultivar Osmanlı. Ilgın *et al.*, (2002) reported similar results in terms of average fruit weight for cultivar Sweet Charlie. Our results were found to be lower than that of Kafkas (2004) in terms of average fruit weight of hybrids 3, 5, 6, 8, 11, 12, 13 and 17.

Results for growth shape, plant density, plant vigour, leaf size, leaf softness, beginning of flowering time, and response to Fe deficiency chlorosis of experimental genotypes were given in Table 5. Plant growth shape was observed to be erect in hybrids 3, 5, 8, 13, 17, MT 99/121/9, MT J24/2, MT 99/163/14, MT 99/163/19 and MT 99/163/22 and in cultivars Camarosa, Marlate, Gaviota, Ciloe, Paros, Diamante whereas hybrid 92/340/13 and cultivars Osmanlı, Cilady and Sophie showed dropping to ground trait. Others were observed as medium in terms of growth shape character. In regards to this trait, dense, medium high dense, and open positions were observed as shown in Table 5. Plant vigour was observed in all Italian hybrids as strength whereas in cultivars Sophie and Diamante this trait was observed as weak. Leaf size of experimental genotypes were observed as large in hybrids 6, 8, 11, 13, 17, MT 99/121/9, MT J24/2, MT 99/163/14 and MT 99/163/22 and as small in cultivar Osmanlı. In others leaves were medium size. Leaf softness also differed in experimental genotypes as soft, medium and harsh. The earliest flowering time was observed in hybrid number 8 whereas the latest ones was observed in hybrid number MT J24/2 and cultivars Cilady, Cigoulette, Ciloe. The response of Fe chlorosis of strawberries differed in experimental genotypes, also. Hybrids 6, MT 99/121/9 and MT J 24/2 and cultivar Cilady were observed as highly resistance.

Table 5.
Some plant characteristics of experimental strawberry genotypes

Genotypes	Growth shape	Plant density	Plant vigour	Leaf size	Leaf softness	Beg.of flow. time	Responce to Fe chlor.
3	erect	dense	medium	medium	harsh	early	susceptible
5	erect	dense	med.strength	medium	medium	medium	susceptible
6	medium	dense	med.strength	large	harsh	medium	high. resis
8	erect	dense	strength	large	harsh	v. early	medium
11	medium	dense	strength	large	medium	early	medium
12	medium	dense	med.strength	large	medium	medium	medium
13	erect	dense	strength	large	medium	early	resistance
17	erect	medium	strength	large	harsh	early	susceptible
92/340/13	droop.ground	open	strength	medium	medium	medium	resistance
Osmanlı	droop.ground	High.dense	med.strength	small	harsh	late	resistance
Camarosa	erect	medium	med.strength	large	medium	medium	high suscep.
S.Charlie	medium	medium	med.strength	medium	medium	early	resistance
Marlate	erect	medium	strength	large	medium	early	resistance
Cilady	droop.ground	medium	med. strength	medium	harsh	late	high. resist.
Gaviota	erect	medium	strength	large	harsh	medium	resistance
Cigoulette	medium	medium	med. strength	medium	harsh	late	resistance
Ciloe	erect	medium	strength	large	harsh	late	resistance
Paros	erect	dense	strength	large	harsh	medium	resistance
Sophie	droop.ground	open	weak	medium	harsh	medium	resistance
Maya	medium	open	medium	medium	medium	early	resistance
Diamante	erect	open	weak	medium	harsh	medium	resistance
MT 99/121/9	erect	dense	strength	large	soft	early	high. resist.
MT J24/2	erect	medium	strength	large	medium	late	high. resist.
MT 99/163/14	erect	dense	strength	large	harsh	early	resistance
MT 99/163/19	erect	medium	strength	medium	medium	medium	medium
MT 99/20/1	medium	dense	strength	medium	medium	early	resistance
MT 99/163/22	erect	medium	strength	large	harsh	early	resistance

Conclusion

In this paper, performance of our local, European and American cultivars and cultivar candidates from our and Italian breeding programmes were compared. As a result, hybrids MT J24/2 and MT 99/163/22 were found to be very satisfactory in average yield/plant and fruit weight, respectively. Hybrid number 8 from our breeding program was observed the earliest one, while MT J24/2 from Italian breeding program the latest one. Cultivar Cilady and hybrids 6, MT 99/121/9 and MT J24/2 were observed as the ones with highest resistance to chlorosis which caused Fe deficiency.

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