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Effects of Short Day Conditioning, Chilling and GA_3 Treatments to Yield and Fruit Quality in Strawberry Plug Transplants Aiming Early Fruit Production

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Abstract

In this study, we tested the effects of short day (SD), chilling (Ch) and gibberalic acid (GA_3) treatments on the yield and fruit characteristics of 'Camarosa' and 'Sweet Charlie' plug plants under a freeze-protected greenhouse in Mediterranean conditions for two growing seasons in 2006-2007 and 2007-2008. The treatments included control (ambient day length and temperature); SD (8 h days) and ambient temperature; SD + Chilling (Ch) (18/12°C day/night temperatures); SD + Ch (10°C); SD + Ch (2°C); and, GA_3 (10 ppm applied to the plants in November). In each growing season, the plug plants were planted in mid-August using bag culture. Yield, fruit weight, firmness, total soluble solids (SS), titratable acidity (TA), and SS/TA ratio were investigated. Considerable amounts of early yield (March and April) were recovered from 'Sweet Charlie'; 116 and 72 g/plant in the first and second growing seasons, respectively. 'Sweet Charlie' also had consistently higher total yield than 'Camarosa' (457 *vs.* 400 g/plant in the 2006-2007 season and 446 *vs.* 406 g/plant in the 2007-2008 season). Treatment did not have a consistent effect on the fruit quality traits measured. The results indicated that although SD conditioning, Ch and GA_3 treatments may have an effect on the total and early yield of strawberries, these effects may be cultivar-dependent and further regulated by environmental factors. Therefore, we propose that low-chilling varieties be utilized for early fruit production that can initiate flower buds in warmer, longer days.

Keywords: earliness, *Fragaria* × *ananassa*, plug plant, protected cultivation, quality

Introduction

Turkish strawberry production has rapidly increased in the last 20 years and has reached 299,940 t (Anonymous, 2010). The production is centered in the Mediterranean, Aegean and Marmara Regions. Among these, the Mediterranean region is most suitable for early production. In the current Mediterranean production systems, harvests are centered at the end of March or early April, depending on the year (Turhan and Paydaş Kargı, 2007). However, even earlier production, between November and February, has not reached its full potential. Increasing the amount of very early production would be very important as the prices are a lot higher than during the regular season and would be a way of extending the harvesting period.

For early strawberry production, protected culture is generally utilized with cultivars with very low chilling requirements. Plug plants could be an integral part of such a production scheme, as they offer many advantages over the standard types of transplants (fresh-dug bare root and cold-stored frigo plants) such as lower mortality rate, quicker establishment, reduced water requirements during establishment period and only limited use of pesticides (Bish *et al.*, 1997; Durner *et al.*, 2002; Lareu and Lamarre, 1993; Polling, 2000). Plug plants are usually planted in July to September, depending on the production area. Recent studies conducted in Turkey have also generated promising results using plug plants (Özdemir and Gündüz, 2004). In these studies, conducted in a wide range of ecological conditions, plug plants were compared with freeze and/or fresh plants, and plug plants almost always produced higher early yields than other planting material types.

Recent experiments with plug plants concentrated on short day (SD) cultivars with low chilling (Ch) requirements, which can form flower buds under relatively longer days and/or warm temperatures. To promote flower bud formation on the plug plants and therefore promote the early yield, these cultivars may need conditioning under SD and/or low temperatures (Durner *et al.*, 2002; Hancock, 1999; Paroussi *et al.*, 2002 a, b). Some plant growth regulators such as GA_3 and benzyl adenine have also been tried to stimulate early yields (Khangi *et al.*, 1992; Türemiş and Kaşka, 1997). The objective of this study was to test the effects of SD, Ch and GA_3 treatments on the early yields, total yield and fruit characteristics of 'Camarosa' and 'Sweet Charlie' (both SD cultivars) in a freeze-protected greenhouse under Mediterranean conditions for two growing season.

Materials and methods

To determine the effects of SD, Ch and GA_3 on yield and fruit characteristics, 'Camarosa' and 'Sweet Charlie' cultivars were used. 'Camarosa' was selected because it is the one of the most commonly grown strawberry cultivar in Turkey, while 'Sweet Charlie' was selected for its low chilling requirement and early flower bud formation (Turhan and Paydaş Kargı, 2007). Both of these cultivars are well-adapted to the Mediterranean conditions.

Runner tips from these cultivars were collected on 1 July and rooted, plug plants were produced a month later as described by Özdemir *et al.* (2009). In short, the runner tips were places on the sandy media at ~90% humidity for the first two weeks, ~70% humidity for the third week and ambient conditions for the fourth week. The whole rooting process was under ~60%, dark blue shading material. Except for the SD and GA_3, the treatments were applied for a 15-day period from 1 to 15 August prior to planting for fruit production. The treatments included:

1) Control: The plants were grown under ambient conditions;

2) SD: This treatment was applied to the plants after the plug plants were transplanted to soil; during 1 and 15 October. They received natural day conditions between 08:00 and 16:00, and were covered the rest of the day with black plastic, so they received 8 h of light SD + Ch (18/12°C).

3) The planting material was kept on a walk-in growth chamber with 18/12°C day/night temperatures where the day length was 8 h (between 08:00 - 16:00). The plants were transplanted immediately to the experimental greenhouse at the end of the treatment;

4) SD + Ch (10°C): As in the previous treatment, the planting material was maintained in a growth chamber with 10°C constant temperature and the same SD conditions;

5) SD + Ch (2°C): This treatment had the same conditions as the two previous treatments except the temperature was held at 2°C;

6) GA_3: In this treatment, 10 ppm GA_3 was applied to the plants in November.

The experiments were repeated in a greenhouse for two growing seasons (2006-2007 and 2007-2008) using a Completely Randomized Design with three replications and 18 plants per replication. All treatments were planted on 15 August. The greenhouse was only heated to maintain a minimum temperature of 5°C. The plants were grown in bag culture. The bags were placed on benches at 1 m in height. Each bag contained six plants set in double rows; a replication consisted of three bags. A bumble bee (*Bombus bimaculatus* Cresson) hive was placed in the greenhouse to facilitate pollination.

The fruits were harvested weekly from late fall to end of May. At each harvest, the date and total fruit weight was recorded. The monthly yield and total yield was determined for each replication. The harvests before the end of February were considered early. Soluble solid content (SS) were calculated using a digital refractometer (Model RA-250HE, Kyoto Electronics Manufacturing Co. Ltd., Japan) at 22°C. Titrable acidity (TA) was measured using the titrametric method. Fruit firmness measurements were conducted using a penetrometer with 5 mm plunger (Nippon Optical Works Co., Ltd, Japan) inserted at the equatorial region of the fruit.

The statistical analyses were conducted using SAS procedures (SAS 2005). Mean and standard deviations were calculated using TABULATE procedure, while the analysis of variance (ANOVA) tables were constructed by GLM (Generalized Linear Model) procedure. The initial, combined analyses indicated significant year interactions; and, consequently the growing seasons were analyzed separately. Mean separations for significant main factors were calculated by LSD (Least Significant Difference) method at 0.05.

Results

A considerable amount of early yield was recovered from 'Sweet Charlie'; 116 and 72 g/plant in the first and second growing seasons, respectively. The ANOVAs for yield are presented in Tab. 1. As it can be seen from the table, the total yield was not affected by the treatments in either of the growing seasons. The differences between the cultivars for total yield, however, were significant in both seasons. 'Sweet Charlie' had consistently higher yield than 'Camarosa' (457 *vs*. 400 g/plant in 2006-2007 season and 446 *vs*. 406 g/plant in 2007-2008 season) (Tab. 2). For the early, April and May yields, significant differences were observed in the first year. Except for May yields, the cultivar × treatment interactions were significant as well. In May, GA_3 treatments had the greatest average (79 g/plant). For early yield, the GA_3 treatment produced significantly higher yields than the other treatments except control. This treatment produced the lowest yields in April, while the other Ch treatments were placed in the same mean group. In May, the GA_3 treatment had significantly higher yields than all other treatments.

The distribution of total production into the early, March, April and May harvest dates was 4, 9, 81 and 6% for 'Camarosa', and 25, 25, 32 and 18% for 'Sweet Charlie' (Tab. 2, Fig. 1 and 2). In other words, 'Sweet Charlie' has a much uniform yielding patterns across months compared to 'Camarosa'. Fig. 1 and 2 show the effects of the treatments on cultivars for the yield variables tested. As it can be seen from the figures, although significance differences were recovered from ANOVA for some traits in the first growing season, no apparent and consistent superiority was detected among treatments.

Tab. 1. Analysis of variance tables of yield, fruit weight, firmness, soluble solids (SS), titrable acidity (TA) and SS/A for 'Camarosa' and 'Sweet Charlie' strawberry cultivars subjected to several treatments and grown in 2006-2007 and 2007-2008 seasons

Source	df[z]	Yield					Fruit weight			Firmness	Soluble solids (SS)	Acidity (TA)	SS/TA
		Early[y]	March	April	May	Total	March	April	May				
2006-2007													
Cultivar (C)	1	92958**	51144**	281802**	28988**	29053**	276.7**	5.6	1.3	0.269**	3.4	0.215**	59.2**
Treatment (T)[v]	5	1491*	522	13826**	1117**	7682	7.5	8.6	6.0*	0.001	0.3	0.001	0.3
C x T	5	4346**	1541**	6380*	284	10944*	4.9	1.1	1.9	0.001	0.3	0.003	0.2
Error	24	478	353	2115	158	3454	5.4	3.3	1.5	0.001	0.2	0.002	0.4
2007-2008													
Cultivar (C)	1	38483**	37558**	115997**	4891**	14237*	38.2**	61.0**	31.2**	0.349**	0.3	0.261**	24.7**
Treatment (T)[v]	5	205	1252	6835*	677	5789	6.1**	3.8	1.1	0.001	0.5*	0.012	2.4
C x T	5	345	1148	1690	173	4400	0.5	0.7	1.5	0.003	0.6*	0.006	2.1
Error	24	150	1702	2163	336	2810	1.1	3.3	1.5	0.003	0.2	0.005	1.3

* and ** represent significant at 0.05 and 0.01, respectively;
[z]Degree of freedom;
[y]Early yield included the yield obtained until the end of February;
[v]Treatments are control (ambient day length and temperature conditions); short day (SD) (8 h days) and ambient temperature; SD + Chilling (Ch) (18/12°C day/night temperature); SD + Ch (10°C); SD + Ch (2°C); GA_3 (10 ppm)

Tab. 2. Analysis of variance tables of yield, fruit weight, firmness, soluble solids (SS), acidity (TA) and SS/TA for 'Camarosa' and 'Sweet Charlie' strawberry cultivars subjected to several treatments and grown in 2006-2007 and 2007-2008 seasons

Source	Yield (g/plant)					Fruit weight (g/fruit)			Firmness (kg)	Soluble solids (SS) (%)	Acidity (TA) (%)	SS/TA
	Early[z]	March	April	May	Total	March	April	May				
2006- 2007												
Cultivar												
Camarosa	14	37	325	24	400	15.7	10.7	8.8	0.568	6.2	0.843	7.4
Sweet Charlie	116	113	148	81	457	10.2	11.4	8.4	0.395	6.8	0.688	9.9
$LSD_{0.05}$	15.0	12.9	31.6	8.6	40.4	1.6	1.3	0.9	0.026	0.3	0.030	0.5
Treatment[y]												
Control	80	83	263	53	478	13.7	11.0	8.2	0.504	6.7	0.767	8.9
SD	58	81	207	45	391	12.6	9.7	8.6	0.468	6.7	0.769	8.8
SD + Ch (18/12 °C)	50	77	253	44	424	13.5	10.2	7.6	0.480	6.5	0.774	8.4
SD + Ch (10 °C)	55	82	280	43	459	14.1	11.7	8.5	0.473	6.2	0.746	8.5
SD + Ch (2 °C)	58	59	263	51	431	12.7	10.7	8.2	0.474	6.3	0.752	8.5
GA_3	89	69	152	79	389	11.0	13.1	10.5	0.490	6.8	0.785	8.8
$LSD_{0.05}$	26.1	22.4	54.8	15.0	70.0	2.8	2.2	1.5	0.046	0.5	0.052	0.8
Mean	65	75	236	52	429	12.9	11.0	8.6	0.481	6.5	0.766	8.7
2007 - 2008												
Cultivar												
Camarosa	7	99	245	56	406	14.0	12.5	10.8	0.625	7.2	0.892	8.2
Sweet Charlie	72	164	131	79	446	11.9	9.9	8.9	0.428	7.1	0.722	9.9
$LSD_{0.05}$	8.4	28.4	32.0	12.6	36.5	0.7	1.3	0.8	0.038	0.3	0.049	0.8
Treatment												
Control	33	146	201	65	445	13.1	11.0	9.4	0.548	7.6	0.766	10.0
SD	36	139	183	55	414	13.2	10.4	9.5	0.538	7.4	0.826	8.9
SD + Ch (18/12 °C)	36	147	204	79	466	13.3	11.0	10.6	0.505	6.9	0.850	8.3
SD + Ch (10 °C)	39	114	194	68	414	13.4	10.7	9.7	0.517	7.0	0.818	8.9
SD + Ch (2 °C)	44	118	221	58	442	13.6	12.5	9.9	0.529	6.9	0.738	9.6
GA_3	49	125	124	81	378	10.9	11.9	9.9	0.522	7.1	0.846	8.5
$LSD_{0.05}$	14.6	49.2	55.4	21.8	63.2	1.2	2.2	1.5	0.066	0.5	0.084	1.3
Mean	40	131	188	68	426	12.9	11.2	9.8	0.526	7.1	0.807	9.0

[z]Early yield included the yield obtained until the end of February;
[y]Treatments are control (ambient day length and temperature conditions); short day (SD) (8 h days) and ambient temperature; SD + Chilling (Ch) (18/12°C day/night temperature); SD + Ch (10°C); SD + Ch (2°C); GA_3 (10 ppm)

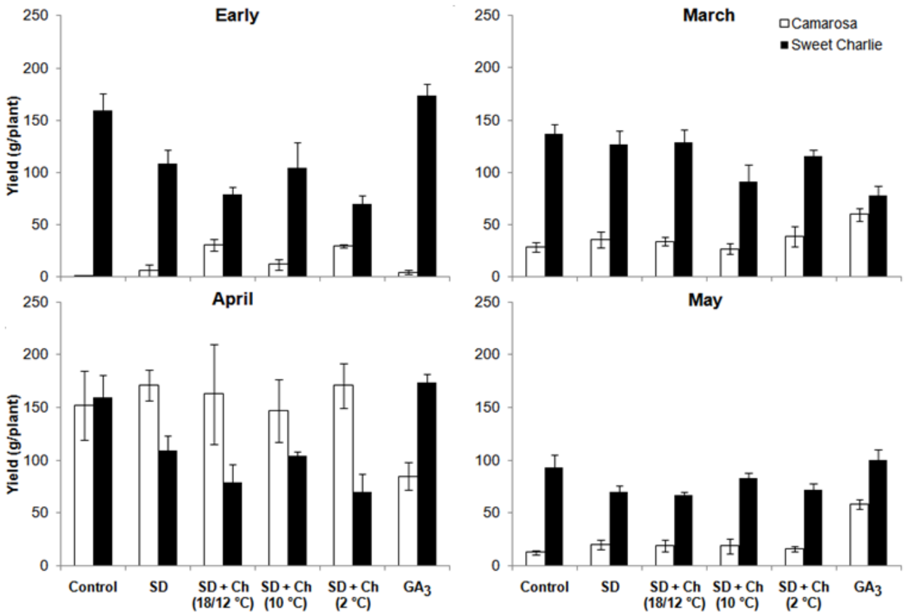

Fig. 1. Means (and standard deviations) of early, March, April and May yields for 'Camarosa' and 'Sweet Charlie' strawberry cultivars subjected to several treatments and grown in 2006-2007 seasons. Treatments included control (ambient day length and temperature conditions); short day (SD) (8 h days) and ambient temperature; SD + Chilling (Ch) (18/12°C day/night temperature); SD + Ch (10°C); SD + Ch (2°C); GA_3 (10 ppm)

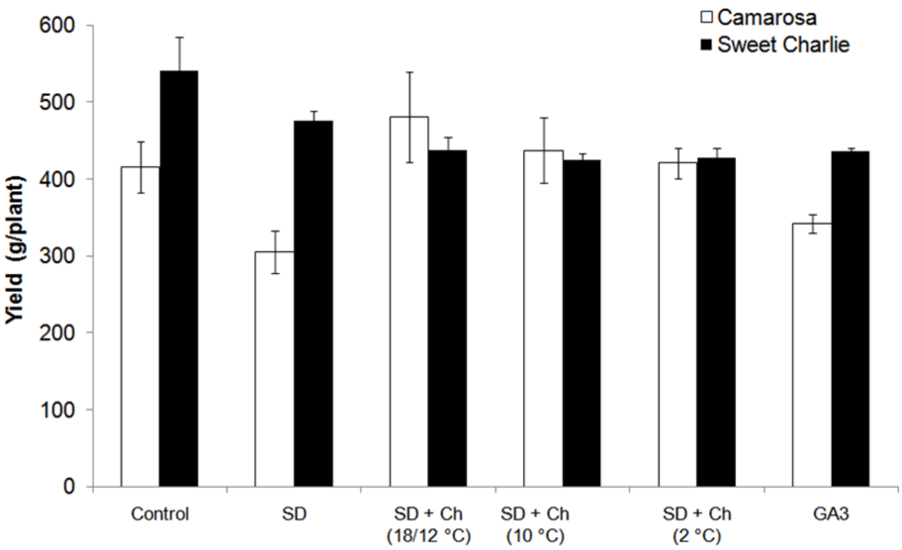

Fig. 2. Means (and standard deviations) of total yield for 'Camarosa' and 'Sweet Charlie' strawberry cultivars subjected to several treatments and grown in 2006-2007 seasons. Treatments included control (ambient day length and temperature conditions); short day (SD) (8 h days) and ambient temperature; SD + Chilling (Ch) (18/12°C day/night temperature); SD + Ch (10°C); SD + Ch (2°C); GA_3 (10 ppm)

Different significance patterns were observed for treatments and cultivar × treatment interaction in the second year of experiment (Tab. 1). Among the yield variables, only April yield was significant different across treatments, and the cultivar x treatment interaction was not significant. In April, the lowest mean yields were recovered from the GA_3 treatments, while the control, SD and Ch treatments were not significantly separated.

The individual fruit weights were determined separately during March, April and May. In the first growing season, the cultivars were different for the March fruit weight (Tab. 1), as 'Camarosa' had significantly larger berries than 'Sweet Charlie' (15.7 *vs*. 10.2 g/fruit) (Tab. 2). In the second growing season, the fruit weight measurements differed among the cultivars for all three months, and 'Camarosa' had consistently larger berries than 'Sweet Charlie'. Treatments were significant for only one month in each experimental year. In the first growing season, GA_3 treatment produced the greatest fruit weight, while chilling at 2°C produced the largest berries in the second year.

Firmness, SS, TA and SS/TA were determined during peak harvest. ANOVAs indicated that the cultivars were significantly different for firmness, TA and SS/TA for both years (Tab. 1). 'Camarosa' was firmer (0.568 *vs*. 0.395 kg in the first season and 0.625 *vs*. 0.428 kg in the second season, respectively) and more acidic (0.843 *vs*. 0.688 kg in the first season and 0.892 *vs*. 0.722 in the second season, respectively) than 'Sweet Charlie' (Tab. 2). The differences between cultivars for the SS were not significant. The differences among treatments for the other fruit quality parameters were not significant except for second year SS.

Discussion

We studied the effects of SD conditioning, Ch and GA_3 treatments on strawberries grown in a frost-protected greenhouse for seasonal patterns of production and their fruit characteristics. Our results suggested that 'Sweet Charlie' produces a significant amount of early yield. Using the same cultivar, 'Sweet Charlie', Paranjpe *et al.* (2008) recovered 195-202 g/plant in early yields between 28 November 2001 to 28 January 2002 and 133-195 g/plant in early yield between 25 November 2002 to 31 January 2003. In another study of 'Sweet Charlie', Paranjpe *et al.* (2003) recovered 136-181 g/plant (2000) and 167-172 g/plant (2001) in early yield, depending on the plug type and growing container. These results suggest that profitable, high early yields can be achieved by 'Sweet Charlie'. Our early yields were lower than those reported in the literature, which was likely caused by environmental and growing conditions differences. We had lower temperatures, during the winter months, than those of the areas where early strawberry production is conducted such as Huelva and Florida.

None of the treatments had a consistent effect on the fruit quality traits measured. Significant treatment effects on seasonal patterns of production were observed in the first year, but not in the second. It is highly likely that the differences between the experimental seasons for the treatment effects were caused by the environmental differences between the seasons such as maximum and minimum temperatures.

All three photoperiodic types (SD, long day and day-neutral) exist among commercial strawberry cultivars and the critical day length among SD cultivars varies between 8 - 11 h (Hancock, 1999; Hancock *et al.*, 2008). Recent studies demonstrated that temperature may also be a major factor controlling flowering responses of strawberries (Serçe and Hancock, 2005; Sønsteby and Heidi, 2007 a and b; 2008). Flower buds are not formed at temperatures outside of 7 - 28°C, regardless of photoperiod, and between 7 - 14°C, all types of cultivars form flower buds regardless of photoperiod, Flower bud formation is only regulated by photoperiod between the temperatures 14 - 28°C.

To manipulate flower bud formation in strawberry, several studies experimented with temperature x photoperiod interactions have been carried out. In these studies, different plant materials were utilized. For example, Konsin *et al.* (2001 and 2002) compared different photoperiods (12, 13.5 or 15 h) at varying durations (21, 35 or 49 d) using the SD cultivar 'Korona'. Only the treatments of 12 and 13.5 h day resulted in induction.

Given their importance in early production and their increasing popularity (Durner *et al.*, 2002), we only concentrated our studies on plug plants. Durner (1999), kept 'Sweet Charlie' plug plants under 9 h days at 21°C constant temperatures and then some of them were conditioned for a week under SD, followed by cold treatments. This treatment produced higher yields during January and February when compared to untreated controls. Durner and Polling (2000) studied 'Camarosa' and 'Sweet Charlie' cultivars at 22/10 or 22/16°C day/night temperatures and 8 h SD along with four other treatments including 3 h low-level incandescent radiation treatments on varying times. They concluded SD conditioning of plug plants significantly increased early yield regardless of cultivar or temperature conditions. While the total yield was not affected in 'Sweet Charlie', in 'Camarosa', conditioning at 10°C significantly enhanced total yield.

In the first season of our experiment, the treatments effects varied depending on the cultivars. For 'Camarosa', some treatments increased the early yield significantly. Indeed, the treatments generally had greater effects on 'Camarosa', compared to 'Sweet Charlie'. It is possible that the treatments did not have an effect or relatively smaller effects on 'Sweet Charlie' than 'Camarosa', because 'Sweet Charlie' may have a lower chilling requirement and can form flower buds under ambient conditions. 'Camarosa' may have a greater chilling requirement and possibly a shorter and/or longer period of SD exposure under cool temperatures (Bigey, 2002).

GA_3 treatments have been shown to stimulate early yields. Previous experiments indicated that treatments of low concentrations (5, 10, 20, 50 and 200 ppm) may be advantageous in increasing early yields in protected culture, while treatments of high concentration reduced fruit weight (Paroussi *et al.*, 2002 a and b; Tehranifar and Battey, 1997). It should be noted that these experiments were conducted on frigo plants. In our experiment conducted on plug plants, while GA_3 treatments increased early yields in some cases, the effect of the GA_3 treatments was not consistent. The discrepancy between our study and the previous ones may also be caused by the environmental factors, specially maximum and minimum temperatures during the course of the experiment, and the cultivars effects.

Conclusions

Our results indicated that short day conditioning, chilling and GA_3 treatments can have an effect on early and total yields. However, these effects interact with other external environmental factors and the effects are cultivar-dependent. Therefore, in any production scheme aiming to generate significant early harvest (starting in November), low-chilling varieties should be utilized that can initiate flower buds in relatively warmer longer days.

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References

Anonymous (2010). www.fao.org.

Bigey J (2002). Chilling requirements and compensation for the lack of chilling in strawberry. Acta Hort 567:269-272.

Bish EB, Cantliffe DJ, Hochmuth GJ, Chandler CK (1997). Development of containerized strawberry transplants for Florida's winter production system. Acta Hort 439:461-468.

Durner EF (1999). Winter greenhouse strawberry production using conditioned plug plants. HortScience 34:615-616.

Durner EF, Polling EB (2000). Phytotron research investigations with conditioned Sweet Charlie and Camarosa plug. Acta Hort 513:403-408.

Durner EF, Poling EB, Maas JL (2002). Recent advances in strawberry plug transplant technology. HortTechnology 12:545-550.

Hancock JF (1999). Strawberries. CAB International, Wallingford, UK.

Hancock JF, Weebadde C, Serçe S (2008). Challenges faced by day-neutral strawberry breeders in the continental climates of the eastern USA and Canada. HortScience 43:1635-1636.

Khangi EM, Fujime Y, Nakamura E (1992). Effects of chilling and growth regulators on runner production of three strawberry cultivars under tropical conditions. HortScience 67:381-384.

Konsin M, Voipio I, Palonen P (2001). Influence of photoperiod and duration of short-day treatment on vegetative growth and flowering of strawberry (*Fragaria* × *ananassa* Duch.). J Hortic Sci Biotechn 76:77-82.

Konsin M, Voipio I, Palonen P (2002). Effect of photoperiod and the duration of short day treatment on vegetative and generative growth of strawberry 'Korona'. Acta Hort 567:561-563.

Lareu J, Lamarre M (1993). Late planting of strawberries using bare root or plug plants. Acta Hort 348:245-247.

Özdemir E, Gündüz K (2004). Comparison of bag and raised bed treatments for strawberry production under unheated greenhouse conditions. J Amer Pomol Soc 58:118-122.

Özdemir E, Kaşka N, Gündüz K, Serçe S (2009). Strawberry runner tip production on open field for plug plants. Hort Environ Biotechnol 50:1-6.

Paranjpe AV, Cantliffe DJ, Lambb EM, Stoffella PJ, Powell C (2003). Winter strawberry production in greenhouses using soilless substrates: an alternative to methyl bromide soil fumigation. Proc Fla State Hort Soc 116:98-105.

Paranjpe AV, Cantliffe DJ, Stoffella PJ, Lambb EM, Powell CA (2008). Relationship of plant density to fruit yield of 'Sweet Charlie' strawberry grown in a pine bark soilless medium in a high-roof passively ventilated greenhouse. Sci Hortic 115:117-123.

Paroussi G, Voyiatzis DG, Paroussis E, Drogoudi PD (2002a). Effect of GA_3 and photoperiod regime on growth and flowering in strawberry. Acta Hort 567:273-276.

Paroussi G, Voyiatzis DG, Paroussis E, Drogoudi PD (2002b). Growth, flowering and yield responses to GA_3 of strawberry grown under different environmental conditions. Sci Hortic 96:103-113.

Polling EB (2000). Strawberry plug transplant technology. Acta Hortic 513:393-401.

SAS Institute Inc. (2005). SAS users guide; SAS/STAT, Version 6. SAS Institute Inc., Cary, N.C.

Serçe S, Hancock JF (2005). The temperature and photoperiod regulation of flowering in *F. chiloensis*, *F. virginiana*, and *F.* × *ananassa* genotypes. Sci Hortic 103:167-177.

Sønsteby A, Heidi OM (2007a). Long-day control of flowering in everbearing strawberries. J Hortic Sci Biotechn 82:875-884.

Sønsteby A, Heidi OM (2007b). Quantitative long-day flowering response in the perpetual-flowering F_1 strawberry cultivar Elan. J Hortic Sci Biotechn 82:266-274.

Sønsteby A, Heidi OM (2008). Temperature responses, flowering and fruit yield of the june-bearing strawberry cultivars Florence, Frida and Korona. Sci Hortic 119:49-54.

Tehranifar A, Battey NH (1997). Comparison of the effects of GA_3 and chilling on vegetative vigour and fruit set in strawberry. Acta Hortic 439:627-631.

Türemiş N, Kaşka N (1997). The effect of gibberalic acid on the production and quality of strawberry runners. Turk J Agric For 21:41-47.

Turhan E, Paydaş Kargi S (2007). Strawberry production in Turkey. Cron Hortic 47:18-20.