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THE EFFECT OF THE PASSIVE SOLAR HEATING SYSTEM AND OF THE KIND OF COVERING MATERIAL ON YIELD AND QUALITY OF MELONS CULTIVATED IN LOW TUNNELS

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Abstract: The effect of using the passive solar system in low tunnel covered with different plastic materials, on air temperature and on melon yield and quality was investigated. The different covering materials did not significantly affect the minimum and the maximum air temperatures in the unheated tunnels. However, significant differences were observed between the tunnels heated by the passive solar system compared to the unheated ones in the air temperatures. Also, the total melon yield was higher in low tunnels heated by the passive solar system while the earliness was by 10 days. The mean fruit weight and the length of the fruit were bigger than the control. Soluble solids content, firmness, pH, and titratable acidity of the melon fruits were not significantly affected.

INTRODUCTION

The use of the passive solar system (PSS) with water filled plastics tubes in Mediterranean greenhouses has been reported to increase the minimum air, soil and plant temperatures by 2 to 4 °C (Grafiadellis, 1990), to decrease the maximum air temperature by 1.1 to 6.9 °C (Sallambas et al., 1989) and the relative humidity by 6-12% (Grafiadellis, 1986; Nisen et al., 1990). Such a system is simple, inexpensive, easily understood by the growers and operates when active systems fail despite the absence of control and difficulties to adapt to greenhouse architecture. From other researchers it is known that greenhouses heated with the passive solar system and covered with EVA film showed a 1-2 °C higher minimum air temperature compared to PE film (Mougou and Verlodt, 1990).

Earlier production of melons has been achieved by the use of low tunnels covered with simple polyethylene (SPE) films of 40 to 80 microns thickness with high transmissivity to visible light and with high heat loss (Keveren, 1973; Dauple, 1990). PVC, EVA and modified polyethylene (MPE) films generally maintain the minimum air temperatures at night by 1 to 2 °C higher compared to the SPE in low tunnels (Nisen et al., 1990). High fruit weight, yield and earliness was obtained in melons grown under low tunnels covered with EVA crystal, EVA opal and PVC compared to SPE (Esquira et al., 1989). The passive solar system used in melon production (Esquira et al., 1989) resulted in good fruit set particularly of the flowers in the initial side growth which are normally sterile leading to earlier fruiting and an increase of the yield of the first crop. Davis et al., (1965) reported that muskmelon is a native of warm and humid or sometimes arid regions of the world, it requires relatively long periods of preferably dry, warm weather and it is easily damaged by frost during all stages of the development. It was also proved that the low temperature reduces the growth and increases the formation of female flowering and that eating quality of melons could be assessed by the soluble solids content and flesh firmness, (Mutton et al., 1981).

The aim of this research work was to evaluate the effect of four kinds of covering materials and of the heating with the passive solar system on the earliness, the yield and the quality of melons grown in low tunnels.

MATERIAL AND METHODS

Twenty-four, Nante-type low tunnels (5x1m) were installed NE to SW orientation at the Mediterranean Agronomic Institute of Chania (24^{o} 02 E longitude, 35^{o} 30 N latitude, 8 m altitude). The low tunnels were covered with simple polyethylene (PE), thermic polyethylene (TPE), ethylene vinyl acetate copolymers (EVA) and coextruded PE with a sandwiched EVA layer (TP3L) films in three replications. The passive solar system (PSS), consisting of two transparent polyethylene sleeves (60cm of circumference and 4 m of length) filled with water plus 10 g of copper sulphate per tube to prevent algae growth.

In each tunnel seven andromonoecious melon plants (*Cucumis melo*) cv. Antalya F1 were transplanted on March 29th in planting distances of 50cm. The soil was previously cleaned, graded and fertilised according to standard horticultural practise and mulched with black polyethylene film. Melon plants during growth were drip fertigated and received the appropriate plant protection treatments as well as the necessary thinning. The tunnels were daily ventilated manually from morning to sun set.

The maximum and minimum air temperatures inside and outside the low tunnels were recorded daily by accurate mercury thermometers placed in the middle of the tunnels (at about 30cm height). The fruits were harvested at commercial maturity (abscission zone developed between the fruit and the peduncle, and the change of the colour from green to yellow). To determine fruit quality, height, firmness (by a pressure tester, equipped with a 7.9 mm diam. probe), soluble solids content (SSC - by hand refractometer), pH and titratable acidity (TA- titration of 10ml of juice with 0.01 N NaOH to pH 8.2) were measured.

The analysis of variance was carried out with a SAS computer program.

RESULTS AND DISCUSSION

From table 1 it can be observed that the maximum air temperatures were higher in all the unheated tunnels regardless of the cover type. During the first 30-40 days from transplanting the maximum air temperatures in the PSS-heated tunnels were lower than the non-heated. However, from the 40 days on, the temperature differences were reduced since the tunnels were permanently ventilated (due to the improvement of the weather conditions) and plants were of increased growth (covering the water tubes) (Table 1). Conversely, the minimum air temperatures during the cultivation time were always 2 to 3 ^{o}C higher in the PSS-heated tunnels compared to the unheated tunnels. Tunnels covered with EVA film had the highest minimum air temperatures (Table 1).

Excessive temperature rise has caused burning of the leaves and has restricted the growth of melon in low tunnels indicating the need of ventilation. PSS was considerably contributing to low tunnel cooling thus decreasing the needs of ventilation depending on the whether conditions. From other research is also reported that the PSS is increasing the minimum air temperatures by 2 to 4^{o}C and is decreasing the maximum air temperatures by 1.1 to 6.9 ^{o}C thus improving temperature conditions (Grafiadellis 1986; Sallambas et al., 1989). Esquira et al., (1989) reported that the difference between maximum air temperatures in PSS-heated low tunnels with 2 water tubes compared to the control was 2^{o}C.

Table 1: Maximum and minimum air temperatures during the growing period of melons in PSS-heated and unheated low tunnels covered with different types of plastics material

Growth time (days)	CONTROL				PSS-HEATED			
	SPE	TPE	EVA	TP3L	SPE	TPE	EVA	TP3L
	Maximum temperature (°C)							
1-10	35.9±1.2	31.1±1.0	33.0±0.5	33.1±1.6	30.6±2.1	28.0±1.8	28.0±1.3	30.3±2.2
11-20	35.7±1.2	35.5±1.5	35.0±0.9	34.7±1.6	33.9±1.2	29.7±1.4	30.7±2.1	32.2±2.4
21-30	32.3±4.1	37.9±4.3	32.2±5.8	33.1±2.6	30.2±3.0	28.0±3.1	29.9±3.2	30.0±3.5
31-40	31.6±2.8	34.9±1.8	32.9±1.8	29.9±1.3	30.3±2.3	28.7±2.4	29.8±2.1	30.4±2.9
41-50	30.6±2.7	·34.2±1.6	31.9±1.1	30.2±2.2	30.9±1.5	29.0±2.6	32.2±3.1	30.7±2.0
51-60	31.0±1.2	35.3±3.0	31.9±1.0	31.0±1.0	31.1±1.9	28.7±3.2	34.0±3.4	32.0±2.4
	Minimum temperature (°C)							
1-10	7.4±0.3	7.7±0.2	7.8±0.4	7.5±0.2	10.6±1.7	10.5±0.9	10.8±0.8	10.1±1.2
11-20	8.9±0.3	9.2±0.3	9.4±0.5	8.6±0.3	12.0±1.3	12.4±1.2	12.3±0.6	11.5±1.2
21-30	6.7±0.5	7.6±0.8	7.9±0.8	7.2±0.2	9.7±1.6	9.9±2.2	9.8±1.1	8.6±0.9
31-40	7.8±0.3	8.2±0.3	8.4±0.3	8.4±0.5	10.0±1.2	10.2±1.7	10.0±0.6	9.1±1.2
41-50	11.7±0.7	10.9±0.5	11.5±0.5	11.8±0.6	12.7±1.4	12.9±1.3	13.4±1.1	12.1±1.2
51-60	11.7±0.6	11.6±0.3	12.0±0.4	12.5±0.7	13.6±1.3	15.0±1.4	15.2±1.1	13.5±1.6

SPE: (Simple PE), TPE:(Thermic PE), TP3L: (Coextruded PE with a sandwiched EVA layer) PSS: (Passive solar system).

PSS-heated tunnels produced significantly higher yield compared to the non-heated ones (Table 2). Simple PE in both PSS-heated and control tunnels had the highest yield (41.6 kg) followed by EVA (35.2 kg), the thermic PE (34.7 kg) and the thermic TP3L with 34.8 kg (Table 2). The peak melon production was obtained 90 days after transplanting. The fruits were harvested mature starting from day 55 in the PSS-heated tunnels while the control fruit were first harvested 10 days later (Figure 1). The covering materials of EVA and of the simple PE had mainly effected the melons. Higher (by 70%) and earlier yields suitable for exportation as well as fruit weight of melon in PSS-heated tunnels was reported by Esquira et al., (1989). Dauple (1979) reported that in unheated low tunnels covered with EVA the fruit weight and the yield of melons was higher than in tunnels covered with PE.

Table 2: Quality characteristics and total yield of melon fruit produced in PSS-heated and unheated low tunnels covered with different types of plastics material

Quality characteristics	CONTROL				PSS-HEATED			
	SPE	*TPE*	*EVA*	*TP3L*	*SPE*	*TPE*	*EVA*	*TP3L*
Fruit weight (g)	953b	919b	941b	958b	1068a	1156a	1008a	1094a
Calibrate (mm)	108.5c	109.5bc	108.1c	111.7bac	117.4bac	118.8ba	121.1a	114.7bac
Length (mm)	109.5b	112.1ba	110.7b	111.2ba	119.3ba	120.7a	120.8a	114ba
Firmness (kg)	0.53b	0.58ba	0.58ba	0.57ba	0.62ba	0.74a	0.62ba	0.53b
SSC (%)	9.9ba	9b	9.9ba	9.7ba	9.5ba	9.8ba	10.2a	10a
pH	6.1a	5.9a	6.2a	5.9a	6.2a	6.1a	6.1a	6a
Acidity	5.7a	5.9a	6.1a	6a	5.7a	6.1a	5.8a	5.8a
Total yield	27.6c	20.2bc	22.5c	23.0c	41.6a	34.7ba	35.2a	32.8ba

SPE: (Simple PE), TPE:(Thermic PE), TP3L: (Coextruded PE with a sandwiched EVA layer), PSS: (Passive solar system)

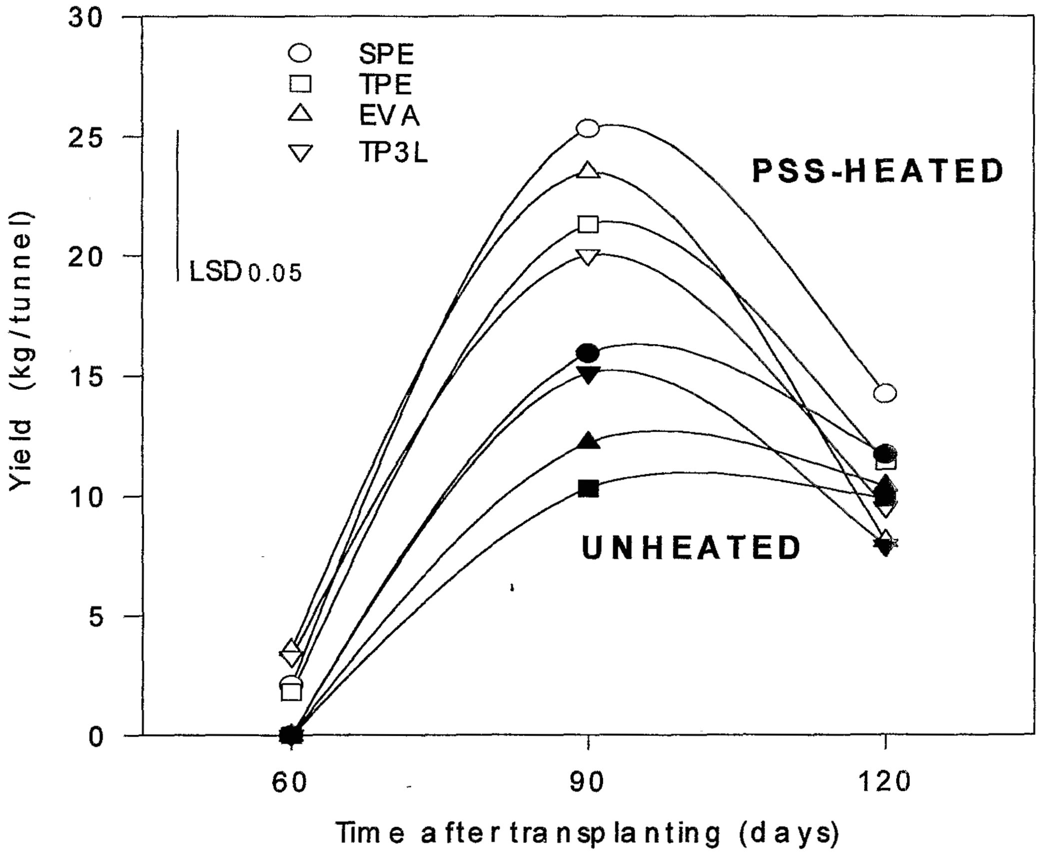

Figure 1. Production of melons in kg during the growing period in PSS-heated and unheated low tunnels covered with different plastic materials

The fruit weight was significantly higher in PSS-heated tunnels averaging 1081g compared to the control with only 943g. The fruit produced in PSS-heated tunnel were very attractive and had higher diameters while firmness, SSC, pH and titratable acidity did not differ from the ones produced in the control tunnels (Table 2). Melons from PSS-heated tunnels had bigger fruits and better calibrate than the non-heated. From other researches Mutton et al. (1981) found that only soluble solids content and firmness were essential in deriving a predictive equation to judge the eating quality of melons. Winsor and Adams (1975) reported that the improvement in fruit quality from spring to summer was affected by the increase of light intensity and the day length. From other investigations it was found that at the beginning of harvest of melons, the SSC is lower; however, with the ripening the sugar content increases and the acidity decreases (Hulme, 1971, Winsor and Adams, 1975). The fruit picked from the low tunnels heated with the passive solar system had better aroma (data not shown), one of the important quality characteristics of melons.

As a conclusion can be mentioned that the passive solar system installed in low tunnels is of great importance for the growth of melon plants since it increases the minimum air temperatures by 3 to 4°C than the control. Melon cultivated under such conditions is enforced to grow faster, to become more vigorous and produce higher and earlier by 10 days yield of improved quality.

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