Heating strategies for an Eggplant (*Solanum Melongena* L.) crop on Mediterranean Greenhouses

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Abstract

Horticulture greenhouse production in the Mediterranean area is based on the use simple low-cost structures with a very limited climate control. During the autumn-spring cycle, low temperatures reduce yield and quality of the different crops. Heating systems allow an increase of both, but the fuel consumption makes difficult its justification, thus it is necessary to evaluate them for local climate conditions. The goal of this work was to study the productivity of an eggplant crop in three multispan type greenhouses under three heating treatments, which levels were: minimum night air temperature of 12ºC, 16ºC and 20ºC, with a minimum diurnal air temperature of 20ºC for all of them. Marketable yields for the whole cycle (204 days) were 13.5, 11.8 y 11.6 kg m^{-2}, for 12º, 16º y 20º C, respectively. Fuel consumption (propane) was 8.4 kg m^{-2}, 11.8 kg m^{-2} and 18.2 kg m^{-2}, for 12º, 16º y 20º C, respectively. Therefore, the treatment with a minimum night temperature of 12ºC, achieved the highest yield and the lowest fuel consumption for an eggplant greenhouse crop. These results can be explained in the view of the fact that higher night temperatures modify distribution of assimilates, thus stimulating a higher vegetative growth.

INTRODUCTION

The largest greenhouse area in Spain is concentrated in the coastal area of the province of Almería (approximately 27.000 ha according to Sanjuán, 2004). The great majority of these greenhouses, as it is common in the rest of Spanish Mediterranean greenhouse areas, are low cost structures in which it is possible to grow vegetables without heating systems, although due to the sub-optimal climate conditions during the winter, yield and quality is usually lower (López, 2003). In order to solve this situation, heating systems which are very similar to those installed on greenhouses of temperate climate are being installed, without considering such systems have been designed to perform in growing areas with climate and agronomic conditions which differ greatly from those of the Spanish Mediterranean coastal areas. All this makes necessary a local study of the performance and management of such systems to adapt them to our conditions (Hernández, 1998; Baille et al., 2004).

The main goal of the experiment was to determine the best heating strategy in order to reduce the energy consumption without affecting the yield of a greenhouse eggplant crop in Almería.

MATERIAL AND METHODS

The experiment took place in the Experimental Station of the Cajamar Foundation, in three adjacent asymmetric multi-tunnel type greenhouses, each one covering 2.400 m^2. The greenhouses were covered with new colourless 200 µm thickness plastic film, installed on 07/26/04. An eggplant crop was cultivated, transplanted on 09/21/04 finishing the crop cycle on 04/19/05. Plant density was 2.4 plants m^{-2}. Each one of the three greenhouses had a convection-radiation hot water heating system with metallic pipes. The fuel burnt on the heater was liquefied propane. The following treatments were compared: T12: average night temperature of 12 ºC and minimum day temperature of 20 ºC; T16: average night temperature of 16 ºC and minimum day temperature of 20 ºC; T20: average night temperature of 20 ºC and minimum day temperature of 20 ºC.

Total and marketable yield were determined as well as dry weight of the aerial organs, temperatures and fuel consumption.

Solarimenter used during the experiment (2004/05)

Detail of the crop, Solanum melongena L. cv. Cristal, during crop season 2004/05

RESULTS AND DISCUSSION

Temperature

Temperature differences between treatments started in October, when the heating systems started to work, in coincidence with the beginning of the harvests. Until then the average temperature was always above the set temperatures. The average day temperature was quite homogeneous in the three greenhouses, close to 20 ºC, during the whole growing cycle (Table 1). The temperature differences appeared, mainly, during the night period, whereas the average daytime temperatures were similar for the three treatments, and slightly higher than the outside temperature. In relation to average night temperatures, treatment T20 achieved temperatures close to 20 ºC along the whole cycle, with a period between 80-170 dat in which temperature oscillations occurred. This period corresponds

to the winter months, in which maintaining 20 ºC constantly became difficult. Treatments T12 and T16 did not suffered these oscillations, with almost constant night temperatures through the whole cycle.

Yield

The treatment which achieved higher both total and marketable yield at the end of the growing cycle was the lower temperature one (T12), with 14.0 kg m^{-2} and 13.5 kg m^{-2}, respectively. However, the treatment which achieved a lower marketable production was the one with higher set temperature (20 ºC), with 11.6 kg m^{-2}, a difference of almost 2 kg m^{-2} in relation to the higher marketable yield treatment. Significant statistical differences were observed for final yield between treatments (Table 2).

These differences, favourable to the lower thermal level treatment can be explained for the higher distribution of assimilates to the leaves on the treatments with higher thermal level, 41%, 49% y 52% for T12, T16 and T20, respectively. At the end of the growing cycle an average distribution value of 63 % was achieved for the fruits for the three treatments.

Fuel consumption

The accumulated propane consumption, to maintain 12 ºC of minimum temperature was 8.36 kg m^{-2}; for 16ºC it was 11.8 kg m^{-2}, and for 20ºC it was 18.2 kg m^{-2}.

CONCLUSIONS

The conclusions derived from the present work, for the different minimum night thermal treatments experimented (12 ºC, 16 ºC and 20 ºC) for the eggplant greenhouse crop were:

- Total marketable yield was higher in the lower temperature treatment, T12 with 13.5 kg m^{-2}, being lower for the higher temperature treatment T20 with 11.6 kg m^{-2}.
- The heating system fuel consumption (propane) of the higher temperature treatment, 20 ºC, was 18 kg m^{-2}, whereas for the 12 ºC the consumption was 8 kg m^{-2}.
- The fuel saving strategy: ‘minimum night set temperature of 12ºC and minimum daytime temperature of 20ºC allowed a lower fuel consumption and a higher yield, thus it is a strategy recommended for this eggplant growing cycle.

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Tables

Table 1. *Average daily values of average daily, daytime, night, maximum and minimum temperatures (ºC).*

Temperature (Cº)	**Outdoor**	**T12**	**T16**	**T20**
Daily average	14,2	17,9	19,5	20,6
Diurnal average	16,4	21,8	22,4	22,3
Night average	12,2	14,7	17,0	19,2
Maximum average	18,8	25,7	26,1	25,6
Minimum average	9,9	12,8	15,7	17,5

Table 2. *Total and marketable yield, in kg m^{-2}, for an eggplant crop with heating system.*

Treatments	Total yield	Marketable yield
T12	14,0 a	13,5 a
T16	12,7 b	11,8 b
T20	11,9 c	11,6 b

Figures

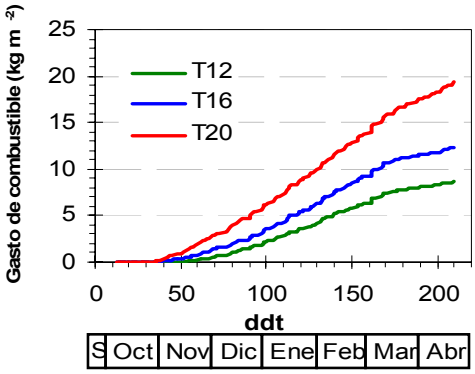

Figure 1. *Accumulated daily consumption of propane (kg m^{-2}), for an eggplant crop under different thermal regimes (12 ºC, 16 ºC, 20 ºC), during the growing season 2004/2005.*