WFL Publisher
Science and Technology

Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.7 (3&4) : 248-253. 2009 www.world-food.net

Influence of different types of pruning on cherry tomato fruit production and quality

José L. Franco, Manuel Díaz, Fernando Diánez and Francisco Camacho*
*"Plant Yield in Mediterranean Crop Systems" Research group, University of Almeria, Spain. *e-mail:fcamacho@ual.es*

Received 15 July 2009, accepted 7 October 2009.

Abstract

The aim of this study was to determine the most efficient pruning system with cherry tomato to achieve the highest level of production without loss of quality and, thus, to provide growers with an efficient management system. The study was done at the University of Almeria Anecoop Experimental Farm Foundation, Almeria, Spain (36º51'78"N; 2º17'08"W). Two pruning systems, T0 with a main stem and a secondary stem (2S) and T1 with a main stem and a secondary stem plus four lateral branches with two racemes each (2S + 4B), were compared using the cherry tomato cultivar Salomée. System T1 resulted in a significantly larger quantity of fruit and a greater output in terms of weight per unit surface area. There was no significant difference in the quality parameters measured. Two elevated phases of production, harvesting in the greenhouses and in the summer, were obtained during the crop cycle for system T1, coinciding with harvesting from the additional branches (4B).

Key words: Cherry tomato, pruning, stems (branches), production, quality.

Introduction

In Spain, production of the cherry tomato (*Lycopersicon esculentum* var. *cerasiforme* Hort. cv. Salomée) in greenhouses is very labour-intensive. The fruit of this solanaceous crop is of high commercial value worldwide [8]. The choice of a suitable pruning system is an important factor for achieving a profitable balance between labour costs and crop yield without loss of quality.

Pruning consists of leaving a chosen number of stems to form the axis or axes of the plant. Pruning to leave 1 or 2 stems (shoots) is frequent practice for *L. esculentum*, and pruning to leave a single stem is normal when larger fruit are desired. If a plant dies, a second stem is often allowed to grow on an adjacent plant. Choosing the type of pruning must take into account the characteristics of the cultivar being grown [4]. Researchers [2] studied the growth and fruit yield of cherry tomato and analysed the effects of plant spacing and the number of stems per plant. They obtained the best results with 0.6 m between plants, 0.9 m between rows and pruning to two stems per plant. The type of pruning, the number of stems per plant and planting density together affect the relationship between the number of fruits per surface unit and the number of fruits per plant; however, these do not affect biomass production or the distribution between the fruit and the vegetative parts of the plant, although they can affect fruit size and quality (split fruit and soluble solids), which is of concern for commercial production [6].

Cherry tomato crops in Southern Spain are always pruned to two stems, and we used this system as the control group in this study. For a long time, producers and technicians have managed tomato crops through pruning techniques, without considering the genetic potential of each variety. Pruning on a single stem (branch) eliminates lateral buds, and fruit is harvested as it ripens. This leads to the use of a larger number of plants per surface unit, which entails greater expenditure on seed and seedbeds. Nevertheless, in the two-stem or "fork" type of pruning, all buds are eliminated except the one that emerges underneath the first raceme, which is left as the second main stem. "Hardy pruning" consists of allowing one of the auxiliary shoots to grow (starting from the 2nd or 3rd leaf after the first inflorescence) so that two main stems or shoots are available (the main stem and the auxiliary shoot) [10].

It has been reported [1] that the influence of a chosen type of pruning on tomato productivity is connected to planting density and the variety, concluding that controlling the number of shoots or main stems per square metre should be considered. In another experiment carried out in Almeria, where 2 types of pruning (1 or 2 branches) and planting densities (1 and 2 plants/m^2) were tested. The greatest yield was obtained by pruning to 2 stems and with 2 plants/m^2 [7].

The effect of de-leafing as the fruit ripened has been studied and stem vigour and diameter were significantly inferior when de-leafing was done every 21 days compared to every 7 days, with a decrease in vegetative growth and leaf area [9]. Extensive research on the productive response of the cultivar Blazer has been conducted, with various planting frameworks and pruning systems, and it was concluded that the production of a bud can have an indirect detrimental effect on fruit size [3].

The results presented here refer to a particular operation: pruning and production on 2 stems, plus lateral branches. This operation consists of pruning a plant to leave 2 leading shoots and 4 lateral branches to bear fruit. The objective of this study was to determine whether this type of pruning can lead to an increase in yield while maintaining the quality of fruit.

There are few studies of commercial pruning systems in the literature. The current choice of pruning method for commercial crops is influenced by the genotypic and phenotypic characteristics of the cultivar, and is limited by plant vigour and planting density [5]. This study used a cultivar of undetermined growth and with excellent vigour. The experiments were done in the productive seasons 2004–2005 (experiment one) and 2005–2006 (experiment two).

Materials and Methods

Environmental parameters: Both experiments with *L. esculentum* var. *cerasiforme* (Hort.) cv. Salomée were done in a 5-tunnel plastic house; each tunnel was 8 m wide and 45 m long, providing 1800 m^2 of greenhouse surface area. The arch of each tunnel reached a height of 5.7 m and a height of 4.5 m at the water spout, with a height of 4 m at the entrainment trellis. The covering was 3 layers of 200 µm thick thermal polyethylene, with passive zenith ventilation. Planting was in double rows positioned NE–SW, with 0.6 m between rows and 0.75 m between plants, with 1.06 m wide alleys between each pair of rows, giving a density of 1.6 plants/m^2. The soil was sand-covered (typical of the region) and the climatic conditions are summarized in Table 1. Nutrition was provided through fertirrigation according to guidelines from a commercial enterprise.

Treatments and experimental design: The trials used a random block experimental design with 2 treatments and 4 repetitions, according to the following linear statistical model:

$$y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}; \forall\, i = 1.2.\, and\;\; j = 1.2.3\; and 4.$$

y_{ij} = the variable response associated with the *ij*th experimental unit;
μ = the global average;
α_i = the effect associated with the *i*th treatment evaluated;
β_j = the effect associated with the *j*th block;
ε_{ij} = the effect of the experimental error on that associated with the *i*jth experimental unit.

Pruning the control group (T0) consisted of leaving the main stem and the stem arising from the node under the second inflorescence, which becomes the second stem, producing a plant with two stems or axes (2S) (Fig. 1). Lateral buds that appeared in the leaf axilla were removed periodically.

Plants in the T1 group also had 2 stems, leaving the bud underneath the second inflorescence of the 2 stems in autumn. When these lateral shoots had 2 well-shaped inflorescences, the apical bud was removed, and the shoots were fastened with plastic clips to the 2 main stems (which were entrained with raffia). The operation was repeated in spring, so that 4 new racemes were obtained per stem for winter and summer (2S + 4B), giving 8 additional racemes per plant as compared to the control group (Fig. 1).

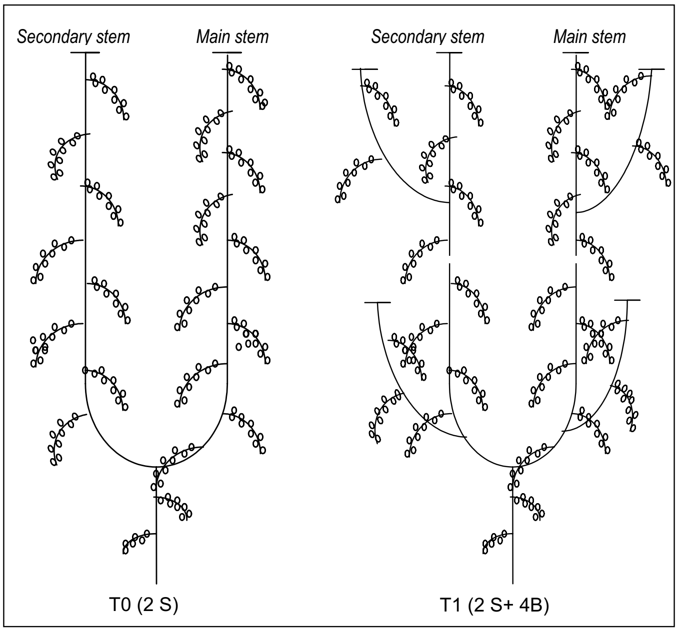

Figure 1. Treatments were as follows: T0, 2 stems (main and secondary) (2S) and T1 2 stems (main and secondary) plus 4 lateral branches with 2 racemes (2S + 4B).

Experiment 1: seedbeds were planted on 20 July 2004 and transplanting was done on 26 Aug. 2004. The crop season was from this date until 29 June 2005, the date of the last harvest.

Experiment 2: seedbeds were planted on 15 July 2005 and transplanting was done on 23 Aug. 2005. The crop season was from this date until 4 July 2006, the date of the last harvest.

The greenhouse was divided into 4 blocks; random treatments were applied in each block, for a total of the above-mentioned 4 repetitions per treatment to obtain 8 experimental units. Each repetition included a pair of rows. In each repetition, 8 plants were chosen at random and marked for analysis.

Measurement of yield parameters: Harvesting was done every 7 days and yield was measured in both experiments as total weight and the number of fruits per harvest for the 8 marked plants. A sample of 25 fruits was taken at random per repetition, and the diameter and weight were measured for 100 fruits per treatment and for 200 fruits per experiment and harvest day.

Total yield was measured from all the plants per repetition (2 rows). The number of fruits per surface unit (m^2) and average fruit weight (AFW) from the marked plants were measured.

The quality of the fruit gathered from the eight marked plants was evaluated. Data were collected at alternate pickings. A random sample of 25 fruits was taken per repetition, and the diameter, °Brix and pH were measured. We used an MR32ATC Milwaukee refractometer (measures from 0 to 32% with a sensitivity of 0.2) and a WTW 340i pH meter (with a sensitivity of 0.01).

Table 1. Climatic conditions during cropping.

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
					Average temp.[a] (ºC)						
Experiment 1	30.1	25.7	22.3	15.7	14.3	12.4	13.3	16.6	18.2	21.0	24.8
Experiment 2	28.7	26.2	20.9	15.0	13.1	12.4	14.1	16.8	18.9	21.6	25.2
					Average RH[b] (%)						
Experiment 1	71.8	68.4	72.3	74.4	77.4	68.9	70.1	70.8	70.1	66.7	63.8
Experiment 2	59.6	57.8	77.8	78.5	80.9	81.4	74.6	67.4	73.1	69.9	67.5

[a] Temperatures were taken inside the greenhouse. [b] Relative humidity (RH) was measured inside the greenhouse.

Statistical analysis: All data were subjected to an analysis of variance (ANOVA) and means separation through Fisher's least significant difference (LSD) procedure (statistical significance was set at $P \leq 0.05$) according to the $y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$ model, using the STATGRAPHICS Plus 4.0 statistical package for Windows.

Results

Effect on production of the type of pruning: Harvesting began 76 days after transplanting in Experiment 1 and at 77 days after transplanting in Experiment 2. No difference was observed in the duration of the vegetative stage; however, greater precocity was seen in Experiment 2, chiefly in the maturity of T1 lateral branches, which were harvested at the end of December, while the harvest for Experiment 1 was at the beginning of January.

Yield from the T1 group in Experiment 1 was 10.7% higher compared to the T0 control group. Statistically significant differences were observed between both treatments. Similarly, a difference of 13.35% was observed in the T1 group for Experiment 2 compared to the T0 control (Table 2). Therefore, the addition of the lateral branches was responsible, at least in part, for the increased yield (Fig. 2). Increases of 1.29 and 1.73 kg/m^2 were obtained for the T1 group in both experiments, which is equivalent to 0.81 kg/plant in Experiment 1 and 1.08 kg/plant in Experiment 2.

There were significant differences among the average values of harvests in Experiment 1 (Table 2). There was an increase for the T1 group between Harvest 9 (134 days after transplanting (d.a.t.)) and Harvest 10 (144 d.a.t.) that coincided with harvesting from the first pair of lateral branches. There were increases also between Harvests 25 (250 d.a.t.), 26 (257 d.a.t.) and 27 (263 d.a.t.) that coincided with harvesting from the second pair of lateral branches (Fig. 3a).

In Experiment 2 there were significant differences among harvest averages. There were increases for T1 between Harvests 7 (128 d.a.t.) and 8 (135 d.a.t.), coinciding with harvesting from the first pair of lateral branches. There was a second increase between Harvests 23 (266 d.a.t.) and 24 (273 d.a.t.), coinciding with harvesting from the second pair of lateral branches (Fig. 3b).

The number of commercial fruits from both experiments was significantly different for the T1 group compared to the T0 control, with an increase of 15.78% (Table 2). Similarly, there was an increase of 16.39% in Experiment 2. This trend was observed also in the harvest average (Fig. 4). Lastly, these increases produced 180.01 and 236.64 fruits/m^2 more for the T1 group compared to the T0 control group in both seasons.

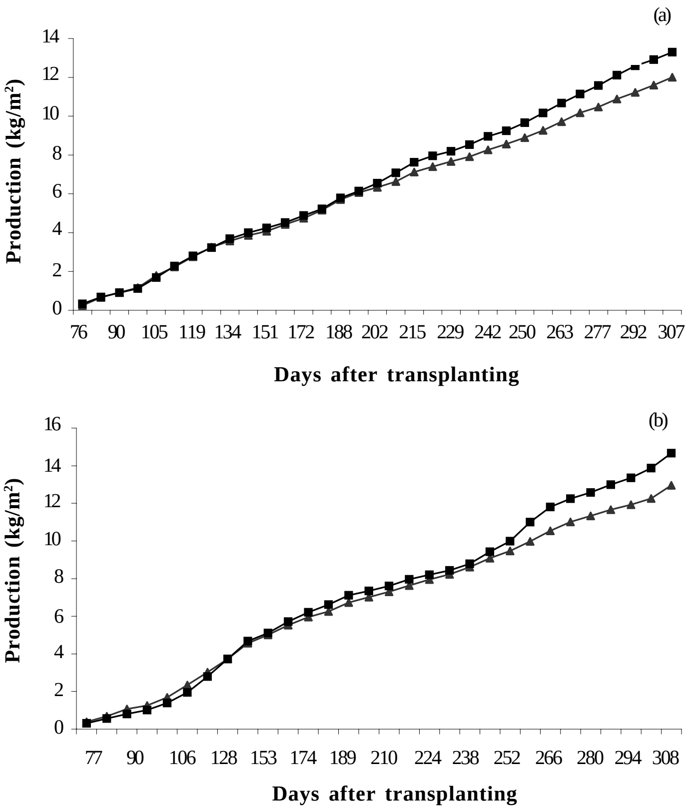

Figure 2. Effect of pruning to 2S (T0, ▲) and 2S + 4B = (T1, ■) on fruit production (kg/m^2) by cherry tomato cultivar Salomée crops in (a) Experiment 1 and (b) Experiment 2 in the greenhouse.

Effect on quality of the type of pruning: The AFW values for Experiments 1 and 2 were not significantly different between the T1 group and the T0 controls (Table 3). The AFW (in both groups) higher in early pickings, decreased in the intermediate pickings and increased in later pickings (Fig. 5).

Table 2. Effect of pruning on production components.

Treatment	Production components					
	Commercial production (kg/m^2)		Average production per picking (kg/m^2)		No. commercial fruits m^{-2}	
	Experiment 1	Experiment 2	Experiment 1	Experiment 2	Experiment 1	Experiment 2
To	12.01 b	12.96 b	0.36 b	0.43 b	1141.03 b	1444.04 b
T1	13.30 a	14.69 a	0.40 a	0.49 a	1321.04 a	1680.68 a
ANOVA	**	*	*	*	*	*

The probabilities are shown as $*P < 0.05$, $**P < 0.01$, $***P < 0.001$ and not significant (ns). Numbers followed by different letters denote statistical significance according to Fisher's LSD test (P <0.05).

Table 3. Effect of pruning on average fruit weight (AFW) and fruit diameter.

Treatment	Quality components			
	AFW		Diameter (mm)	
	Experiment 1	Experiment 2	Experiment 1	Experiment 2
To	10.41 a	9.14 a	27.10 a	26.76 a
T1	10.01 a	9.05 a	26.75 a	26.53 a
ANOVA	ns	ns	ns	ns

The probabilities are shown as $*P < 0.05$, $**P < 0.01$, $***P < 0.001$ and not significant (ns). Numbers followed by a different letter denote statistical significance according to Fisher's LSD test (P <0.05).

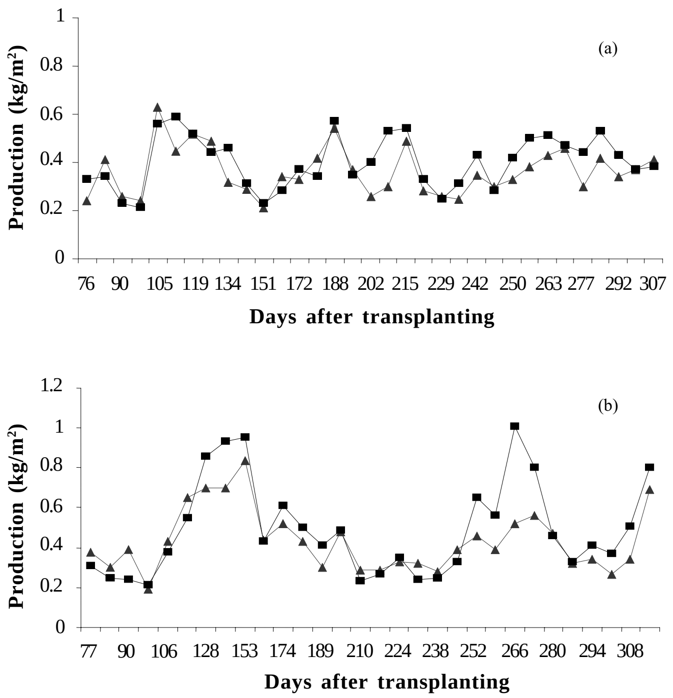

Figure 3. Effect of pruning to 2S (T0, ▲) and 2S + 4B (T1, ■) on changes of fruit production (kg/m^2) in the productive cycle of cherry tomato cultivar Salomée in (a) Experiment 1 and (b) Experiment 2 in the greenhouse.

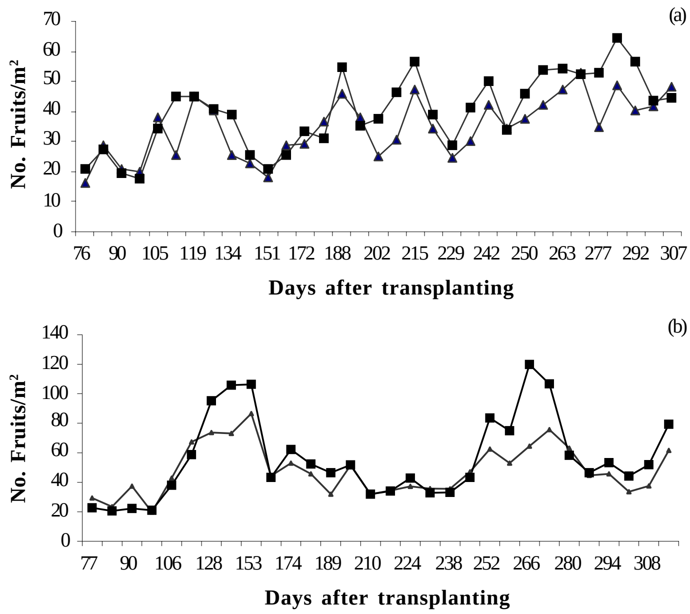

Figure 4. Effect of pruning to 2S (T0, ▲) and 2S + 4B (T1, ■) on changes of fruit production (number of fruits/m^2) in cherry tomato cultivar Salomée in (a) Experiment 1 and (b) Experiment 2 in the greenhouse.

Fruit diameter (in both groups) was directly proportional to AFW (Table 3). There were decreases during harvesting from the lateral branches in Harvests 9 (134 d.a.t.) and 10 (144 d.a.t.) for the first experiment, and Harvests 7 (128 d.a.t.) and 8 (135 d.a.t.) for the second experiment, maintaining this trend at the end of cropping (Fig. 6).

The average soluble solids content (ºBrix) for Experiment 1 was highly significantly different for the T1 group compared to the T0 controls, with smaller, more stable fluctuations. There was no difference in Experiment 2, although a greater variation in values was observed (Table 4). Pruning of the T1 group increased fruit sugar content, which was reflected as an increase in soluble solids when harvesting fruits from the lateral branches (Fig. 7). There was no significant difference in pH values between the T0 and T1 groups within each experiment (Table 4, Fig. 8).

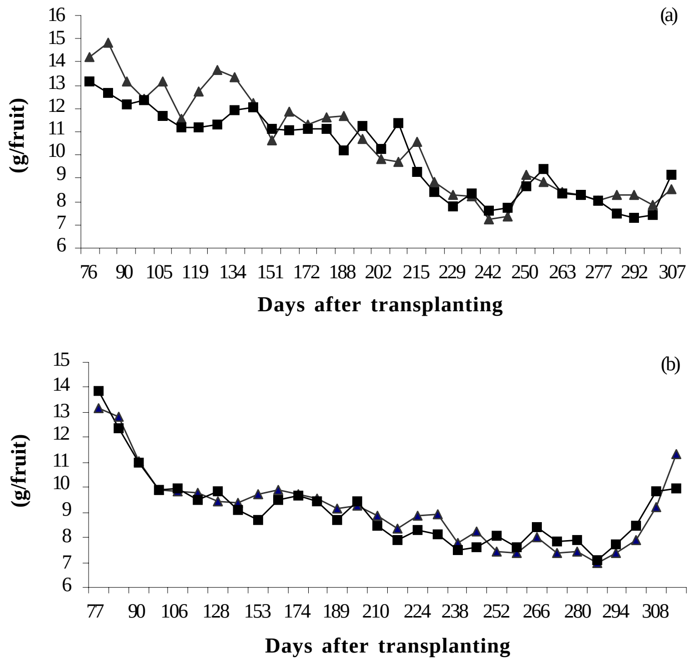

Figure 5. Effect of pruning to 2S (T0, ▲) and 2S + 4B (T1, ■) on changes of AFW (g/fruit) in cherry tomato cultivar Salomée in (a) Experiment 1 and (b) Experiment 2 in the greenhouse.

Discussion

The effect of pruning on yield was 10.7% increase for the T1 group compared to the control for the first experiment, and a 13.35% increase for the second experiment, due to the larger number of racemes per plant. This result demonstrated that the increased

Table 4. Effect of pruning on tomato quality components.

Treatment	Quality components			
	ºBrix		pH	
	Experiment 1	Experiment 2	Experiment 1	Experiment 2
T0	8.80 b	9.02 a	4.06 a	4.31 a
T1	8.89 a	9.07 a	4.06 a	4.33 a
ANOVA	**	ns	ns	ns

The probabilities are shown as *P < 0.05, **P < 0.01, ***P < 0.001 and not significant (ns). Number of values followed by a different letter denote statistical significance according to Fisher’s LSD test (P <0.05).

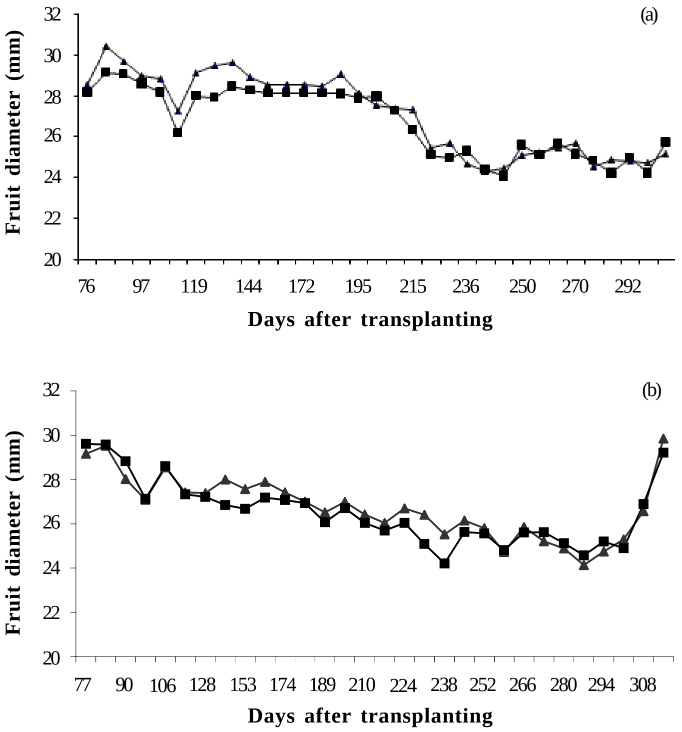

Figure 6. Effect of pruning to 2S (T0, ▲) and 2S + 4B (T1, ■) on changes of fruit diameter (mm) for cherry tomato cultivar Salomée in (a) Experiment 1 and (b) Experiment 2 in the greenhouse.

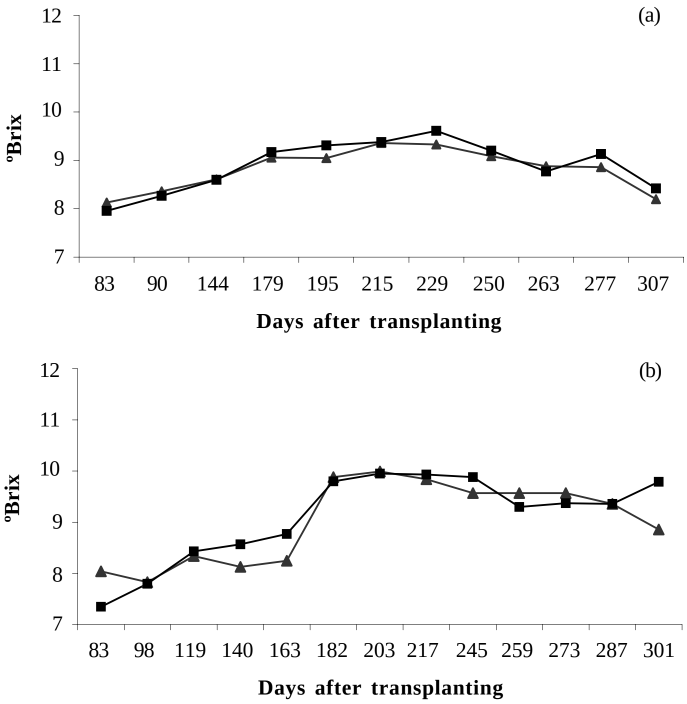

Figure 7. Effect of pruning to 2S (T0, ▲) and 2S + 4B (T1, ■), on ºBrix in cherry tomato cultivar Salomée fruit grown in the greenhouse in (a) Experiment 1 and (b) Experiment 2.

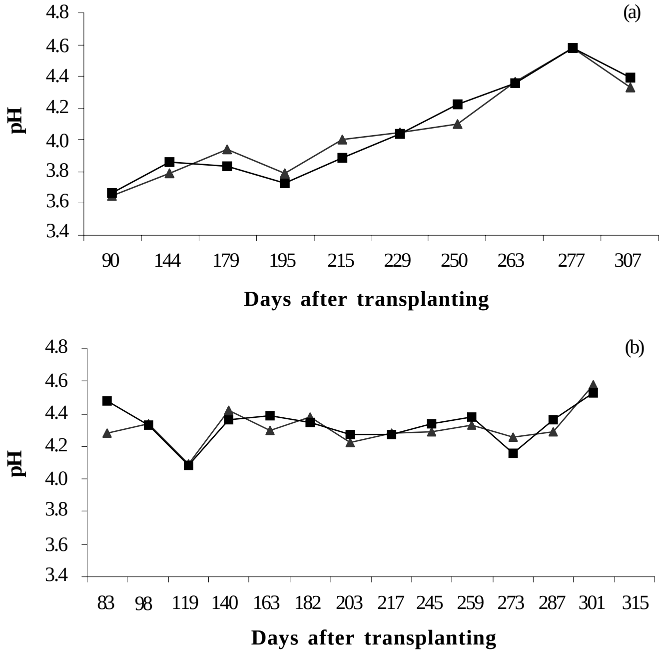

Figure 8. Effect of pruning to 2S (T0, ▲) and 2S + 4B (T1, ■), on the pH of cherry tomato cultivar Salomée fruit grown in the greenhouse in (a) Experiment 1 and (b) Experiment 2.

production associated with the T1 type of pruning was the consequence of the presence of additional lateral clusters without reduction of the flowering or fructification potential in other plant clusters. There was a noticeable increase within the productive cycle, mainly in winter and summer when production usually diminishes as a consequence of adverse environmental conditions.

The number of fruits was increased in the T1 group. However, AFW was somewhat lower, which is explained by the greater quantity of fruit, and the larger expenditure of resources plus reduced products of photo-assimilation. The pattern of production during the whole cycle was similar for both experiments (Fig. 3).

Regarding fruit quality, a directly proportional relationship was observed between AFW and fruit diameter, which decreased in winter, probably due to lower temperatures and a lower source-drain relationship. The soluble solids content was increased in the T1 group; throughout harvesting the sugar content of fruit from these plants was almost always higher compared to the T0 control, with greater differences observed during harvesting of the additional racemes produced by pruning.

Conclusions

The T1 pruning system resulted in significant increases of the number and weight of total and commercial fruit per surface unit compared to the T0 control group. The increased production was directly proportional to the number of racemes formed by the plant. Increases in the production curve were obtained in T1 in winter and in summer, which coincided with harvesting the additional racemes. This is advantageous for the growers, since production is normally decreased at this time of year. Increasing the number of stems per plant in the cherry tomato cultivar Salomée does not affect the soluble solids content of the fruit.

References

[1]Álamo, M. and Tabares, J.M. 1984. Experiencia comparativa de poda y marco de cultivo de tomate. Revista Horticultura **16**:29-34.

[2]Balraj, S. and Mahesh, K. 2005. Effect of plant spacing and stem pruning on growth and yield of cherry tomato in greenhouse. Haryana J. Hortic. Sci. **34**(1-2):179-180.

[3]Borreli, A. 1983. Influenza Della densita d investimento e Della cimatura Bulla produzione del pomodoro cultivato in serra. Revista di Ortoflorofrutt Italiana **67**:113-122.

[4]Camacho, F. 2003. Técnicas de producción en cultivos protegidos. 2 V. Caja-Rural Intermediterránea. Ediciones Agrotécnicas, Madrid, Spain, 775 pp.

[5]Geisenberg, C. and Stewart, K. 1986. Field crop management. In Atherthon, J.G. and Rudich, J. (eds). The Tomato Crop: A Scientific Basis for Improvement. Chapman and Hall, UK, pp. 511-557.

[6]Heuvelink, E. 1995. Effect of plant density on biomass allocation to the fruits in tomato (*Lycopersicon esculentum* Mill.). Sci. Hortic. **64**:193-225.

[7]López, G J. and Segovia, C. 1995. El tomate en invernadero. Horto Fruticola **6**:37-42.

[8]Moccia, S., Frezza, D., Chaera, V. and Mónaco, E., 1998. Tomate Cherry: Evaluación de componentes de calidad en tres híbridos durante el almacenamiento. Horticultura Argentina **17**:5-10.

[9]Navarrete, M., Jeannequin, B. and Sebillotte, M. 1997. Vigour of greenhouse tomato plants (*Lycopersicon esculentum* Mill.): Analysis of the criteria used by growers and search for objective criteria. J. Hort. Sci. **72**:821-829.

[10]Rodríguez, R.R., Rodríguez, J.M.T. and San Juan, J. 1984. Cultivo Moderno del tomate. Mundi-Prensa, Madrid, Spain, 240 pp.