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Short communication. Ratoon cropping technique combined with pluriannual character improves soilless pepper (*Capsicum annuum* L.) fruit yield

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Abstract

The aim of this work was to test the ratoon cropping technique for hydroponically grown pepper plants. The ratoon cropping system consists of mowing the crop, the next crop being the result of the first crop regrowth. Pepper plants were mowed every six months during two years and the production was compared to that of the new transplanted young-plants at the time of each cycle of pruning. Thus, at the end of the experiment, mowed plants were two years old and were pruned three times. The ratoon cropping technique significantly increased ($p < 0.03$) marketable production up to 27% compared to that of newly planted plants. In addition, the percentages of the non marketable fruits were never significantly different ($p < 0.05$). The ratoon cropping technique for pepper plant soilless culture showed several advantages: i) the energy production cost was reduced, ii) new plants and substrate acquisition cost was eliminated and iii) in some cases, the labor cost was reduced. Nevertheless, use of this technique could be limited by the possibility of transmission of mechanically spread diseases, such as virosis, and by pepper plants roots health.

Additional key words: greenhouse, hydroponic system, pepper, protected-crop, rockwool.

Resumen

Comunicación corta. La técnica de poda-rebrote combinada al carácter plurianual mejora la producción de pimiento (*Capsicum annuum* L.) en cultivo sin suelo

El objetivo de este estudio fue investigar la posibilidad de usar la técnica de poda-rebrote en un cultivo hidropónico de pimiento. Esta técnica consiste en aprovechar la capacidad de rebrote de la planta tras una poda drástica. Las podas se realizaron aprox. cada 6 meses durante dos años y se comparó la producción a la de un cultivo recién transplantado en cada ciclo de poda. Así, al finalizar el estudio, las plantas podadas tenían dos años de vida y fueron podadas 3 veces. La técnica de poda-rebrote incrementó significativamente ($p < 0,03$) la producción comercial hasta un 27% en comparación con el cultivo recién plantado. Además, las producciones de destrío nunca fueron significativamente diferentes ($p > 0,05$). Esta técnica presenta varias ventajas: i) el coste energético de la producción es menor, ii) permite suprimir el coste del plantel y del sustrato y iii) en ciertos casos se reducen las horas de trabajo. Sin embargo, la aplicación de la técnica de poda-rebrote podría verse limitada por la transmisión mecánica de virus y el buen estado sanitario de las raíces.

Palabras claves adicionales: cultivo protegido, invernadero, lana de roca, sistema hidropónico.

Under heated-greenhouse conditions, growers can choose between either one long or two short yearly pepper (*Capsicum annuum* L.) crop cycles (lasting about 10 months and 6 months respectively). This implies removing the crop once or twice per year, leading to an increase in the production costs. The ratoon cropping system consists of mowing the crop, the next crop being the result of the first crop regrowth. This cultural practice is currently used in several crops such as sugarcane (*Saccharum officinarum* L.) (Bokhtiar and Sakurai, 2007), papaya (*Carica papaya* L.) (Elder *et al*., 2002) and rice (*Oryza sativa* L.) (Nakano and Morita, 2007). Ratoon cropping has been positively tested for autumn pepper production under open field conditions (Kahn and Leskovar, 2001). Unander *et al*. (1991) showed that this technique

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increased pepper production if the growing season is long enough to permit a ratoon crop. The aim of this work was to test the ratoon cropping technique for hydroponically grown pepper plants over a period of two years. Thus, at the end of the experiment, plants were two years old and were mowed thrice. Pepper crop is commonly cultivated anually, but under suitable climatic conditions, *Capsicum* genus can be a perennial small shrub, living for a decade or more (Bosland, 1996).

Pepper plants var. 'Derio' were grown hydroponically in an automated polycarbonate-covered greenhouse (Venlo-type) located at The Basque Institute of Agricultural Research and Development (NEIKER, A.B., Biscay, northern Spain, latitude 43° 17' N, longitude 2° 52' W, altitude 65 m).

Plants with 4 fully-developed leaves were placed on rockwool slabs (Grodan Expert, $7.5 \times 15 \times 100$ cm) at a density of 1.7 plants m^{-2} (distance between rows was 1.77 m and between plants was 0.33 m). The composition of the nutrient solution was as follows ($mmol_c\ L^{-1}$): 3 Mg^{2+}, 0.5 Na^+, 5.0 K^+, 1.0 NH_4^+, 2.6 Ca^{2+}, 0.5 Cl^-, 8.0 NO_3^-, 2.0 $H_2PO_4^-$ and 3 SO_4^{2-}. Micronutrients were added using a commercial mixture (Nutrel C, Phosyn, Spain) containing the following elements (µM): copper 0.76, iron 20.15, manganese 9.01, zinc 1.38, boron 9.71 and molybdenum 0.31. The electrical conductivity was 1.8 dS m^{-1} and the pH was 5.5. Automated fertigation was scheduled to obtain a daily average drainage of 30%.

Minimal temperature set points controlling air-heating were 15°C/18°C night/day, and maximal temperature set points were 18°C/20°C night/day. Vent opening temperatures were 20°C/25°C night/day. When needed, plants were staked with vertical twines passing along both sides of each plant and separated by 0.40 m.

The production of this sweet pepper variety is characterised by the harvest of the fruits at an immature stage. The fruit shape is elongated and the blossom end is blunt. Growers harvest the green fruits when the fruit length reaches about 8 cm. At this stage, the fruit weight is about 11 g. In comparison, length and weight of the mature fruits are about 14 cm and 40 g.

Two treatments were applied: new young plants (control) and old plants hand-pruned just beyond the second node above the first fork of the main stem. A non-pruned treatment has not been included because it is not possible to manage such plants during two consecutive years. Following the cultural practices of the local growers, the duration of each crop cycle was about 6 months. The first crop cycle began on 11th July 2005 with only young plants. The second cycle began on 4th January 2006 when these plants were pruned and control plants with 4 fully-developed leaves were planted on new rockwool slabs. The third cycle began on 3rd August 2006. The old-pruned plants were pruned again and new control plants were planted on new rockwool slabs. The 4th cycle began on 29th January 2007 when old-double-pruned plants were pruned again and new control plants were planted on new rockwool slabs. Only two new vigorous stems were kept from the second nodes. All other side shoots were removed. The studied pepper variety presented plants with 2-3 secondary stems above the first fork of the main stem. Thus, from 4 to 6 new re-grow stems per plant were maintained.

Hand harvests of immature fruits were performed twice weekly until the following crop cycle. The experimental design consisted of randomised complete-blocks replicated three times per treatment. Each replicate contained 48 plants. A GLM univariate procedure was performed to provide analysis of variance.

The commercialization of this local variety of pepper is made by dozen fruits, consequently, special attention was given to number of fruits produced. For all crop cycles and treatments, production reached from 94 to 218 fruits per plant (Fig. 1). For the three crop cycles, the pruned plants produced significantly ($p < 0.03$) more fruits per plants than control plants. At the end of each cycle, the mean production differences between control and pruned plants were 41, 10 and 46 fruits per plant, respectively. Since, the ratoon cropping technique increased marketable production 25%, 11% and 27% for each crop cycle, respectively. Final marketable productions reached from about 1,100 g m^{-2} in autumn cycles to 2,600 g m^{-2} in spring cycles and were always significantly greater ($p < 0.03$) in pruned plants (Fig. 2). The first set of flowers coming from the pruned plants presented amorphous features, thus the fruits were non marketable because they were flattened, small and parthenocarpic. This observation is explained by the fact that the flower morphology in pepper plants is partially controlled by source-sink relationships (Aloni *et al.*, 1999).

Nevertheless, the final percentages of the non marketable fruits were never significantly different ($p > 0.05$) between treatments (Fig. 3). For all crop cycles, the production of non marketable fruits reached from 24 to 33%.

In comparison, Unander *et al*. (1991) observed a similar increment (25%) in the total yield of the pruned pepper plants in open field and under warm climate.

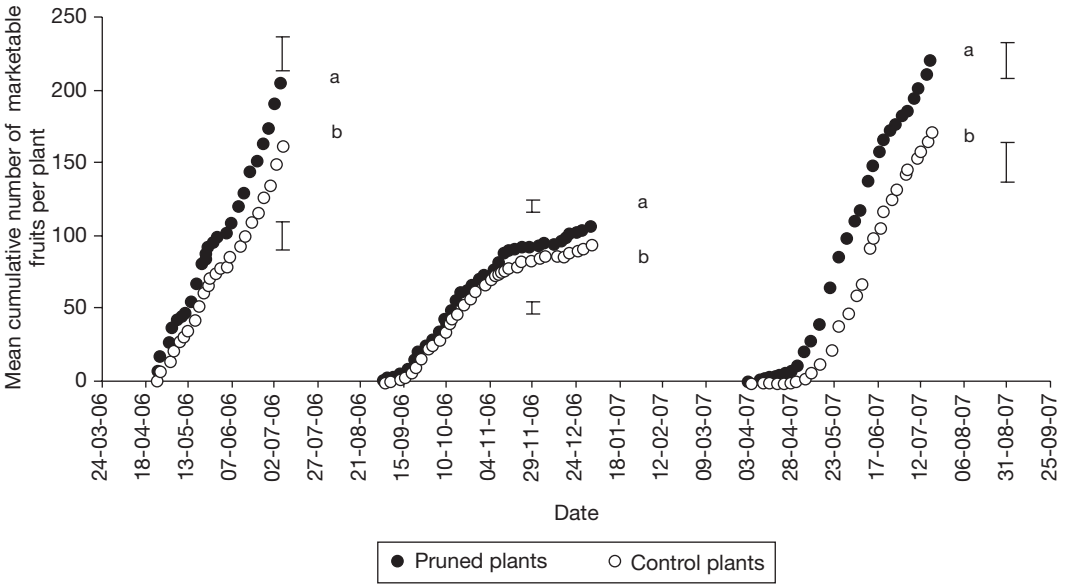

Figure 1. Cumulative number of marketable fruits per plant. Final productions with different letters are significantly different at 5% level. Vertical bars represent the maximal standard deviation for each treatment.

In contrast, mowed pepper plants produced less total marketable fruit weight and more premium fruits than control plants for fall production (Kahn and Leskovar, 2001).

Under our crop conditions, greater production of the pruned-plants was explained by i) a greater number of stems, from 4 to 6 new re-grow stems per plant (see method description), compared to newly planted plants having from 2 to 3 stems above the first fork and ii) greater vigor of the pruned-plants possibly due to carbohydrate reserves in old stems and roots. The effects of shoot numbers on sweet pepper plant fruiting and yield have been previously investigated by Guo *et al.* (1990). They showed that, in four pepper varieties, fruit number and yield increased due to the greater number of shoots. Moreover, highly significant correlations have been identified between yield and total leaf area (Guo *et al.,* 1990).

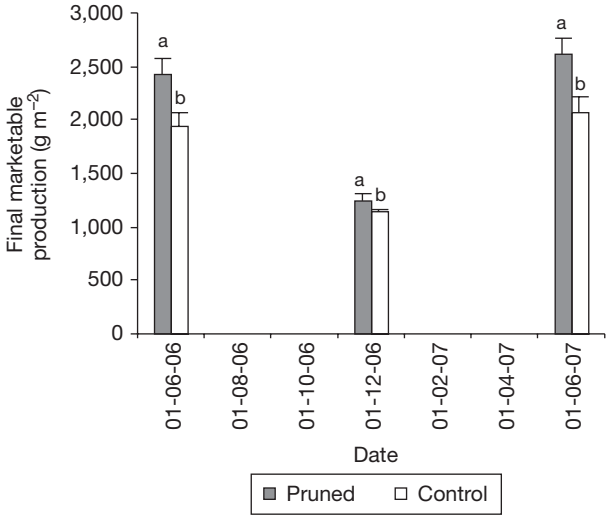

Figure 2. Final marketable production for the three crop cycles. Vertical bars represent the standard deviation. When no bar is shown, it is included in the width of the symbol. Data with different letters are significantly different at 5% level.

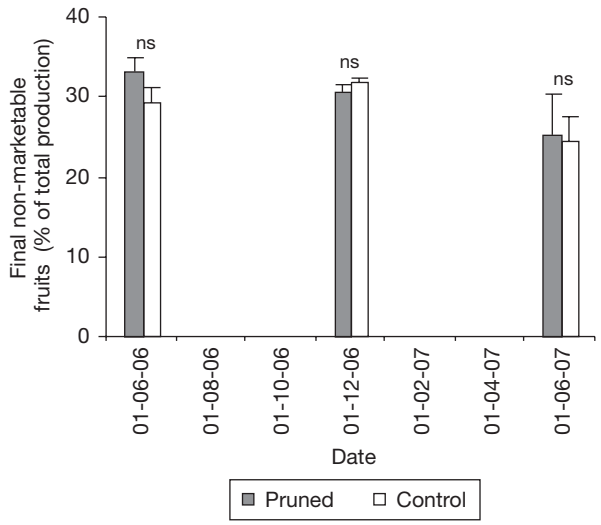

Figure 3. Final non-marketable fruis for the three crop cycles. Vertical bars represent the standard deviation. ns: not significantly different at 5% level.

Total labor time need to mow the crop, including all operations such as removing twines, mowing, clearing cut branches, cleaning the floor, and removing side shoots has been estimated at 100 h for an area of 1,000 m^2. In comparison, total labor time needed to transplant new plants was estimated from 93 h (if old substrate was maintained), to 140 h (if the substrate was replaced).

In conclusion, the ratoon cropping technique in pepper plant soilless culture has several advantages: i) The production energy cost is reduced because elapsed time between sowing and harvesting was 80-90 days in contrast to 35-45 days needed for a pruned plant to produce (data not shown). Moreover, the production per plant was greater for the same energy expense. ii) New plants and substrate acquisition cost was eliminated. And iii) in some cases, the labor cost was reduced.

Nevertheless, the use of this technique could be limited by i) the possibility of transmission of mechanically spread diseases, such as virosis, through stem physical injury and ii) by the health of the pepper plants, in particular how healthy their roots are.

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