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PLANT BREEDING - Article

Maintenance pruning in physalis commercial production

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ABSTRACT: Due to field and literature divergences about the best management of physalis (*Physalis peruviana* L.), this paper aimed to verify the effect of maintenance pruning on the productivity and quality of its fruit. The plants were submitted to 4 different ways of management during their entire cycle: (i) no stem pruning; (ii) keeping only 4 stems; (iii) keeping 6 stems; and (iv) keeping 8 stems. The sampling began 80 days after transplantation (DAT) of the seedlings and it was executed weekly, totaling 7 evaluations. The results demonstrated that pruned plants produced higher caliber fruits. However, the plants that did not receive pruning were the most productive. Therefore, as long as the price of physalis fruit is a matter of quantity and not of quality, it is not recommended to perform maintenance pruning on the plants.

Key words: *Physalis peruviana* L., post-harvest, small fruits, culture management.

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INTRODUCTION

The fruit physalis (*Physalis peruviana* L.) is being diffused gradually due to its high nutritional and economical value (Velázquez et al. 2007; Bolzan et al. 2011; Fischer et al. 2012, 2014). The large-scale production of this fruit is an excellent alternative for farmers in southern Brazil. It could change Brazil's commercial position from actual physalis importer to an exporter country (Rufato et al. 2008). The physalis fruit is a fleshy berry, globe-shaped, with a diameter ranging from 12.5 to 25.0 mm and fresh weight between 4 and 10 g (Rufato et al. 2008). The plant is herbaceous, shrubby, and perennial, with a height between 1.0 to 2.0 m and very dense branching, which causes difficulty in keeping its stems erect. It is cultivated as an annual plant in commercial plantations (Fischer and Lüdders 2002). The main stem bifurcates naturally, creating productive stems in dichotomous form where, in each node, development of the leaves, one vegetative bud, and a flower bud occur (Trillos González et al. 2008; Ramírez et al. 2013).

In Colombia, the world's main producer of physalis, maintenance pruning is recommended in commercial productions (Muniz et al. 2014, 2015). In Brazil, the production technology of this species is still not consolidated, and the handling of the number of stems per plant stands out among the necessary techniques to improve the production of this crop, especially due to the increase in the caliber of the fruit (Muniz et al. 2011; Criollo et al. 2014; Betemps et al. 2014; Moura et al. 2016).

According to Angulo (2005), physalis trimming should be performed only when plants reach 20 cm high and already have 2 leaves. On the other hand, Rufato et al. (2008) recommended that pruning should be done when the plants reach 15 to 20 cm high and have 3 to 4 leaves. In soils subjected to flooding, plants should not be pruned because physalis is sensitive to high humidity (Rufato et al. 2008). Given the above, the objective of this study was to evaluate the effects of different types of maintenance pruning in physalis commercial production.

MATERIAL AND METHODS

This study was conducted in Brazil, in the city of Pinhais, Paraná State (lat 25°17′30″S, long 49°13′27″W, and 1,027 m altitude). The climate is characterized as Cfb according to the Köppen classification. The average temperature during the experiment duration (November 2010 to January 2011) was 16 °C, and the monthly average precipitation was 380 mm, according to the Meteorological System of Paraná (SIMEPAR). The soil of the experimental area is a Red Yellow Oxisol. It was taken from the 0 – 20-cm layer which presented the following average values: pH ($CaCl_2$) = 5.9; pH SMP = 6.6; Al^{3+} = 0; H + Al = 3.2 $cmol_c·dm^{-3}$; Ca^{2+} = 6.6 $cmol_c·dm^{-3}$; Mg^{2+} = 3.4 $cmol_c·dm^{-3}$; K^+ = 1.42 $cmol_c·dm^{-3}$; P = 88.5 $mg·dm^{-3}$; C = 35.1 $g·dm^{-3}$; V% = 78 and CTC = 14.62 $cmol_c·dm^{-3}$.

The sowing of physalis was done in September in polystyrene trays with 200 cells filled with commercial substrate (Plantmax®) and kept in a greenhouse with intermittent mist irrigation system with 25 min of watering and an interval of 15 s between each watering stage. After 38 days, the seedlings were transplanted into 180-mL plastic cups, filled with soil and kept in a greenhouse. After 20 days, when the plants were about 20 cm high, they were transplanted to a planting bed with 80 m length and 1.2 m width. The planting bed had been previously fertilized with 240 kg of organic fertilizer containing poultry litter, with a gap of 1 m between plants, totaling 80 plants.

The plants were conducted in a vertical staking system with narrow ribbon. Four handling types were used during the whole culture: (i) no stem pruning; (ii) plants with 4 stems during the whole cycle; (iii) plants with 6 stems during the whole cycle; (iv) plants with 8 stems during the whole cycle. Seven samples were collected throughout the crop cycle, respectively, 80; 90; 97; 104; 111; 133 and 140 days after transplantation (DAT) of the seedlings to the field.

For each harvest, the following variables were evaluated: number of fruits per plant, fresh weight (g), yield per plant (g), estimated yield ($t·ha^{-1}$), and the equatorial diameter of the fruit, measured by digital caliper. Based on the equatorial diameter, the fruits were categorized by size, according to the Colombian Institute of Technical Standards and Certification - Technical Standard 4580 (Icontec 1999): A (≤ 15.0 mm); B (15.1 – 18.0 mm); C (18.1 – 20.0 mm); D (20.1 – 22.0 mm) and E (≥ 22.0 mm).

Chemical analysis of the fruit samples collected at 90, 97, and 104 DAT was carried out: soluble solids (SS), expressed in °Brix determined by refractometry, titratable acidity (TA), determined by titration of neutralization, expressed as the percentage (%) of citric acid per 100 g of fruit, as well as the SS/TA ratio.

Quantitative plant analysis

At 180 DAT after the fruit sampling period, plants were removed from the experimental area in order to get data for: length of the stems (LS), number of buds (NB), leaf area (LA), dry mass of leaves (DML), and dry mass of stems (DMSt). LS was measured by using a graduated scale, and the results were expressed in cm. To obtain LA, all the leaves of each stem were removed and analyzed by the computer program WinRhizo® coupled to an LA1600 scanner (Regent Instruments Inc, Canada). To obtain DML and DMSt, samples of leaves and stems were placed in an oven with air circulation at 60 °C until a constant weight was reached. It was quantified by using an analytical scale, and the results were expressed in g.

Regarding experimental design, a randomized block type was adopted, with 4 treatments and 5 replications, where each experimental unit consisted of 4 plants, totalizing 80 plants. The results were submitted to analysis of variance and the means, compared by Tukey's test ($p \leq 0.05$).

RESULTS AND DISCUSSION

The pruning of physalis plant stems affected the growth and development of the plants. Longer stems were produced in plants without pruning unlike those managed with 4 stems (Table 1). However, for other characteristics (NB, DML, DMSt, and LA), higher values were reached in plants managed without pruning. The plants managed without stem pruning showed higher NB and LA, indicating a possible increase in photosynthesis rate. Consequently, the increase in this index may have provided greater accumulation of assimilates, resulting in higher dry mass than in the other treatments. According to Criollo et al. (2014), plants that are not submitted to maintenance pruning are constantly sprouting and will always have young leaves performing photosynthesis, unlike what occurs in pruned plants. Similar results were obtained by Silva et al. (2016) by applying shading conditions on the physalis plants.

The average weight of all produced fruits was 4.73 g in this experiment, similarly to what is produced in the main regions of Colombia (Niño et al. 2008) and which is recommended by the local Technical Standards (Icontec 1999).

Plants without pruning produced 73% of their fruit with caliber B and C (Table 2). On the other hand, pruned plants produced 70% of their fruit with caliber C and D. This shows that the lower number of vegetative and reproductive drains on pruned plants, compared with unpruned ones, conditioned the size of the fruit. Higher caliber fruit was also obtained in other studies of physalis using pruning management (Valerio et al. 2012; Criollo et al. 2014). Probably, the pruning of stems promoted a higher incidence of solar radiation and less competition for nutrients and assimilates in plants. Furthermore, reducing the length and number of stems makes it possible to control the amount and size of fruit due to better distribution of photoassimilates (Fischer et al. 2012; Moura et al. 2016).

SS levels were not different among the treatments. The average value was 11.44 °Brix, which is inferior to the minimum recommended for marketing physalis in Colombia (14 °Brix) (Icontec 1999). However, Balaguera-López et al. →

Table 1. Average length of the stems, number of buds, leaf area, dry mass of leaves, and dry mass of stems of physalis plants (*Physalis peruviana* L.) submitted to different kinds of pruning.

Plant treatments	LS (cm)	NB	DML (g)	DMSt (g)	LA (cm²)
Without pruning	127.45ab*	765.20a	20.75a	79.17a	4,670.35a
With 8 stems	21.12c	104.40b	3.09b	55.53b	556.84b
With 6 stems	113.90b	117.20b	6.53b	60.85b	1,220.73b
With 4 stems	133.92a	95.60b	5.80b	57.55b	822.40b
CV (%)	**9.98**	**21.03**	**30.60**	**13.98**	**45.36**

*Means followed by the same letter in the column do not differ statistically among themselves by Tukey's test ($p \leq 0.05$). LS = Length of the stems; NB = Number of buds; DML = Dry mass of leaves; DMSt = Dry mass of stems; LA = Leaf area; CV = Coefficient of variation.

Table 2. Percentage of physalis fruit (*Physalis peruviana* L.) per plants for different types of maintenance pruning management in accordance with the caliber.

Plant treatments	Caliber (%)				
	A	B	C	D	E
Without pruning	4.81	32.15	41.01	14.43	7.59
With 8 stems	0.80	14.51	33.87	35.48	15.32
With 6 stems	0.62	14.28	39.13	36.64	9.31
With 4 stems	2.63	9.64	35.08	29.82	22.80

A ≤ 15.0 mm; B 15.1 – 18.0 mm; C: 18.1 – 20.0 mm; D: 20.1 – 22.0 mm; E: ≥ 22.0 mm.

(2014) obtained a sugar content increase from 10 to 17 °Brix after storage for about 10 days under ambient temperature.

The plants treated with more drastic maintenance pruning (i.e. plants with 4 stems) showed the lowest levels of citric acid compared to plants handled without pruning. Inverse behavior was observed for the SS/TA ratio, probably due to reduced acidity levels. These differences may be a reflection of the delay in the start of production in pruned plants against plants managed without pruning (Figure 1), probably due to lower amounts of assimilates available for the plant.

Plants without pruning had more fruit and productivity compared to other forms of management (Table 3). Despite the intra-specific competition for water, light, and nutrients, the higher number of stems in plants managed without pruning provided a 4-times higher productivity than pruned plants. This was probably due to greater accumulation of assimilates. In addition, the higher LA of unpruned plants resulted in a larger area for interception of solar radiation and, consequently, higher photosynthetic rate (Maldaner et al. 2009).

The definition of which type of pruning will be used depends on the requirements of the consumer market and the price applied according to the size of the fruit. Certainly, for the decoration of candies, cakes, and savory dishes, which is one of the most important culinary uses of this fruit, larger fruits have higher benefit. However, for physalis jam production, a much smaller market at the time, size, SS content, and TA of fruits make no difference. In the last 6 years, an increase in the volume of physalis was observed in major wholesale markets, with an average price of R$ 35.21 per kg of fruit (Watanabe and Oliveira 2014). However, there is no price differentiation regarding the quality of the product; in other words, regardless of size and other attributes, the price is the same. In addition, the fruit is sold with its balloon-shaped sepals, a feature that makes it much appreciated for decoration of dishes, but ends up preventing display of the fruit at the time of purchase.

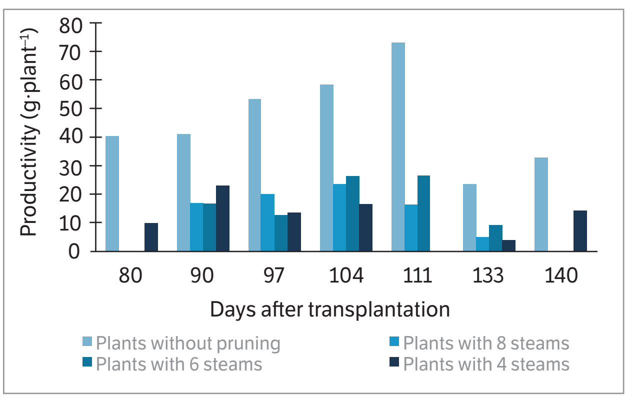

Figure 1. Average productivity of physalis plants (*Physalis peruviana* L.) against the days after transplantation and type of pruning.

Allied to market requirements, the lack of a national standard for classification and commercialization results in an informal physalis market. Besides, it also confuses the producer when defining which pruning system must be used. Furthermore, pruning activity is more labor-intensive and, therefore, increases production costs. Thus, while the price is the same without distinction of fruit size, it is best for the producer not to carry out the pruning of plants.

CONCLUSION

Stem maintenance pruning resulted in lower productivity of the physalis plant. Therefore, as long as the price is the same without distinction in the fruit size, the pruning of physalis plants is not recommended.

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Table 3. Average number of fruits per plant, fresh weight (g·fruit^{-1}), production per plant (g), estimated yield (t·ha^{-1}), soluble solids, titratable acidity, and the ratio SS/AT of physalis (*Physalis peruviana* L.) subjected to different types of maintenance management pruning.

Plant treatments	Fruits per plant	Fresh weight	Yield per plant	Estimated yield	SS	TA	SS/TA ratio
Without pruning	78.8a*	4.16b	323.49a	2.58a	11.94	1.64a	7.62ab
With 8 stems	17.6 b	4.82ab	81.94b	0.65b	11.34	1.49ab	7.82ab
With 6 stems	18.0 b	5.12a	91.75b	0.74b	11.07	1.56ab	7.55b
With 4 stems	16.6 b	4.84a	81.27b	0.65b	11.41	1.32b	8.94a
CV (%)	**16.50**	**7.78**	**21.05**	**21.05**	**11.44**	**21.63**	**17.36**

*Means followed by the same letter in the column do not differ statistically among themselves by Tukey's test ($p \leq 0.05$). SS = Soluble solids; TA = Titratable acidity; CV = Coefficient of variation.

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