

**Season and technique of green pruning on physiological and sensorial aspects of Maciel  
peaches**

**Época e técnica de poda verde sobre aspectos fisiológicos e sensoriais de pêssegos Maciel**

**Época y técnica de poda verde en los aspectos fisiológicos y sensoriales del melocotón  
Maciel**

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### **Abstract**

One of the aspects that should be considered regarding the fruit market is the quality. Appearance is considered an important factor as the color of the skin. One of the management techniques to improve the peach quality is green pruning. The objective of this study was to determine the season and the technique for green pruning. The study was carried out in a commercial orchard at Dois Vizinhos city, Paraná State, Brazil. The experimental design was a completely randomized experimental with four replications and two trees by experimental unit. The techniques were first to remove vertical branches facing the center of the canopy and in the base of the tree with reference to broken and poorly ones and, the second the belding of these. The use of green pruning for Maciel peach tree in five to four weeks before harvesting, improved fruit quality.

**Keywords:** *Prunus persica*; Orchard management; Fruit.

### **Resumo**

Um dos aspectos que devem ser considerados no mercado de frutas frescas de pessegueiro é a qualidade de seus frutos. Considera-se a aparência como fator importante, sendo a coloração da epiderme relevante. Um dos fatores que influenciam a qualidade do pêsego diz respeito ao manejo no pomar, como com a execução da poda verde. Uma das técnicas de manejo que visam melhorar a qualidade dos frutos é a poda verde. O objetivo deste trabalho foi determinar o período e a forma de execução da poda verde. O trabalho foi conduzido em pomar comercial de pessegueiro, cultivar Maciel, no município de Dois Vizinhos (PR), Paraná - Brasil, O delineamento experimental foi inteiramente casualizado, com 4 repetições, com 2 plantas. As técnicas da poda verde. foram primeiro com a retirada dos ramos ladrões no interior e na base dos ramos, ramos quebrados e mal posicionados e, segundo no dobramento destes. Conclui-se que o uso da poda verde em plantas de pessegueiro Maciel a cinco e quatro semanas antes da colheita proporcionou frutos com melhor qualidade.

**Palavras-chave:** *Prunus pérsica*; Manejo de pomar; Frutos.

## Resumen

Uno de los aspectos que se debe considerar en el mercado del melocotón fresco es la calidad de sus frutos. La apariencia se considera un factor importante, siendo relevante el color de la epidermis. Uno de los factores que influye en la calidad del melocotón se refiere al manejo en el huerto, como ocurre con la ejecución de la poda en verde. Una de las técnicas de manejo que tiene como objetivo mejorar la calidad del fruto es la poda en verde. El objetivo de este trabajo fue determinar el período y la forma de ejecución de la poda en verde. El trabajo se realizó en un huerto comercial de durazno, cultivar Maciel, en el municipio de Dois Vizinhos (PR), Paraná - Brasil, el diseño experimental fue completamente al azar, con 4 repeticiones, con 2 plantas. Técnicas de poda verde. fueron primero con la remoción de las ramas ladronas del interior y en la base de las ramas, ramas rotas y mal posicionadas y, segundo al doblarlas. Se concluyó que el uso de la poda en verde en las plantas de durazno Maciel cinco y cuatro semanas antes de la cosecha proporcionó frutos de mejor calidad.

**Palabras clave:** *Prunus pérsica*; Gestión de huertos; Frutas.

## 1. Introduction

The peach cultivate has great economic and social importance in the three States of the South of Brazil and in some of the Southeast, with a larger production in the Rio Grande do Sul State, that it is responsible for more than 60% of national production (Barbosa et al., 2010; Oliveira et al., 2011). In the Paraná State, the peaches cultivate is a great alternative for diversification of properties since it absorbs the family labor force and it allows the generation of income in small areas. However, in order to increase its cultivate, it is important know market demands regarding the quality of the fruits produced.

Several management practices are adopted in the orchards with objective to increase the yield and fruit quality (Retamales, 2011). Among these, there is the green pruning, which is did before harvest. The purpose of its use is to increase solar radiation entrance inside the canopy, as well as to improve the architecture of the plant and to change some characteristics of the fruits such as color, size, soluble solids content and flavor (Coutinho et al., 2005).

Green pruning is one of the recommended management practices that, in addition to the advantages of its use, also favors the reduction of disease incidence (Rangel et al., 2007). This pruning is necessary to remove vigorous branches directed towards the inside of the canopy, which generates shading of the fruits and leaves, or that it is broken, with pathogenic or poorly located ones (Bernardi & Hoffmann, 2003). It also contributes to the aspects related

to the appearance of the fruit that is a relevant factor, since they are the most attractive for the consumer (Trevisan et al., 2006), besides the qualitative characteristics, involving the physical and chemical properties of these fruits (Soares et al., 2010). Green pruning in peach trees has been used only by some farmers, because this practice need labor and time (Rom & Ferree, 1985).

According to Barradas & Priestley (1992), green pruning reduces leaf area, increasing the exposure of fruits and remaining leaves to light, which it reduces the demand for water and assimilates due to the elimination of large number of branches and leaves in the shading. Seeley et al. (1980) reported that with green pruning there is 9% increase in solar radiation entrance, which it is enough to stimulate an increase in anthocyanin synthesis. Gerhardt et al. (1991) verified in peach tree that the use of green pruning 40 and 20 days before harvest increased the percentage of red color on the fruit in relation to the control, however, the firmness and soluble solids content were not affected. For these authors, the firmness of the fruits is related to the maturation stage of the fruits.

On the other hand, with the use of green pruning, branches are removed from the plant, which, although poorly located, produce photoassimilates in its leaves and distribute them to the other parts, what it can interfere in the aspects of plant growth and fruit flavor, despite a proven improvement in coloration. Thus, one of proposed this work was to improve the aeration and illuminance inside the canopy without the immediate removal of the branch, but with the folding of the branch, allowing some movement of photoassimilates for the fruit and plant.

This work aimed to evaluate the season and type of management technique for green pruning, as well as the practice of the thinning associated to obtain fruits of better quality.

## **2. Methodology**

The experiment was carried out in a commercial peach orchard with six years old, of Maciel variety grafted on Capdbosq, located at Dois Vizinhos city, Paraná State, Brazil (25°51'S, 53°06'W, 594m), in the productive cycles 2009/2010, 2010/2011 and 2011/2012. In the first cycle, fruit thinning was not carried out, and in the last cycle no physical-chemical and biochemical characteristics were evaluated because haven't fruit set caused by phytotoxicity.

The experimental design was completely randomized, in a 3 x 3 factorial (season x green pruning management technique), with 4 replications, considering each two trees as experimental unit.

The management of green pruning on peach trees was based on the removal of branches facing the center of the canopy and with the base of other branches, as that broken, with diseases and poorly positioned as recommended for culture (Bruckner, 2003). The other technique was to fold of the same branches mentioned above, but it maintained in the tree. The control treatment did not undergo any type of management related to green pruning. The seasons tested for green pruning were the third, fourth and fifth weeks before harvest.

After reaching the harvest point, the fruits were harvested and taken to the Laboratório de Fisiologia Vegetal for physicochemical and biochemical evaluations. The characteristics analyzed in the 2009/2010 and 2010/2011 cycles were color of the epidermis (% of red) (Wagner Júnior, 2007); pulp firmness (pounds); sutural, equatorial and polar diameters (mm); soluble solids content (°Brix); titratable acidity (expressed as gram equivalent of malic acid per 100 mL of juice); soluble solids content of the pulp/titratable acidity ratio; mass of fresh matter of pulp and fruit (g); anthocyanins and flavonoids. For these evaluation were used twenty fruit by replications, it being four by tree.

The firmness was determined on opposite faces in the equatorial region of each fruit, after removal of the epidermis, through Lutron digital penetrometer, model FG-5020, 8 mm diameter tip, placed in adapted metal support. Soluble solids content of the fruits was analyzed from juice extracted by a digital refractometer (RTD-45), values expressed as °Brix. The evaluation of the sutural, equatorial, and polar diameter was determined with the aid of a digital caliper.

For analysis of the titratable acidity the samples were crushed, with 10 mL of the juice added in 90 mL of distilled water. From this solution the pH was evaluated by a pH meter. Subsequently, to determine the acidity, the solution was titrated with NaOH 0.1N until reaching pH 8.1. The acidity was expressed in g of malic acid per 100 mL of juice and quantified based on the calculation described by Aoac (1997). Soluble solids content of the pulp/titratable acidity ratio was obtained by the division of these variables.

In the production cycles 2010/2011 and 2011/2012, the illuminance (lux) was analyzed in the center of the crown projection, at 1,50 cm height from the ground and below the canopy projection. To obtain the illuminance data below the canopy projection, there was calculated the mean of the values obtained in the four quadrants of each plant, distanced 0,5 and 1,0 m from the main trunk by a portable luxmeter.

In 2011/2012 cycle, physiological analyzes of the plants were also performed 30 days after the last management practice. All plants were evaluated, comparing leaves of folded branches with the ones without green pruning techniques. The gas exchange readings always started at 9:30 a.m. by an open gas measurement system equipped with the LI-6400XT (LI-COR, Lincoln, Nebraska - USA) infrared gas analyzer (IRGA) and artificial red and blue light source. The evaluations were performed on the fully developed and healthy middle third leaves of two plants per plot, it being used 20 leaves. The microclimatic conditions in the sample chamber were maintained constant during the readings in the different treatments, being 1100  $\mu\text{mol m}^{-2} \text{s}^{-1}$  of photosynthetically active radiation and ambient  $\text{CO}_2$  concentration (average of 383  $\mu\text{mol CO}_2 \text{mol}^{-1}$ ). The variables rate of assimilation of  $\text{CO}_2$  ( $\mu\text{mol CO}_2 \text{m}^{-2} \text{s}^{-1}$ ), water conductance ( $\text{mol H}_2\text{O m}^{-2} \text{s}^{-1}$ ), intracellular  $\text{CO}_2$  concentration ( $\mu\text{mol CO}_2 \text{mol}^{-1} \text{m}^{-2} \text{s}^{-1}$ ) and foliar temperature ( $^{\circ}\text{C}$ ) were analyzed.

Samples were also separated for biochemical analyzes of fruits in the 2010/2011 cycle for anthocyanins and flavonoids. These samples were stored at  $-20^{\circ}\text{C}$  until evaluations (10 days). Biochemical analyzes were performed with tissues of fruit's epidermis and pulp. For the determination of the anthocyanin and flavonoid content of the fruits the method described by Lees & Francis (1972) was used. The data were submitted to the normality test of Lilliefors, and it was transformed by  $\sqrt{(x + 1)}$  in 2009/2010 cycle for color; sutural diameter and titratable total acidity. In 2010/2011 cycle, pulp firmness; soluble solids content; sutural, equatorial and polar diameter; mass of the fresh matter of the pulp and fruit were transformed using the same parameters. In 2011/2012 cycle, illuminance inside the canopy was transformed. Subsequently, data was submitted to analysis of variance and Duncan's test ( $\alpha = 0.05$ ). All analyzes were performed by SANEST computational application (Zonta & Machado, 1984).

### 3. Results and Discussion

The sutural and polar diameters of Maciel peaches at 2009/2010 cycle (Tables 1 and 2, respectively) were higher when green pruning or bend of branches practices were used. The hypothesis that can explain these results is that due to the decrease of the productive load with the removal of pruned branches or by folding them, there was a change in the relation source x drain of the plant. It was observed that the decrease of this productive load was compensated by the occurrence of fruits of greater caliber (sutural and polar diameters).

However, in 2010/2011 cycle, the means were statistically similar for suture and polar diameters according to pruning season and management practice, as well as in the interaction of these factors (Tables 1 and 2, respectively). This response may already be a consequence of the thinning carried out in this cycle (2010/2011), a management that was not performed in the previous cycle (2009/2010).

**Table 1.** Sutural diameter (mm) of fruits during the 2009/2010 and 2010/2011 production cycles, according to the management technique and green pruning season.

Cycle	Season	Management Practice		
		Without practice	Bend of branches	Green pruning
2009/2010	5 weeks	60.88	68.72	67.37
	4 weeks	60.88	67.80	67.50
	3 weeks	60.88	70.11	67.64
	MEAN	60.88 B*	68.87 A	67.50 A
2010/2011	5 weeks	63.01	63.21	64.50
	4 weeks	63.01	66.65	64.15
	3 weeks	63.01	62.56	63.70
	MEAN	63.01 <sup>ns</sup>	64.13	64.12

\*Means with different letters differ by Duncan's test ( $p = 0.05$ ).

<sup>ns</sup> Not significant.

Source: Authors.

**Table 2.** Polar diameter (mm) of fruits during the 2009/2010 and 2010/2011 production cycles, according to the management technique and green pruning season.

Cycle	Season	Management Practice		
		Without practice	Bend of branches	Green pruning
2009/2010	5 weeks	63.36	69.75	69.58
	4 weeks	63.36	68.76	68.95
	3 weeks	63.36	68.33	69.02
	MEAN	63.36 B*	68.95 A	69.18 A
2010/2011	5 weeks	64.84	63.88	64.95
	4 weeks	64.84	65.80	64.29
	3 weeks	64.84	63.00	65.63
	MEAN	64.84 <sup>ns</sup>	64.22	64.96

\*Means with different letters differ by Duncan's test ( $p = 0.05$ ).

<sup>ns</sup> Not significant.

Source: Authors

The mass of the fresh matter of the pulp and fruit were superior when the management was done with the green pruning and folding practices, in the 2009/2010 cycle (Tables 3 and 4, respectively).



**Table 3.** Mass of the fresh matter of the pulp (g) during the productive cycles 2009/2010 and 2010/2011, according to the management technique and green pruning season.

Cycle	Season	Management Practice		
		Without practice	Bend of branches	Green pruning
2009/2010	5 weeks	110.98	154.94	143.72
	4 weeks	110.98	150.34	148.45
	3 weeks	110.98	153.08	157.51
	MEAN	110.98 B*	152.78 A	149.84 A
2010/2011	5 weeks	134.50	127.65	140.48
	4 weeks	134.50	154.57	134.45
	3 weeks	134.50	123.68	143.07
	MEAN	134.50 <sup>ns</sup>	134.97	139.31

\* Means with different letters differ by Duncan's test ( $p = 0.05$ ).

<sup>ns</sup> Not significant.

Source: Authors

**Table 4.** Mass of the fresh matter of the fruit (g) during the productive cycles 2009/2010 and 2010/2011, according to the management technique and green pruning season.

Cycle	Season	Management Practice		
		Without practice	Bend of branches	Green pruning
2009/2010	5 weeks	118.14	164.89	152.18
	4 weeks	118.14	159.94	158.45
	3 weeks	118.14	163.42	167.83
	MEAN	118.14 B*	162.74 A	159.42 A
2010/2011	5 weeks	141.19	134.91	147.67
	4 weeks	141.19	161.96	140.22
	3 weeks	141.19	129.95	149.12
	MEAN	141.19 <sup>ns</sup>	141.94	145.64

\*Means with different letters differ by Duncan's test ( $p = 0.05$ ).

<sup>ns</sup> Not significant.

Source: Authors

The sprouts and leaves may be photoassimilate drains, especially if positioned in shaded locations in the canopy, which it may impair the yield (Luchi et al., 2008). Thus, it is believed that the superiority obtained for mass of the fresh matter of the pulp and fruit in managed plants may have occurred as a consequence of the decrease of the drains inside the canopy, maximizing the use of photoassimilates and water for the remaining fruits.

In the following cycle (2010/2011), although the plants presented a higher mass of the fresh matter of the pulp compared to the previous cycle (Table 3), this it did not present significant differences between the factors analyzed, with the same statistical equality for mass of fresh matter of fruit (Table 4), which it is also a consequence of the thinning performed in this cycle, uniformizing the caliber and mass gain of the fruits.

Wagner Júnior (2007) observed that mass of fresh matter of fruits is important and it should be observed by the producer since it has direct correlation with the success of the orchard, since it's responsible for the monetary return as the fruits are sold by the association of the caliber with fresh matter mass.

In 2010/2011 cycle, the performance of green pruning can produce more acidic fruits, it being this result different from the previous cycle, whose averages not differed statistically (Table 7). In the 2009/2010 and 2010/2011 cycles, the soluble solids content of the fruits did not differ from each other in both cycles (Table 5).

**Table 5.** Soluble solids content (°Brix) of fruits during the production cycles 2009/2010 and 2010/2011, according to the management technique and green pruning season.

Variable	Cycle	Season	Management Practice		
			Without practice	Bend of branches	Green pruning
SST	2009/2010	5 weeks	7.97	8.22	8.39
		4 weeks	7.97	8.77	8.39
		3 weeks	7.97	8.60	8.03
		MEAN	7.97 <sup>ns</sup>	8.53	8.26
	2010/2011	5 weeks	10.07	9.71	9.55
		4 weeks	10.07	10.37	10.76
		3 weeks	10.07	9.32	10.25
		MEAN	10.07 <sup>ns</sup>	9.80	10.18

<sup>ns</sup>Not significant.

Source: Authors.

The fold and remotion of branches also provided the production of peaches with firmer pulp in 2009/2010 cycle, which is important mainly when it is made the commercialization in places far from orchard. However, in 2010/2011 cycle the firmness of the fruits resembled statistically among the analyzed factors (Table 6). However, in general, there was observed fruits with less firmness in the first cycle (2009/2010).

**Table 6.** Firmness (Pounds) of fruits during the productive cycles 2009/2010 and 2010/2011, according to the management technique and green pruning season.

Cycle	Season	Management Practice		
		Without practice	Bend of branches	Green pruning
2009/2010	5 weeks	21.38	24.30	26.57
	4 weeks	21.38	24.66	25.82
	3 weeks	21.38	24.56	25.07
	MEAN	21.38 B*	24.50 A	25.82 A
2010/2011	5 weeks	24.53	28.73	27.09
	4 weeks	24.53	26.03	23.81
	3 weeks	24.53	24.81	29.15
	MEAN	24.53 <sup>ns</sup>	26.50	26.64

\*Means with different letters differ by Duncan's test ( $p = 0.05$ ).

<sup>ns</sup> Not significant.

Source: Authors.

The lower acidity when in the fruits with higher soluble solids content allows a better flavor (Table 7). In the two analyzed cycles (2009/2010 and 2010/2011) the non-performance of management practices resulted in fruits with a higher soluble solids content/acidity ratio compared to other management practices (Table 8). This may be a consequence of the higher rate of CO<sub>2</sub> assimilation and water conductance of this treatment (Table 10) since that both are linked to higher photosynthetic rate and the second to photoassimilate translocation. Associated with this, there is the higher leaf temperature of the plants managed with the removal or folding of the branches (Table 10), generating an unfavorable condition to the plant, affecting the photosynthesis and the amount of water inside the leaf by transpiration.

**Table 7.** Titratable total acidity (g of malic acid/100 ml of juice) of fruits during the productive cycles 2009/2010 and 2010/2011, according to the management technique and green pruning season.

Cycle	Season	Management Practice		
		Without practice	Bend of branches	Green pruning
2009/2010	5 weeks	2.84	3.04	2.51
	4 weeks	2.84	3.34	3.27
	3 weeks	2.84	3.29	4.31
	MEAN	2.84 <sup>ns</sup>	3.22	3.33
2010/2011	5 weeks	4.87	6.68	6.89
	4 weeks	4.87	6.25	7.80
	3 weeks	4.87	6.34	8.00
	MEAN	4.87 C*	6.42 B	7.56 A

\*Means with different letters differ by Duncan's test ( $p = 0.05$ ).

<sup>ns</sup> Not significant.

Source: Authors.

**Table 8.** Soluble solids content/acidity ratio (SS/TA), during the productive cycles 2009/2010 and 2010/2011, according to the management technique and green pruning season.

Cycle	Season	Management Practice		
		Without practice	Bend of branches	Green pruning
2009/2010	5 weeks	3.58	2.64	3.09
	4 weeks	3.58	2.55	2.48
	3 weeks	3.58	2.33	2.00
	MEAN	3.58 A*	2.50 B	2.51 B
2010/2011	5 weeks	1.90	1.25	1.16
	4 weeks	1.90	1.41	1.07
	3 weeks	1.90	1.36	1.01
	MEAN	1.90 A*	1.34 B	1.08 B

\*Means with different letters differ by Duncan's test ( $p = 0.05$ ).

<sup>ns</sup> Not significant.

Source: Authors.

However, as regards the visual aspect based on the percentage of red coloration of the epidermis, it was under what was desired as fruits from unmanaged plants having a higher concentration of red in its epidermis in the 2009/2010 cycle. These values were much higher than described in literature for this cultivar. The same result did not repeat in the following cycle (2010/2011), having means difference significative among themselves for the factors analyzed (Table 9). Trevisan et al. (2006) also showed no increase in epidermis coloration when they used green pruning on peaches of the Maciel cultivar, which is the same as the present work.

**Table 9.** Coloration (%) of fruits during the productive cycles 2009/2010 and 2010/2011, according to the management technique and green pruning season.

Cycle	Season	Management Practice		
		Without practice	Bend of branches	Green pruning
2009/2010	5 weeks	46.85	9.72	21.26
	4 weeks	46.85	12.71	13.40
	3 weeks	46.85	13.30	15.42
	MEAN	48.84 A*	11.86 B	16.54 B
2010/2011	5 weeks	30.89	31.78	26.41
	4 weeks	30.89	25.19	27.30
	3 weeks	30.89	33.76	31.48
	MEAN	30.89 <sup>ns</sup>	30.13	28.35

\*Means with different letters differ by Duncan's test ( $p = 0.05$ ).

<sup>ns</sup> Not significant.

Source: Authors.

The flavonoid content of the fruits presented the highest values when the tree were not managed or with the bend of branches in 2010/2011 cycle (Table 10). For the anthocyanins, there were no significant differences between the means of the treatments (Table 10).

It is assumed that the greater production of flavonoids in the fruits is due to the greater amount of photoassimilates in the plant, since there was no removal of leaves, thus more carbons could be destined for its synthesis.

The higher leaf temperature obtained with green pruning and bend of branches is a consequence of shading reduction, improving light penetration, as obtained in the analysis of the irradiance in the center of the canopy.

**Table 10.** Anthocyanins, flavonoids, assimilation rate of CO<sub>2</sub> (μmol CO<sub>2</sub> m<sup>-2</sup> s<sup>-1</sup>), water conductance (mol H<sub>2</sub>O m<sup>-2</sup> s<sup>-1</sup>) and leaf temperature (°C) in the productive cycles 2010/2011, according to the management technique and green pruning season.

Variable	Management Practice			CV (%)
	Without practice	Bend of branches	Green pruning	
Anthocyanins	5.13 <sup>ns</sup>	4.54	5.37	25.54
Flavonoids	73.60 A *	63.01 AB	49.40 B	18.46
Assimilation rate of CO <sub>2</sub>	11.76 A	8.75 B	11.83 A	10.19
Water conductance	0.12 A	0.06 B	0.12 A	1.96
Leaf temperature	30.68 B	32.19 A	31.08 AB	2.20

\*Means with different letters differ by Duncan's test ( $p = 0.05$ ).

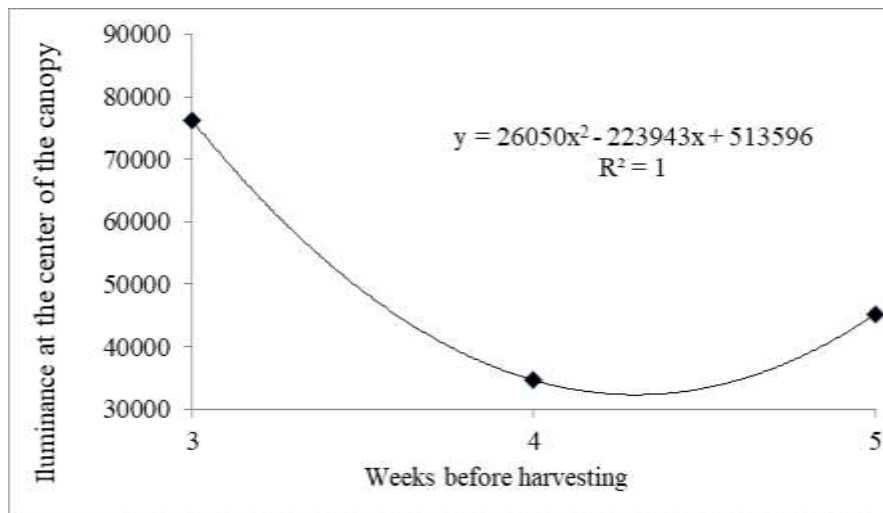
<sup>ns</sup> Not significant.

Source: Authors.

It was observed that there was greater illuminance in the center of the canopy when pruning was performed in the third week before fruit harvest (Figure 1), but this no influenced for peach with better quality. The illuminance analyzed in the center of the canopy showed decreasing quadratic behavior with the increase in the harvest period, and it was higher when the management practices were performed in the three weeks prior to harvest (Figure 1). However, Marini (1985) using the same cultivar, found that green pruning with the shortening or removal of the top branches of the plant, about a month before harvesting, increased the penetration of light inside the canopy.



**Figure 1.** Illuminance (lux) at the center of the canopy in the production cycle 2011/2012, according to the weeks prior to harvesting.



Source: Authors.

#### 4. Conclusions

It is concluded that the use of green pruning in Maciel peach trees regardless of the season and management practice of green pruning or bend of the branches provided improvements in the quality of its fruits.

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