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Chemical thinning of 'Sensação' peach trees

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Abstract

Peach tree thinning is essential for harvesting quality fruits and maintaining balanced fruit production for several years. Manual thinning of peach trees requires a large workforce, thereby increasing the production costs. Chemical thinning may be an alternative solution, but its efficiency depends on the dose of the chemical and plant species. This study aimed to evaluate the effect of different concentrations of metamitron on the chemical thinning of peach trees in southern Brazil. The experiment was carried out in a commercial orchard of peach cultivar 'Sensação' in Morro Redondo, Rio Grande do Sul (RS) state, Brazil. Different metamitron concentrations100 mg L^{-1}, 200 mg L^{-1}, 300 mg L^{-1}, and 400 mg L^{-1}were applied, and manual thinning was carried out 40 days after full bloom (DAFB) and to the treatment where the plants had no thinning. Fruit abscission, effective fructification, total number of plants per plant, production per plant, mean mass, and fruit diameter were evaluated. Applications of 300 and 400 mg L^{-1} metamitron 40 DAFB promoted high fruit abscission, in addition to decreasing the number of fruits and production. In contrast, applications of 100 and 200 mg L^{-1} of metamitron 40 DAFB was as efficient in thinning as manual thinning practice with respect to fruit production and fruit mass and its diameter.

Keywords: fruit abscission, manual thinning, metamitron, production, *Prunus persica*

Introduction

Efficiency of peach orchard cultivation depends on the production capacity, fruit quality, and production costs. In turn, the fruit quality and orchard productivity depend on several factors, mainly those related to edafoclimatic conditions and cultural practices, such as pruning and fruit thinning (Farias et al., 2019; Barreto et al., 2019). However, many of these factors directly require manual operation, thereby suggesting that the workforce represents the highest production cost in an orchard (Petri et al., 2016).

Thinning is one of the management practices that demands a large workforce in an orchard. Thinning is generally carried out manually on the 40–50 days after full bloom (DAFB) in almost all peach-growing regions (Oliveira et al., 2017). However, it is a complex operation that demands large workforce and hence, increases the production costs; it contributes up to a third of the total production cost (Petri et al., 2016). In addition, it is often difficult to find a qualified workforce to carry out activities in fruit orchards in several Brazilian regions.

To ensure the efficiency and decrease the work time of thinning process, studies have suggested alternatives to manual fruit thinning, including mechanical and chemical thinning of the fruit trees (Barreto et al., 2019; Farias et al., 2020).

Some studies have shown that chemical thinning can potentially be used in peach tree cultivation (McArtney et al., 2012; Giovanaz et al., 2016; Barreto et al., 2018; Farias et al., 2020). Among chemicals that have been tested for chemical thinning of temperate fruit trees, metamitron stands out (McArtney et al., 2012; Mcartney & Obermiller, 2014; Goulart et al., 2017; Gabardo et al., 2017). Metamitron acts on photosystem II by inhibiting electron transport, and when applied to fruit trees, it contributes to physiological fruit fall (Basak, 2011; Stern,

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2014).

Chemical thinning agents have been most efficient when they are applied post-bloom before endocarp hardening, that is, between 40–50 DAFB (Oliveira et al., 2017). Studies have shown that doses of metamitron ranged between 100 and 400 mg L^{-1} when it was used as a chemical thinning agent for peach trees (McArtney et al., 2012). In addition to metamitron concentrations, the success of chemical thinning practice also depends on the genetic characteristics of the cultivar (Farias et al., 2019, 2020). Therefore, this study aimed at evaluating different metamitron concentrations in thinning, production and quality of peaches borne by ‘Sensação’ cultivars.

Material And Methods

The experiment was carried out in a commercial peach orchard in Morro Redondo, Rio Grande do Sul (RS) state, Brazil (31°32’40.9’’S and 52°34’42.42’’W). Here, the ‘Sensação’ cultivars were grafted onto Capdeboscq rootstocks. The orchard was established in 2006; plants were conducted in a vase system with spacing between rows of 5 m, while spacing among plants was 2 m, resulting in a density of 1,000 plants ha^{-1}.

The experiment was conducted using a randomized block design with five replicates. Every plant was considered as a unit. Different doses of metamitron were applied to peach tree thinning in 2015 and 2016, that is, concentrations of 100 mg L^{-1}, 200 mg L^{-1}, 300 mg L^{-1} and 400 mg L^{-1} were applied 40 DAFB. Moreover, manual thinning was carried out 40 DAFB, and witness plants (with no thinning) were chosen. Manual thinning was conducted to leave the fruits of the peach tree branches from 10 to 15 cm. In the chemical thinning treatment, no manual thinning was performed.

Metamitron application at different concentrations was carried out using a Jactoback pack sprayer (working pressure: 40 psi). The limit of the volume applied to fruits was the runoff point, with a total of 1000L ha^{-1} syrup, on average. Metamitron solutions were prepared in the field and immediately applied to the trees. The metamitron source contained 70% active ingredient, and 0.05% non-ionic spreader-sticker was added to all treatments.

The mean daily temperatures and daily solar radiation for days when metamitron solution was applied to the trees for 2015 and 2016 are shown in Figure 1. There were 219 cold hours during the period of metamitron application in 2015 and 348 cold hours in 2016. Temperatures equal to or below 7.2 °C were considered as cold; the temperature values were obtained from the meteorological station at the Embrapa Clima Temperado located in Cascata, Pelotas, RS, Brazil (31°40'53.16"S. 52°26'23.60"W).

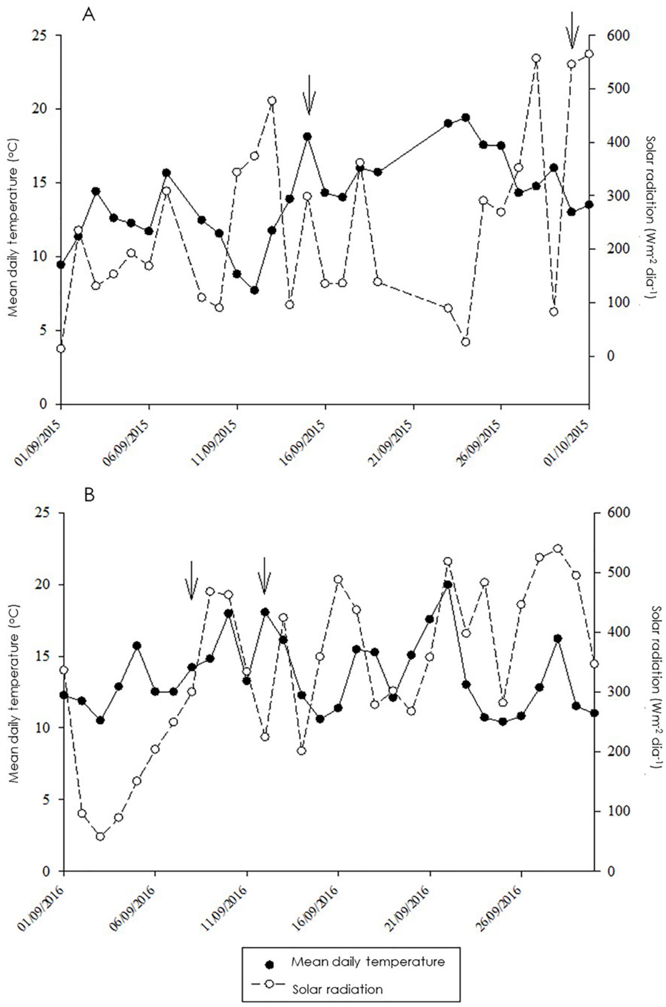

Figure 1. Daily temperatures and solar radiation during the periods of metamitron application to peach trees in (A) 2015 and (B) 2016 in Pelotas, Rio Grande do Sul, Brazil.

Fruit abscission (%) was evaluated in the field; six twigs were randomly selected from each peach tree and the number of fruits were counted before the treatment and during the harvest. Fruit set (%) was evaluated for the six twigs per plant by counting the number of flowers at full bloom and the number of fruits at harvest time. The number of fruits per plant (fruits $plant^{-1}$) and production per plant (kg $plant^{-1}$) were evaluated by counting and weighing fruits at harvest time.

Single-pass harvests were carried out on November 9th, 2015 (95 DAFB), and November 10th, 2016 (104 DAFB). After harvest, 50 fruits per replicate were evaluated for calculating the mean mass (g), which was determined by weighing the fruits on a digital scale, and mean fruit diameter (mm), which was measured using a digital caliper.

Data were evaluated for normality (Shapiro-Wilk test) and homoscedasticity (Hartley’s test) and subjected to analysis of variance using the F-test ($p \leq 0.05$). Further, the means were compared using Tukey’s test at $p \leq 0.05$. Polynomial regression was used for the metamitron concentration when significant. The software Sisvar version 5.6 was employed to carry out the statistical analysis (Ferreira, 2014).

Results And Discussion

Metamitron application led to a thinning effect on the fruits borne by peach trees in 2015 as well as 2016 (Table 1). Data on fruit abscission for both years were adjusted to ascending linear regression; the highest abscission was found at the highest metamitron concentration (400 mg L^{-1}) (Table 1). The application of metamitron may have caused fruit abscission as it directly promotes photosynthesis inhibition by inhibiting photosystem II and electron transport (Basak, 2011; Stern, 2014). According to Oliveira Jr. et al. (2011), inhibition occurs because of the binding between the active ingredient and the binding site of plastoquinone QB on protein D1 in photosystem II, which blocks electron transport from QA to QB. Subsequently, CO_2 fixation and ATP and $NADPH_2$ production - which are essential for the production of carbohydrates, sugars, and other compounds - are interrupted (Gabardo et al., 2017; Taiz et al., 2017).

Table 1. Abscission of fruits and fruit set borne by plant of ‘Sensação’ peach trees that were subjected to manual and chemical thinning using different metamitron concentrations in Morro Redondo, RS, Brazil, in 2015 and 2016 crops.

Treatments	Abscission of fruits (%)				Fruit set (%)			
	2015		2016		2015		2016	
Manual thinning	68.40	cd	71.20	ab	13.10	b	13.80	ab
No thinning	56.40	d	59.49	b	25.20	a	23.75	a
100 mg L^{-1} metamitron	68.69	cd	72.66	ab	15.43	b	16.99	ab
200 mg L^{-1} metamitron	74.30	bc	70.44	ab	9.69	bc	16.46	ab
300 mg L^{-1} metamitron	86.23	ab	73.59	ab	5.46	cd	14.97	ab
400 mg L^{-1} metamitron	96.52	a	81.92	a	3.01	d	12.04	b
Linear	*(1)		*(2)		*(3)		*(4)	
Quadratic	ns		ns		ns		ns	

Means followed by the same lowercase letter do not differ from each other according to Tukey’s test at 5% error probability. ns = not significant. (1) $y = 56.872 + 0.0978x$ ($R^2 = 0.9905$); (2) $y = 62.462 + 0.0458x$ ($R^2 = 0.8077$); (3) $y = 21.93 - 0.0254x$ ($R^2 = 0.8693$); (4) $y = 22.628 - 0.0544x$ ($R^2 = 0.9388$).

Application of 100 mg L^{-1} metamitron led to abscission, which was similar to the abscission observed for manual thinning in 2015 (Table 1). In 2016, application of 100, 200, and 300 mg L^{-1} of metamitron led to similar fruit abscission as manual thinning practice; thinning. However, concentration of 400 mg L^{-1} metamitron caused high fruit abscission in peach trees. Similarly, it has been reported that an increase in metamitron doses increases fruit abscission in peach cultivar Maciel (Farias et al., 2019). According to McArtney & Obermiller (2014), metamitron may lead to excessive fruit fall. Thus, the metamitron concentration as well as phenological stages of plants should be considered during the application of metamitron.

In the present study, fruit set responded with a descending linear regression in 2015 as well as 2016. It reached its minimum value at the highest dose of metamitron (400 mg L^{-1}) (Table 1). The results of fruit set corroborate the data regarding fruit abscission - an increase in metamitron concentrations caused a higher intensity of fruit fall (Table 1). As chemical thinning may be used for complementing manual thinning of fruits, it is important to determine the concentration that reduces fruit load and makes it easier to complete the technique by using manual work. This study showed that the concentration of 100 mg L^{-1} metamitron kept the value of fruit set close to those reached by manual thinning in 2015 and concentrations of 100, 200, and 300 mg L^{-1} of metamitron in 2016. Brunner (2014) reported tht metamitron showed variability in chemical thinning in apple trees, with different effects being observed based on the cultivar, concentration, and time of application. According to Nava et al. (2009) have reported that peach trees usually have high fruit set rates, with the contribution of environmental conditions such as flowering coinciding with sunny, mild, and dry days. These authors also claim that inadequate climatic conditions during the flowering period can also influence fruit establishment, which, in addition to temperature, rain, or high relative humidity, facilitate the occurrence of diseases in flowers.

The production of peaches at concentrations of 100 and 200 mg $L^{-1}$and treatment no thinning treatment showed no difference from manual thinning in 2015 (Table 2). Production per plant exhibited quadratic behavior in response to metamitron concentrations in 2015, when the highest metamitron concentration under investigation

(400 mg L^{-1}) decreased production per plant (Table 2), since this treatment also led to the highest fruit abscission (Table1) and the lowest number of fruit (Table2) in apple trees, chemical thinning with metamitron decreases production per plant when high concentrations are applied (Brunner, 2014). According to Moyano et al. (2010) and El-Boray et al. (2012), the lowest production of chemically thinned peach trees results from an intense decrease in the number of fruits.

Table 2. Production and number of fruits per plant of 'Sensação' peach trees submitted to manual and chemical thinning with different metamitron concentrations in Morro Redondo, RS, Brazil, in 2015 and 2016 crops.

Treatments	Production (Kg)				Number of fruits			
	2015		2016		2015		2016	
Manual thinning	39.83	a	34.97	ns	469	a	425	b
No thinning	30.15	ab	44.82		457	a	795	a
100mg $L^{-1}$of metamitron	36.21	ab	37.03		403	ab	592	ab
200mg $L^{-1}$of metamitron	32.81	ab	42.60		425	a	608	ab
300mg $L^{-1}$of metamitron	25.38	b	38.97		255	b	603	ab
400mg L^{-1} of metamitron	6.96	c	34.22		73	c	587	ab
Linear	ns		ns		*(2)		ns	
Quadratic	*(1)		ns		ns		ns	

Means followed by the same lowercase letter do not differ from each other according to Tukey's test at 5% error probability. ns = not significant. (1)$y = 30.174 + 0.0942x - 0.0004x^2$ ($R^2 = 0.9954$); (2) $y = 505.8-0.916x$
($R^2 = 0.8235$).

Thus, a decrease in the number of fruits per plant was observed in 2015 as metamitron concentrations increased. The lowest number of fruits was reached at a concentration of 400 mg L^{-1} (Table 2). This decrease in fruit load may have occurred because the application of metamitron impacts photosynthesis and/or leads to partitioning among fruits and new buds, which end up competing for resources. Therefore, either because of interference in production or due to the translocation of carbohydrates, their deficit in fruits may have worked as a thinning agent. Gabardo et al. (2017) also observed that an increase in metamitron concentrations in apple tree thinning decreased the number of fruits per plant. Compared to plants that did not receive metamitron, at a concentration of 400 mg L^{-1}, the number of fruits was reduced by 44% in the cultivar Maciel peach grown in southern Brazil (Farias et al., 2019).

In 2016, the production per plant was not influenced by the application of metamitron (Table 2). Although plants without thinning showed a greater number of fruits (Table 2), these plants also obtained fruits of less mass and smaller diameter in 2016 (Table 3), which occurs in fruits of less commercial value.

Table 3. Mean mass and fruit diameter of fruits borne by 'Sensação' peach trees submitted to manual and chemical thinning with different metamitron concentrations in Morro Redondo, RS, Brazil, in 2015 and 2016 crops.

Treatments	Mean mass of fruits (g)				Fruit diameter (mm)			
	2015		2016		2015		2016	
Manual thinning	82.99	b	82.50	a	55.65	b	53.93	a
No thinning	81.00	c	56.37	c	58.75	a	47.35	c
100mg $L^{-1}$of metamitron	89.87	ab	63.07	bc	57.60	ab	49.40	bc
200mg $L^{-1}$of metamitron	76.55	c	71.27	ab	54.30	c	51.90	ab
300mg $L^{-1}$of metamitron	99.05	a	65.19	bc	59.55	a	50.28	bc
400mg L^{-1} of metamitron	95.90	a	58.85	bc	58.58	a	48.74	bc
Linear	ns		ns		ns		ns	
Quadratic	ns		*(1)		ns		*(2)	

Means followed by the same lowercase letter do not differ from each other according to Tukey's test at 5% error probability. ns = not significant. (1)$y = 55.768 + 0.1224x - 0.0003x^2$ ($R^2 = 0.9030$); (2) $y = 47.18771 + 0.03595x - 0.00008x^2$ ($R^2 = 0.9038$).

A concentration of 100 mg L^{-1} of metamitron resulted in mass and fruit diameter values that were similar to those obtained by manual thinning (Table 3). For these same variables, manual thinning did not differ much from the concentration of 200 mg L^{-1} of metamitron in 2016. Concentrations of 300 and 400 mg L^{-1} of metamitron exhibited the highest mean fruit mass in 2015. An increase in mass results from a decrease in the plant load as it decreases competition for carbohydrates and improves the distribution of photoassimilates in the fruits. Similar results were found in peach mass when chemical thinning was carried out using 400 mg L^{-1} of benzyladenine; this treatment resulted in the lowest number of fruits per plant (Barreto et al., 2018).

Fruit diameter showed a quadratic regression in 2016. The highest mean of the diameter was found when the concentration of metamitron was close to 200 mg L^{-1} (Table 3). This result corroborates the fact that the concentrations around 200 mg L^{-1} of metamitron helped to increase both fruit mass and size in 2016 (Table 3). In addition, the concentration of 200 mg L^{-1} metamitron led to values of fruit diameter that were similar to those of manual thinning in 2016.

Conclusions

Application of 400 mg L^{-1} metamitron to peach trees causes thinning and promotes high fruit abscission and decreases the number and production of fruits. Application of 100 and 200 mg L^{-1} metamitron 40 DAFB provided values of fruit production and fruit mass and diameter similar to those obtained by manual thinning.

However, with thinning efficiency of metamitron is dependent on climatic conditions, temperature and humidity, plant carbohydrate reserve conditions, and genetic characteristics of cultivars.

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