PAB
Pesquisa Agropecuária Brasileira

Pomology/ Original Article

ISSN 1678-3921

Journal homepage: www.embrapa.br/pab

For manuscript submission and journal contents, access: www.scielo.br/pab

Carbohydrate content in branches and abscission of fruit of peach trees subjected to chemical thinning

Abstract – The objective of this work was to evaluate the effect of chemical thinning with metamitron on fruit of the Maciel and Sensação peach (*Prunus persica*) tree cultivars, as well as to identify its relation to the carbohydrate content in their branches. The experimental design was randomized complete blocks, and the treatments were trees with no thinning, manual fruit thinning, and chemical thinning with 200 mg L^{-1} metamitron applied at 20, 40, and 60 days after full blooming. The evaluated variables were: abscission percentage, yield per plant, number of fruit, presence of lignin in fruit, and carbohydrate content in the branches. The carbohydrate content was evaluated in trees with and without chemical thinning seven days after the application of the product. The use of metamitron promotes fruit thinning in the 'Maciel' and 'Sensação' peach trees, with a decrease in the carbohydrate content in their branches. Metamitron application 20 and 40 days after full blooming favors fruit abscission in both studied cultivars.

Index terms: *Prunus persica*, blooming, fruit quality, metamitron, number of fruit.

Teor de carboidratos nos ramos e abscisão de frutos de pessegueiros submetidos ao raleio químico

Resumo – O objetivo deste trabalho foi avaliar o efeito do raleio químico com metamitron em frutos de pessegueiro (*Prunus persica*) das cultivares Maciel e Sensação, bem como a sua relação com o teor de carboidratos nos seus ramos. O delineamento experimental foi de blocos ao acaso, e os tratamentos foram plantas sem raleio, raleio manual de frutos e raleio químico com 200 mg L^{-1}de metamitron aos 20, 40 e 60 dias após a plena floração. As variáveis analisadas foram: percentagem de abscisão, produção por planta, número de frutos, presença de lignina nos frutos e teores de carboidratos nos ramos. O teor de carboidratos foi avaliado em plantas com e sem raleio químico, sete dias após a aplicação do produto. O uso de metamitron promove raleamento dos frutos dos pessegueiros 'Maciel' e 'Sensação', com redução no conteúdo de carboidratos nos seus ramos. A aplicação de metamitron aos 20 e 40 dias após a plena floração favorece a abscisão dos frutos de ambas as cultivares estudadas.

Termos para indexação: *Prunus persica*, floração, qualidade de fruto, metamitron, número de frutos.

Caroline Farias Barreto[1], Roseli de Mello Farias[2], Renata Diane Menegatti[1], Renan Ricardo Zandoná[1], Carlos Roberto Martins[3] ✉, Marcelo Barbosa Malgarim[1] and Paulo Mello-Farias[1]

[1] Universidade Federal de Pelotas, Departamento de Fitotecnia, Campus Universitário, s/nº, CEP 96010-610 Capão do Leão, RS, Brazil. E-mail: carol_fariasb@hotmail.com, renata.d.menegatti@gmail.com, renan_zandona@hotmail.com, malgarim@yahoo.com, mellofarias@yahoo.com.br

[2] Universidade Estadual do Rio Grande do Sul, Avenida Presidente Tancredo Neves, nº 210, Piraí, CEP 97670-000 São Borja, RS, Brazil. E-mail: roseli-farias@uergs.edu.br

[3] Embrapa Clima Temperado, Rodovia BR-392, Km 78, 9º Distrito, Monte Bonito, Caixa Postal 403, CEP 96010-971 Pelotas, RS, Brazil. E-mail: carlos.r.martins@embrapa.br

✉ Corresponding author

Received
January 20, 2021

Accepted
August 05, 2021

How to cite
BARRETO, C.F.; FARIAS, R. de M.; MENEGATTI, R.D.; ZANDONÁ, R.R.; MARTINS, C.R.; MALGARIM, M.B.; MELLO-FARIAS, P. Carbohydrate content in branches and abscission of fruit of peach trees subjected to chemical thinning. **Pesquisa Agropecuária Brasileira**, v.56, e02401, 2021. DOI: https://doi.org/10.1590/S1678-3921.pab2021.v56.02401.

Introduction

Since peach (*Prunus* spp.) trees exhibit abundant blooming, thinning practices are necessary in orchards to decrease total fruit load and keep energy balance (Farias et al., 2020b). These practices result in larger fruits, with an unique flavor and an adequate color throughout commercialization (Farias et al., 2019). Peach trees are usually thinned manually between 40 and 50 days after full blooming (DAFB) (Oliveira et al., 2017), a period recommended to minimize fruit competition for carbohydrates, with no interference in cell division processes, allowing the adjustment of the number of fruits to the volume of the canopy (Petri et al., 2016).

In peach trees, carbohydrates, both stored as starch and produced by photosynthesis, are used for maximum effective fructification (Gonçalves et al., 2016). However, their availability is not enough to ensure full fruit growth throughout the cell division process if the fruit load is not adjusted to the volume of the vegetative canopy (Robinson & Lakso, 2011). For this reason, for apple (*Malus* spp.) tree cultivation, a chemical thinning model that uses temperature and radiation to predict carbohydrate offer and demand was established (Lakso et al., 2006). Robinson & Lakso (2011) concluded that trees produce more carbohydrate than they need on cold and sunny days for leaf, bud, fruit, and root growth, resulting in a daily carbohydrate surplus. However, for peach tree cultivation, studies of the relationship between carbohydrate dynamics and chemical thinning have just started, stimulating the search for knowledge of the effects of the application of certain chemical thinning agents on fruit abscission.

Interferences in the production or translocation of carbohydrates may act as a thinning agent in fruit, especially in those that are in a rapid growth phase, undergoing intense cell division, which is a process that depends on a high amount of metabolic energy (Farias et al., 2019). According to these authors, the application of metamitron decreases tree fruit load, which may be attributed to its impact on photosynthesis and/or partition between fruit and new buds that end up competing for reserves.

Chemical thinning, therefore, shows promising results in temperate fruit trees, especially peach, because its management is quite fast and it may be applied to both flowers and fruit (McArtney et al., 2012; Farias et al., 2019, 2020b). Metamitron stands out among the products that have been tested for chemical thinning of temperate fruit trees (Farias et al., 2019), acting on photosystem II (PHII) by inhibiting electron transport and also contributing to physiological fruit drop (Oliveira Jr. et al., 2011; Stern, 2014). However, the success of this practice depends mainly on the application period of the product, sensitivity of the used genetic material, nutritional status of the trees, and adequate concentration of the used compound. In the case of peach trees, information is still scarce about the process of fruit abscission and compounds of the carbohydrate reserves, as well as about the relationship with chemical thinning.

The objective of this work was to evaluate the effect of chemical thinning with metamitron on fruit of the Maciel and Sensação peach tree cultivars, as well as to identify its relation to the carbohydrate content in their branches.

Materials and Methods

The experiment was carried out in a commercial orchard of peach [*Prunus persica* (L.) Batsch] trees, located in the municipality of Morro Redondo, in the state of Rio Grande do Sul, Brazil (31º32'41"S, 52º34'42"W), in the 2015 and 2016 crop seasons. Vase-shaped trees, at a 5x2 m spacing (rows and trees, respectively), had been planted in 2006, resulting in density of 1,000 trees per hectare. 'Maciel' and 'Sensação' grafted on 'Capdeboscq' were used. Both cultivars produce peaches with yellow pulp, but their cycle periods are different. 'Maciel' has a long cycle, with full blooming at the end of July and beginning of August, and harvest in the second or third week of December, whereas 'Sensação' has a short cycle, with full blooming in the second fortnight of July and harvest in the first fortnight of November (Raseira et al., 2014). In the present study, full blooming of 'Maciel' peach trees was recorded on August 1, 2015, and on July, 23, 2016, while full blooming of 'Sensação' occurred on August 6, 2015, and on July 25, 2016.

The experimental design was randomized complete blocks with five replicates; each tree was an experimental unit, and each year was analyzed separately. The same peach trees were assessed in both seasons. Field treatments consisted of trees with: no thinning (water application); manual fruit thinning at 40 DAFB, when from 10 to 15 cm were left between

fruit on the branches of the peach trees; and chemical thinning with metamitron, at 20, 40, and 60 DAFB, without any manual thinning. Agricultural practices, such as fertilization, pruning, phytosanitary treatments, and control of spontaneous trees, were carried out in the orchard following the usual procedures adopted by the farmers.

Mean daily temperatures and daily solar radiation during the application of metamitron to peach trees in the 2015 and 2016 seasons are shown in Figure 1. There were 219 and 348 chill hours in 2015 and 2016, respectively; these hours were calculated using temperatures equal to or below 7.2°C, collected by the meteorological station at Embrapa Clima

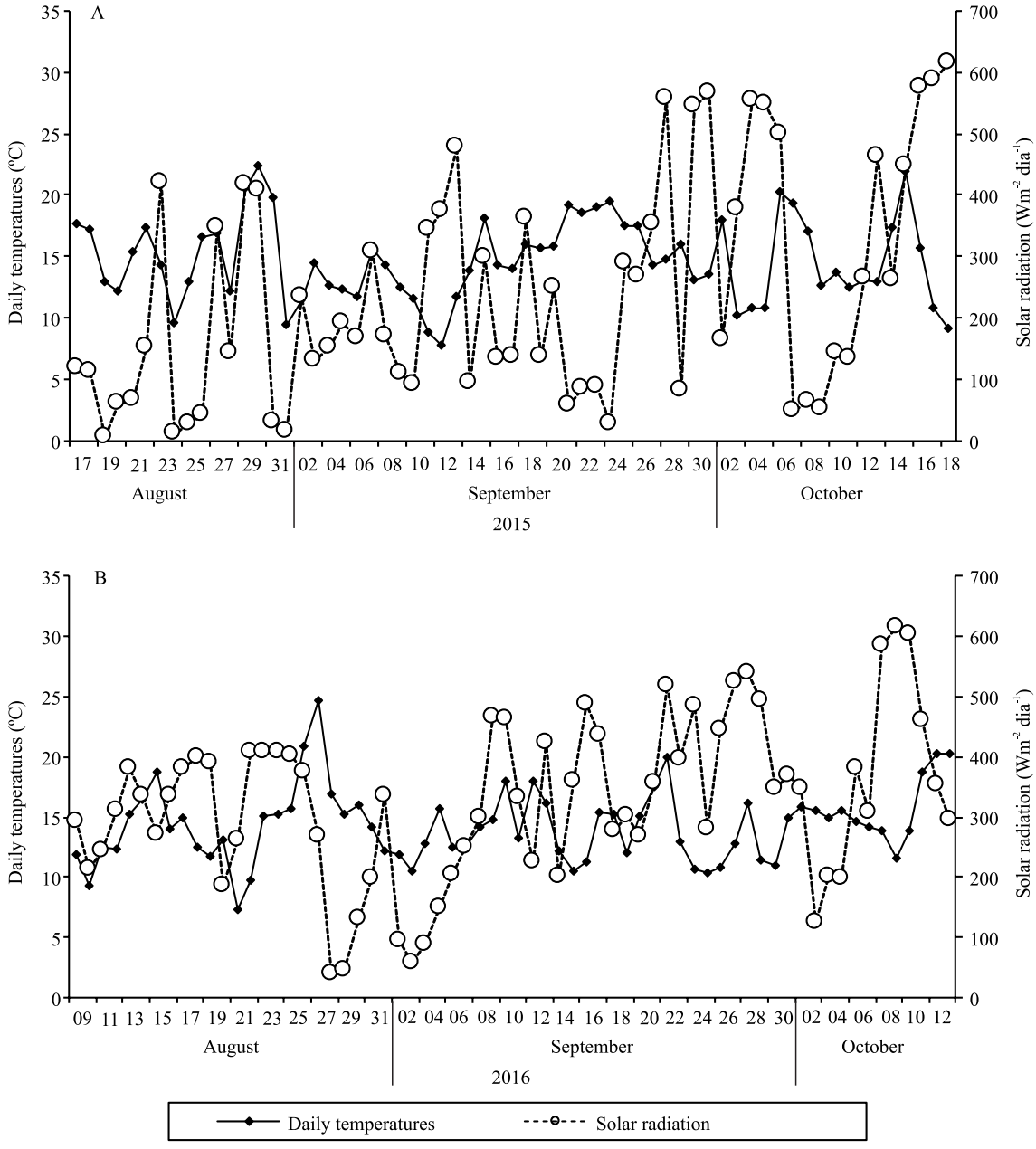


Figure 1. Daily temperatures and solar radiation during the periods of metamitron application to peach (*Prunus persica*) trees in the 2015 (A) and 2016 (B) crop seasons. Data obtained from a meteorological station located in the municipality of Pelotas, in the state of Rio Grande do Sul, Brazil.

Temperado, located in the district of Cascata, in the municipality of Pelotas, in the state of Rio Grande do Sul, Brazil (31°40'53.16"S.52°26'23.60"W).

The source of metamitron was the commercial product Goltix, with 70% active ingredient (Adama Brasil, Londrina, PR, Brazil). The 0.05% Silwet L-77 nonionic adhesive spreader (Momentive Performance Materials Inc., Waterford, NY, USA) was added to all treatments. The used solutions were prepared on the field right before they were applied by the Jacto PJH backpack sprayer (Máquinas Agrícolas Jacto S.A., Pompeia, SP, Brazil), with hollow cone tips, at an angle of 80° and operating pressure of 40 psi. The limit of the volume applied to the trees was the point of drip, totaling 1,000 L ha^{-1} stock, on average. During the application period, mean air relative humidity (%), temperature (°C), and wind velocity (m s^{-1}) were 77%, 20.3°C, and 1.4 m s^{-1}, respectively.

Fruit abscission (%) was evaluated by randomly marking six 25 cm long branches on every peach tree and counting the number of fruit before the beginning of treatments and at harvest time. The number of fruit per tree and yield per tree (kg per tree) were assessed by counting the total number of fruit also at harvest time. 'Maciel' fruit were harvested on December 10, 2015, at 131 DAFB, and on December 14, 2016, at 144 DAFB, while 'Sensação' was picked on November 9, 2015, at 95 DAFB, and on November 10, 2016, at 104 DAFB.

Twenty fruit per sample were separated to determine mean fruit diameter (mm) and to qualitatively observe the presence of lignin in the endocarp. Fruit diameter was measured using a digital pachymeter. To determine lignin in the endocarp, fruit were cut in half and soaked in a solution of phloroglucinol [1% (p/v) phloroglucinol, 12% HCl (v/v), and 85% ethanol (v/v)] for 1 hour, following the methodology of Callahan et al. (2009).

To obtain carbohydrate content, ten 10 cm long branches per tree were collected seven days after chemical thinning both from peach trees subjected to this treatment or to no thinning. The branches were taken to a laboratory where their fruit and bark were separated. Samples with ten segments of bark were put in an oven and dried for 96 hours at 65°C, manually triturated, ground by a Wiley mill with a 0.8 mm sieve, and stored in an ultrafreezer at -80°C. Then, their total carbohydrate contents (mg g^{-1}) were determined by reactions with anthrone (Hodge & Hofreiter, 1962), based on absorbance at 620 nm. The carbohydrates were evaluated in a 2x3 factorial arrangement, with five replicates, where factor A are trees that were not thinned or that were chemically thinned with 200 mg L^{-1} metamitron, while factor B are the three different application periods (20, 40, and 60 DAFB).

The obtained results were tested for normality by Shapiro-Wilk's test and for homoscedasticity by Hartley's test. Afterwards, they were subjected to the analysis of variance by the F-test, and the means of the significant variables ($p<0.05$) were compared by Tukey's test. The Sisvar software, version 5.6, was used to carry out these procedures (Ferreira, 2014).

Results and Discussion

The use of metamitron as a chemical thinning agent in 'Maciel' and 'Sensação' peach trees had an effect on fruit abscission (Table 1). In both cultivars, in 2015, the decrease in the number of fruit in trees thinned with metamitron was higher than that in trees that were not subjected to any thinning. Metamitron application causes fruit abscission on peach trees due to its direct action on photosynthesis inhibition (Gabardo et al., 2017). The interference in the production or translocation of carbohydrates acts as a thinning agent in fruit, especially in those that are in a rapid growth phase, as previously mentioned (Farias et al., 2019). However, the percentages of fruit abscission resulting from the use of metamitron in peach trees may vary, depending on the concentration and the period in which the product is applied (Farias et al., 2019, 2020b).

Although differences between seasons and cultivars were not evaluated, when compared with manual thinning, the effect of metamitron depended on the cultivar and season (Table 1). 'Maciel' has a long cycle, while 'Sensação' has a short one (Raseira et al., 2014). According to Farias et al. (2019), in the case of the Maciel cultivar, the use of metamitron was more effective in fruit abscission 20 and 30 DAFB, before lignin formation. However, in the case of cultivar Sensação, the percentages of fruit abscission differed in both seasons since the highest values were found for peach trees thinned with metamitron 20 DAFB in 2015 and 30 DAFB in 2016 (Farias et al., 2020b).

For 'Maciel' peach trees, in the 2015 season, the highest fruit abscission was observed with thinning with metamitron 20, 40, and 60 DAFB, in comparison

with the treatment with no thinning, while, in the 2016 season, the highest values were found 20 and 40 DAFB (Table 1). For 'Sensação' peach trees, in 2015, the highest fruit abscission under chemical thinning occurred 20 DAFB, not differing from that at 40 and 60 DAFB, whereas, in 2016, the highest value was verified at 20 and 40 DAFB. The chemical thinning of peach trees using metamitron causes fruit abscission mainly when applied at early stages of fruit growth (Farias et al., 2019). According to Robinson & Lakso (2011), the highest abscission occurs in the stage in which fruit diameters are between 10 and 20 mm, since that is when fruit grow fast and require a large amount of carbohydrates, and, therefore, also when the scarcity of carbon may result in the abscission of weak fruit. In these stages, the fruit diameters were 7–9 and 23–25 cm, respectively (Table 2).

In the 2015 crop season, there was no significant difference in fruit abscission in 'Maciel' peach trees subjected to chemical thinning with metamitron or to manual thinning (Table 1). However, in 2016, fruit abscission was higher with metamitron application 20 and 40 DAFB. In the case of cultivar Sensação, in 2015, the application of metamitron resulted in a higher fruit abscission than manual thinning, but, in 2016, the obtained values were similar. Farias et al. (2020a) verified that concentrations of metamitron from 100 to 200 mg L^{-1} applied to 'PS 10711' peach trees caused a lower decrease in fruit, compared with manual thinning. Therefore, the recommended concentration of metamitron is one that ensures a fruit load that is consistent with the fruit set and abscission obtained by manual thinning, leading to a strategically safer and easier practice.

A decrease in fruit abscission was observed in trees subjected to metamitron application 60 DAFB in 2016, regardless of the used cultivar, which shows that the efficiency of the product may have decreased in that period. In addition, in the same season, fruit abscission due to metamitron application 60 DAFB in cultivar Maciel did not differ from that of trees that were not thinned and was just 11.1% higher in cultivar Sensação. This behavior may be a strategy to maintain the fruit, considering trees use a large amount of carbohydrates to develop and to form lignin to harden their stones, as shown by the results presented in Table 2. Chemical thinning during lignin formation may lead to a decrease in fruit load since trees consume more energy in this stage to form the endocarp (Giovanaz et al., 2015).

Fruit borne by cultivars Maciel and Sensação were 32 and 30 mm in diameter, on average, respectively, 60 DAFB (Table 2). They also showed a large lignin deposition, which may have hindered the thinning effect of the product (Giovanaz et al., 2015; Farias et al., 2020b), which was applied in advanced phenological

Table 1. Fruit abscission (FA), number of fruit (NF), and production per tree (PT) of 'Maciel' and 'Sensação' peach (*Prunus persica*) trees subjected to different thinning treatments in the 2015 and 2016 crop seasons, in the municipality of Morro Redondo, in the state of Rio Grande do Sul, Brazil[(1)].

Treatments	2015 season			2016 season		
	FA (%)	NF	PT (kg)	FA (%)	NF	PT (kg)
			'Maciel'			
No thinning	56.0b	359a	45.6ab	57.0c	598a	50.7ab
Manual thinning	69.0ab	305a	47.1a	66.0b	494ab	62.4a
20 DAPB	79.5a	234b	32.7bc	78.0a	508ab	53.1ab
40 DAPB	74.5a	219b	32.4c	76.2a	454b	46.9b
60 DAPB	72.0a	221b	31.1c	59.0c	516ab	44.6b
p-value	0.0001	0.0004	0.0017	0.0001	0.0258	0.0186
			'Sensação'			
No thinning	40.0c	589a	52.8a	41.3c	795a	44.8[ns]
Manual thinning	64.2b	463ab	38.6b	65.0ab	424b	35.5
20 DAPB	80.3a	574a	52.7a	73.9a	559ab	41.7
40 DAPB	67.0b	425bc	33.9b	70.4a	596ab	43.6
60 DAPB	61.5b	309c	28.4b	52.4b	589ab	38.0
p-value	0.0001	0.0001	0.0001	0.0001	0.0037	0.2765

[(1)]Means followed by equal lowercase letters do not differ by Tukey's test, at 5% probability. DAFB, days after full blooming. [ns]Nonsignificant.

stages. The obtained results are in alignment with those of a research on the characterization of the expression of genes that are in charge of lignin production in peaches (Dardick et al., 2010), in which a high expressivity was observed in the stage of fruit growth deceleration, i.e., as DAFB go by.

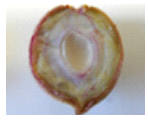
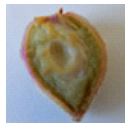
Metamitron, as a thinning agent, may act differently due to variations in temperature, since low temperatures favor fruit abortion (Farias et al., 2020b). In the present study, the variations in temperature and solar radiation were higher in the first season (Figure 1). According to Nava et al. (2009) and Couto et al. (2010), high temperatures – above 24°C – in the blooming and pre-blooming periods are related to an abnormal development of pollen and eggs. The authors also found that negative effects of high temperatures on blooming were higher in the case of 'Granada' than in that of 'Maciel'. Likewise, Farias et al. (2020a, 2020b) reported differences among cultivars due to chemical thinning. These results reinforce the hypothesis that the efficiency of a chemical thinning agent in peach abscission depends on the environmental conditions of the cultivation area and that further studies are fundamental to characterize the effects of this treatment on different cultivars and stages of fruit development. Petri et al. (2016) concluded that both environmental and plant-related factors are involved in a complex interaction in the final response to the application of chemical thinners.

'Maciel' and 'Sensação' peach trees that were not subjected to thinning showed around 50 and 40% fruit abscission, respectively (Table 1). However, these percentages are not enough to enable fruit to develop adequately, interfering in fruit size because abscission occurs after competition for carbohydrate has been established and cell division has been affected (Costa et al., 2013; Greene & Costa, 2013). Contrarily, peach trees that were not subjected to thinning produce a large numbers of fruit, but that have a small diameter and a low mass (Barreto et al., 2019).

Regarding the Maciel cultivar, the highest fruit abscission due to metamitron application resulted in the smallest number of fruit and the lowest yield per tree in the 2015 season, which was also observed in 2016 when metamitron was applied at 40 DAFB. In the first season, the trees that were subjected to manual thinning and to no thinning showed a higher number of fruits and yield per plant than trees thinned with metamitron. However, in the second season, metamitron application did not decrease the number of fruit in comparison with manual thinning, although manually thinned trees showed a higher peach yield than those treated with metamitron 40 and 60 DAFB.

In cultivar Sensação, the highest yield per tree was obtained with metamitron applied at 20 DAFB and also without thinning in the 2015 season (Table 1). In 2016, the number of fruits did not differ between trees that were not subjected to thinning and those that received metamitron; therefore, yield per tree was only affected in 2015. Since photosynthesis is controlled by environmental factors, such as

Table 2. Lignin deposition and fruit diameter at different thinning periods of 'Maciel' and 'Sensação' peach (*Prunus persica*) trees in the 2015 and 2016 crop seasons, in the municipality of Morro Redondo, in the state of Rio Grande do Sul, Brazil.

Cultivar	Treatment[1]	Fruit diameter (mm)	Lignin deposition
'Maciel'	Metamitron at 20 DAFB	07–09	
	Metamitron at 40 DAFB	23–25	
	Manual thinning		
	Metamitron at 60 DAFB	31–33	
'Sensação'	Metamitron at 20 DAFB	07–09	
	Metamitron at 40 DAFB	19–21	
	Manual thinning		
	Metamitron at 60 DAFB	29–31	

[1]DAFB, days after full blooming.

temperature and luminosity (Dotto et al., 2017), this variation in the effects of metamitron on the number of fruit and yield in both crop years may be related to the low temperature and solar radiation registered in 2015. As mentioned before, metamitron acts on PSII by inhibiting electron transport (Basak, 2011; Stern, 2014), i.e., photosynthetic inefficiency decreases the production of carbohydrates that are needed for fruit fixation. This, associated with the inhibition of electron transport in PSII caused by metamitron, may have led to a deficiency in the photosynthetic rate and to changes in the relationship between the source and drain of plants. Therefore, in conditions of radiation deficiency, the effects of metamitron may be potentialized and cause a greater fruit abscission (Farias et al., 2020b).

The carbohydrate contents of the peach tree branches varied according to the different application periods. 'Maciel' peach trees exhibited lower contents when thinned with and without metamitron 40 and 60 DAFB in both seasons (Table 3). The exception was the carbohydrate content in trees that were not thinned in 2016, when no decrease was observed. It should be highlighted that there is a decreasing trend in the amounts of carbohydrates when metamitron is applied. In absolute numbers, between 20 and 60 DAFB, there was decrease of 1.96 and 1.06 mg g^{-1} with and without metamitron application, respectively, in the first season. In the second season, the difference in carbohydrate decrease in branches that were and not thinned with metamitron was even greater: 1.67 vs 0.02 mg g^{-1}. This could be explained by the fact that, in spring, when fruit and branches grow and buds blossom, carbohydrate contents tend to be directed to the new organs, while, at 20 DAFB, trees already had fruit, branches, and small buds, requiring less energy. Metamitron application was also found to interfere in the carbohydrate contents in branches in all periods, except 20 DAFB, in the first season (Table 3). This effect on trees is attributed to the direct action of this product on photosynthesis inhibition (Gabardo et al., 2017), their main process of carbohydrate formation. The same effect observed for trees that were not thinned in the 2015 season may be explained by the number of chill hours, which were fewer than in 2016, affecting the stored carbohydrate contents (Figure 1). Moreover, the greater amount of chill hours in 2016 may have led to a high accumulation of reserve compounds and kept carbohydrate contents in branches even without thinning, while, in 2015, low carbohydrate contents may have led to decreases 40 and 60 DAFB. It should be noted that most carbon fixed throughout photosynthesis is either stored as starch in chloroplasts or transferred to cytosol and converted into soluble carbohydrates (Bassi et al., 2018).

Table 3. Total carbohydrates in branches of 'Maciel' peach (*Prunus persica*) trees subjected to chemical thinning with metamitron 20, 40, and 60 days after full blooming (DAFB) and to no thinning in the 2015 and 2016 crop seasons, in the municipality of Morro Redondo, in the state of Rio Grande do Sul, Brazil[(1)].

Treatment	Total carbohydrates (mg g^{-1})		
	20 DAFB	40 DAFB	60 DAFB
		2015 season	
With metamitron	7.54aA	5.90bB	5.58bB
No thinning	7.80aA	6.59aB	6.74aB
p-value		0.0174	
		2016 season	
With metamitron	6.56bA	5.52bAB	4.89bB
No thinning	7.54aA	6.46aA	7.52aA
p-value		0.0276	

[(1)]Means followed by equal letters, lowercase in the columns and uppercase in the lines, do not differ by Tukey's test, at 5% probability. DAFB, days after full blooming.

Even though no interaction was observed between methods and thinning periods in the 2015 season for cultivar Sensação, a lower total carbohydrate content was found in branches thinned in the most advanced stage of fruit growth – 60 DAFB (Table 4). This result is indicative that the carbohydrates that would be used for accumulating dry matter are redirected to lignin production, fruit growth, and stone hardening, processes that require much metabolic energy (Morandi et al., 2008).

The total carbohydrate contents found in the branches of 'Sensação' peach trees subjected to chemical thinning were lower than those of trees that were not thinned, regardless of the application period (Table 4). 'Maciel' peach trees exhibited similar results (Table 3). In the 2016 season, total carbohydrate contents were also lower in 'Sensação' branches treated with metamitron than in those of trees that were not subjected to thinning, in all three periods under evaluation (Table 4).

Table 4. Total carbohydrates in branches of 'Sensação' peach (*Prunus persica*) trees subjected to chemical thinning with metamitron 20, 40, and 60 days after full blooming (DAFB) and to no thinning in the 2015 and 2016 crop seasons, in the municipality of Morro Redondo, in the state of Rio Grande do Sul, Brazil[(1)].

Treatment	Total carbohydrates (mg g^{-1})		
Time of application (TA)	2015 season		
20 DAFB	8.63a		
40 DAFB	8.74a		
60 DAFB	5.88b		
p-value$_{(TA)}$	0.0006		
Chemical fruit thinning			
With metamitron	7.11b		
No thinning	8.39a		
p-value$_{(chemical\ fruit\ thinning)}$	0.0231		
p-value$_{(chemical\ fruit\ thinning\ x\ TA)}$	0.0767		
	Total carbohydrates (mg g^{-1})		
	20 DAFB	40 DAFB	60 DAFB
Chemical fruit thinning	2016 season		
With metamitron	5.72bA	4.08bB	5.91bA
No thinning	9.00aA	6.85aB	7.02aB
p-value $_{(chemical\ thinning\ x\ thinning)}$	0.0060		

[(1)]Means followed by equal letters, lowercase in the columns and uppercase in the lines, do not differ by Tukey's test, at 5% probability. DAFB, days after full blooming.

Conclusions

1. The use of metamitron promotes fruit thinning in the Maciel and Sensação peach tree (*Prunus persica*) cultivars and causes a decrease in the carbohydrate contents in their branches.

2. Metamitron application 20 days after fruit abscission (DAFB) (7–9 mm fruit diameter) and 40 DAFB (23–25 mm fruit diameter) favors fruit abscission in 'Maciel' peach trees.

3. Metamitron application 20 DAFB (7–9 mm fruit diameter) and 40 DAFB (19–21 mm fruit diameter) favors fruit abscission in 'Sensação' peach trees.

Acknowledgments

To Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), for financial support; and to Dr. José Carlos Fachinello, for his aid (in memoriam).

References

BARRETO, C.F.; ANTUNES, L.E.C.; FERREIRA, L.V.; NAVROSKI, R.; BENATI, J.A.; PEREIRA, J.F.M. Mechanical flower thinning in peach trees. **Revista Brasileira de Fruticultura**, v.41, e-465, 2019. DOI: https://doi.org/10.1590/0100-29452019465.

BASAK, A. Efficiency of fruitlet thinning in apple 'Gala Must' by use of metamitron and artificial shading. **Journal of Fruit and Ornamental Plant Research**, v.19, p.51-62, 2011.

BASSI D.; MENOSSI M.; MATTIELLO, L. Nitrogen supply influences photosynthesis establishment along the sugarcane leaf. **Scientific Reports**, v.8, art.2327, 2018. DOI: https://doi.org/10.1038/s41598-018-20653-1.

CALLAHAN, A.N.; DARDICK, C.; SCORZA, R. Characterization of 'Stoneless': a naturally occurring, partially stoneless plum cultivar. **Journal of the American Society for Horticultural Science**, v.134, p.120-125, 2009. DOI: https://doi.org/10.21273/JASHS.134.1.120.

COSTA, G.; BLANKE, M.M.; WIDMER, A. Principles of thinning in fruit tree crops – needs and novelties. **Acta Horticulturae**, v.998, p.17-26, 2013. DOI: https://doi.org/10.17660/ActaHortic.2013.998.1.

COUTO, M.; RASEIRA, M.C.B.; HERTER, F.G.; SILVA, J.B. Influence of high temperatures at blooming time on pollen production and fruit set of peach 'Maciel' and 'Granada'. **Acta Horticulturae**, v.872, p.225-230, 2010. DOI: https://doi.org/10.17660/ActaHortic.2010.872.30.

DARDICK, C.D.; CALLAHAN, A.M.; CHIOZZOTTO, R.; SCHAFFER, R.J.; PIAGNANI, M.C.; SCORZA, R. Stone formation in peach fruit exhibits spatial coordination of the lignin and flavonoid pathways and similarity to *Arabidopsis* dehiscence. **BMC Biology**, v.8, art.13, 2010. DOI: https://doi.org/10.1186/1741-7007-8-13.

DOTTO, M.; PIROLA, K.; WAGNER JUNIOR, A.; RADAELLI, J.C.; ANTUNES, L.C.; CITADIN, I. Physiological and sensorial aspects of peach fruits cv. Chimarrita depending on the season and management of green pruning. **Brazilian Journal of Agriculture**, v.92, p.261-270, 2017. DOI: https://doi.org/10.37856/bja.v92i3.2975.

FARIAS, R. de M.; BARRETO, C.F.; ZANDONÁ, R.R.; HELLWIG, C.G.; MARTINS, C.R.; MALGARIM, M.B.; MARODIN, G.A.B. Metamitron in the chemical thinning of 'PS 10711' peach trees. **Semina: Ciências Agrárias**, v.41, p.1923-1936, 2020a. Suplemento 1. DOI: https://doi.org/10.5433/1679-0359.2020v41n5Supl1p1923.

FARIAS, R. de M.; BARRETO, C.F.; ZANDONÁ, R.R.; MARTINS, C.R.; MELLO-FARIAS, P.C. de. Application time of chemical thinning with metamitron in 'Sensação' peach trees. **Revista Ceres**, v.67, p.16-22, 2020b. DOI: https://doi.org/10.1590/0034-737x202067010003.

FARIAS, R. de M.; MARTINS, C.M.; BARRETO, C.F.; GIOVANAZ, M.A.; MALGARIM, M.B.; MELLO-FARIAS, P. Time of metamitron application and concentration in the chemical

thinning of 'Maciel' peach. **Revista Brasileira de Fruticultura**, v.41, e-017, 2019. DOI: https://doi.org/10.1590/0100-29452019017.

FERREIRA, D.F. Sisvar: a guide for its bootstrap procedures in multiple comparisons. **Ciência e Agrotecnologia**, v.38, p.109-112, 2014. DOI: https://doi.org/10.1590/S1413-70542014000200001.

GABARDO, G.C.; KRETZSCHMAR, A.A.; PETRI, J.L.; COUTO, M.; HAWEROTH, F.J.; SILVA, C.D.S. e. Taxa fotossintética em macieiras tratadas com metamitron. **Revista Eletrônica Científica da UERGS**, v.3, p.617-633, 2017. DOI: https://doi.org/10.21674/2448-0479.33.617-633.

GIOVANAZ, M.A.; SPAGNOL, D.; BARTZ, J.; PASA, M. da S.; CHAVES, F.C.; FACHINELLO, J.C. Abscisic acid as a potential chemical thinner for peach. **Pesquisa Agropecuária Brasileira**, v.50, p.989-992, 2015. DOI: https://doi.org/10.1590/S0100-204X2015001000015.

GONÇALVES, B.H.L.; LEONELl, S.; SOUZA, J.M.A.; TECCHIO, M.A.; ARRUDA, L.L.; SILVA, M. de S. Carbohydrate levels in 'Douradão' peach tree grown under subtropical conditions. **Australian Journal of Crop Science**, v.10, p.1635-1639, 2016. DOI: https://doi.org/10.21475/ajcs.2016.10.12.PNE225.

GREENE, D.; COSTA, G. Fruit thinning in pome- and stone fruit: state of the art. **Acta Horticulturae**, v.998, p.93-102, 2013. DOI: https://doi.org/10.17660/ActaHortic.2013.998.10.

HODGE, J.E.; HOFREITER, B.T. Determination of reducing sugars and carbohydrates. In: WHISTLER, R.L.; WOLFROM, M.L. (Ed.). **Methods in carbohydrate chemistry**. New York: Academic Press, 1962. v.1, p.380-394.

LAKSO, A.N.; ROBINSON, T.L.; GREENE, D.W. Integration of environment, physiology and fruit abscission via carbon balance modeling – implications for understanding growth regulator responses. **Acta Horticulturae**, v.727, p.321-326, 2006. DOI: https://doi.org/10.17660/ActaHortic.2006.727.38.

MCARTNEY, S.J.; OBERMILLER, J.D.; ARELLANO, C. Comparison of the effects of metamitron on chlorophyll fluorescence and fruit set in apple and peach. **HortScience**, v.47, p.509-514, 2012. DOI: https://doi.org/10.21273/HORTSCI.47.4.509.

MORANDI, B.; GRAPPADELLI, L.G.; RIEGER, M.; LO BIANCO, R. Carbohydrate availability affects growth and metabolism in peach fruit. **Physiologia Plantarum**, v.133, p.229-241, 2008. DOI: https://doi.org/10.1111/j.1399-3054.2008.01068.x.

NAVA, G.A.; DALMAGO, G.A.; BERGAMASCHI, H.; PANIZ, R.; SANTOS, R.P. dos; MARODIN, G.A.B. Effect of high temperatures in the pre-blooming and blooming periods on ovule formation, pollen grains and yield of 'Granada' peach. **Scientia Horticulturae**, v.122, p.37-44, 2009. DOI: https://doi.org/10.1016/j.scienta.2009.03.021.

OLIVEIRA JR., R.S. de; CONSTANTIN, J.; INOUE, M.H. (Ed.). **Biologia e manejo de plantas daninhas**. Curitiba: Omnipax, 2011. 348p.

OLIVEIRA, P.D. de; MARODIN, G.A.B.; ALMEIDA, G.K. de; GONZATTO, M.P.; DARDE, D.C. Heading of shoots and hand thinning of flowers and fruits on 'BRS Kampai' peach trees. **Pesquisa Agropecuária Brasileira**, v.52, p.1006-1016, 2017. DOI: https://doi.org/10.1590/s0100-204x2017001100006.

PETRI, J.L.; HAWERROTH, F.J.; LEITE, G.B.; SEZERINO, A.A.; COUTO, M. **Reguladores de crescimento para frutíferas de clima temperado**. Florianópolis: Epagri, 2016. 141p.

RASEIRA, M. do C.B.; NAKASU, B.H.; BARBOSA, W. **Cultivares**: descrição e recomendação. In: RASEIRA, M. do C.B.; PEREIRA, J.F.M.; CARVALHO, F.L.C. (Ed.). Pessegueiro. Brasília: Embrapa, 2014. p.73-141.

ROBINSON, T.L.; LAKSO, A.N. Predicting chemical thinner response with a carbohydrate model. **Acta Horticulturae**, v.903, p.743-750, 2011. DOI: https://doi.org/10.17660/ActaHortic.2011.903.103.

STERN, R.A. The photosynthesis inhibitor metamitron is an effective fruitlet thinner for 'Gala' apple in the warm climate of Israel. **Scientia Horticulturae**, v.178, p.163-167, 2014. DOI: https://doi.org/10.1016/j.scienta.2014.08.005.