Application time of chemical thinning with metamitron in 'Sensação' peach trees[1]

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ABSTRACT

Thinning is a cultural practice that leads to balance between fruit yield and quality. It is carried out in a short period of time and requires qualified workforce, whose shortage ends up increasing costs. This study aimed at evaluating the thinning effect of metamitron on peach trees at different periods of time after bloom. The experiment was carried out in a commercial orchard of 'Sensação' peach trees located in Morro Redondo, Rio Grande do Sul (RS) state, Brazil, in 2015-2016 crops. Treatments were the application of 200 mg L^{-1} metamitron, 20, 30, 40, 50 and 60 days after full bloom (DAFB), and manual thinning 40 DAFB. Fruit abscission, effective fructification, period of manual and chemical thinning, number of fruits and yield per plant, mean fruit mass and fruit caliber were evaluated. When metamitron was applied 40 DAFB, percentages of fruit abscission and fruit set, besides the number of fruits, were similar to the ones found when manual thinning was carried out. The intensity of the thinning effect of metamitron in peach trees depends on the application period.

Keywords: *Prunus persica*; fruit set; fruit abscission; manual thinning.

INTRODUCTION

Peach trees exhibit high fruit set, which results in plants with an excessive number of fruits. Hence, the need for fruit thinning practices whose main objective is to better fruit quality and the secondary one is to avoid production alternation. Trees with high load of fruits usually bear little fruits with low commercial value, besides the fact that branches may break as the result of their weight (Pereira & Raseira, 2014; Giovanaz *et al*., 2016).

Current thinning practices have been carried out manually in orchards. They enable picked fruits to be selected, i. e., damaged, little and badly located ones are eliminated. However, this practice requires qualified workforce and must be carried out in a short period. Thus, it hinders its execution and, consequently, increases production costs (McArtney & Obermiller, 2014; Simões *et al*., 2013).

Other techniques, such as chemical thinning, have been studied as alternatives to replacing manual thinning. Chemical thinning is feasible for peach tree cultures, since it is a fast practice which uses different chemical substances, not only to better fruit quality but also to decrease costs and working time. Regarding peach trees, some products have been studied to thin their fruits (McArtney *et al*., 2012; Meitei *et al.*, 2013; Giovanaz *et al*., 2014; Giovanaz *et al*., 2016). Metamitron, for instance, has become an alternative to managing peach tree thinning (McArtney *et al*., 2012).

Metamitron has shown adequate results in relation to thinning apple tree fruits by inhibiting photosynthesis (Petri *et al*., 2016; Goulart *et al*., 2017; Gabardo *et al*., 2017a). Fruits, throughout their development, are the main drains of end products of photosynthesis; in the case of interruption or decrease in the photosynthetic rate, fruits

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may fall due to competition (Gabardo *et al*., 2017a). Metamitron acts on Photosystem II by inhibiting electron transport its effect occurs because it acts on Photosystem II and inhibits electron transport on the chloroplast of plastoquinone QA to QB. Thus, it decreases production of ATP, NADPH and CO_2 fixation, which leads to photosynthesis inhibition (Basak, 2011; Stern, 2014). According to McArtney *et al*. (2012), there may be excessive fall of fruits from peach and apple trees, depending on the phenological period in which metamitron was applied and on its concentration.

Efficiency in the use of metamitron as a chemical thinner has been associated with certain factors, such as the cultivar, concentration and period of application and weather conditions (McArtney & Obermiller, 2014; Brunner, 2014; Petri *et al*., 2016). In the south of Brazil, where most peach-growing regions are located, there is little information on both the chemical thinning of peach tree fruits and on the use of metamitron.

Fruits of the cultivar ‘Sensação’ have been recommended to be used by industries and to be consumed *in natura*. Their ripening is precocious and their harvest usually starts in the first fortnight of November in the south of Rio Grande do Sul. Besides, they are commonly large and their yellow firm pulp does not adhere to the stone (Raseira *et al*., 2014).

According to Pavanello & Ayub (2012), the ideal chemical thinner is the one that can lead to partial fruit abscission soon after a single application. Several studies have shown satisfactory results of metamitron as a chemical thinner in apple tree cultures (Petri *et al*., 2016; Goulart *et al*., 2017; Gabardo *et al*., 2017a), even though there is no information on peach tree cultures in Brazil. Therefore, this study aimed at evaluating the thinning effect of metamitron on peach trees at different periods of time after bloom in the south of Brazil.

MATERIAL AND METHODS

The experiment was carried out in a commercial peach tree orchard located in Morro Redondo (31º32’40.9’’S and 52º34’42.42’’W), Rio Grande do Sul (RS) State, Brazil, in 2015-2016 crops. The cultivar ‘Sensação’ was grafted on ‘Capdeboscq’, which was implanted in 2006, conducted in a vase system. Spacing was 5 m among rows and 2 m among plants, while density reached 1000 plants ha^{-1}. Cultural treatments agreed with recommendations issued by Fachinello *et al.* (2005). Nitrogen (applied at full bloom, during thinning and postharvest) and potassium (applied at full bloom) fertilization in soil, winter pruning in every July, phytosanitary treatments and control spontaneous plants. These management practices were carried out in all treatments in both years under study.

Values of daily mean temperatures and solar radiation (Figure 2) at the period of metamitron application to peach trees were provided by the meteorological station at the Embrapa Clima Temperado – Cascata, located in Pelotas, RS: 219 and 348 cold hours were registered in 2015 and 2016, respectively. The amount of cold was determined by the Number of Cold Hours (CF) model. Calculation was based on temperatures below or equal to 7.2 °C (Morais & Carbonieri *et al.*, 2015).

The experiment was a randomized block design with five replicates of every plant. Treatments were composed of metamitron application – at 200 mg L^{-1} (McArtney *et al.*, 2012) – 20, 30, 40, 50 and 60 days after full bloom (DAFB) and manual thinning 40 DAFB (Table 1). Full bloom (FB) of peach trees took place on August 6th, 2015 and July 25th, 2016. Manual thinning, which was always carried out by the same person, allowed from 10 to 15cm among fruits on peach tree branches, depending on plant vigor. It should be mentioned that no manual thinning process was carried out in chemical thinning treatments.

The source of metamitron was the commercial product Goltix® (70% of chemical ingredient); 0.05% of Silwet L-77® non-ionic surfactant was added to all treatments. Solutions were prepared on the field right before they were applied. Treatments were applied by a Jacto knapsack sprayer whose average water volume was 1000 L ha^{-1} and working pressure was 40 psi.

At every application period of the chemical thinner, twenty peaches per treatment were measured so as to have their mean diameters determined by a digital pachymeter. All fruits were cut in half to allow lignin deposition; they were placed in a solution of phloroglucinol [1% (p/v) of

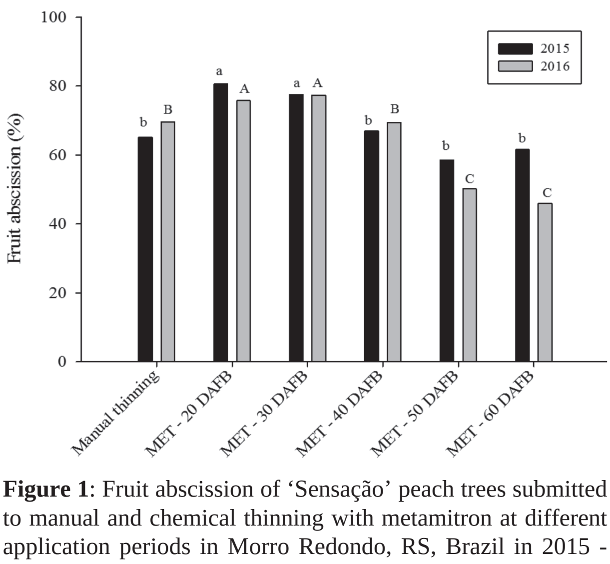

Figure 1: Fruit abscission of ‘Sensação’ peach trees submitted to manual and chemical thinning with metamitron at different application periods in Morro Redondo, RS, Brazil in 2015 - 2016 crops. Different small letters show differences in treatments in 2015 whereas different capital letters show differences in treatments in 2016, by the Scott-Knott test at 5% probability. MET = metamitron. DAFB = days after full bloom.

phloroglucinol, 12% of HCl (v/v) and 85% of ethanol (v/v)] for an hour, in agreement with the method described by Callahan *et al*. (2009) (Table 3).

Fruit abscission (%) was evaluated: every peach tree had six branches randomly marked and fruits were counted before the treatments and at harvest time. Effective fructification (%) was evaluated on those six branches per plant, i. e., the number of flowers in FB and the number of fruits at harvest time were counted. The number of fruits per plant (fruits plant^{-1}) and yield per plant (kg plant^{-1}) were measured by counting the total number of fruits at harvest time.

Fruit harvest was carried out at once on November 9th, 2015 (95 DAFB) and on November 10th, 2016 (104 DAFB). After harvest, a sample of 50 fruits per replicate was evaluated regarding mean fruit mass, determined by weighing fruits on a digital scale, results were expressed in grams and fruit caliber, determined by five diameter classes, i. e., above 65mm, 65-60mm, 60-55mm, 55-50mm and below 50mm.

Data were evaluated for normality (Shapiro-Wilk test), submitted to the analysis of variance by the t-test and means were compared by the Scott-Knott test at p d” 0.05. The Sisvar 5.6 program was used for carrying out the statistical analysis (Ferreira, 2014).

RESULTS AND DISCUSSION

Fruit abscission of peach trees was influenced by the application period of metamitron. The highest percentages

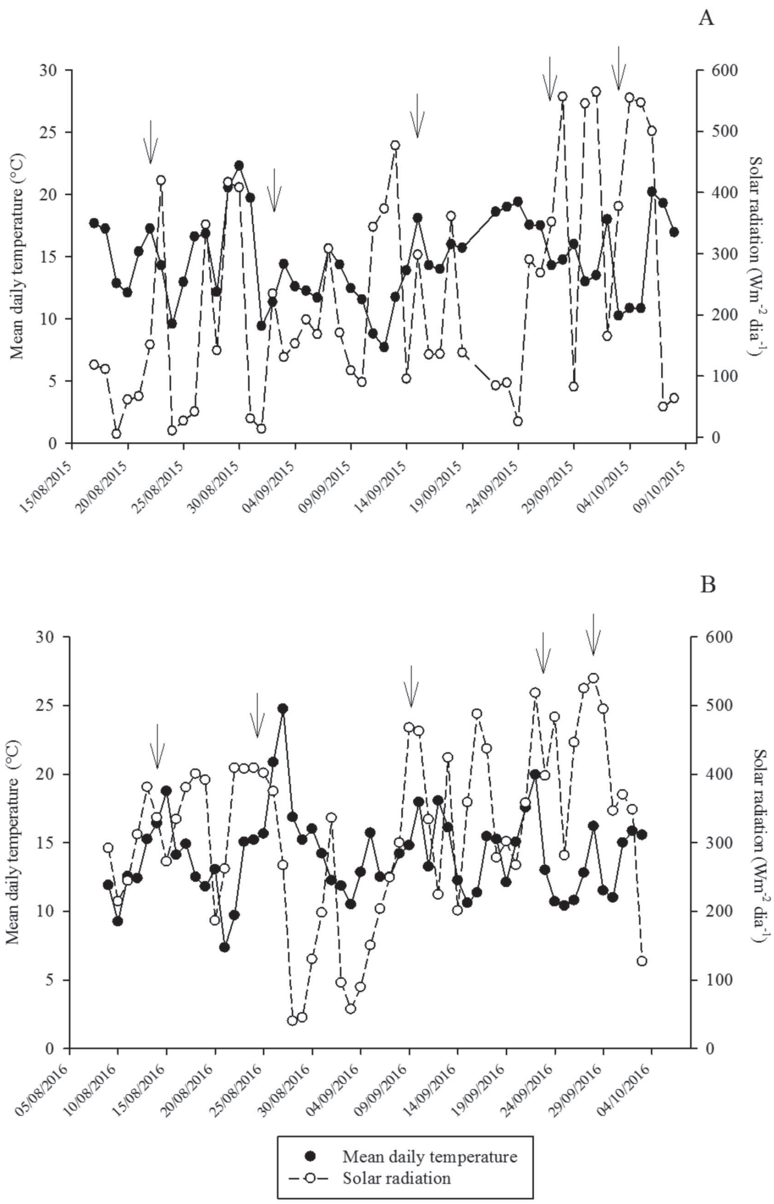

Figure 2: Mean daily temperature and solar radiation throughout the application period of metamitron in 2015 (A) and 2016 (B) in Pelotas, RS, Brazil. Embrapa Clima Temperado - Cascata, Pelotas, RS, Brazil.

of fruit abscission were found in peach trees thinned with metamitron 20 DAFB in 2015 and 30 DAFB in 2016 (Figure 1). Fruit abscission resulting from metamitron applied 40 DAFB was observed to be similar to the one reached by manual thinning in both years under evaluation. In the 2016 crop, the lowest percentages of fruit abscission were found in plants thinned with metamitron 50 DAFB and 60 DAFB. According to Farias *et al.* (2019), the highest percentages of fruit abscission in ‘Maciel’ peach trees with the use of metamitron occurred 20 and 40 DAFB. They stated that metamitron application to fruits at early stages increases fruit abscission, since lignin has not formed at these stages yet. The fact that metamitron contributed to higher fruit abscission at early stages was also observed in apples (Petri *et al*., 2016; Gabardo *et al*., 2017b).

Results of fruit set did not show any significant difference among different application periods of metamitron. In 2015, it ranged from 10.20 to 16.64%, while, in 2016, it ranged from 14.85 to 21.15% (Table 2). The genetic characteristic of the ‘Sensação’ variety is that it has intense bloom and exhibits, on average, from 12 to 14 pairs of floral gems every 25cm in length on the branch (Raseira *et al.*, 2014). This condition, associated with good uniformity in plant bloom, may have contributed to make remaining flowers develop fruits. Besides, Figure 2 shows that environmental conditions, regarding temperature, were similar in both years (14-19 °C). Even though ‘Maciel’ peach trees had different behavior from the one in the year of application, they did not exhibit any trend in fruit set in relation to the period in which metamitron was applied (Farias *et al.*, 2019). According to Nava *et al.* (2009), peach trees usually have high fruit set rates, with the contribution of environmental conditions, such as sunny, mild and dry days during blooming. These authors also state that inadequate climatic conditions, such as temperature, rain and relative humidity, in the blooming period may influence fruit establishment and lead to diseases in flowers.

According to McArtney & Obermiller (2014), metamitron changes the photosynthetic apparatus from 7

Table 1: Treatments applied to peach trees in 2015-2016 crops: manual thinning and chemical thinning with metamitron at 200 mg L^{-1}, mean diameter and lignin deposition on peaches at different application periods after full bloom

Treatments	Diameter (mm)	Lignin deposition
MET - 20 DAFB	07 – 09	
MET - 30 DAFB	14 – 16	
MET - 40 DAFB - Manual thinning	19 – 21	
MET - 50 DAFB	28 – 30	
MET - 60 DAFB	29 – 31	

Table 2: Fruit set and number of fruits per ‘Sensação’ peach tree submitted to manual thinning and chemical thinning with metamitron at different application periods in Morro Redondo, RS, Brazil in 2015-2016 crops

Treatments	Fruit set (%)		Number of fruits per plant	
	2015	2016	2015	2016
Manual thinning	15.77 ns	14.85 ns	483 b	424 ns
MET - 20 DAFB	15.62	21.15	574 a	559
MET - 30 DAFB	16.64	19.75	445 b	494
MET - 40 DAFB	15.41	16.41	456 b	586
MET - 50 DAFB	15.40	19.71	579 a	599
MET - 60 DAFB	10.20	16.76	309 c	589
CV (%)	34.44	21.98	21.75	22.17

Means followed by the same small letter do not differ by the Scott-Knott test at 5% probability. MET = metamitron. DAFB = days after full bloom. CV = Coefficient of variation. ns = not significant.

to 10 days after its application and decreases electron transport rates up to 60%. Petri *et al*. (2013) state that the response of chemical thinners in apple trees depends on the interaction between genotype and weather conditions, mainly temperature and solar radiation, which are intrinsic to every production region. Concerning weather conditions, Figure 2 shows that temperature amplitudes were similar in both crops; however, amplitude of solar radiation in the first harvest was greater than in the second one. At applications periods, temperatures ranged from 14 to 18 ºC (2015) and from 15 to 19 ºC (2016), while radiation ranged between 200 and 550 Wm^{-2} day^{-1} (2015) and between 400 and 530 Wm^{-2} day^{-1} (2016). Thus, behavior of peach trees, which is similar to the one of apple trees (Petri *et al*., 2013), clearly shows that results of chemical thinners depend on genotype interaction and climatic conditions. For instance, high temperatures – above 24 °C – at blooming and pre-blooming periods delay the development of eggs and damage pollen, thus, affecting fruit set in 'Granada' peach trees, but not affecting 'Maciel' cultivars (Couto *et al*., 2010). Oscillation of solar radiation and temperature in the 2016 crop may have determined the lowest fruit abscission rate in the most advanced stages of floral development (50 and 60 DAFB), i. e., it may have decreased the thinning effect. Another example of the influence of solar radiation takes place in less vigorous plants, since it is better distributed inside the crown, a fact that favors increase in flower buds (Tomaz *et al.*, 2010).

The number of fruits and yield per plant were affected by the application period of metamitron in the 2015 crop (Tables 2 and 3). The highest number of fruits was found in peach trees which were thinned with metamitron 20 and 50 DAFB, whereas the lowest number of fruits was found in those plants submitted to metamitron application 60 DAFB (Table 2). Plants thinned with metamitron 60 DAFB borne fewer fruits per plant; diameters ranged between 29 and 31 mm (Table 1). However, their fruits had high mean mass (Table 3) and high percentage of fruits in the class above 65 mm (Figure 3). Decrease in fruits per plant favors the balance between source and drain, minimizes consumption of reserves and gibberellin synthesis, besides contributing to yield fruits with high mass (Costa *et al*., 2013; Greene & Costa, 2013). Metamitron acts on Photosystem II by inhibiting electron transport (Basak, 2011; Stern, 2014), i. e., photosynthetic inefficiency decreases production of carbohydrates that are needed for fruit fixation.

Photosynthesis is controlled by environmental factors, such as temperature and luminosity (Dotto *et al.*, 2017). As a result, variation in results of effects of metamitron on numbers of fruits and production in both years may be related to the low temperature and solar radiation in 2015. This fact, associated with inhibition of electron transport in PSII caused by metamitron may have led to deficiency in the photosynthetic rate and changes in the relation between the source and drain of plants, since it was higher than the one found in 2016. Thus, in conditions of radiation deficiency, effects of metamitron may be potentialized and cause more fruit abscission.

The highest mean fruit mass was found in plants thinned with metamitron 20, 30 and 60 DAFB in 2015, whereas fruit mass was higher when manual thinning and thinning with metamitron 20 and 40 DAFB were carried out in 2016 (Table 3). Similar behavior was found in both crops as the result of thinning with metamitron 20 DAFB, when the highest mean peach mass was reached. It may be due to the fact that, at this time, lignin has not formed yet and fruit diameters range from 7 to 9mm (Table 1).

Table 3 shows that lignin formed in peaches 40 DAFB, when they started to get pink. Giovanaz *et al*. (2015) observed that thinning with abscisic acid in 'Chiripa' peach trees resulted in a small number of fruits and effective fructification when it is carried out 40 DAFB, during fruit lignin development. The authors also reported that conducting chemical thinning before lignin development

Table 3: Mean fruit mass and yield per plant of 'Sensação' peach trees submitted to manual thinning and chemical thinning with metamitron at different application periods in Morro Redondo, RS, Brazil in 2015-2016 crops

Treatments	Mean fruit mass (g)	Yield per plant (Kg)		
	2015	2016	2015	2016
Manual thinning	83.51 b	83.90 a	40.33 a	35.50 ns
MET - 20 DAFB	87.04 a	74.53 a	49.95 a	41.60
MET - 30 DAFB	87.19 a	69.45 b	38.80 a	34.30
MET - 40 DAFB	79.97 b	74.48 a	36.46 a	41.65
MET - 50 DAFB	74.59 b	62.49 b	43.18 a	37.44
MET - 60 DAFB	90.63 a	65.32 b	28.05 b	38.45
CV (%)	8.33	14.25	19.75	18.84

Means followed by the same small letter do not differ by the Scott-Knott test at 5% probability. MET = metamitron. DAFB = days after full bloom. CV = Coefficient of variation. ns = not significant.

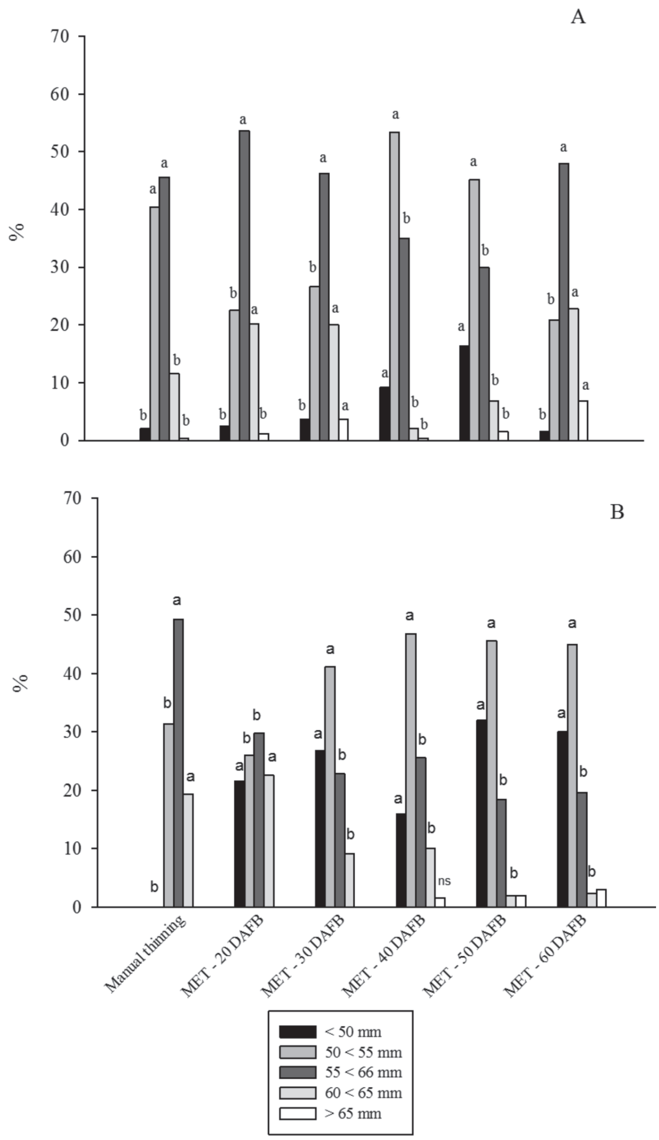

Figure 3: Class of peach fruits submitted to manual thinning and chemical thinning with metamitron at different application periods after full bloom, in Morro Redondo, RS, Brazil in 2015 (A) and 2016 (B) crops. DAPF = days after full bloom. Means followed by the same small letter do not differ by the Scott-Knott test at 5% probability. ns = not significant.

leads to decrease in the culture load, which may be due to the fact that these plants consume more energy in this phase to form the endocarp and, consequently, the resulting deficit in carbohydrates may favor chemical thinning.

There was no difference in yield per peach tree, whose values ranged between 36.53 and 49.35 kg, except when metamitron was applied 60 DAFB in 2015 (Table 3). Despite the high fruit mass found when metamitron was applied 60 DAFB in 2015 yield did not correspond to it, due to the small number of fruits per plant in this treatment. In 2016, thinning treatments did not show any difference regarding yield per plant. Productivity and mean fruit mass of fruits borne by ‘Maciel’ cultivars were not affected by metamitron, regardless of its application period (Farias *et al*., 2019).

Peaches were classified into five classes, depending on fruit diameters, in both crops under evaluation (Figure 3). The < 50mm class showed the lowest percentage of fruits in manual thinning and in chemical thinning with metamitron 20, 30 and 60 DAPF in 2015, and in manual thinning in 2016. The highest percentage of fruits yielded by plants which were submitted to manual thinning was classified into the category from 55 < 60mm, in both crops. Metamitron applied to peach trees 30 and 60 DAFB contributed to the high percentage of fruits in the category > 65mm in 2015.

Application periods of chemical thinning in peach trees must take into consideration that precocious thinning may pose risks when there is late frost. However, the high cost of manual thinning and lack of workforce in peach-growing regions should be taken into account.

CONCLUSIONS

Intensity of the thinning effect of metamitron in peach trees depends on the application period. Metamitron applied to 'Sensação' peach trees 40 DAFB enables them to exhibit percentages of fruit abscission, fruit set and number of fruits per plant which are similar to the ones of manual thinning. Thinning with metamitron is effective in 'Sensação' peach trees when it is carried out up to 40 DAFB.

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