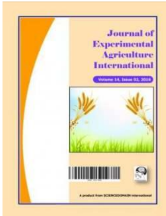

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Effect of Chemical Thinning Season Using Metamitron on Peaches 'Sensação' Quality

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RMF and CFB designed the study and performed the statistical analysis. Authors RMF, CFB, PCMF, MBM and CRM wrote the manuscript. Authors RMF, CFB, CRM, AVS and CGH managed the analyses of the study. Authors MBM, PCMF, RMF, CGH and AVS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The objective of this study was to evaluate peach fruits quality after chemical thinning using metamitron at different times in the South of Brazil.
Study Design: The experimental design was in randomized blocks, with five replications of three plants, fruits were harvested and evaluated the central plant in the plot, and twenty fruits were evaluated in each replicate.
Place and Duration of Study: The experiment was conducted in a commercial peach orchard 'Sensação', in the city of Morro Redondo, Rio Grande do Sul, Brazil, in the years 2015 and 2016.
Methodology: Treatments were composed of metamitron application (200 mg L^{-1}) at 20, 30, 40, 50 and 60 days after full bloom (DAFB) and manual thinning performed at 50 DAFB. The epiderms color, pulp firmness, ripening index, soluble solids, titratable acidity, pH, total phenolic compounds and antioxidant activity were evaluated.

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Results: The manual and chemical thinning at 20 and 30 DAFB contributed to the epidermis greenish-yellow fruits coloration in the year 2015. The lowest maturation indices were verified in fruits submitted to chemical thinning at 20 and 30 DAFB during the two years evaluated. The firmness of fruit pulp increased when peach trees were submitted to chemical thinning at 30 and 60 DAFB in the year 2015. The phenols and antioxidant activity of fruits presented higher concentrations of these compounds in manual thinning during the two years evaluated.
Conclusion: Peaches quality was altered according to the thinning methods and the application time of the metamitron performed in the trees. The use of metamitron in peach chemical thinning did not affect the fruits soluble solids content in relation to manual thinning. Thinned fruits quality presented differences in relation to the cycles evaluated for epidermis color, firmness and soluble solids.

Keywords: Prunus persica; physico-chemical; phytochemical; plant growth regulators.

1. INTRODUCTION

Peach trees present high effective fruit set which gives the plants excessive amount of fruit. Plants with very high fruit load cause small fruits, of low commercial value [1] and fruit weight may cause branches break [2]. In order to regulate peach trees fruit set, it is necessary to carry out the practice of thinning, whose main objective is to improve fruits quality, besides avoiding alternate bearing.

Currently, the practice of thinning used in orchards is done manually. In the manual thinning it is possible to select the removed fruits, eliminating the damaged ones, of smaller size and poorly located in the plant. However, this practice requires a high demand for skilled labor, adequate for a short execution period, which ends up making it difficult to use and especially raising production costs [3,4].

As an alternative to manual thinning, other techniques, such as chemical thinning, have been studied. Chemical thinning is a viable alternative for peach tree cultivation because it is a quick practice, through the use of different products, allowing the fruits quality increase and reducing the labor cost and time. It has been studied some products in peach trees with the purpose of fruits thinning [1,5,6], among them, the metamitrom has been presented as an efficient insertion alternative in peach blossom management [3].

Metamitron has been shown to be efficient in apple trees [7,8] and peach trees chemical thinning [3]. Despite the efficiency of thinning, they can cause injury to fruits and leaves [9]. Metamitron is a product of the triazinones group with herbicidal action that steps in photosystem II and inhibits the electrons transport, this product has a positive effect reducing the amount of fruit due to its direct action in the photosynthesis inhibition, which causes fruits drop [10,11,12]. Among other factors, the effect of chemical thinning depends on the interaction of the cultivar with the climatic conditions leading to test in each producing region. Metamitron application (dose 350 mg.L^{-1}) when used as thinner in apple ‘Elstar’, did not cause leaf injury, very small fruits, poor fruit formation and russeting or detectable residue levels in the fruit [13].

However, there is still insufficient information about chemical thinning in peach tree crop, as well as the effect of metamitron used in the thinning in relation to fruit quality. Chemical thinning efficiency varies according to the product, cultivar, time of application and product dose. In this sense, the objective of this work was to evaluate the quality of the peach fruit after chemical thinning with metamitron under different application times in the South of Brazil.

2. MATERIALS AND METHODS

The experiment was conducted in a commercial orchard installed in 2006, at Morro Redondo (31°32'40,9 "S and 52°34'42,42"W), South of Brazil, during the years 2015 and 2016. It was used a peach orchard of ‘Sensação’ cultivar, grafted on 'Capdeboscq' rootstock, managed in pot system, and spaced 5 m between rows and 2 m between plants, totalling a density of 1,000 plants ha^{-1}. The thinning in this orchard has always been done manually.

Climatic conditions during the peach tree cycle were collected from Embrapa Clima Temperado weather bureau at the Cascata Experimental Station, located in Pelotas city, RS, Brazil. The sum of cold hours (CH ≤ 7.2°C) during the year 2015 was 219 CH and in the year of 2016 was 348 CH.

The treatments were composed of metamitron application (200 mg L^{-1}) dose at 20, 30, 40, 50 and 60 days after full bloom (DAFB) and manual thinning performed at 50 DAFB, leaving 10 to 15 cm distance between the fruits. Full bloom (FB) occurred on August 6, 2015 and July 25, 2016. As a source of metamitron, the commercial product Goltix® (48% metamitron) was used and in all treatments 0.05% Silwet L-77® non-ionic sprout adhesive was added.

The different doses were sprayed with a backpack sprayer (40psi working pressure) with an average water volume of 1000 L ha^{-1}, the chemical product was sprayed to the run-off point.

The fruits were harvested at 95 DAFB in the year 2015 and 104 DAFB in the year 2016. Peaches were harvested and evaluated for epidermis color, using the Minolta CR-300® colorimeter with light source D65, where "L" (luminosity), "a *", "b*" and the hue or chromatic hue were represented by the" hue angle "(ºHue); Pulp firmness evaluated by a manual penetrometer (TR Turoni – Italy) brand, model 53205 with 8 mm tip, at two opposite points in the equatorial region of the peeled fruits, the results were expressed in Newtons (N); ripening index (RI), its calculation was based on absorbance difference between two wavelengths near the chlorophyll-a absorption peak. Readings were standardized, two spots on both fruit sides were verified by a portable spectrophotometer DA meter® (Turony, Italy); Soluble solids, obtained with the Atago® brand digital refractometer, with results expressed in ºBrix; pH determined using fruit juice and reading in the pH meter; Quantified titratable acidity in 10 mL of juice diluted in 90 mL of distilled water and titrated with 0.1 mol L NaOH solution to pH 8.1, using the Quimus® brand pH, expressed as percentage of citric acid.

Fruits were peeled and the pulps were chopped and ground for phytochemical analysis. The following analysis were performed: Phenolic compounds determined by the method based on reaction with the Folin-Ciocalteau reagent according to method adapted from [14], with the result expressed in mg equivalent of Gallic acid in 100 g of sample; Antioxidant activity determined by the DPPH radical method adapted from [15] and the results expressed mg trolox equivalent 100 g fresh weight.

The experimental design involved randomized blocks, each plot composed of five plants. The plants at the ends of each plot were disregarded, amounting to nine useful plants. Twenty fruits were used per repetition, totalizing 100 evaluated fruits by treatment. Data were submitted to analysis of variance using the F test, and the means were compared by the Tukey test ($p \leq 0.05$).

3. RESULTS AND DISCUSSION

In 2015, the skin color of manual thinning and 20DAFB peaches had 5% significant difference with that of 40 and 60 DAFB (Table 1). The fruits of the plants submitted to manual thinning and to the chemical thinning with metamitron at 20 and 30 DAPF presented a yellow-green color, whereas the plants thinned with metamitron at 40, 50 and 60 DAPF presented a yellow-orange epidermis. However, in 2016, there was no significant difference in the skin color overall thinning methods. It is known that the peaches epidermis color is highly affected by the genotype [16], green pruning management [17] of fruit maturation [18]. Metamitron is expected to act in the electron transport chain, blocking the triplet chlorophyll synthesis that reacts with oxygen, forming singlet oxygen and reactive oxygen species, and consequently promoted chlorophyll destruction [19].

Table 1. Epidermis color (ºHue) and pH of peach fru it pulp submitted to manual and chemical thinning with metamitron (MET), in Morro Redondo city, Rio Grande do Sul, Brazil, during 2015 and 2016

Treatments	Epidermis color		pH	
	2015	2016	2015	2016
Manual thinning	88.25 a	88.21 ns	3.24 ns	3.34 a
MET - 20 DAFB	88.19 a	86.36	3.24	3.26 ab
MET - 30 DAFB	86.39 ab	87.52	3.19	3.33 a
MET - 40 DAFB	84.16 b	88.43	3.22	3.08 b
MET - 50 DAFB	84.30 b	88.15	3.23	3.20 ab
MET - 60 DAFB	84.89 b	88.83	3.22	3.30 a
CV(%)	2.47	1.87	1.10	3.24

Means followed by the same lowercase letter do not differ from each other by the Tukey test at the 5% error probability level. CV (%) = Coefficient of variation. ns = not significant

Peaches pH values did not show any difference between treatments in the year 2015 (Table 1). However, in the year 2016, the peaches harvested from the plants manually and chemically thinned with metamitron at 30 and 60 DAPF presented the highest values of juice pH, in relation to chemical thinning with metamitron at 40 DAFB. It was observed no difference in fruit pH, testing plum tree thinning with different doses of ethephon [20].

The peaches ripening index (RI) was altered by the tree thinning method in both crops evaluated (Fig. 1A). Peach RI was lower when manual thinning and chemical thinning with metamitron were performed at 20 and 30 DAFB in the two evaluated crops. These lower RI values in peaches indicate that there was a chlorophyll content reduction [21], therefore mature fruits and in an advanced maturation stage due to the pectins solubilization and cohesion reduction between the cells [22]. When the chemical thinning with metamitron was performed at 40, 50 and 60 DAFB, the peaches presented higher RI values, indicating a lower maturation degree of these fruits.

When peaches pulp firmness variable was evaluated, the applied treatments only changed this variable in the year 2015 (Fig. 1B). The most firm fruits were verified in the plants treated with metamitron at 60 and 30 DAFB in relation to the fruits harvested from manually thinned plants. Thus, although pulp firmness is important for 'Sensação' cultivar, which has potential for in natura consumption and for industry, it was not possible to establish a direct relation between chemical thinning seasons. Because there were differences between evaluated crops. Therefore, depending on the crop, the firmness pulp response was altered, in the year 2016 the metamitron did not change this variable and this same result was also observed in apple trees [23].

Unlike the apple tree culture, the apple pulp firmness did not present difference with metamitron thinning (350 mg L^{-1} dose) at four different application seasons (petal fall, fruits 5 - 10 mm diameter, fruits 15-20 mm in diameter and fruits more than 20 mm in diameter) [23].

Soluble solids contents varied between treatments and between the evaluation years of this study (Fig. 2A). In the year 2015, the fruits submitted to chemical scaling with metamitron at 60 and 30 DAPF provided greater concentrations of soluble solids to the peaches but did not differ from manual thinning and chemical thinning at 20 DAFB. In apples, the soluble solids content was higher when applied metamitron at the 350 mg L^{-1} dose in the period of petal fall [23]. Other studies using chemical thinners in peach trees did not find alteration of total soluble solids, pulp firmness and color index of 'Eldorado' peach fruits [24] and BR1 [25].

Peaches tree thinning treatments did not show differences in soluble solids content in 2016 (Fig. 2A). In plum fruits, Pavanello [20] observed that fruits soluble solids were not affected by the chemical thinning with Ethephon. According to Goulart [8] did not observe changes in the soluble solids in apples that were harvested from plants submitted to chemical thinning with different metamitron doses, and this product was applied to fruits with 5 to 8 mm of diameter. The fact that there is no difference between the chemical thinning seasons in the year 2016 may be due to the reason that this variable is associated with other management factors, such as the fruit position in the plant, light penetration inside the canopy, branch type and pruning [26], in addition to the interaction between irrigation and exposure to sunlight [27].

Peaches titratable acidity showed differences in the two evaluated crops (Fig. 2B). It was observed that the peaches had a higher acidity in the year 2015. But in 2016, the highest fruit acidity was observed in the peaches harvested from plants thinned with metamitron at 40, 50 and 60 DAFB. Among them, the lowest fruit acidity levels were observed in manual thinning and chemical thinning when applied at 20 DAFB in 2016. According to Meitei [5], the acidity reduction under chemical thinning treatments may be due to the conversion of organic acids to sugar, whereas, the increase in acidity may be due to increased organic acid biosynthesis.

Regarding the total phenols content of peach fruits, it was verified that fruits subjected to manual thinning and chemical thinning with metamitron at 30 DAFB presented higher contents of these compounds, but did not differ from the chemical thinning at 20 and 60 DAPF in the year of 2015 (Table 2). In the year 2016, the total phenols of the peach fruits presented higher levels of these compounds in the fruit submitted to manual thinning but did not differ the chemical thinning at 20 DAFB. In general, it was observed that phenolic compounds presented higher concentrations with manual thinning during two years of studies. In relation to fruits antioxidant activity, the manual thinning presented higher contents of these compounds, in both crops evaluated (Table 2). The lowest antioxidant activity concentrations of peaches were observed in chemical thinning with metamitron at 50 DAPF in the year 2015 at 30, 40 and 50 DAFB in the year 2016.

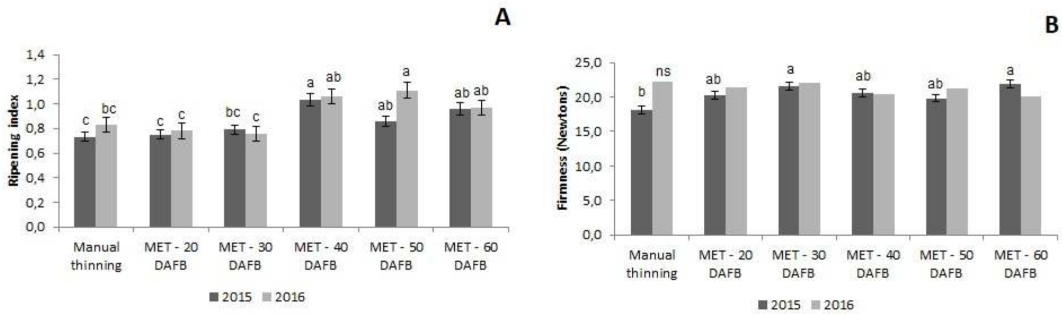

Fig. 1. Ripening index (A) and pulp firmness (B) of peach fruit pulp submitted to manual and chemical thinning with metamitron (MET), in Morro Redondo city, Rio Grande do Sul, Brazil, during 2015 and 2016. Means followed by the same lowercase letter do not differ from each other by the Tukey test at the 5% error probability level

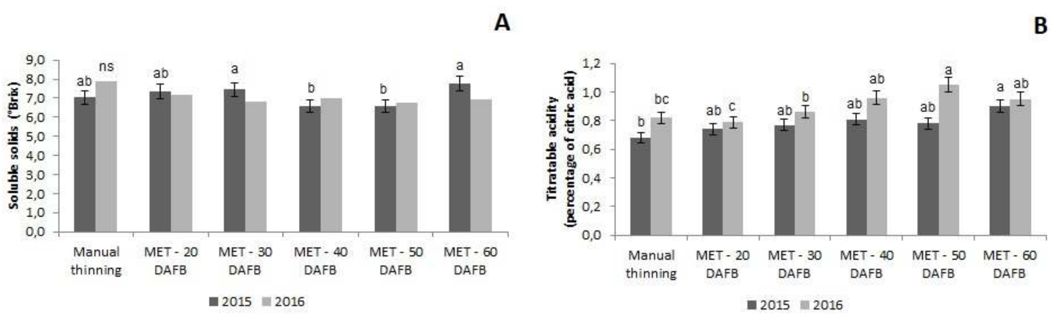

Fig. 2. Soluble solids (A) and titratable acidity (B) of peach fruits submitted to manual and chemical thinning with metamitron (MET), in Morro Redondo city, Rio Grande do Sul, Brazil, during 2015 and 2016. Means followed by the same lowercase letter do not differ from each other by the Tukey test at the 5% error probability level

Table 2. Total phenols and antioxidant activity of peach fruits submitted to manual and chemical thinning with metamitron, in Morro Redondo city, Rio Grande do Sul, Brazil, during 2015 and 2016

Treatments	Total phenols¹		Antioxidant activity²	
	2015	2016	2015	2016
Manual thinning	130.12 a	191.45 a	312.39 a	387.36 a
MET - 20 DAFB	114.00 ab	154.20 ab	270.31 ab	377.63 ab
MET - 30 DAFB	117.93 ab	112.62 bc	278.75 ab	191.75 c
MET - 40 DAFB	85.23 b	90.65 c	247.58 ab	142.36 c
MET - 50 DAFB	90.10 b	80.04 c	229.79 b	215.32 b
MET - 60 DAFB	105.27 ab	127.91 bc	258.46 ab	284.77 ab
CV(%)	13.46	18.21	10.92	12.14

¹mg galic acid equivalent 100 g^{-1} fresh weight. ² mg trolox equivalent 100 g^{-1} fresh weight.
Means followed by the same lowercase letter do not differ from each other by the Tukey test at the 5% error probability level. CV (%) = Coefficient of variation. ns = not significant

4. CONCLUSION

Peaches quality was altered according to thinning methods, chemical application season and the crop year. The use of metamitron in peach chemical thinning did not affect the fruits soluble solids content in relation to manual thinning. The other physico-chemical characteristics do not maintain a direct relation with the treatments, being able to be altered because of the harvest.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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