

## COMPARISON AMONG CHEMICAL THINNERS APPLIED TO ‘MACIEL’ AND ‘SENSAÇÃO’ PEACH TREES

### COMPARAÇÃO ENTRE RALEANTES QUÍMICOS EM PESSEGUEIROS ‘MACIEL’ E ‘SENSAÇÃO’

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**ABSTRACT:** Peach tree thinning, which aims at reducing plant load so as to ensure productivity and fruit quality, has been manually carried out within a short period of time in the stage of fruit development. Due to the need and shortage of qualified man power, chemical thinning is one of the alternatives that can solve these difficulties found in manual thinning. This study aimed at evaluating the effect of different products which have been applied – either alone or in combination – to fruit thinning of peach tree cultivars ‘Sensação’ and ‘Maciel’ in Pelotas, Rio Grande do Sul (RS) state, Brazil. The experiment was conducted in the 2015/2016 crop in a commercial peach orchard located in Morro Redondo, RS, Brazil. The following seven treatments were carried out 40 days after full bloom (DAFB): plants with no thinning, manual thinning, metamitron, benzyladenine, benzyladenine + metamitron, ethephon, ethephon + metamitron. Fruit abscission, effective fructification, number of fruits and production per plant, mean mass and fruit classification into caliber classes, epidermis color, pulp firmness and soluble solids were evaluated. Production and number of fruits per plant decreased excessively, whereas fruits placed in categories of higher caliber increased when ethephon was either used alone or in combination with metamitron. When both metamitron and benzyladenine were applied, either alone or in combination, they led to fruit abscission and resulted in mean fruit size and weight, at harvest time, similar to those found in manual thinning. Application of chemical products – either alone or in combination – may be an alternative of peach tree thinning in orchard management.

**KEYWORDS:** Abscission. Benzyladenine. Ethephon. Metamitron. Production. *Prunus persica*.

## INTRODUCTION

In Brazil, thinning has been manually carried out by peach producers not only because of the excessive number of fruits yielded by plants that cannot hold them but also to avoid production alternation. Manual thinning has been carried out in peach trees when fruit diameter is 20mm, between 40 and 50 days after full bloom (DAFB) (PETRI et al., 2016; OLIVEIRA et al., 2017). Thus, this operation must be conducted in a short period of time and also requires skilled manpower. As a

and genotype, may interfere in the effective application of this method of thinning to fruit trees (TAHERI et al., 2012; PETRI et al., 2013; FALLAHI et al., 2014; PETRI et al., 2016; GABARDO et al., 2017).

Regarding products used for chemical thinning in temperate fruit trees, benzyladenine (BRUNNER, 2014; FALLAHI et al., 2014; BARRETO et al., 2018), ethephon (TAHERI et al., 2012; PAVANELLO; AYUB, 2012) and, recently, metamitron (PETRI et al., 2016; GOULART et al., 2017; GABARDO et al., 2017) have stood out.

al., 2012; SIMÕES; VOLETA; BELUSIC, 2015).

In order to find alternatives to replace manual thinning in fruit trees, other techniques, such as chemical and mechanical thinning, have been studied and applied to flowers and fruits. Chemical thinning has been considered a fast practice which enables work time and production costs to be decreased by using chemical substances. Several factors, such as the product itself, its form of application – either alone or in combination –, time of application, concentration, weather conditions

in different plant physiological processes. Benzyladenine may lead to increase in fruit size as the result of the thinning effect and, because it is a compound of the cytokinin group, it triggers cell division (PETRI et al., 2013; PETRI et al., 2016). Ethephon, which is an inhibitor of auxin transport, stimulates its synthesis by releasing ethylene and leads to fruit fall (BANGERTH, 2000). Metamitron acts in photosystem II by inhibiting electron transport (BASAK, 2011; STERN, 2014).

Concerning peach tree cultures, some studies of chemical thinning carried out with benzyladenine (GIOVANAZ et al., 2016; BARRETO et al., 2018) and ethephon (TAHERI et al., 2012; SARDAKI, 2012; GIOVANAZ et al., 2016) have shown satisfactory results. However, there is scarce information on the use of metamitron, either alone or in combination with other products. In general, results of chemical thinning in peach trees have been inconsistent due to variations in weather conditions, products and genotypes.

In the south of Rio Grande do Sul (RS) state, Brazil, peach tree cultivars have been grown, mainly for processing. 'Maciel' is one of the most traditional dual-purpose cultivars which has been grown by producers in that region. According to Raseira, Nakasu and Barbosa (2014), one of the characteristics of the cultivar 'Maciel' is that its harvest period starts in the second fortnight in December. Besides, it requires between 200 and 300 hours of cold and its round-conic fruits, which weigh about 120g, have firm yellow pulp which does not adhere to the stone. The cultivar 'Sensação', which is also a dual-purpose one, has been recently grown. Its large fruits have yellow non-fusing and firm pulp. Its ripening process is more precocious than the one of the cultivar 'Maciel', since its harvest usually starts in the first fortnight in November (RASEIRA; NAKASU; BARBOSA, 2014).

Since information on peach tree chemical thinning is still scarce, more knowledge must be gathered about this technique. Therefore, this study aimed at evaluating the effect of different products – either alone or in combination – applied to fruit thinning of peach tree cultivars 'Sensação' and 'Maciel' in Pelotas, RS, Brazil.

## MATERIAL AND METHODS

The experiment was carried out in 2016 in a commercial peach orchard located in Morro Redondo, RS, Brazil (31°32'40.9''S and 52°34'42.42''W). The climate in the region is humid temperate with hot summers, i. e., "Cfa" in the Köppen climate classification (KOTTEK et al., 2006). Data provided by the meteorological station that belongs to the Embrapa Clima Temperado experimental station located in Cascata, Pelotas, RS, Brazil, show that there were 348 hours of cold in 2016; calculation was based on temperatures equal to and below 7.2°C. Peach orchards comprised cultivars 'Maciel' and 'Sensação' grafted on 'Capdeboscq' implanted in 2006. Plants, whose

density is 1,000 plants ha<sup>-1</sup>, are conducted in a vase system. Spacing is 5 m among rows and 2 m among plants.

The experiment was carried out as a randomized block design with five replicates and treatments composed of T1: plants with no thinning; T2: manual thinning (MT); T3: metamitron 200 mg L<sup>-1</sup>; T4: benzyladenine 200 mg L<sup>-1</sup>; T5: benzyladenine 200 mg L<sup>-1</sup> + metamitron 200 mg L<sup>-1</sup>; T6: ethephon 50 mg L<sup>-1</sup>; and T7: ethephon 50 mg L<sup>-1</sup> + metamitron 200 mg L<sup>-1</sup>. All treatments were conducted 40 DAFB. Full bloom took place on July 23rd in the case of 'Maciel' peach trees and on July 25th in the case of 'Sensação' ones. It should be highlighted that manual thinning was not carried out in treatments with chemical thinning. Depending on the plant vigor, manual thinning left from 10 to 15 cm, on average, among fruits on peach tree branches. The source of benzyladenine was the commercial product named Maxcel<sup>®</sup>, which contains 2% of active ingredient (AI), whereas Goltrix<sup>®</sup> was the source of metamitron with 70% of AI and Ethrel<sup>®</sup> was the source of ethephon, with 24% AI. Besides, 0.05% non-ionic spray adjuvant Silwet L-77<sup>®</sup> was added to all treatments.

Solutions of these products were prepared right before they were applied to the plants. Treatments were carried out by a Jacto backpack sprayer (working pressure: 40psi). Throughout application, products were sprayed up to the point of runoff, which was, on average, 1,000L ha<sup>-1</sup>. Cultural practices, such as fertilization, pruning, phytosanitary treatments and control of spontaneous plants, were conducted in the orchard by the producer.

Regarding variables under evaluation, fruit abscission (%) was calculated by randomly choosing six branches in each peach tree whose fruits were counted before the treatments and at harvest time. Effective fructification (%) was evaluated in those six branches per tree 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<sup>-1</sup>) and production per plant (Kg.plant<sup>-1</sup>) were measured by counting all fruits at harvest time.

Peach harvest was carried out on December 14th, 2016 (144 DAFB) and November 7th, 2016 (101 DAFB) in cultivars 'Maciel' and 'Sensação', respectively. Only one episode was conducted. After harvest, a sample of 50 fruits per plant was evaluated in terms of mean fruit mass, determined by weighing the fruits on a digital scale; results were expressed as grams (g). Mean fruit diameter was evaluated by a digital pachymeter; results were

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expressed as millimeters (mm). Fruit caliber was determined in four diameter classes, i. e., above 65mm, 65-60mm, 60-55mm and below 55mm. Pulp firmness was measured by a TR TURONI manual penetrometer (model 53205 – Italy), with an 8-mm tip, in two opposite spots along the fruit equatorial region; results were expressed as Newtons (N). Epidermis color was determined by a Minolta CR-300<sup>®</sup> colorimeter, with a D65 light source; readings of “L” (luminosity), “a\*”, “b\*” and the matrix or chromatic tonality represented by the Hue angle (°Hue) were carried out. Soluble solids were determined by an Atago<sup>®</sup> digital refractometer; results were expressed as °Brix.

Data were submitted to the analysis of variance ( $p \leq 0.05$ ). In case of statistical significance, means were compared by the Tukey’s test at  $p \leq 0.05$ .

## RESULT AND DISCUSSION

Effective fructification of peach trees ‘Maciel’ and ‘Sensação’ exhibited significant differences among thinning treatments (Table 1). Plants that did not undergo thinning had higher percentages of effective fructification. Regarding plants that underwent thinning, the highest percentages of effective fructification were found in peach trees that were manually thinned and the ones with application of isolated chemical products (metamitron and benzyladenine) in the case of cultivar ‘Maciel’, whereas the highest rates of effective fructification of peach trees ‘Sensação’ were found in manual thinning, application of metamitron and application of the combination of benzyladenine + metamitron.

**Table 1.** Effective fructification, production per plant, mean mass and diameter of fruits produced by ‘Maciel’ and ‘Sensação’ peach trees submitted to different thinning treatments in Morro Redondo, RS, Brazil.

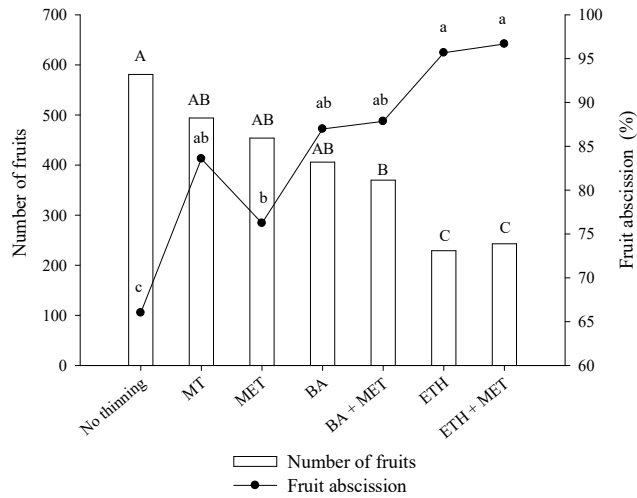
Treatments	Effective fructification (%)	Production per plant (kg)	Mean mass fruits (g)	Diameter of fruits (mm)
Maciel				
No thinning	22.69 a	48.70 ab	83.74 b	53.85 b
MT	12.78 ab	64.28 a	130.58 a	63.12 a
MET	14.37 ab	47.00 ab	103.60 ab	58.51 ab
BA	10.38 ab	46.08 ab	116.70 ab	60.63 ab
BA + MET	9.25 b	39.37 ab	106.01 ab	58.37 ab
ETH	3.26 c	30.52 b	132.45 a	63.03 a
ETH + MET	1.95 c	30.30 b	126.20 a	62.15 a
CV (%)	21.43	25.32	17.37	6.13
Sensação				
No thinning	22.59 a	46.46 a	57.39 c	47.81 c
MT	13.18 ab	35.50 ab	83.90 ab	54.11 ab
MET	15.88 ab	43.65 a	74.48 ab	52.79 ab
BA	7.75 c	26.79 bc	85.27 ab	53.19 ab
BA + MET	20.15 ab	39.67 ab	69.02 b	49.41 bc
ETH	3.27 d	21.70 cd	94.50 a	55.06 a
ETH + MET	3.12 d	15.57 d	83.90 ab	53.27 ab
CV (%)	29.41	22.62	13.16	4.92

Means followed by the same small letter do not differ among them by the Tukey’s test at 5% error probability. TM = manual thinning. MET = metamitron. BA = benzyladenine. ETH = ethephon. CV = coefficient of variation.

The lowest percentages of effective fructification were found when chemical thinning of both cultivars was carried out with ethephon alone and in combination with metamitron. This result corroborates their high percentage of fruit abscission (Figures 1 and 2). According to Pavanello and Ayub (2014), the metabolic process triggered by most

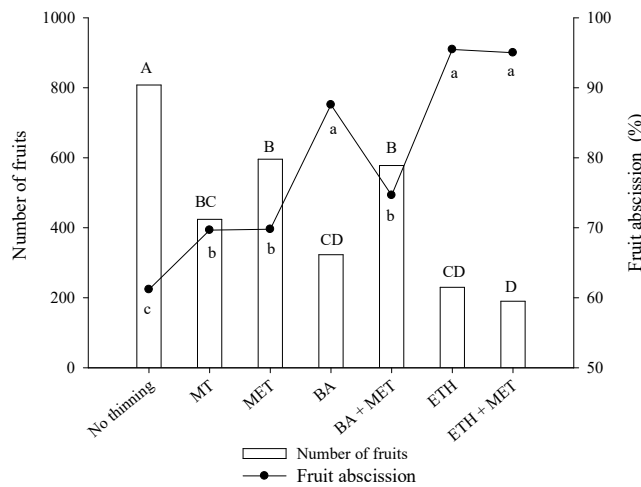
chemical products used as chemical thinners consists in promoting imbalance in auxin fluxes, thus leading to fruit abscission. When concentrations of auxin decrease in the distal region of the abscission zone, sensitivity of the tissue to ethylene increases and the abscission process results

from increase in the synthesis of cellulase (FACHINELLO; NACHTIGAL; KERSTEN, 2008).



**Figure 1.** Fruit abscission and number of fruits produced by ‘Maciel’ peach trees submitted to different thinning treatments in Morro Redondo, RS, Brazil.

Different capital letters show differences in the number of fruits per plant. Different small letters show differences in fruit abscission by the Tukey’s test, at 5% probability. TM = manual thinning; MET = metامتيترون; BA = benzyladenine; ETH = ethephon.



**Figure 2.** Fruit abscission and number of fruits produced by ‘Sensação’ peach trees submitted to different thinning treatments in Morro Redondo, RS, Brazil.

Different capital letters show differences in the number of fruits per plant. Different small letters show differences in fruit abscission by the Tukey’s test, at 5% probability. TM = thinning manual. MET = metامتيترون. BA = benzyladenine. ETH = ethephon.

Concerning fruit abscission, plants submitted to the activity of chemical thinners – either alone or in combination – were found to exhibit fruit drop which was similar to the one that occurred after manual thinning, in the case of the cultivar ‘Maciel’. Similar effect of manual thinning occurred when metامتيترون was used alone and in combination with benzyladenine, in the case of the cultivar ‘Sensação’ (Figures 1 and 2). Therefore, regardless of the cultivar, metامتيترون can promote

an abscission rate which is similar to the one of manual thinning.

In the case of the cultivar ‘Maciel’, production per plants submitted to manual thinning was 47.47 and 47.13% higher than the one of plants that underwent chemical thinning with ethephon and ethephon + metامتيترون, respectively. However, production did not differ between manual thinning and the chemical one with metامتيترون, benzyladenine and benzyladenine + metامتيترون. In

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the case of the cultivar ‘Sensação’, production per plant was higher when chemical thinning was conducted with metamitron, but it did not differ significantly from the combination of benzyladenine + metamitron and manual thinning (Table 1).

Plants that did not undergo thinning exhibited the highest rates of production and numbers of fruits per plant, in the cases of both cultivars (Figures 1 and 2). However, these fruits had the lowest mean mass and the smallest diameter (Table 1). These cultivars also had the highest percentage of fruit in the smallest diameter class (<55mm) (Table 2), a fact that is not well-accepted by industries and consumers of fresh fruits. These data corroborate the ones found by Sardaki (2012),

who observed low fruit mass in peach trees which had not been thinned, by comparison with fruits of peach trees submitted to chemical thinning. This fact can also be observed in other fruit trees, such as apple trees, i. e., the highest number of fruits per plant and lowest mass per fruit occurred in plants that had not been submitted to thinning (McARTNEY et al., 2014). Increase in the number of fruits per plant reduces the source/drain relation and contributes to the production of smaller fruits, which have low commercial value. According to Bussi, Lescourret and Genard (2009), growth of branches and fruits is limited in plants that have high load of fruits, i. e., excessive load of fruits may decrease their size.

**Table 2.** Diameter classes of fruits produced by ‘Maciel’ and ‘Sensação’ peach trees submitted to different thinning treatments in Morro Redondo, RS, Brazil.

Treatments	Diameter classes of fruits (%)			
	< 55 mm	55 < 60 mm	60 < 65 mm	> 65 mm
Maciel				
No thinning	48.20 a	29.80 <sup>ns</sup>	16.80 <sup>ns</sup>	5.20 <sup>ns</sup>
MT	0.00 b	13.20	37.80	49.00 a
MET	5.60 b	37.80	45.00	11.60 a
BA	9.60 b	23.20	35.20	32.00 a
BA + MET	9.60 b	33.20	25.60	21.60 a
ETH	2.00 b	12.00	43.60	42.40 a
ETH + MET	4.00 b	16.00	38.80	41.20 a
Sensação				
No thinning	92.00 a	8.00 c	0.00 b	0.00 <sup>ns</sup>
MT	31.40 c	49.20 a	16.20 ab	3.20
MET	64.00 b	25.60 b	10.00 b	0.40
BA	38.40 bc	39.60 ab	19.20 ab	2.80
BA + MET	73.60 b	23.80 b	2.60 b	0.00
ETH	18.20 c	45.60 ab	32.60 a	3.60
ETH + MET	35.20 c	54.00 a	9.20 b	1.60

Means followed by the same small letter do not differ among them by the Tukey’s test at 5% error probability. TM = manual thinning. MET = metamitron. BA = benzyladenine. ETH = ethephon. ns = not significant.

In the case of the cultivar ‘Maciel’, mean fruit diameter was larger in plants submitted to manual thinning, besides chemical thinning with ethephon and ethephon + metamitron. In the case of the cultivar ‘Sensação’, mean fruit diameter was larger in plants thinned with ethephon, but it did not differ statistically from the one of plants which were manually thinned, thinned with benzyladenine, ethephon + metamitron and metamitron (Table 1).

Chemical thinning treatments with ethephon and ethephon + metamitron decreased production per plant and are strongly related to the low number

of fruits per plants and the high percentage of fruit abscission in both cultivars under evaluation (Figures 1 and 2). Besides, in the case of the cultivar ‘Sensação’, chemical thinning with benzyladenine also led to a low number of fruits per plants and high fruit abscission (Figure 2). In these cases, the high percentage of fruit abscission due to chemical thinning may lead to excessive decrease in production, a fact that is not expected, even if there is increase in fruit mass (STOVER; DAVIS; WIRTH, 2004; REIGHARD; OUELLETTE; BROCK, 2006). Ethephon may increase absorption

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through the plant tissue and be hydrolyzed up to ethylene release, thus, promoting inhibition of auxin synthesis or transport (BANGERTH, 2000). Therefore, when ethephon is applied to peach trees, increase in tissue sensitivity to ethylene may occur, a fact that causes the fruit abscission process (SALAYA, 2012). Studies of metamitron are still scarce, even though this compound may have contributed to both variables fruit abscission and number of fruits, since it is a product that acts on photosystem II, inhibits electron transport in chloroplasts of plastoquinone from QA to QB and decreases production of ATP, NADPH and CO<sub>2</sub> fixation, which triggers photosynthesis inhibition (BASAK, 2011; STERN, 2014).

Table 2 shows that peach tree fruits were classified into four classes, depending on their

diameters at harvest time. In the case of the cultivar ‘Maciel’, plants that had not undergone thinning exhibited small fruits, i. e., most fruits were in the smallest class (< 55mm), and even lower percentages were found in the class of fruits larger than 65 mm. This situation is even clearer in the case of the cultivar ‘Sensação’, whose plants which had not been thinned produced fruits that were classified into the < 55 mm class. Fruits with diameters above 60 mm were not found.

Epidermis color of peaches was not altered by any treatment applied to both cultivars (Table 3). The fact that chemical thinning did not change their color – similar to results of manual thinning – may be due to effective products that affect neither peach appearance nor color for commercialization.

**Table 3.** Epidermis color, pulp firmness and soluble solids found in fruits of peach trees submitted to different thinning treatments in Morro Redondo, RS, Brazil.

Treatments	Epidermis color (°Hue)	Pulp firmness (N)	Soluble solids (°Brix)
Maciel			
No thinning	88.10 <sup>ns</sup>	26.35 <sup>ns</sup>	12.54 <sup>c</sup>
MT	87.58	25.11	12.70 <sup>bc</sup>
MET	87.04	23.66	12.60 <sup>bc</sup>
BA	87.77	27.45	12.96 <sup>bc</sup>
BA + MET	86.48	26.55	14.08 <sup>ab</sup>
ETH	86.57	25.04	14.26 <sup>ab</sup>
ETH + MET	85.25	25.05	15.04 <sup>a</sup>
CV (%)	2.21	8.44	6.00
Sensação			
No thinning	88.50 <sup>ns</sup>	20.06 <sup>b</sup>	7.88 <sup>c</sup>
MT	87.40	22.22 <sup>ab</sup>	8.40 <sup>ab</sup>
MET	88.43	20.36 <sup>b</sup>	7.02 <sup>c</sup>
BA	87.87	25.09 <sup>a</sup>	7.58 <sup>bc</sup>
BA + MET	87.72	21.03 <sup>ab</sup>	6.78 <sup>c</sup>
ETH	88.66	21.27 <sup>ab</sup>	9.14 <sup>a</sup>
ETH + MET	87.81	20.07 <sup>b</sup>	8.70 <sup>ab</sup>
CV (%)	1.68	9.74	8.08

Means followed by the same small letter do not differ among them by the Tukey's test at 5% error probability. TM = manual thinning. MET = metamitron. BA = benzyladenine. ETH = ethephon. CV = coefficient of variation. ns = not significant.

The ‘Maciel’ has a larger cycle in relation to the ‘Sensação’ and concerning pulp firmness, there were no significant differences among products applied to ‘Maciel’ peach trees (Table 3). However, peaches of the cultivar ‘Sensação’ exhibited the highest firmness after thinning with benzyladenine, but it differs neither from manual thinning nor from treatments with benzyladenine + metamitron and ethephon. The fact that benzyladenine attributes greater firmness to the fruits may be associated with the early cycle of this cultivar and also with the increase in cell division promoted by cytokinin, which increases the number of cells.

Soluble solids of ‘Maciel’ peaches resulted in higher values when fruits were produced by plants that had been thinned with ethephon + metamitron, ethephon and benzyladenine + metamitron (Table 3). In the case of the cultivar ‘Sensação’, the highest contents of soluble solids were found in plants thinned with ethephon and ethephon + metamitron. In general, similar behavior may be observed in both cultivars, since the highest values of soluble solids were found in treatments with ethephon and ethephon + metamitron. Increase in these values may be due to the fact that plants exhibited a low number of fruits per plants and, thus, low competition for carbohydrates. These

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results agree with the ones found by Sardaki (2012), who stated that fruit sugars increased as doses of ethephon were applied to peach tree thinning, due to the low number of fruit per plant.

## CONCLUSION

Concentrations of 50 mg L<sup>-1</sup> ethephon, either alone or in combination with 200 mg L<sup>-1</sup> metamitron applied 40 DAFB, excessively decrease the number of fruits and fruit production in the case of both cultivars 'Maciel' and 'Sensação'. However, when they are submitted to chemical thinning with 200 mg L<sup>-1</sup> benzyladenine and 200 mg L<sup>-1</sup>

metamitron, either alone or in combination, their fruits exhibit mean mass and diameter similar to fruits produced by trees which underwent manual thinning. Peaches 'Sensação' exhibited the highest firmness after thinning with benzyladenine.

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**RESUMO:** O raleio em pessegueiro visa reduzir a carga da planta para assegurar a produtividade e a qualidade dos frutos, sendo realizado manualmente em um curto período durante a etapa de desenvolvimento dos frutos. Devido à exigência e falta de mão de obra qualificada, o raleio químico é uma das alternativas para suprir essa demanda encontrada no raleio manual. O objetivo deste trabalho foi avaliar o efeito de diferentes produtos aplicados de forma isolada ou combinada no raleio de frutos de pessegueiros das cultivares Sensação e Maciel na região de Pelotas. O experimento foi conduzido na safra 2015/2016, em pomar comercial de pessegueiro localizado no município de Morro Redondo, RS. Foram realizados sete tratamentos aos 40 dias após a plena floração, consistindo em plantas sem raleio, raleio manual, metamitron, benziladenina, benziladenina + metamitron, ethephon, ethephon + metamitron. Avaliou-se a abscisão dos frutos, frutificação efetiva, número de frutos e produção por planta, massa média e classificação dos frutos em classes de calibre, coloração da epiderme, firmeza de polpa e sólidos solúveis. A produção e o número de frutos por planta reduziram excessivamente, enquanto a alocação dos frutos em categorias de maior calibre aumentou, quando utilizado o ethephon isolado ou em combinação com o metamitron. O metamitron e a benziladenina aplicados isolados ou em combinação promoveram a abscisão dos frutos e resultaram em tamanho e peso médio dos frutos na colheita semelhantes aos provenientes do raleio manual. Aplicação de produtos químicos isolados ou em combinação pode ser uma alternativa de manejo dos pomares para o raleio de pessegueiros.

**PALAVRAS-CHAVES:** Abscisão. Benziladenina. Ethephon. Metamitron. Produção. *Prunus persica*.

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