DOI: 10.5965223811712342024611

Revista de Ciências Agroveterinárias 23 (4): 2024
Universidade do Estado de Santa Catarina

Applying Etefom as a chemical thinner on apple trees in the Planalto Norte Catarinense

Aplicação de Etefom como raleante químico na cultura da macieira no Planalto Norte Catarinense

Mateus Ribeiro Fernandes (ORCID 0000-0002-5310-9371), Nabor Pires Neto (ORCID 0000-0001-5774-8376), Douglas André Würz *(ORCID 0000-0001-6109-9858)

Federal Institute of Santa Catarina, Canoinhas, SC, Brazil. *Corresponding author: douglaswurz@hotmail.com

Submission: 01/13/2024 | *Acceptance: 16/07/2024*

RESUMO

Tem-se como objetivo deste trabalho avaliar o efeito da aplicação de Etefom como raleante químico de frutos em macieiras cultivadas no Planalto Norte Catarinense. O experimento foi desenvolvido no município de Monte Castelo, Santa Catarina, em um pomar comercial, sob a cultivar de maçã Eva, com 2.500 plantas/ha. Os tratamentos avaliados foram: T1 – Raleio Manual; T2 - Etefom. T3 - Etefom + repasse manual; T4 - Duas aplicações de Etefom. Foi utilizado o produto Ethrel® (Etefom), com uma dose de 2 L/ha. O raleio químico é eficiente ao resultar em queda de frutos, no entanto, faz-se necessário a adoção do repasse manual. O raleio manual apresentou menor custo, no entanto, demanda elevado período de realização por hectare, o que pode inviabilizar a realização do manejo do raleio de frutos no momento adequado, e dessa forma, a aplicação do raleante químico torna-se um importante manejo na cultura da maçã, em função do reduzido tempo para sua realização.

PALAVRAS-CHAVE: *Malus domestica;* raleio de frutos; custo de produção.

ABSTRACT

The aim of this study was to evaluate the effect of applying Etefom as a chemical fruit thinner on apple trees grown on the northern plateau of Santa Catarina. The experiment was carried out in the municipality of Monte Castelo, Santa Catarina, in a commercial orchard, under the Eva apple cultivar, with 2,500 plants/ha. The treatments evaluated were: T1 - Manual; T2 - Etefom. T3 - Etefom + manual transfer; T4 - two applications of Etefom. Ethrel® (Etefom) was used at a dose of 2 L/ha. Chemical thinning is efficient when it results in fruit drop; however, it is necessary to use manual thinning. Manual thinning is less costly, but it requires a long period of time per hectare, which can make it unfeasible to manage fruit thinning at the right time, and so the application of chemical thinning becomes an important management tool in apple growing, due to the short time it takes to carry it out.

KEYWORDS: *Malus domestica; fruit thinning; production costs.*

The practice of thinning the apple tree crop aims to improve the size and quality of the fruits, as well as to prevent production alternation by removing the excessive load of fruits before the floral transformation for the following year (PETRI et al. 2013), being one of the most important practices. It is estimated that 5-10% of pollinated flowers are sufficient for optimal fruit set, and under normal conditions, fruit load is typically high, requiring thinning to mitigate biennial bearing (PETRI et al. 2021).

The main purpose of thinning is to balance vegetative and reproductive plant development by reducing nutrient reserves consumption and gibberellin synthesis by seeds. Furthermore, thinning reduces fruit competition, promoting fruit growth (increased size) and color development, thereby enhancing final fruit quality.

In producing regions, labor shortages and high workforce costs in orchard operations are key factors that increase production expenses, driving up final product prices and hindering the expansion of cultivated areas (AHRENS et al. 2014), it is necessary to seek alternatives to reduce the demand for labor and reduce the time to carry out the orchard management activities.

Among the available methods for thinning, chemical thinning can have advantages as it is a quick operation and allows for thinning flowers and fruits at the right time (COSTA et al. 2006) it is an essential practice for obtaining higher quality fruits; however, it is a labor-intensive activity that requires significant workforce, ultimately increasing production costs.

Chemical thinning is now widely used as it enables thinning to be carried out in a short time frame while reducing labor requirements. Among the chemical thinners for apple cultivation, naphthalene acetic acid (NAA), Promalin® (GA4+7 +BA), ethephon, and benzyladenine (BA) stand out (PETRI et al. 2018).

Ethephon is an exogenous ethylene-releasing compound that promotes fruit abscission (WERTHEIM 2000), with enhanced effectiveness at higher temperatures (WEBSTER & SPENCER 2000). In a study conducted by PETRI et al. (2018) demonstrated that post-bloom thinning with benzyladenine combined with naphthalene acetic acid (NAA) or ethephon showed results most similar to hand thinning.

Given the need to optimize orchard labor management and the importance of fruit thinning, this study aimed to evaluate the effect of Ethephon application on chemical thinning of apple trees grown in the Northern Plateau of Santa Catarina, Brazil.

This study was conducted in Monte Castelo, Santa Catarina State, in the Northern Plateau region of Brazil, at an altitude of 820 m above sea level (26º26'16.24"S, 50º13'49.71"W).

The study was conducted in a commercial orchard established in 2016, consisting of Eva apple cultivar trees grafted onto M-9 and Marubakaido rootstocks. The orchard consists of medium-sized plants averaging 2.20 meters in height, spaced 4 m between rows and 1 m between plants, totaling 2,500 plants/ha^{-1}.

The experiment was conducted in a randomized block design with four treatments and four replicates per treatment. The experimental unit consisted of 5 plants, with two border plants, and measurements were taken from the three central plants of each treatment.

Os tratamentos avaliados foram: T1 - Manual Thinning; T2 - Etefom; T3 - Etefom + manual transfer; T4 - Two Etefom applications (sequential, depending on fruit size).

Table 1. Description of the treatments performed, fruit size for each thinning management.

	Treatment	Fruit diameter
1	Manual Thinning	5 mm
2	Etefom (2 L/ha)	5 mm
3	Etefom (2 L/ha) + Manual Thinning (Repass)	5 mm + 11 mm
4	Etefom (2 L/ha) + Etefom (2 L/ha)	5 mm + 11 mm

In early September 2022, when fruits were developing with an average diameter between 5 and 15 mm, floral clusters were tagged, selecting those containing 5 fruits. One hundred floral clusters per replicate were marked for subsequent evaluation.

The calibration of the sprayer was carried out for a solution volume of 1,000 liters/hectare. The product was applied using a 20-L backpack sprayer. The average daily temperature at the time of application was 23 ºC, with a relative humidity of 75%. Weather data were recorded using a digital thermo-hygrometer under field conditions.

The evaluations of fruit thinning effects were conducted fourteen days after applying the thinning agent by counting marked fruit clusters (initially containing 5 fruits) in treatments T2, T3, and T4. Thus, fruit drop percentage was calculated by comparing the total number of fruits before and after the application of the

thinning agent. Finally, manual thinning was performed in all treatments, leaving only one fruit per cluster.

The time required for both manual thinning and chemical thinning agent application per tree was recorded to evaluate and compare labor requirements and costs between the two methods.

To perform the cost calculations for each thinning method, it was used the methodology described by WURZ et al. (2018). The costs associated with each fruit thinning management are detailed in Table 2. In Monte Castelo - SC, the acquisition cost of Ethrel® (Ethephon) thinning agent was R$ 360.00 L^{-1} (application rate of 2 L/ha). Tractor operational costs were calculated based on fuel consumption per working hour, averaging 14 L/hour, with a spraying time of 30 minutes per hectare, resulting in diesel consumption of 7 L/ha for chemical thinning.

The operational cost of the rural worker for manual thinning was calculated based on the regional minimum wage of SC, which is R$: 1,468.00, for the operational tractor operator (where chemical thinning of the fruits was carried out), the calculation basis was (regional minimum wage + 30% hazard pay).

Table 2. Unit operational cost for carrying out different thinning methods in the apple tree crop in the municipality of Monte Castelo - SC, harvest 2022/2023.

Cost of Fruit Thinning Management	Thinning Method of Fruits			
	Manual Thinning	Chemical thinning (1 application)	Chemical Thinning + Manual Thinning	Chemical thinning (2 applications)
Acquisition of Etefom (R$ application^{-1})	0,00	720,00	720,00	1440,00
Operational Tractor (R$ hour^{-1})	0,00	74,25	74,25	148,50
Operational Worker (R$ hour^{-1})	6,67	8,67	15,34	17,34
Total Operational (R$ hour^{-1})	6,67	82,92	89,59	165,84

The data was submitted to analysis of variance (ANOVA), and if there were significant statistical differences, they were compared using the Tukey test at a 5% probability of error.

Fruit thinning effects were observed across all evaluated methods, although with varying responses among treatments. At the end of the thinning process, the objective was to maintain only one fruit per flower cluster, with manual thinning proving to be the most effective and precise method.

Manual thinning can be done more efficiently, but in a slower way and with greater labor use (CARVALHO et al. 2015, BAUCHROWITZ et al. 2016).

The isolated application of Etefom showed a fruit thinning effect, reducing the number of clusters with five fruits, resulting in a predominance of clusters with two to three fruits, thus requiring manual thinning to maintain only one fruit per cluster. The decision to maintain only one fruit per cluster was due to high fruit set, which was directly related to the plant's productive load during the evaluated year.

Sequential etefom applications were not effective, showing no statistical differences compared to a single application. These findings suggest that the second application was ineffective, likely due to fruit size exceeding the recommended threshold of 11 mm at the time of application, considering the fourteen-day interval between treatments. It is emphasized that etefom is known as an exogenous stimulant of ethylene production that promotes fruit abscission (WERTHEIM 2000).

The interval between applications and fruit size are directly related to the effectiveness of the second application. This behavior is repeated in works by PETRI et al. (2017) who found low fruit thinning efficiency when etefom was applied to fruits larger than 15 mm. Additionally, the second application should be performed in combination with another chemical thinning agent.

Other authors demonstrate that the sequential applications of hormonal thinning chemicals and growth regulators with different active ingredients and different mechanisms of action are more effective than sequential applications of products with the same active ingredient (CLINE et al. 2019).

Table 3. Effect of different thinning methods (manual thinning, chemical thinning, chemical + manual thinning) on the number of floral clusters as a function of the number of fruits after the thinning of fruits. Monte Castelo, harvest 2022/2023.

Management of Thinning of Fruits	Number of inflorescences based on the number of fruits remaining after thinning management						Total Evaluated Inflorescences
	0	1	2	3	4	5	
Manual Thinning	0 Bb	100 Aa	0 Bb	0 Bb	0 Bb	0 Cb	100
Etefom (2 L/ha)	6 Ab	13 Bb	29 Aa	32 Aa	11 Ab	9 Ab	100
Etefom (2 L/ha) + Manual Thinning (Repass)	0 Bb	100 Aa	0 Bb	0 Bb	0 Bb	0 Cb	100
Etefom (2 L/ha) + Etefom (2 L/ha)	7 Ab	13 Bb	35 Aa	35 Aa	8 Ab	2 Bc	100

Averages followed by the same uppercase letter in the column and the same lowercase letter in the row do not differ statistically by the Tukey Test at 5% probability.

Table 4 shows the time required for fruit thinning and the cost of each treatment. Manual thinning required 207.6 hours/hectare, while chemical thinning plus manual touch-up required 151.40 hours/hectare. Chemical thinning alone required 0.50 and 1.00 hours/hectare for single and double applications, respectively. This demonstrates that despite the efficiency of hand thinning, as shown in Table 1, its time-consuming nature necessitates exploring alternative methods that reduce cultural management time, considering the specific requirements of apple cultivation.

Regarding fruit thinning costs, chemical thinning (single application) was the most economical at R$750.00/hectare, while dual etefom applications cost R$1,600.00/hectare. Chemical thinning plus manual follow-up was the most expensive at R$1,750.00/hectare, whereas manual thinning alone cost R$1,375.00/hectare. According to PETRI et al. (2017) and LAZZAROTTO (2018), while fruit thinning remains a crucial practice in apple orchard management, rising labor costs have created significant operational constraints, necessitating the exploration of labor-efficient alternatives.

Table 4 Time required for the implementation of different thinning methods in apple cultivation and the cost for their implementation in the municipality of Monte Castelo - SC, harvest 2022/2023.

Cost of Fruit Thinning Management	Thinning Method of Fruits			
	Manual Thinning	Chemical thinning (1 application)	Chemical Thinning + Manual Thinning	Chemical thinning (2 applications)
Time thinning/plant (sec)	299	0,72	217,72	1,44
Time thinning/hectare (h)	207,6	0,50	151,40	1,00
Cost thinning (R$ plant^{-1})	0,55	0,32	0,70	0,64
Cost thinning (R$ hectare^{-1})	1.375,00	800,00	1750,00	1600,00

Although chemical thinning did not eliminate the need for hand thinning, it significantly reduced the time required for fruit thinning management by approximately 56.2 hours per eight-hour workday, representing a seven-day reduction in the time needed to thin one hectare of orchard.

According to PETRI et al. (2017), thinning costs are equally burdensome, with manual thinning time ranging from 30 to 70 man-days per hectare of orchard. Chemical thinning adoption significantly reduces the need for manual fruit thinning, resulting in lower labor costs.

According to MACEDO et al. (2016), although chemical thinning has a higher cost compared to manual thinning, it is highly desirable in orchards as it enables early fruit thinning, reducing competition among fruits for plant assimilates, allowing the plant to achieve vegetative balance that enables fruit weight gain and prevents alternate bearing.

Therefore, chemical fruit thinning is crucial for fruit development, and despite its higher costs, literature demonstrates the benefits of early implementation within a shorter timeframe.

Alternative approaches should be explored to optimize orchard labor through mechanization and chemical fruit thinning methods, thereby reducing manual labor requirements and enabling management practices to align with appropriate plant phenological stages, potentially enhancing both productivity and quality indices. Therefore, further research should be conducted in the Northern Plateau region of Santa Catarina to explore chemical thinning alternatives, evaluating recommended thinning agents, along with their application rates and timing.

Chemical thinning is effective in promoting fruit drop; however, manual follow-up thinning is necessary

after chemical thinning application to achieve optimal results. Manual thinning showed lower costs but required extensive time per hectare, which may prevent fruit thinning at the optimal timing. Therefore, despite higher costs, chemical thinning remains crucial in apple production due to its rapid implementation.

Further research is needed to validate these findings and explore alternative fruit-thinning agents.

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