IMPACTO CIENTÍFICO EDITORA

EVALUATION OF ETHYLENE PRECURSOR IN THE UNIFORMIZATION AND ACCELERATION OF MATURATION OF COFFEE FRUITS

AVALIAÇÃO DO PRECURSOR DE ETILENO NA UNIFORMIZAÇÃO E ACELERAÇÃO DA MATURAÇÃO DE FRUTOS DE CAFEEIRO

EVALUACIÓN DEL PRECURSOR DE ETILENO EN LA UNIFORMIZACIÓN Y ACELERACIÓN DE LA MADURACIÓN DE FRUTOS DE CAFÉ

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ABSTRACT

Coffee trees vary in maturity, influenced by genetic, climatic, and management factors, which can compromise harvest efficiency and beverage quality. Therefore, this study aimed to evaluate the effects of applying different doses of ethephon to accelerate fruit maturation and provide greater uniformity in coffee bean maturation in the Nova Alta Paulista region of São Paulo. The experiment was conducted in a commercial Arabica coffee plantation, cultivar Obatã, in the Nova Alta Paulista region of São Paulo, in a randomized complete block design using four doses of the ripening agent Etherel 720 (0, 300, 500, and 700 mL ha^{-1}) with five replicates. Evaluations included the percentage of fruits at different maturity stages and the quantification of leaf abscission. The results showed a significant reduction in the proportion of green fruits and an increase in the cherry and ripe stages in the treatments with the regulator, demonstrating the effectiveness of ethephon in accelerating and synchronizing ripening. Although an increase in the percentage of leaf abscission was observed, it is assumed that this did not detrimental to postharvest recovery or biennial production. It is concluded that under the conditions studied, the use of ethephon, especially at a dose of 300 mL ha^{-1}, represents a strategic tool for coffee management, contributing to earlier and more uniform harvest. However, the importance of further evaluations regarding cup quality is emphasized.

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RESUMO

O cafeeiro apresenta variação no período de maturação, sendo influenciado por fatores genéticos, climáticos e de manejo, o que pode comprometer a eficiência da colheita e a qualidade da bebida. Nesse contexto, o presente trabalho objetivou avaliar os efeitos da aplicação de diferentes doses de etefom para acelerar a maturação dos frutos e proporcionar maior uniformidade na maturação dos grãos de café, na região da Nova Alta Paulista. O experimento foi conduzido em lavoura comercial de café arábica, cultivar Obatã, na região da Nova Alta Paulista - SP, no delineamento em blocos casualizado utilizando quatro doses do maturador Etherel 720 (0, 300, 500 e 700 mL ha^{-1}), em cinco repetições. As avaliações compreenderam a porcentagem de frutos em diferentes estádios de maturação e a quantificação da abscisão foliar. Os resultados demonstraram redução significativa na proporção de frutos verdes e incremento dos estádios cereja e passa nos tratamentos com o regulador, evidenciando a eficácia do etefom na aceleração e sincronização da maturação. Embora se tenha constatado aumento na porcentagem de abscisão foliar, pressupõe-se que esse não se tornou prejudicial à recuperação pós-colheita e à bienalidade produtiva. Conclui-se que nas condições estudadas o uso de etefom, especialmente na dose de 300 mL ha^{-1}, representa uma ferramenta estratégica para o manejo do cafeeiro, contribuindo para a antecipação e uniformidade da colheita. No entanto, ressalta-se a importância de novas avaliações referentes a qualidade de bebida.

Palavras-chave: *Coffea arabica* L. Antecipação. Metabolismo. Fisiologia. Colheita.

RESUMEN

Los cafetos varían en madurez, influenciados por factores genéticos, climáticos y de manejo, que pueden comprometer la eficiencia de la cosecha y la calidad de la bebida. Por lo tanto, este estudio tuvo como objetivo evaluar los efectos de la aplicación de diferentes dosis de etefón para acelerar la maduración del fruto y proporcionar una mayor uniformidad en la maduración del grano de café en la región de Nova Alta Paulista de São Paulo. El experimento se llevó a cabo en una plantación comercial de café Arábica, cultivar Obatã, en la región de Nova Alta Paulista de São Paulo, en un diseño de bloques completos al azar utilizando cuatro dosis del agente de maduración Etherel 720 (0, 300, 500 y 700 mL ha^{-1}) con cinco réplicas. Las evaluaciones incluyeron el porcentaje de frutos en diferentes etapas de madurez y la cuantificación de la abscisión foliar. Los resultados mostraron una reducción significativa en la proporción de frutos verdes y un aumento en las etapas de cereza y maduros en los tratamientos con el regulador, demostrando la efectividad del etefón en la aceleración y sincronización de la maduración. Si bien se observó un aumento en el porcentaje de abscisión foliar, se asume que esto no perjudicó la recuperación poscosecha ni la producción bienal. Se concluye que, en las condiciones estudiadas, el uso de etefón, especialmente en una dosis de 300 mL ha^{-1}, representa una herramienta estratégica para el manejo del café, contribuyendo a una cosecha más temprana y uniforme. Sin embargo, se enfatiza la importancia de realizar evaluaciones adicionales sobre la calidad de taza.

Palabras clave: *Coffea arabica* L. Cosecha Temprana. Metabolismo. Fisiología. Cosecha.

1 INTRODUCTION

The harvest time of the coffee tree (*Coffea sp.*) is variable in Brazil, being influenced mainly by the number of flowerings, precocity of the cultivar, climatic conditions and vegetative volume of the plants (Silva *et al*., 2009). For the harvest to present good yields, it is essential that the proportion of mature grains is higher than that of green grains, and it is recommended that the participation of these does not exceed 20% of the total grains. When there is a high number of green beans, they make manual melting difficult, increase the costs of the process and compromise the quality of the beverage (Matiello *et al.,* 2005).

An alternative to facilitate harvesting is the use of the hormone regulator ethylene, present in most plant cells, whose production is intensified in injured organs, dormant buds and during periods of senescence and tissue abscission. The hormonal precursor is applied to coffee fruits with the objective of promoting greater uniformity and anticipating the harvest (Carvalho *et al*., 2003).

In coffee growing, the flowerings occur between August and November, in an indeterminate number, with an average of two, this variation depends on the volume of rainfall recorded in the flowering period (Soares et al., 2005). Inexpressive rainfall is not enough to trigger significant blooms, which tend to occur after subsequent rains. Irrigation management can influence the time, intensity, and number of blooms, but remains conditioned by climatic variations that regulate the process (Silva *et al*., 2009; Reindeer; Maestri, 1986).

The maturation process, in turn, is affected by variety, vegetative volume and climate. Late varieties, such as Arara and IPR 100, require more time for fruit ripening, in the same way, regions with a colder climate (average temperature < 19 ºC) prolong the maturation cycle. Under these conditions, it is common to have less fruit drop and later harvests, usually from July onwards (Santinato et al., 2020).

The combination of low temperatures with late varieties can result in excessively late harvests, the presence of green beans or incomplete harvests, when fruits that have not yet completed their cycle (non-garnet fruits) are removed. This situation leads to productivity losses, since the fruits are harvested, but do not turn into grains, occurring more frequently in lowland areas where there is an accumulation of cold air, which also compromises the quality of the beverage (Rodrigues *et al*., 2019).

Ethephon, a hormone precursor of ethylene, can be adopted in coffee management, being efficient in advancing and standardizing the harvest (Santos, 2016; Carvalho *et al.,* 2003). The phytoregulator should be used when approximately 90% of the fruits of the "skirt" of the plants are physiologically ripe, this condition can be verified by cutting the fruits with

the help of a blade, if the interior is hard, with the grain formed, it is indicated that the fruits have reached physiological maturity.

However, the speed of transition from garnet fruits to the point of harvest is quite variable, depending on the variety, climatic conditions and vegetative volume (Foloni, 2000). The present study aimed to evaluate the effects of the application of different doses of etefom to accelerate fruit maturation and provide uniformity in coffee beans in the region of Nova Alta Paulista.

2 METHODOLOGY

2.1 LOCATION AND WEATHER CONDITIONS

The experiment was conducted at Chácara Nossa Senhora Aparecida, located in the municipality of Osvaldo Cruz-SP, from July 2024 to August 2025, in a commercial Arabica coffee plantation, cultivar Obatã, with 12 years of age, implanted at a spacing of 3.0 m between rows and 0.6 m between plants (Figures 1 and 2). The municipality has a Cwa-type climate, according to the Koppen classification, characterized as humid tropical with dry winter and rainy summer, with an average annual temperature of around 22 °C and average annual precipitation of approximately 1,300 mm, concentrated in the months of October to March (Climatempo, 2025).

Figure 1

Cultivate Obatã during the fruit maturation period

Source: The authors (2025).

Figure 2

Place of implementation of the experiment

Source: The authors (2025).

2.2 EXPERIMENTAL DESIGN

The experimental design was in randomized blocks, consisting of four doses of the etefom ripener (Ethrel 720®), corresponding to 0, 300, 500 and 700 mL ha^{-1}, applied at a rate of 500 L ha^{-1}, with five replications. Thus, a total of 20 experimental units were obtained, with each plot consisting of six plants arranged in a row, from which the two central plants were selected for evaluations, in order to minimize the border effect.

The application of the ethylene precursor was carried out in the afternoon, using a manual knapsack sprayer, equipped with a conical nozzle, in order to provide uniform coverage of the branches and fruits. The definition of the time of application was based on the physiological stage of fruit maturation, and was carried out when approximately 90% of the fruits were in the garnet-green stage (Figure 3). This point was determined through weekly sampling within the plots, collecting fruits and making longitudinal cuts, according to the methodology described by Benini (2002), in which the presence of formed grain and firm consistency of the endosperm indicate physiological maturation.

2.3 EVALUATIONS PERFORMED

a) Fruit maturation stages (Figure 4): average percentage of fruits in the green, cherry and raisin stages, recorded at the time of application and in two subsequent periods, at intervals of 20 days until harvest. The harvest was carried out when the percentage of unripe fruits reached about 20%. For this evaluation, branches of the upper, middle and lower thirds were collected on both sides of the two central plants of the plot, totaling 12 branches per experimental unit.

b) Leaf abscission: branches located in the three thirds of the plants (upper, middle and lower) were previously marked, and the number of leaves present before the application of the ripener and again at the time of harvest was counted, allowing the quantification of leaf loss associated with the use of the product.

Figure 3

Branch selected in the middle third, before spraying with ethephon

Source: The authors (2025).

Figure 4

Different stages of grain maturation

Source: The authors (2025).

2.4 STATISTICAL ANALYSIS

The data were submitted to analysis of variance (ANOVA) by the F test. To evaluate the effect of the precursor and provide greater clarity in the interpretation of the results, regression analysis was used. The means were compared by Tukey's test, at the level of 5% probability (Ferreira, 2000).

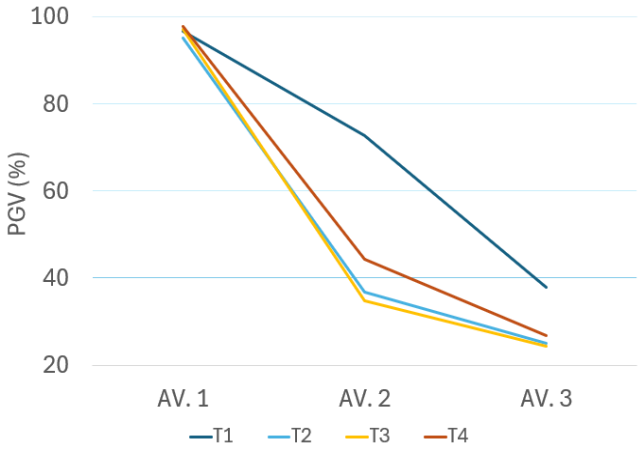
3 RESULTS

The evaluations allowed us to observe the effects of the ethylene precursor on the anticipation of harvest, the uniformity of grain maturation and the leaf abscission of the coffee plant. Although the evaluated characteristics did not present statistical differences, the regression analyses indicated favorable trends, denoting the positive effect of the ethylene precursor. Regression analyses also indicated a higher rate of leaf abscission in relation to the use of the ethylene precursor. The variables analyzed present similar values in the dosages of 300, 500 and 700 ml $^{ha-1}$ of ethrel, differing from the control portion.

For the percentage of green beans (PGV), a decreasing trend was observed in the plots treated with ethefom, the same occurred in the control plot, but this maintained a higher persistence of green fruits throughout the evaluations (Figure 5). This behavior confirms the effectiveness of the regulator in accelerating the maturation process, reducing the presence of immature fruits at the time of harvest (Figure 6).

Figure 5

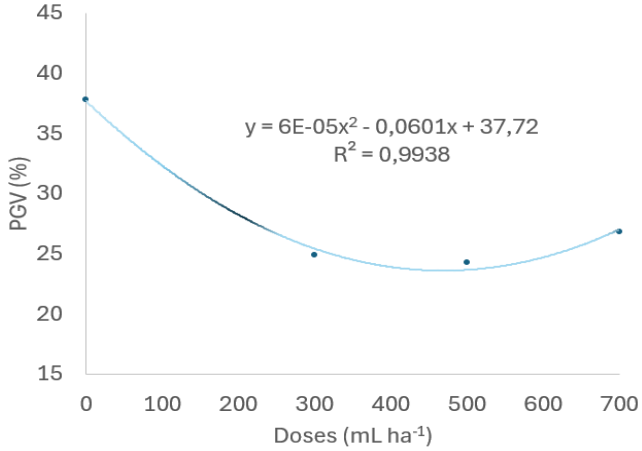
Percentage of green beans (PGV) as a function of treatments and evaluations



Source: The authors (2025).

Figure 6

Regression analysis under the variable percentage of green grains (PGV)

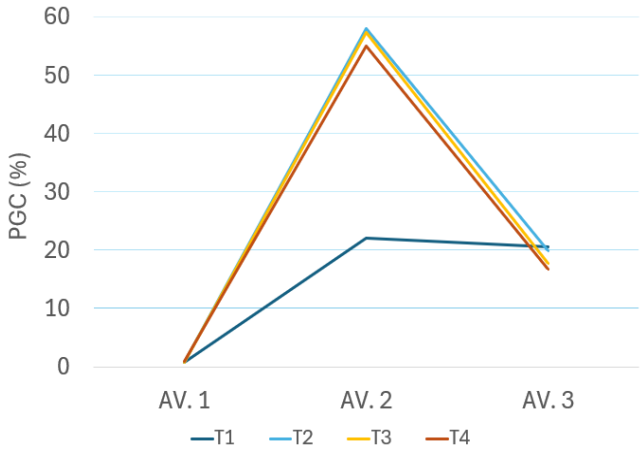


Source: The authors (2025).

The variable percentage of cherry beans (PGC) indicated a significant increase after the application of the regulator, showing a rapid increase followed by stabilization in subsequent evaluations (Figure 7). This result suggests that the etefom promoted anticipation and synchronization of maturation, even though, in the third evaluation, the percentages were close to the control portion (Figure 8).

Figure 7

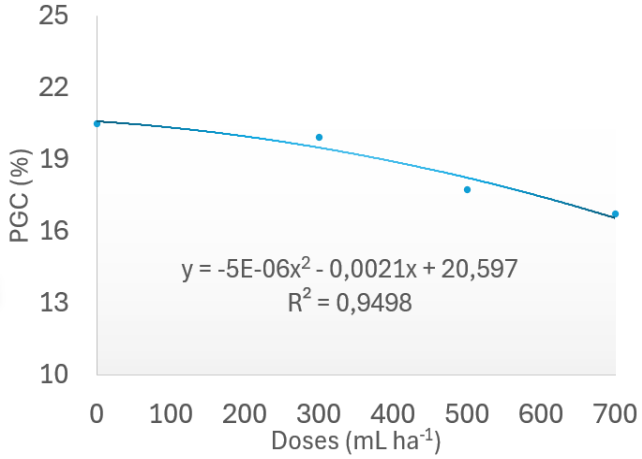
Percentage of cherry beans (PGC) as a function of treatments and evaluations



Source: The authors (2025).

Figure 8

Regression analysis under the variable percentage of cherry beans (PGC)

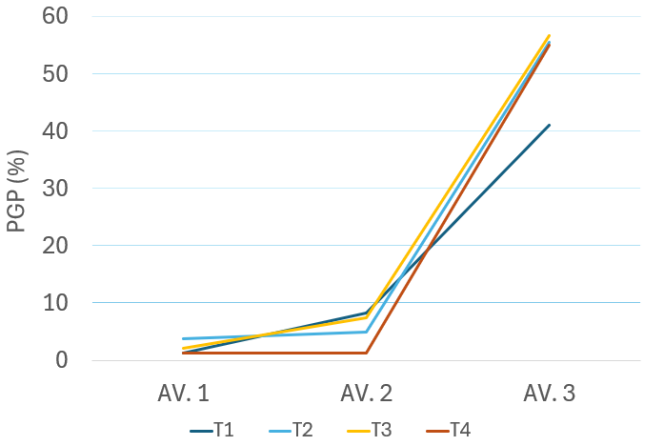


Source: The authors (2025).

For the percentage of raisins (PGP), the regression analysis revealed an increasing behavior in the plants submitted to the regulator, with a more accentuated positive trend in the last evaluation, while the control showed a more gradual evolution (Figure 9). This response reinforces the effect of etephon in accelerating the maturation cycle, leading the fruits more quickly to the final stage (Figure 10).

Figure 9

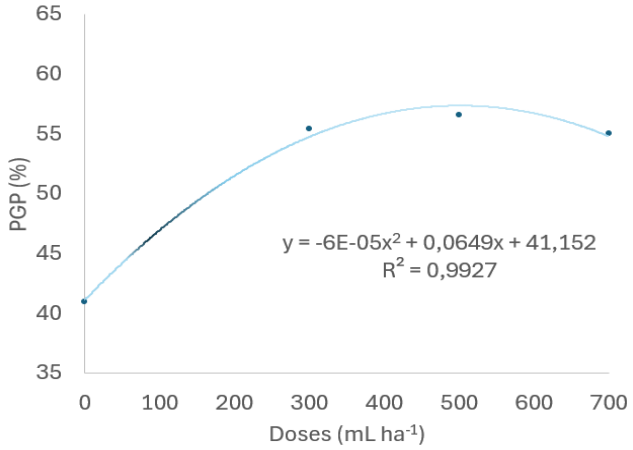
Percentage of grains passes (PGP) as a function of treatments and evaluations



Source: The authors (2025).

Figure 10

Regression analysis under the variable percentage of grains passes (PGP)

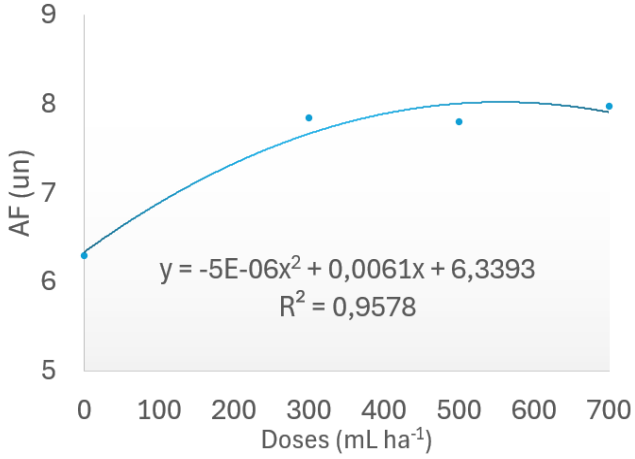


Source: The authors (2025).

Regarding leaf abscission (FA), the regression analysis indicated a trend of increased defoliation in coffee plants treated with etefom (Figure 11). However, even with this increase, the values remained within a range considered not harmful to plant development, suggesting that the observed effect does not compromise post-harvest recovery or productive biennial.

Figure 11

Regression analysis under the variable leaf abscission (FA)



Source: The authors (2025).

4 DISCUSSION

The results obtained demonstrate the efficiency of the hormonal precursor for the acceleration of grain maturation and harvest uniformity. The trend of increasing fruits in the cherry and raisin phenological stages and the reduction of unripe fruits in the treatments with etefom confirm the expected effect of the hormone regulator, since ethylene is directly related

to the stimulation of climacteric respiration and the acceleration of maturation processes (Winston *et al.,* 1992; Carvalho *et al*., 2003).

The observation of a higher percentage of cherry beans right after spraying is particularly relevant, as it evidences the efficiency of etefom in promoting uniformity in maturation. This result is in line with research that highlights the role of ethylene in the synchronization of maturation, a determining factor for the quality of the beverage and for the efficiency of the harvest (Crisosto; Grantz; Osgood 1992; Santinato *et al*., 2020). In addition, the higher percentage of ripe fruits has direct positive implications on the sensory quality of coffee, since this stage is considered ideal for obtaining beans with greater potential for market appreciation.

The persistence of green grains in the control plots reinforces the importance of the regulator's application. In the production context, the high presence of unripe fruits is harmful, because in addition to compromising the quality of the drink, it increases the costs of harvesting, either by prolonging the manual process or by the need for transfers in mechanized harvesting. In this sense, the application of etefom represents a management strategy that contributes to greater operational efficiency and cost reduction, as already pointed out by Kashima *et al.* (1986).

The regression analysis showed that there were consistent trends that favor the use of etefom. This finding is important because it demonstrates that the regulator can bring practical benefits to the production system, even when the quantitative effects are not robustly differentiated.

In the case of leaf abscission, it was observed that treatments with etefom resulted in a more accentuated defoliation. However, it is presumed that this effect did not cause damage to postharvest recovery or to the biennial of the plants, since the percentage of defoliation was similar to that of the control treatment. Studies conducted by Felipe (1986) have already indicated the association between ethylene and senescence, emphasizing, however, that in adequate doses this effect does not compromise the productive biennial of the coffee plant.

5 CONCLUSION

Under the conditions evaluated, the ethylene precursor proved to be efficient in promoting the anticipation and uniformity of the harvest, without compromising the post-harvest recovery or significantly interfering in the biennial production, however, the importance of new experiments regarding the analysis of beverage quality is emphasized. The results obtained reinforce the practical applicability of the hormone regulator, recommending a dosage of 300 mL ha^{-1}, which showed good performance combined with

lower cost. Thus, the ethylene precursor is a useful tool in the management of Arabica coffee crops in the region of Nova Alta Paulista - SP.

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