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Hydrogenated cyanamide in the budding of 'Eva' apple tree in a mild winter region

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Abstract: This study was carried aiming to evaluate different hydrogen cyanamide concentrations (0.00%; 0.26%; 0.52% 0.78% and 1.04%) associated with (3%) mineral oil on the bud growth of the 'Eva' apple tree in a high-altitude tropical climate region in the state of Minas Gerais. Sprouting percentage, fruit set: ratio between number of fruits and number of flowers (%), number of fruits per plant and flowering phenology were evaluated during the 2020 and 2021 production cycles. Even not being submitted to temperatures below 7.2°C, the 'Eva ' cultivar completed its production cycle in two subsequent years. Hydrogen cyanamide application combined with mineral oil promoted increased budbreak and flowering uniformity, in addition to anticipating the beginning of flowering of the 'Eva' apple cultivar.

Index terms: *Malus domestica*, phenology, budbreak promoter, dormancy.

Cianamida hidrogenada na brotação da macieira 'Eva' em região de inverno ameno

Resumo: O presente trabalho teve como objetivo analisar o efeito de diferentes concentrações de cianamida hidrogenada (0,00; 0,26; 0.52; 0.78; e 1,04%) associadas a 3% de óleo mineral sobre o desenvolvimento de gemas da macieira 'Eva', em região de clima tropical de altitude, no Estado de Minas Gerais. Foram avaliados o percentual de brotação, a frutificação efetiva, o número de frutos por planta e a fenologia da floração durante os ciclos produtivos de 2020 e 2021. Mesmo não sendo submetida a temperaturas inferiores a 7,2°C, a cultivar 'Eva' completou seu ciclo de produção em dois anos subsequentes. A aplicação de cianamida hidrogenada, combinada com óleo mineral, promoveu maior brotação e uniformidade de floração, além de antecipar o início da floração da cultivar 'Eva'.

Termos para indexação: *Malus domestica*, fenologia, indutor de brotação, dormência.

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Introduction

Apple tree (*Mallus domestica* Borkh) is a species grown in temperate regions because temperature plays a fundamental role in apple production. The occurrence of low temperatures (<7.2 °C) is important because cold is required to overcome bud dormancy, an adaptive mechanism that allows plants to survive under unfavorable conditions characterized by excessive cold (LEITE et al., 2018).

Under natural conditions, the apple tree resumes the metabolic activity of buds and the development of new sprouts occurs after cold accumulation during the autumn and winter periods. Thus, it is necessary for the plant to be exposed for a period under temperatures below 7.2 °C, known as the cold requirement, for sprouting uniformity (PETRI et al., 2021).

In Brazil, the cultivation expansion of the apple tree to areas news, depends on the adaptation of cultivars to the climatic conditions of different regions and the efficiency of some chemical products for inducing sprouting. The southern region is the largest producer in the country due to the occurrence of low temperatures during the winter. However, it is necessary to intensify studies to expand cultivation to new regions to meet the market growth trend.

In regions with mild winter, with insufficient cold, the apple tree has irregular flowering, marked by strong apical dominance, with consequent uneven fruiting, impairing practices such as thinning and harvesting. In these regions, the selection of cultivars with lower winter cold requirement, such as 'Eva', is a promising alternative (CHAGAS et al., 2012; LOPES et al., 2012).

Budbreak promoters have been applied as complementary strategies to minimize physiological problems such as uneven sprouting and flowering caused by the absence or deficiency of cold. Hydrogenated cyanamide is the budbreak promoter most widely used for this purpose (PETRI et al., 2016). However, its effect has been variable depending on temperature conditions, vigor of cultivars and its combination with mineral oil, which has demanded studies to establish its application under different cultivation conditions and cultivars (HAWERROTH et al., 2009).

The present study was carried out with the aim of evaluating the effect of different hydrogen cyanamide concentrations associated with mineral oil on the bud sprouting of 'Eva' apple cultivar in the northeastern region of Minas Gerais.

Material and Methods

This study was carried out in 2020 and 2021 in an experimental orchard located on the IFMG Campus, municipality of São João Evangelista (MG), at 18°32'52" S, and 42°45'46" W and 689 meters a.s.l. According to Köeppen, the climate of the region is classified as Cwa type, high-altitude tropical, with dry winter and rainy summer. The average annual rainfall is 1,180 mm and the average temperature is 22 °C. The minimum temperatures recorded in the region are higher than 7.2°C. The monthly average maximum and minimum temperatures and accumulated rainfall during the evaluation period are shown in Figure 1.

The orchard was implanted in 2018 using 'Eva' as the main cultivar, grafted onto 'Maruba' rootstock and 'M9' filter. 'Julieta' and 'Princesa' cultivars were planted as pollinators, alternately distributed in rows in the proportion of 20% of the area. All two-years-old plants at the beginning of the experiment. Plants were conducted in a central leader system, using spacing of 4 m between rows and 1.5 m between plants. The management practices adopted for the implantation and management of the orchard were carried out in accordance with recommendations for apple tree production (SANHUEZA et al., 2006).

The experimental design was randomized blocks with five treatments and six replicates (blocks), with each experimental unit consisting of one plant. The experiment was repeated in two production cycles (2020 and 2021). Treatments consisted of the application of four hydrogen cyanamide (HC) concentrations: 0.26%; 0.52% 0.78% and 1.04%, associated with 3% mineral oil (MO) and control treatment (without HC and MO application). Dormex® (52% active ingredient) was the commercial product used as source of hydrogen cyanamide and Assist® (75.6% active ingredient) of mineral oil.

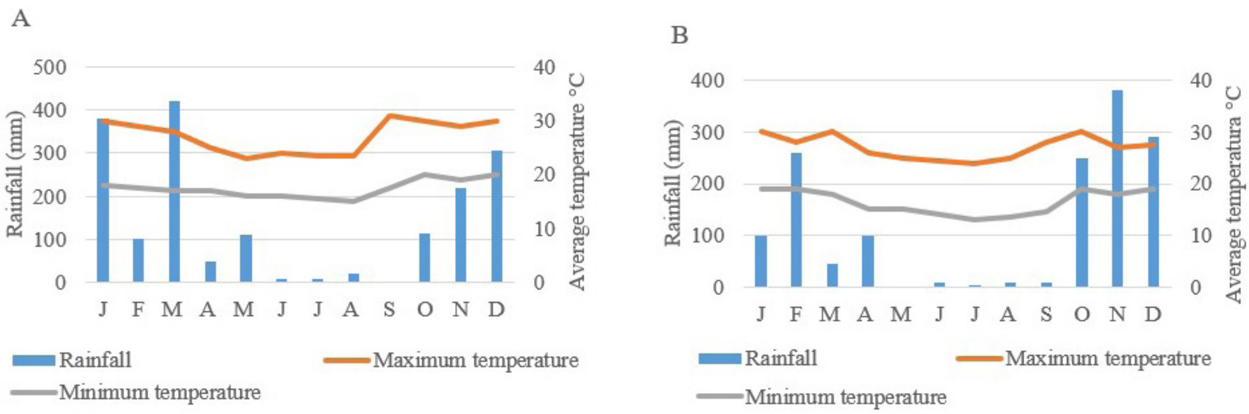

Figure 1. Accumulated rainfall and monthly average maximum and minimum temperatures recorded in São João Evangelista in the years 2020 (A) and 2021 (B).

Treatments were applied when buds were between phenological stages A (dormant bud) and B (swollen bud) on 08/03/2020 and 08/04/2021, according to recommendations of Petri et al. (1996). Before application, plants were manually defoliated. Treatments were applied 10 days after defoliation, spraying all branches up to the runoff point.

Evaluations consisted of determining the beginning and duration of the flowering period, budding rate, effective fruiting and number of fruits per plant. Two lateral branches, in the middle third of each plant, were previously selected to evaluate the development of buds from stage A (dormant) until fruit harvest. Evaluations took place every 3 days. To evaluate the flowering period, the beginning was considered when 5% of flowers are open, full bloom when more than 80% of flowers are open and the end of flowering when the last flowers are open. The sprouting percentage on side branches was determined by the ratio between the total number of sprouts (sprouted buds) and the total number of buds on the branch ([number of sprouts/number of buds]x100). Effective fruiting was obtained from the ratio between number of fruits and number of flower counted during full bloom ([number of fruits/flower]x100). The number of fruits per plant was determined at the time of harvest from the count of all fruits harvested per plant, from each treatment.

Data obtained from each production cycle were submitted to analysis of variance separately and variables that presented significant differences were submitted to regression analysis, using the R software.

Results and Discussion

Differences were observed between HC concentrations for the beginning of flowering and the total flowering period in the 2021 production cycle, sprouting percentage, effective fruiting and number of fruits per plant. Results showed that the 'Eva' apple cultivar, although not exposed to temperatures below 7.2 °C, completed its production cycle under conditions of high-altitude tropical climate in northeastern state of Minas Gerais.

HC application reduced the time for the beginning of flowering and the total flowering period of the 'Eva' cultivar in the 2021 production cycle (Figure 2). Results showed that the highest HC concentration anticipated flowering by around 5 days, while in plants that did not receive HC application, the beginning of flowering was observed 14 days after treatments. Regarding the total flowering period, duration was around 25 days for control treatment plants and 13 days for plants sprayed with HC (1.04%). These results show the importance of overcoming bud dormancy for the management of apple orchards in regions where there is no sufficient cold, since the extension of the budding and flowering phases in apple trees is a consequence of insufficient cold during the dormancy period.

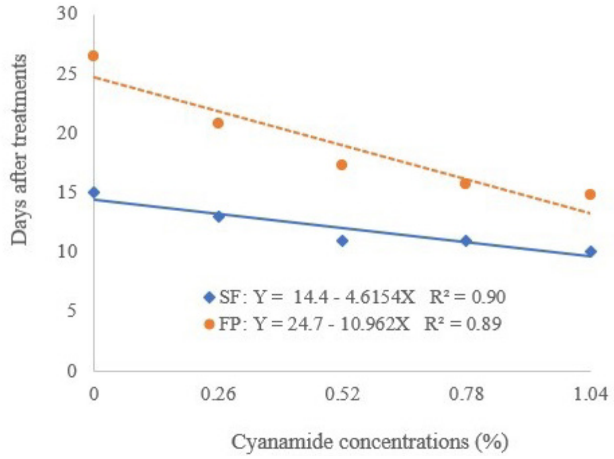

Figure 2. Number of days to beginning flowering (SF) and total flowering period (FP) of 'Eva' apple cultivar as a function of hydrogen cyanamide concentrations associated with 3% mineral oil, São Joao Evangelista (MG), 2021

Flowering anticipation is desirable, as it provides greater permanence of fruits on the plant and contributes to the production of fruits of higher quality, since fruit maturation is not directly correlated with the beginning of flowering (PETRI et al., 2006). In addition, control over the beginning of the flowering period makes it possible to synchronize the flowering of species of interest and their pollinators (HAWERROTH et al., 2009). Another important aspect in relation to the duration of the flowering period is that standardization facilitates orchard management, as it favors thinning and disease control, reducing the number of concomitant phenological stages in the same plant (PETRI; LEITE, 2004).

In the 2020 production cycle (first production cycle of the orchard), no difference was observed between HC concentrations for the beginning of flowering and flowering period. The beginning of flowering occurred 24 days after treatments were applied and the duration was, on average, 29 days. The lack of response to budbreak promoters (HC and MO) in the first year is possibly related to the age of plants. In 2020, the orchard was in formation and this may have influenced carbohydrate reserves, which are essential for the growth and development of new sprouts in apple trees in early spring, as they provide energy for new growth before new leaves become photosynthetically active in the plant (CARVALHO; ZANETTE, 2004). Abreu et al. (2018) also found no significant difference between HC-treated and untreated plants for the beginning of flowering of the 'Eva' cultivar in the third year of cultivation in the state of Rio Grande do Sul.

Regarding effective sprouting, it was found that the highest dormancy break percentages were observed for plants sprayed with HC concentrations of 0.71% in the 2020 production cycle and 1.04% in the 2021 production cycle (Figure 3). In these plants, sprouting rates reached 54.2% and 56.6%, while plants that did not receive budbreak promoters reached only 34.7% and 21.6%, respectively. In the northeastern region of Minas Gerais, HC concentrations to induce efficient sprouting in 'Eva' apple trees are higher than those observed in regions where there is accumulation in the number of cold hours. This can be attributed to the absence of temperatures below 7.2 °C (Figure 1), because depending on climatic conditions and vigor of cultivars, HC concentration associated with mineral oil may vary to overcome plant dormancy (HAWERROTH et al., 2009).

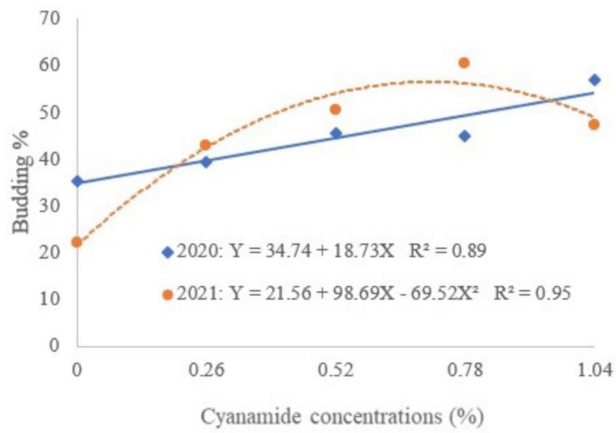

Figure 3. Effective budding of 'Eva' apple tree buds as a function of different hydrogen cyanamide concentrations associated with 3% mineral oil, São Joao Evangelista (MG), 2020 and 2021.

In regions where low temperatures occur, under conditions of humid subtropical climate, but with insufficient cold hours to overcome dormancy, HC associated with MO (3% to 4%) has been applied at concentrations between 0.5% and 0 .6% in the 'Eva' apple cultivar (ROBERTO et al., 2006; DARDE et al., 2019). On the other hand, under conditions of high-altitude tropical climate, management to induce sprouting has been used with superior combinations such as 1.56% HC and 1% MO (CHAGAS et al., 2012), 0.8% HC and 3.0% MO (LOPES et al., 2012).

The sprouting percentages observed in this study (54.2% and 56.6%) are close to results observed (48.8%) for 'Eva' apple cultivar under conditions of humid subtropical climate in the state of Paraná (ROBERTO et al., 2006). However, superior results have been observed in the region where there is accumulation of cold hours, which contribute to dormancy break. According to Cruz Júnior and Ayub (2002), sprouting rates evaluated for 'Eva' cultivar were 93.57% in lateral buds and 93.72% in terminal buds with the application of 1.5% HC and 3% MO after 254 hours of cold accumulation.

Regarding effective fruiting and number of fruits per plant, increments were observed with the application of budbreak promoters (Figure 4). For effective fruiting, there were increases of 94.69% and 79.3% with the application of 1.01% and 0.68% HC in relation to control treatment, in both production cycles, respectively. As for the number of fruits per plant, increases were 47.38% in 2020 and 81.44% in 2021 with the application of HC concentrations of 0.72% and 0.84%, which corresponded to 85.33 and 82.29 fruits per plant, respectively. These numbers are lower than the potential attributed to 'Eva' cultivar (IAPAR – 75), which can produce 156 fruits per plant (PIO et al., 2018). However, in the present study, the number of fruits evaluated is expected in the first production cycles due to the juvenility of the orchard.

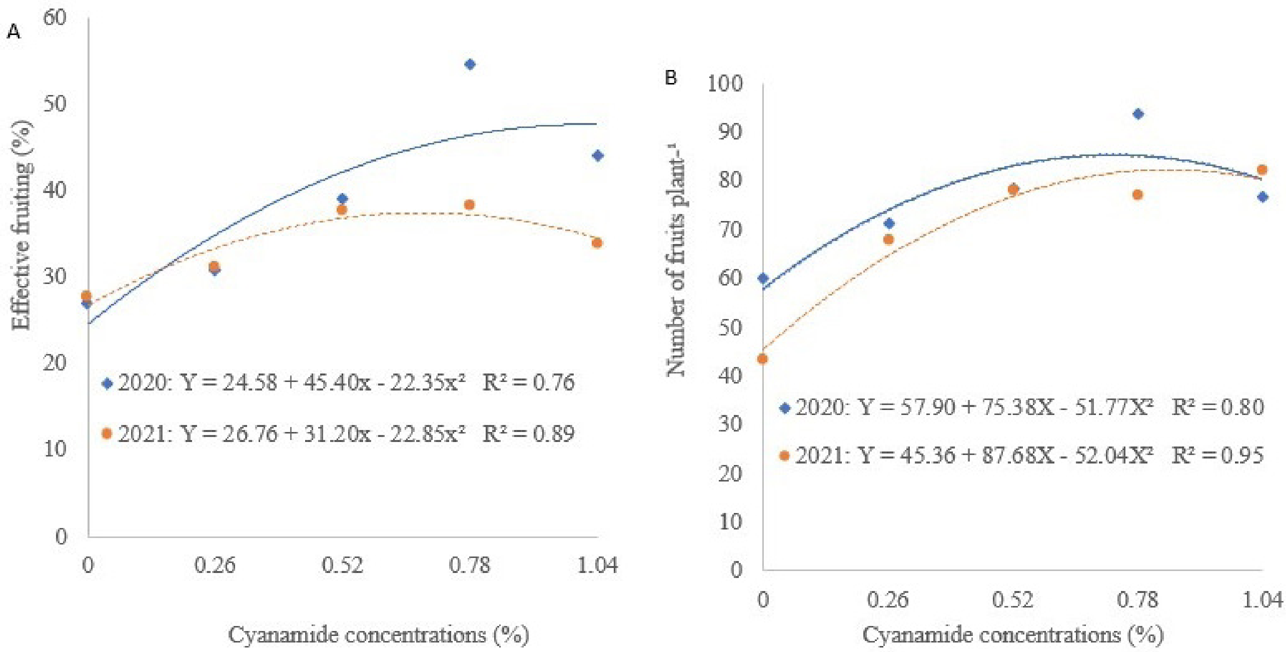

Figure 4. Effective fruiting (A) and number of fruits per plant (B) of 'Eva' apple cultivar as a function of hydrogen cyanamide concentrations associated with 3% mineral oil, São Joao Evangelista (MG), 2020 and 2021

Reduced fruiting may be related to vegetative growth after sprouting, which competes with flowers and fruit development (HAWERROTH et al., 2010). In the present study, effective sprouting was higher in the 2021 production cycle (56.6%), which may have influenced the lower fruiting rate (79.3%). Other factors are pointed out as limiting effective fruiting, such as the formation of small-sized flowers due to the absence of cold. In this type of flowers, ovules present abnormal development and abort from the embryo, resulting in the fall of flowers (RODRIGO; HERRERO, 2002). In addition, plants may present reduction in the period of stigma receptivity, reduction in the length and deformation of pistils, smaller number and size of anthers, reduction in the number of pollen grains per anther, and reduction in the period of ovule viability (HEDHLY et al., 2003). In the present study, effective fruiting rates were high (94.69% to 79.3%), compared to results obtained (7% to 8.28%) in both production cycles of 'Eva' apple cultivar under the climate conditions of the semiarid region of northeastern Brazil, which resulted in the production of 36-46 fruits per plant (LOPES et al., 2012).

Conclusion

The application of hydrogen cyanamide at concentrations of 0.7% to 1.04% with mineral oil (3%) promoted greater sprouting and flowering uniformity, in addition to anticipating the beginning of flowering of the 'Eva' apple cultivar.

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