Application of GA_3 and girdling of branches on the production of extemporaneous fruits of 'Tahiti' acid lime

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RESUMO

The objective of this study was to evaluate the effect of girdling of branches and the application of GA_3, still in the main crop flowering on the formation of reproductive structures, the fruit set of the following extemporaneous flowering of 'Tahiti' acid lime. This work used a randomized block design with five replications in a 4x3 factorial design. The first factor was the foliar application of GA_3, 88 days before extemporaneous flowering at five concentrations (0, 7, 14 and 21 mg.L^{-1}). The second factor was the girdling times, 108 days before flowering onset (A108AF), 78 days before flowering (A78AF) plus no-girdling control (NG). In extemporaneous flowering, the proportion of buds, flowers and fruits that abscised was 38.75, 31.25 and 18.64% respectively and 11.34% of all reproductive structures formed were collected. GA_3 did not affect fruit set. Girdling increased fruit set by 229 and 256% at A108DAF and A78DAF respectively, in relation to NG plants. The GA_3 reduced the formation of floral structures, which resulted in a quadratic increase in field production by reducing the competition for photoassimilates among fruits. The concentration of 21 mg.L^{-1} was the most productive, with 15.97 fruit.plant^{-1}.

Key words: flowering, gibberellin, phloem, reproductive structures.

ABSTRACT

Aplicação de GA_3 e anelamento de ramos na produção de frutos extemporâneos de limeiras ácidas 'Tahiti'

Objetivou-se, neste trabalho, avaliar os efeitos do anelamento de ramos e da aplicação de GA_3, ainda na florada da safra principal, sobre a formação de estruturas reprodutivas, o pegamento e a produção de frutos da florada subsequente, extemporânea, de limeira ácida 'Tahiti'. Utilizou-se o delineamento experimental em blocos casualizados, com cinco repetições, em esquema fatorial 4 x 3. O primeiro fator foi a aplicação foliar de GA_3, 88 dias antes da florada extemporânea, nas concentrações (0, 7, 14 e 21 mg.L^{-1}). O segundo fator foram as épocas de anelamento, 108 dias antes do início do florescimento (A108AF), 78 dias antes do florescimento (A78AF), mais a testemunha, sem anelamento (SA). Na florada extemporânea, as proporções de botões florais, flores e frutos que sofreram abscisão foram de 38,75; 31,25 e 18,64%, respectivamente, e foram colhidas 11,34% de todas as estruturas reprodutivas formadas. O GA_3 não alterou o pegamento. O anelamento aumentou o pegamento dos frutos em 229 e 256%, aos A108DAF e A78DAF, respectivamente, em relação às plantas SA. O GA_3 reduziu a formação de estruturas florais, fato que propiciou aumento, de forma quadrática, da produção, por reduzir a concorrência por fotoassimilados entre os frutos, sendo a concentração de 21 mg.L^{-1} a mais produtiva, com 15,97 frutos.planta^{-1}.

Palavras-chave: giberelina, floração, estruturas reprodutivas, floema.

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INTRODUCTION

The flowering of *Citrus* reaches over 100,000 flowers per plant (Agusti *et al*., 1982), which becomes often excessive and damages the production, since less than 5% of this high production will be harvested (Pereira *et al*., 2011). The acid lime 'Tahiti', seedless variety, presents a more pronounced fruit abscission than cultivars with seeds. The fruit set in this variety is only 1.85% of September flowering and 0.46% of extemporaneous flowering (Spósito & Mourão Filho, 2003).

Despite being valued in the out of season fruit market, its production is almost impossible, mainly because of the large abscission of flowers in the extemporaneous flowering. The acid lime 'Tahiti' is a classic example. By presenting much crop seasonality and abscission of reproductive structures, any gain of fruit set and second flowering production, called extemporaneous, is of fundamental importance for farmers (Rufini *et al*., 2008).

One of the practices that can be used to increase production and fruit set is the girdling, whose function is to promote accumulation of carbohydrates in the aerial parts of plants (Rivas *et al.*, 2006), by increasing the content of starch in the leaves (Pereira *et al*., 2011), which increases the activity of genes that will play roles in the synthesis of enzymes responsible for the availability of soluble sugars in leaves (Li *et al*., 2003).

The use of bio-regulators is another way of interfering in the production. One of the best known bio-regulator is gibberellic acid, which can be used as flowering inhibitor, in the most favorable time for the flowering, reducing the number of flowers.plant^{-1}, but increasing fruit set and fruit production by increasing the supply/drain relationship aiming at higher extemporaneous fruit yield (Serciloto *et al.*, 2003).

Exogenous application of GA_3 can reduce the excess of flower formation, generating better balance between the number of flowers and the carbohydrates in the plant, increasing the percentage of fruit set per plant, therefore the production of citrus in various flowerings (Maia *et al*., 2010).

Thus, the objective of this study was to evaluate the effects of girdling of branches and application of GA_3 at flowering of the main crop, on the fruit set and on production of fruits from the subsequent and extemporaneous flowering of 'Tahiti' acid lime.

MATERIAL AND METHODS

The experiment was carried out in the Fruit Division (Setor de Fruticultura) of the Federal University of Viçosa (UFV) - Viçosa, from the flowering onset in September 2007 to the end of the harvest in late June, 2008.

'Tahiti' lime trees [*Citrus latifolia* (Yu. Tanaka) Tanaka], grafted on Rangpur lime (*C. limonia* Osbeck) were used in the experiment. The trees were planted at a 5-m spacing between rows and 2.5 m between plants, not irrigated, at eight years old. In 2005, a drastic pruning was carried out so the trees presented canopy in growth stage.

A split fertilization was used, following recommendations of the Committee on Soil Fertility of Minas Gerais (1999).

The experimental design was a randomized block design with five replications in a 4 x 3 factorial. The first factor was the leaf application of GA_3, on September 13th, 2007, 88 days before the extemporaneous flowering at four concentrations (0, 7, 14 and 21 mg L^{-1}). The second factor was the two girdling times. The first was carried out 108 days before flowering onset (A108AF), on August 21st, 2007, and the second, 78 days before flowering (A78AF), on September 21st, 2007, plus the control treatment with no girdling (NG).

Spray solution of GA_3 was prepared and applied on the same day (09/13/2007) and consisted of GA_3, water and a silicone glue spreader. The application of GA_3 was performed when about 80% of the normal blossom petals had suffered abscission, 88 days before extemporaneous blooming.

Girdlings were performed at 15 cm above the grafting point, breaking up the phloem at its entire circumference, removing portions of the peel with 5 mm of width.

Abscission of reproductive structures, the fruit set and fruit production were all evaluated.

To determine the abscission of reproductive structures, "Clarité" type nets were placed under the canopy of plants and, the reproductive structures were collected every 15 days, counted and classified into flower buds, flowers and fruits

Extemporaneous fruits were harvested weekly from late April to late June, when the fruits had light-green color and smooth peel, a characteristic of fruit with juice content higher than 40% (Gayet *et al.*, 1995).

Data were submitted to analysis of variance. For qualitative factors, the means were compared using the Turkey's test at 5% probability. As to the quantitative factor, models have been chosen based on the significance of the regression coefficients using the "t" test at 5% of probability of determination; in the value of r^2 (SQRegression/ SQtreatments) and at the model potential to explain the biological phenomenon.

RESULTS AND DISCUSSION

Plants in A78DAF treatment were the most productive, reaching 15.45 fruits per plant^{-1}, 35.27% more than the plants of the NG control, which produced

10.00 fruits per plant^{-1}. The A108DAF treatment plants have intermediate production, 11.05 fruits/plant, 9.5% more than NG and 28.48% less than A78 DAF plants.

The application of GA3 increased in a quadratic manner the production of 'Tahiti' acid lime plants. The highest number of harvested fruits occurred with the concentration of 21 mg.L^{-1}, with 15.97 fruits. Plant^{-1}, 62.3% more than the control, which produced 6.02 fruits per plant^{-1} (Figure 1b).

The highest abscission of reproductive structures occurred at the stage of flower buds, representing 38.75% of all the structures formed. Flowers in anthesis corresponded to 31.25% and the fruits, to 18.64% of all abscission that occurred at extemporaneous flowering (Figure 2). Probably, this result is due to the lower connection between the structures and the plant at flowering onset. After all, it is known that the partition of nutrients and photoassimilates is made in the direction from the source to the drain and the drains regarded as the "strongest" or greater are those which display preferential flow in the plant. (Guedes *et al*., 2008).

Fruit set was not influenced by the application of GA_3. The A108DAF and A78DAF treatments increased fruit set by 229% and 256%, respectively, compared to NG, reaching values of 19.45% and 21.73% of fruit set, respectively, while NG plants had a fruit set of 8.48%. This result is due to the fact that, although the girdling had been performed still in the crop season, its effect lasted until the extemporaneous harvest, blocking the transport of photoassimilates through the phloem, from the aerial part to the roots, paralyzing the vegetative growth of plants (Pereira *et al*., 2010) and the reserves in the aerial part, as a consequence. Therefore, abscission of flower structures was reduced (Mehouachi *et al*., 2009; Pereira *et al*., 2011).

A reduction in fruit abscission was found with the application of GA_3 (Figure 3). At every 1 mg.L^{-1} of bio-regulator added to the spray volume, there was a reduction of 1.64 fruits per planta^{-1} in abscission. This phenomenon occurred due to the effect that the GA_3 has on the flowering, which is in agreement with the results of Maia *et al*. (2010) in a study conducted with

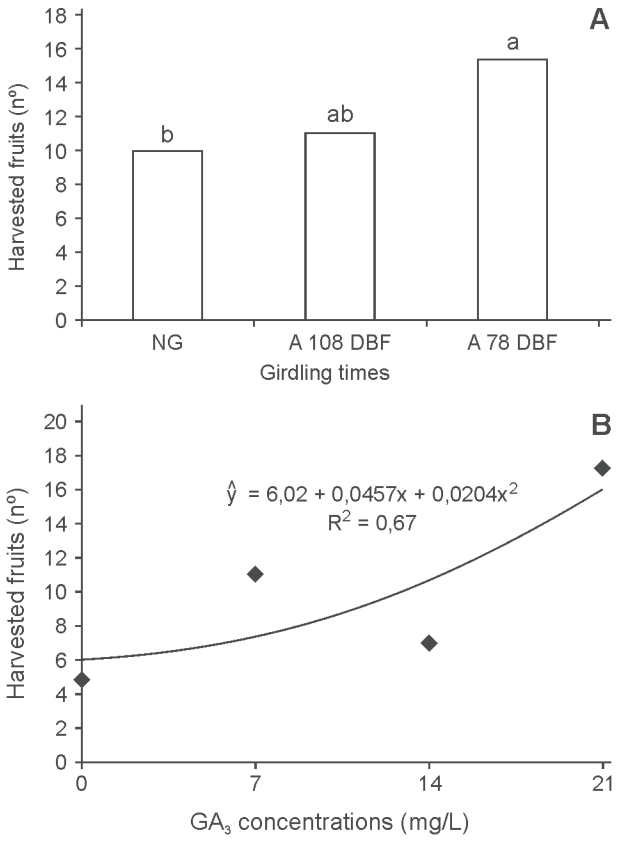

Figure 1. a) Number of fruits harvested in extemporaneous flowering, with no girdling (NG), girdling at 108 days before flowering and A108 DBF and girdling 78 days before flowering. Means followed by the same letters do not differ by the Tuckey's test at 5% of probability. b) Number of fruits harvested in extemporaneous flowering, in function of four GA_3 concentrations (0, 7, 14 and 21 mg/L).

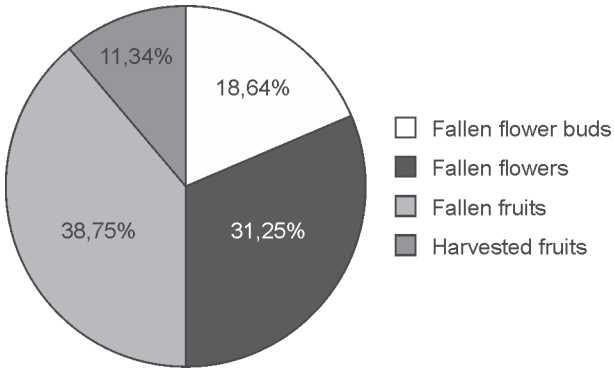

Figure 2. Percentage of reproductive structures that suffered abscission and harvested fruits, in the extemporaneous flowering and in the no-girdling control treatment.

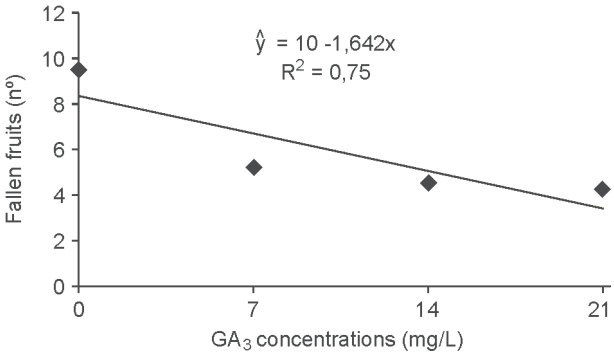

Figure 3. Number of 'Tahiti' acid lime fruits abscised in the 2008 extemporaneous flowering, in function of four concentrations of GA_3(0, 7, 14 and 21 mg/L).

Ponkã tangerine trees (*Citrus reticulata* Blanco). The authors stated that the regulator reduces excessive flowering and may reduce the effect of production alternance, generating higher productivity, over the years of the tangerine trees.

The formation of 133.9 reproductive structures per plant was found in NG treatments, a value higher than those of A78DAF and A108DAF treatments, with means of 86.8 and 82.6, respectively (Figure 4a). However, this increased amount of reproductive structures did not mean greater fruit set or production and what occurred was just the opposite (Figures 1a and 5). This was due to the greater flower set of the regular crop flowering, which reduced the number of branches available for extemporaneous blossoms. Therefore, fewer flowers were formed in the subsequent flowering, the extemporaneous (Medina *et al*., 2005). Nevertheless, even with fewer flowers, girdling reduced the abscission even in that flowering (Figure 5).

For the application of GA_3, the higher the concentration, the smaller the number of total reproductive structures formed (Figure 4b). The

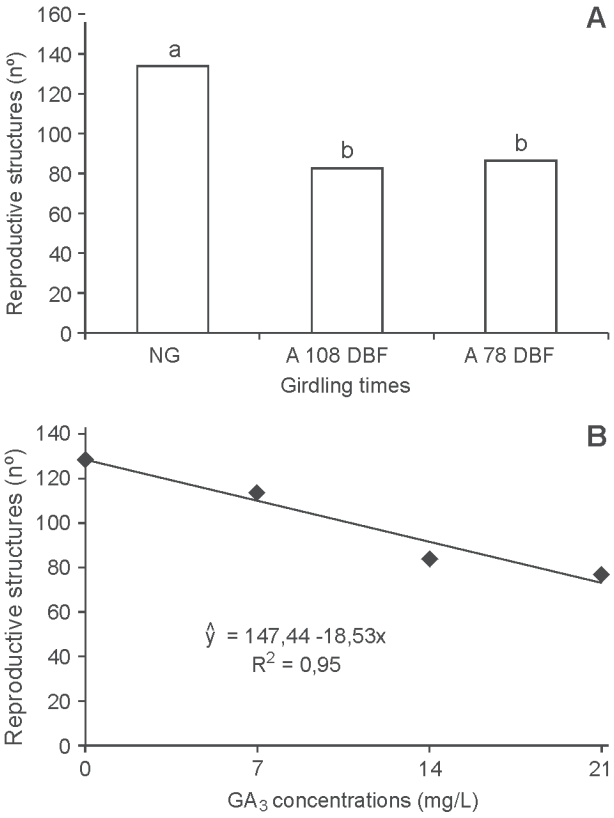

Figure 4. A) Reproductive structures of 'Tahiti' acid lime formed in 2008 extemporaneous bloom with no girdling (NG), girdling at 108 days before flowering and A108 DBF and girdling at 78 days before flowering. Means followed by the same letters do not differ by the Tukey's test at 5% of probability. B) Number of fruits harvested in extemporaneous flowering with four concentrations of GA_3 (0, 7, 14 and 21 mg/L).

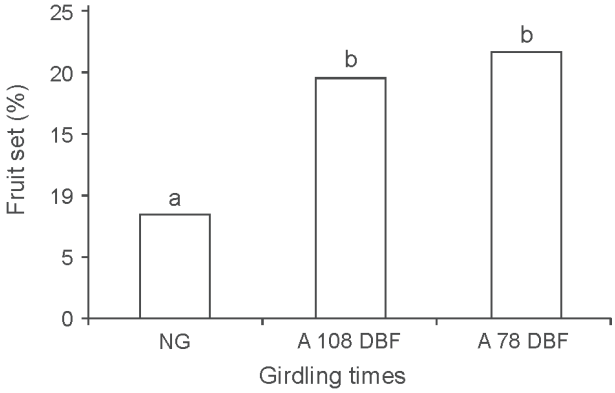

Figure 5. 'Tahiti' acid lime fruit set in 2008 extemporaneous bloom 2008 in treatments with no girdling (NG), girdling at flowering (GAF) and girdling one month after flowering (AMAF). Means followed by the same letters do not differ by the Tukey's test at 5% of probability.

formation of 77 structures was found at a concentration of 21 $mg.L^{-1}$; 84.53 formed structures at 14 $mg.L^{-1}$; 113.87 at 7 $mg.L^{-1}$ and 129 reproductive structures at 0 $mg.L^{-1}$. Thus, this result is corroborating with earlier studies that indicated that the inhibitory effect of GA_3 on the flower differentiation, preventing, or decreasing the production of flowers (Maia *et al*., 2010). With the application of GA_3, the plant decreased the intake of assimilates involved in flowering (Serciloto *et al*., 2003), increasing the supply of carbohydrates to the fruits (Pereira *et al*., 2011).

CONCLUSIONS

The GA_3 increased production in a quadratic manner. The largest number of harvested fruits occurred with the concentration of 21 $mg.L^{-1}$.

The GA_3 reduces fruit abscission; however, it did not affect the fruit set.

Girdling increased extemporaneous fruit set. The plants girdled 78 days before flowering were the most productive.

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