Colegio de Postgraduados

Effect of branch girdling on the alternate bearing, yield, and fruit quality of grapefruit (*Citrus paradisi* Macf.)

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ABSTRACT

Objective: The objective of this research was to evaluate the effect of girdling branches, application of gibberellic acid (GA_3), and foliar urea on the alternating yield and quality of grapefruit (*Citrus paradisi* Macf) fruits.

Design/methodology/approach: The experiment was carried out on trees during abundant harvest ("on" year) and trees with low harvest ("off" year). Foliar applications of GA_3 and foliar urea were performed with a manual sprayer at a rate of 7 L tree^{-1} of solution. Branch girdling (5.0 mm wide) was performed on two-thirds of the secondary branches using a circular-edged knife to avoid damaging the xylem. The experimental design was completely randomized, with 24 factorial arrangements with 16 treatments and 3 repetitions. Each experimental unit was a tree to evaluate fruit yield and quality at the experiment's conclusion.

Results: Branch girdling increased the diameter, the number of fruits, the yield, and the °Brix-Acidity ratio of the juice. Foliar urea applications increased the percentage of juice but delayed ripening. The combination of branch girdling plus foliar urea applications increased fruit weight. The yield increase was attributed to the number of fruits rather than their weight. The treatments did not reduce alternate bearing.

Limitations on study/implications: The commercial cultivation areas for the experiment were limited due to the availability of facilities for testing fruit quality.

Findings/conclusions: To increase the size and number of fruits, with an increase in yield, branch girdling is an effective option. Furthermore, the application of foliar urea increases the percentage of juice and fruit weight, with a slight delay in maduration. However, the treatments did not reduce alternate bearing. Future research is required with other grapefruit varieties at different application times.

Keywords: alternate bearing, GA_3, carbohydrates, grapefruit, foliar urea.

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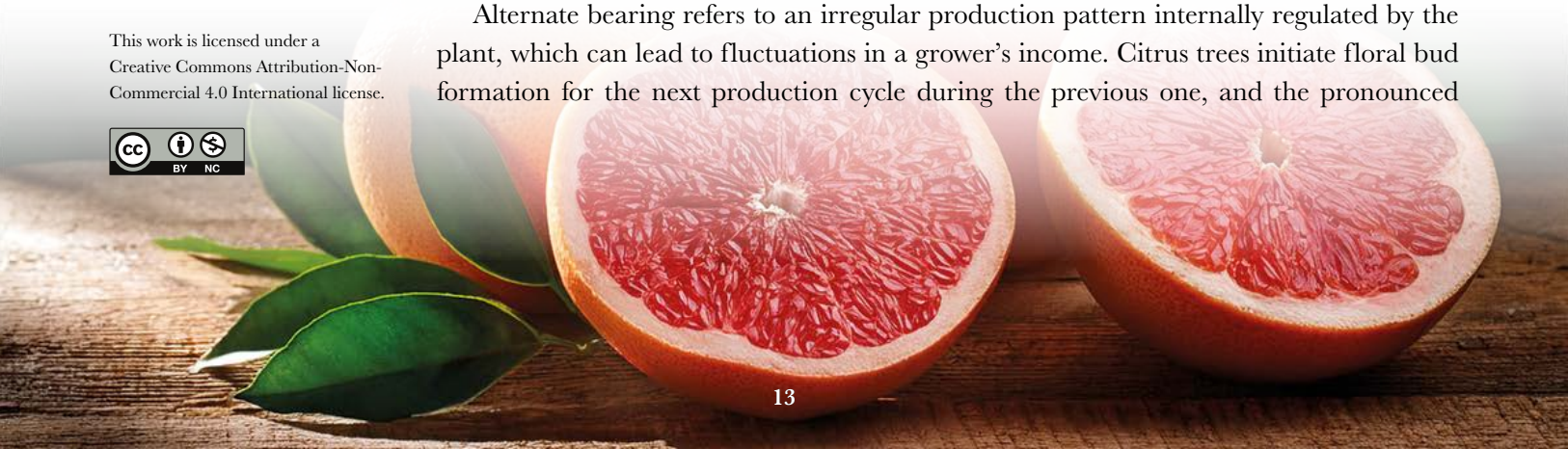
INTRODUCTION

Alternate bearing refers to an irregular production pattern internally regulated by the plant, which can lead to fluctuations in a grower's income. Citrus trees initiate floral bud formation for the next production cycle during the previous one, and the pronounced



alternation between high ("on") and low ("off") harvests is caused by competition between the current crop's production and the floral buds for the next season's harvest. The Rio Red grapefruit variety is highly susceptible to alternate bearing, which may present two consecutive "on" years followed by a low-yield harvest, or occasionally two "off" years followed by one "on" year (Martínez *et al.*, 2012).

Branch girdling or scoring is a technique to increase carbohydrate concentrations in developing fruits while reducing alternate bearing. The changes caused in the endogenous balance of carbohydrates and mineral elements are considered the primary effect of girdling, which aids in fruit set and development (Rivas *et al.*, 2010). A study conducted by Ambriz *et al.* (2018) reported that pruning combined with the application of urea and girdling in September resulted in increased sprouting, flowering, fruit set, as well as higher yield and quality of Persian lime during the winter, compared to the control group. Similarly, Almaguer-Vargas *et al.* (2011) observed an increase in floral differentiation, flowering, and fruit number through the application of pruning, foliar urea, and foliar fertilization in Persian lime. Gaete *et al.* (2007) found an increase in the sugar-acidity ratio by scoring branches in Clementine (*Citrus clementina* Blanco).

The application of foliar urea (0.5% N) in the fall-winter months increased flowering and production in oranges (Albrigo, 1999) and clementines (El-Otmani *et al.*, 1998). In "Washington Navel," it increased fruit set, yield, total fruit number, and the number of commercially sized fruits over three consecutive years, two of which were "on" years and one "off" year (Ali and Lovatt, 1994). During the winter dormancy period, the combined use of gibberellic acid (GA3, at 20-30 ppm) before the flowering of an "on" year and foliar urea (0.5% N) before the flowering of an "off" year can be employed. Both treatments are a good package to partially reduce the effects of alternate bearing (Galván *et al.*, 2006). Agustí *et al.* (1992) performed branch girdling on "Navelate" sweet orange, reporting a 30% increase in the number of harvested fruits and up to 130% in "Clementine" mandarins, increasing yield per hectare. Benhamou *et al.* (2004) observed good control of alternate bearing in "Nour" clementines with the combined application of GA_3 and foliar urea in consecutive "on" and "off" years, respectively. Currently, there is no available information on the effect of branch girdling, GA_3, and foliar urea on grapefruit yield and fruit quality, so research is needed to generate knowledge on this topic.

MATERIALS AND METHODS

The study was conducted in a grapefruit (*Citrus paradisi* Macf) orchard of the Rio Red variety, grafted onto sour orange rootstock (*Citrus aurantium* L.), located at the "Las Anácuas" estate in the municipality of General Terán, Nuevo León, Mexico. The experiment was carried out on trees with abundant harvest ("on" year) and trees with scarce harvest ("off" year). The experimental design used was completely randomized with a 2^4 factorial arrangement with 16 treatments (Table 1) and 3 replications.

The experimental unit was a tree to evaluate fruit yield and quality at the end of the experiment. Healthy trees with full competition were selected. Sample analyses and data collection were carried out at the Faculty of Agronomy in the Campus of Agricultural Sciences at Autonomous University of Nuevo León (UANL).

Table 1. Description of the treatments.

Treatments	Description
1	Tree "on" Without application (control).
2	Tree "on" foliar urea 25 daa, 1 kg 100 L^{-1} of water.
3	Tree "on" GA, 25 daa at 25 ppm.
4	Tree "on" foliar urea 25 daa, 1 kg 100 L^{-1}+GA , 25 daa at 25 ppm.
5	Tree "on" branch girdling, 25 dba.
6	Tree "on" branch girdling, 25 dba+foliar urea, 25 daa, 1 kg 100 L^{-1}.
7	Tree "on" branch girdling, 25 dba+GA , 25 daa at 25 ppm.
8	Tree "on" branch girdling, 25 dba+foliar urea, 25 daa, 1 kg 100 L^{-1}+GA, 25 daa at 25 ppm.
9	Tree "off" Without application (control).
10	Tree "off" foliar urea, 25 daa, 1 kg 100 L^{-1}
11	Tree "off" GA, 25 daa at 25 ppm.
12	Tree "off" foliar urea 25 daa, 1 kg 100 L^{-1}+GA , 25 daa at 25 ppm.
13	Tree "off" branch girdling, 25 dba.
14	Tree "off" branch girdling, 25 dba+foliar urea, 25 daa, 1 kg 100 L^{-1}
15	Tree "off" branch girdling, 25 dba+GA , 25 daa at 25 ppm.
16	Tree "off" branch girdling, 25 dba+foliar urea, 25 daa, 1 kg 100 L^{-1}+GA, 25 daa at 25 ppm.

"on" tree: Tree with abundant harvest. "off" tree: Tree with scarce harvest. dba: Days before anthesis. daa: Days after anthesis. ppm: Parts per million. GA_3: Gibberellic acid.

Foliar applications of GA_3 and foliar urea were carried out with a manual sprayer at a rate of 7 L $tree^{-1}$ of solution. Branch girdling (5.0 mm wide) was performed on two-thirds of the secondary branches using a circular-edged knife to avoid damaging the xylem.

For the analysis of variance, the SPSS (Statistical Package for the Social Sciences) software was used, and for the comparison of means of the variables under study, the experimental designs package, version 1.0 from the Faculty of Agronomy, UANL, was used. Marín N.L. developed by Olivares (1994). The least significant difference (LSD) test ($p \leq 0.05$) was used for the comparison of mean values. The variables measured were diameter (mm), number and weight (g) of fruits, percentage of juice, °Brix-$Acidity^{-1}$ ratio, and yield (t ha^{-1}).

RESULTS AND DISCUSSION

Fruit Diameter (mm)

Girdling increased fruit diameter in "off" trees, while it had no effect on "on" trees (Figure 1). Branch girdling in trees with low harvest increases fruit diameter due to the low competition among fruits, as these are trees with scarce harvest, and due to the redistribution of carbohydrates in the fruits, like what was reported by Martínez *et al.* (2012).

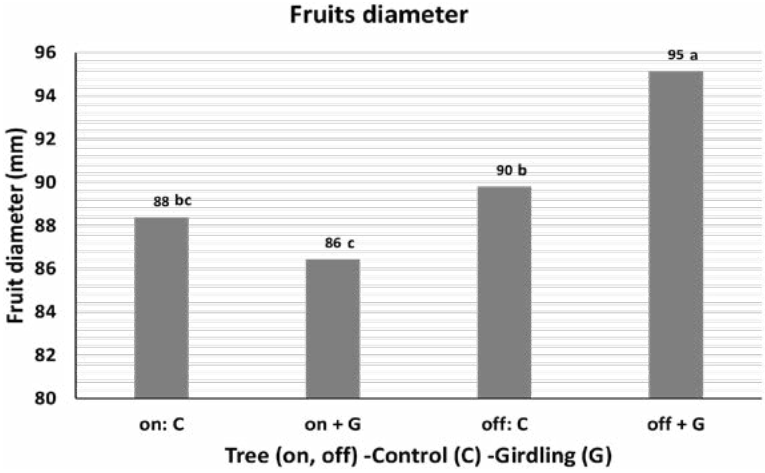


Figure 1. Comparison of means (LSD $p \leq 0.05$) of fruit diameter (mm) in trees with abundant ("on") and scarce ("off") harvest, without (Control: C) and with girdling (G), for the 2014-2015 cycle. Letters that are the same are statistically similar.

Number of fruits

Branch girdling increased the number of fruits (Figure 2), similar to what was reported by Goldschmidt (1999) and Rivas *et al.* (2010). Additionally, there is evidence that girdling has a hormonal effect, increasing GA levels (Mehouachi *et al.*, 2009), altering the GA/ABA ratio and preventing fruit abscission. The girdling treatment was statistically similar to the GA_3 treatment.

Fruit Weight (g)

The treatment with girdling plus urea behaved statistically similarly to the control and differently from the treatments with girdling alone and with only urea application

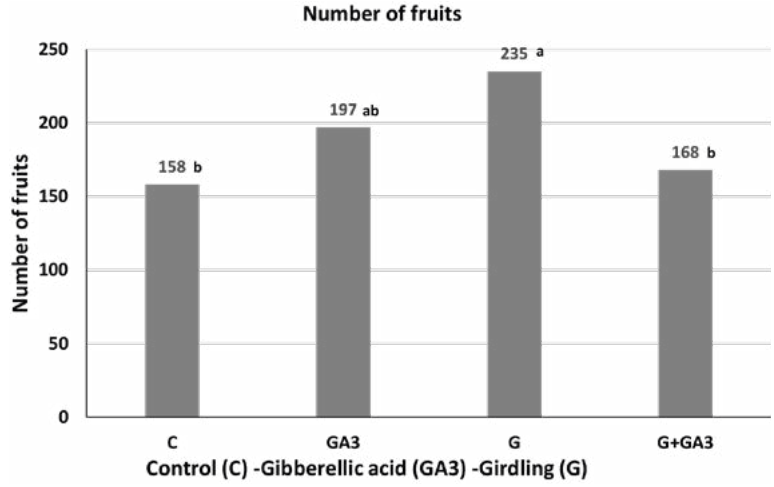


Figure 2. Mean comparison (LSD $p \leq 0.05$) of the number of fruits in trees without application (Control: C), with gibberellic acid (GA_3), and trees with girdling (G), for the 2014-2015 cycle. Letters that are the same are statistically similar.

(Figure 3), with the latter having the lowest fruit weight. The increase in yield is due to the higher number of fruits rather than their individual weight, like the results reported by Martínez *et al.* (2012).

Juice percentage in fruits (%)

Trees that received urea application had a higher juice percentage in fruits but delayed their maturation, possibly due to the nitrogen content in the foliar urea (Figure 4).

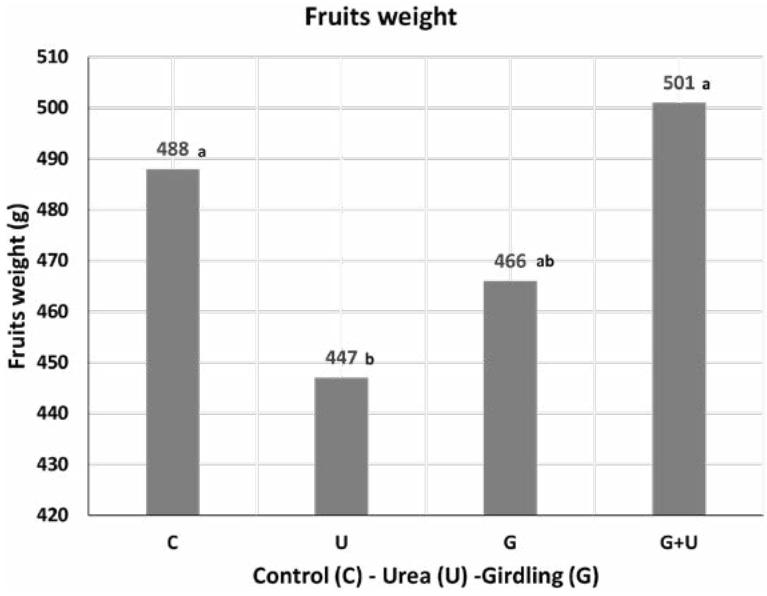


Figure 3. Comparison of means (LSD p≤0.05) of fruit weight (g) in trees without application (Control: C), with urea application (U), and trees with girdling (G), for the 2014-2015 cycle. Letters that are the same are statistically similar.

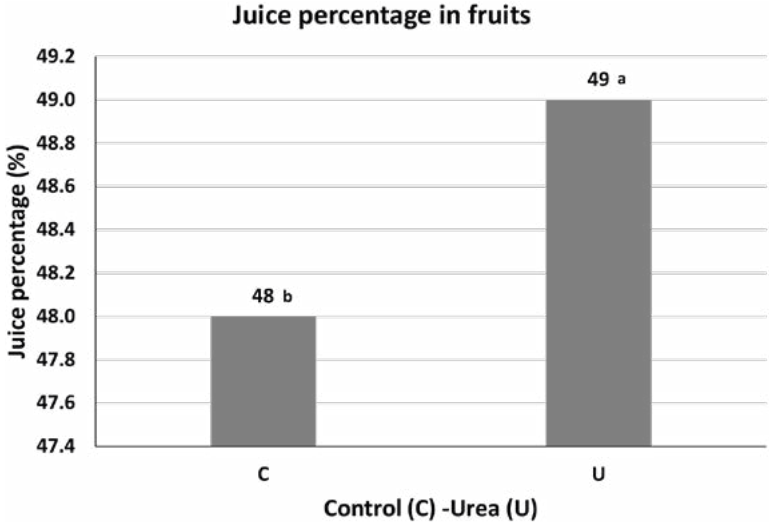


Figure 4. Comparison of means (LSD p≤0.05) of juice percentage in fruits (%), in trees without urea application (Control: C) and trees with urea application (U), for the 2014-2015 cycle. Letters that are the same are statistically similar.

°Brix-Acidity Ratio of the juice

Trees that were only girdled showed a higher °Brix-Acidity ratio (Figure 5), which is consistent with the findings reported by Gaete *et al.* (2007) in "Clementines," where it was mentioned that branch girdling increased this ratio. Additionally, Mehouachi *et al.* (2009) have reported that girdling in citrus increases the carbohydrate concentration in fruits, resulting in earlier maturation.

Yield (t ha^{-1})

The girdling treatment showed the highest yield (tons per hectare), although it was statistically similar to the GA_3 treatment (Figure 6). On the other hand, the control group

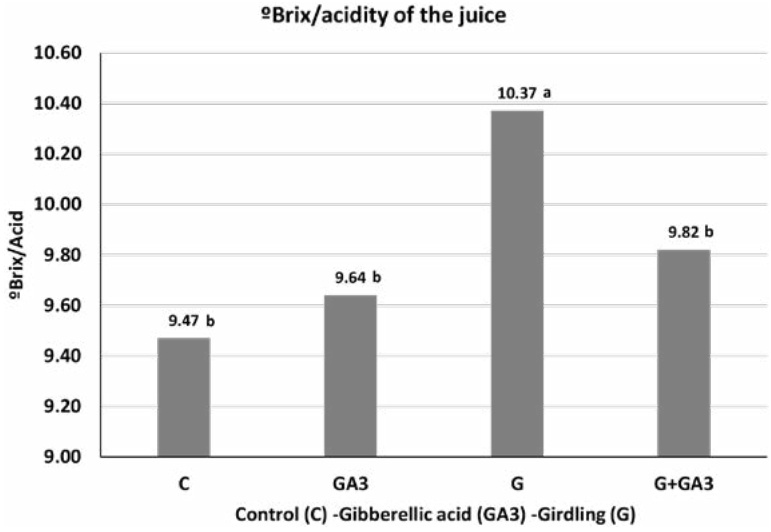


Figure 5. Comparison of means (LSD p≤0.05) of the °Brix-Acidity ratio of the juice, in control trees (T), with gibberellic acid (GA_3), and girdling (A) for the 2014-2015 cycle. Letters that are the same are statistically similar.

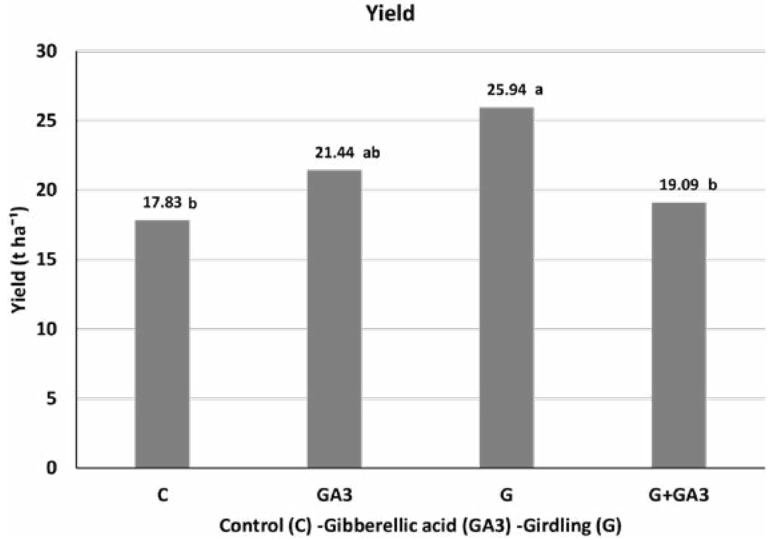


Figure 6. Comparison of means (DMS p≤0.05) of yield (t ha^{-1}) in trees with no application (Control: C), with gibberellic acid (GA_3), and with girdling (G), for the 2014-2015 cycle. Identical letters indicate statistically similar results.

had the lowest yield (tons per hectare). This result agrees with Rivas *et al.* (2010), who report that branch girdling and GA_3 application in citrus positively affect the relationship between gibberellins and abscisic acid, thereby promoting fruit setting. Consequently, an increase in yield was observed due to a higher number of harvested fruits rather than an increase in their individual weight.

CONCLUSION

To increase fruit size and number, and subsequently improve yield, branch girdling is a good option. Additionally, the application of foliar urea increases both the juice percentage and fruit weight, although with a slight delay in ripening. The treatments did not reduce harvest alternation. Future research is needed with other grapefruit varieties and different application timings.

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