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CROP PRODUCTION

Chemical thinning of flowers and fruits of the peach cultivar Coral with hydrogen cyanamide

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ABSTRACT: *Chemical treatment is a mean to accomplish fruit thinning; although its efficiency depends on the compound used, application time, and dosage. Effect of the chemical hydrogen cyanamide (CH_2N_2) on the thinning of flowers and fruits of the peach cultivar Coral was assessed in this study. Treatments consisted of five doses of CH_2N_2 (0, 0.2, 0.4, 0.6, and 0.8%) spray application to the point of run-off, at two stages (50% and 100% flowering). The experiment was conducted in a completely randomized design with six replicates and one plant per plot. The following parameters were assessed: percentage of flowers thinned at 25 days after spraying, percentage of fruits thinned, fruiting index, production per plant, fruit mass, diameter and length, flesh firmness, soluble solids (SS) and titratable acidity (TA). Concentrations of 0.6 and 0.8% CH_2N_2 application at 50% flowering resulted in thinning 84.4 and 84.7% of the flowers and 0.4% CH_2N_2 at 100% flowering thinned 87.3%, values close to index assessed in manual thinning (88.0%) experiments. The highest production per plant was recorded for treatments with CH_2N_2 application at 50% flowering, resulting from a high percentage of flowers opening after spraying the chemical thinner. As such, flowers opening late were not affected by the chemical, thereby ensuring a higher fruiting index. Peach yield with 50% CH_2N_2 was not significantly different from yield observed for manual treatment, and 0.6% spray was reported to be the optimal dosage. Treatment with 0.6% CH_2N_2 application at 50% flowering was not significantly qualitatively different from manual thinning. CH_2N_2 application is efficient for the thinning of 'Coral' peach flowers and fruits.*

Key words: *Prunus persica, phytoregulators, fruit size, production.*

Raleio químico de flores e frutos de pessegueiro cultivar Coral com cianamida hidrogenada

RESUMO: *O tratamento químico consiste numa ferramenta para raleio de frutos, porém sua eficiência depende do produto, época de aplicação e concentração a ser empregado. Avaliou-se a cianamida hidrogenada (CH_2N_2) no raleio químico de flores e frutos de pessegueiro cv. Coral. Os tratamentos consistiram na aplicação de cinco doses de CH_2N_2 (0; 0,2; 0,4; 0,6 e 0,8%), por pulverização até o ponto de escorrimento, em duas épocas (50% e 100% da floração). O experimento foi realizado em delineamento inteiramente casualizado, com seis repetições e uma planta por parcela. Avaliaram-se: % de flores raleadas aos 25 dias após a pulverização, % de frutos raleados, índice de frutificação, produção por planta, massa, diâmetro e comprimento de fruto, firmeza de polpa, SST e AT. As concentrações 0,6 e 0,8% de CH_2N_2 a 50% de floração ralearam 84,4 e 84,7% das flores e a 0,4% de CH_2N_2 a 100% de floração raleou 87,3%, valores aproximados ao índice obtido no raleio manual (88,0%). A maior produção por planta ocorreu nos tratamentos com CH_2N_2 a 50% de floração, decorrente do elevado percentual de flores abertas após a pulverização do raleante químico, as quais não foram atingidas pelo produto, garantindo maior índice de frutificação. A produção com CH_2N_2 a 50% não diferiu estatisticamente do tratamento manual, sendo 0,6% a dosagem que conferiu valores absolutos superiores. O tratamento 0,6% de CH_2N_2 a 50% de floração não diferiu estatisticamente em termos qualitativos do tratamento raleio manual. A aplicação de CH_2N_2 apresenta-se eficiente no raleio de flores e frutos de pessegueiro 'Coral'.*

Palavras-chave: *Prunus persica, fitoreguladores, tamanho de fruto, produção.*

INTRODUCTION

The peach crop is of great national and global importance. In Brazil, it is grown for fresh fruits for consumption, and industrial processing (RASEIRA et al., 2014). The main peach-producing Brazilian states are: Rio Grande do Sul (RS), São Paulo (SP), Minas Gerais (MG), Paraná (PR) and Santa Catarina (SC), accounting for 65.1, 14.0, 11.8, 7.5 and 1.6% of the total production, respectively (FACHINELLO et al., 2011). In RS, growing peach offers social and economic benefits to many small farmers, generating a total production of 128,924tons from 12,574ha of harvested area, with a mean yield of

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10.253ton ha^{-1} (IBGE, 2017), and predominantly with cultivars suited for the dual purposes and processing.

Several factors affect yield and quality of peach fruit, such as genetic material used and crop management practices adopted in the orchard, including pruning, fertilization, phytosanitary treatments, and thinning (RASEIRA et al., 2014). For both fresh market and processing cultivars, excessive fruit load is a major problem resulting in poor-quality production and damage to trees (TURK et al., 2014). Thinning technique aims to remove excess fruitlets from the trees to increase the fruit size, color and quality. Thinning also helps to minimize or eliminate alternate bearing and branch breaking, while decreasing the number of defective fruits and minimizing harvesting costs (GIOVANAZ et al., 2016). SOUZA et al. (2013, 2017) reported that some peach cultivars develop alternate production, with variable yield over consecutive years, which may be minimized by adopting methods that regulate the fruit load of peach trees.

Fruit thinning may be performed manually or chemically (COSTA & VIZZOTTO, 2000). Manual thinning of peach trees is performed 40 to 60 days after full flowering, when the fruits are approximately 1.5-2cm diameter in size (MEITEI et al., 2013). The intensity of the thinning varies according to the vigor of the branch, maintaining a distance of approximately 8 to 12cm between fruits in vigorous branches and 12 to 15cm in less vigorous branches (RASEIRA et al., 2014). Manual fruit thinning is a time-consuming and expensive operation, requiring excessive labor within a short period of time (VEGO et al., 2010; TAHERI et al., 2012).

Chemical treatment is a key tool to streamline and reduce the operational costs of implementing thinning practice. In studies conducted in Marli, Redhaven, Flavorcrest, Eldorado and Diamante peach cultivars, the viability of using hydrogen cyanamide as a dormancy-breaking chemical and flower bud thinner was investigated (MARODIN et al., 1994; FALLAHI, 1997; FALLAHI et al., 1998; RODRIGUES et al., 1999; COUTINHO, 2001). From several reports, it is clear that the choice of product, season of application, concentration, environmental conditions, and cultivar are crucial for the success of this practice. Chemicals often used as thinners are: ammonium thiosulfate, ethephon, fertilizers (urea), surfactants Armothin and Tergitol-TMN-6, caustic agents, endothalic acid, pelargonic acid, hydrogen cyanamide, lime sulfur and mineral oil (TURK et al., 2014).

In this study we tested different concentrations and timing of application of hydrogen cyanamide (CH_2N_2) for flower and fruit thinning, and production of the peach cultivar Coral.

MATERIALS AND METHODS

A peach tree orchard of the cultivar Coral belonging to Fepagro Serra, in Veranópolis-RS was selected for the study. The orchard is located at 28º56'14" South, 51º33'11" West and at an altitude of 705m. The average annual temperature and rainfall of the orchard are 17.5ºC and 1,630mm, respectively. Sum of cold hours (CH) ≤7.2°C ranges from 400 to 600. Peach trees of cultivar Coral, with 8 years old, were planted in the field, were 8 years of age, grafted onto Capdeboscq, managed in apot system, and spaced 6.0m between rows and 4.0m between plants.

Treatments consisted of spraying 0.2, 0.4, 0.6, and 0.8% CH_2N_2 either at the phenological stage of 50% flowering, which occurred on 08/05/14 or 100% flowering that occurred on 08/14/14. The chemical product was top-sprayed to the run-off point using a backpack sprayer with a broth volume of 1.5L per plant. The experiment included a manual thinning treatment, applied as the fruits reached 1.5-2cm diameter, as recommended for peach crop (RASEIRA et al., 2014), and a control treatment (tree without thinning). The experiment was conducted in a completely randomized designed with six replicates and one plant per plot. No products were applied to break dormancy.

Orchard phenology was monitored according to a scale proposed by RASEIRA et al. (2014), considering the beginning of budding; initiation, full bloom, and end of flowering; and the beginning and end of harvest. The following variables were analyzed: i) percentage of thinned flowers, comparing the number of flowers or small fruits with the initial flower count; ii) number of thinned fruits, comparing the number of fruits picked with the number of fruits obtained in the control treatment (reference), and iii) fruit index, comparing the number of fruits picked with the initial number of total flower buds. The evaluations were performed on the 25th day after applying the CH_2N_2 and / or during the harvest, from three branches marked per plant.

The production per plant, in kg, mean fruit mass, in grams, (using an electronic balance), mean fruit length and diameter, in cm, (using a caliper), flesh firmness, in kilograms, (using an 8-mm tip penetrometer, measuring the equatorial region of the fruit), soluble solids (SS), in °Brix (using a manual refractometer) and titratable acidity (TA), in cmol L^{-1} (volumetry with 0.1N NaOH) were also assessed at harvest. Quantitative and qualitative production variables were analyzed by analysis of variance (ANOVA) and using the Tukey's test at $P<0.05$.

RESULTS AND DISCUSSION

Coral peach tree cultivar exhibited an intermediate phenological cycle. In the 2014/2015 harvest, the bloom occurred on 08/03, reaching full flowering (80% total open flowers) on 08/12 and ending on 08/28. Fruit development occurred from 08/29 to 11/27. The harvest began from 11/27 and continued until 12/08. Such findings corroborated with reports by RASEIRA et al. (2014), who discussed the occurrence of full flowering stage in 'Coral' during the second half of August and harvest occurring during the first ten days in December, specifically for South-Brazilian conditions. SIMONETTO et al. (1995), studied 'Coral' from 1987 to 1995, and described that flowering (from beginning to end) occurred from 08/10 to 09/04 and harvest (from beginning to end) from 12/02 to 12/13; specifically, in the municipality of Veranópolis-RS, which match well with those observed in the present study.

The percentage of flower thinning varied according to the treatment. In the control treatment that had noCH_2N_2 application, the percentage of natural fall of flowers was 72.7% (Figure 1A). In manual thinning

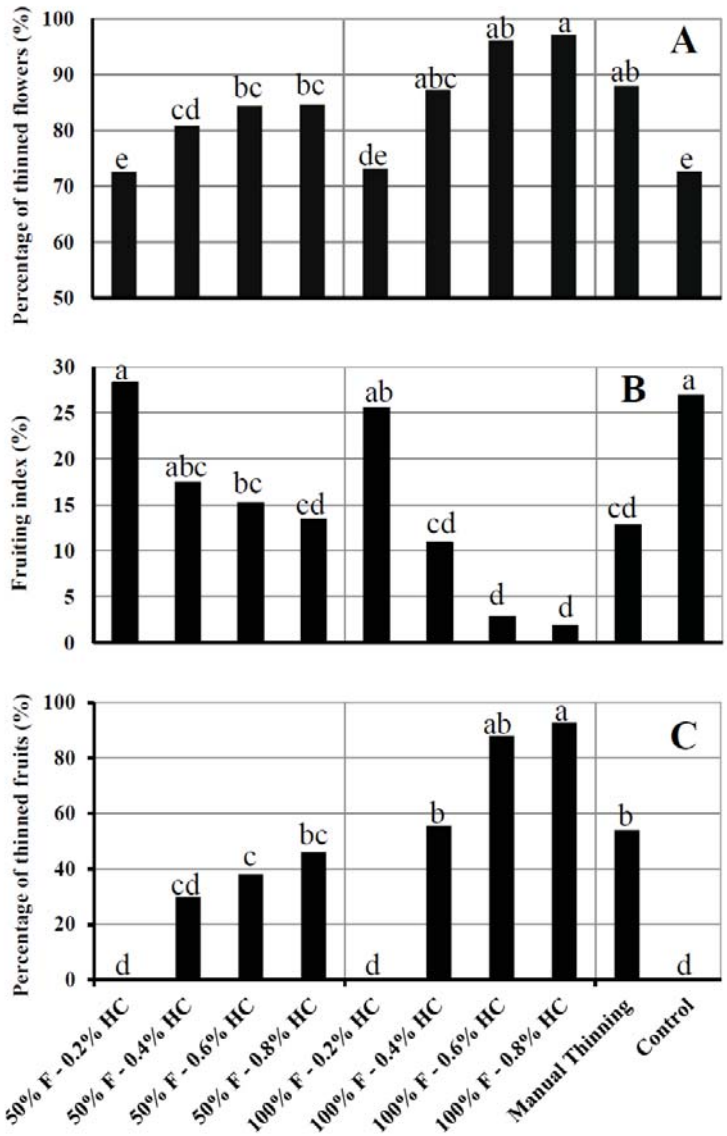

Figure 1 - Percentage of thinned flowers (A), fruiting index (B) and percentage of thinned fruits (C) of the peach cultivar Coral after application of hydrogen cyanamide (HC), at 50% or 100% of flowering (F). Means followed by the same letter do not differ by Tukey's test at 5% probability. Veranópolis, RS, 2015.

treatment, used as management reference, flower fall was slightly higher (88%), impacted by manual thinning. Percentage of thinned flowers in the manual thinning treatment was calculated by subtracting the total number of flowers of the treatment by its fruit index. As a result, the percentage of thinned flowers increased with increase in the concentration of CH_2N_2, reaching values ranging from 72.6 to 84.7% when spraying was carried out at the phenological stage of 50% flowering and from 73.3 to 97.65% when applied at the 100% flowering stage (Figure 1A). Application of CH_2N_2 caused a lower, similar, or higher flower thinning than manual thinning treatment, depending on the treatment dosage and timing of application. When using CH_2N_2 as a chemical thinner in the peach cultivar 'Diamante', COUTINHO (2001) suggested that the product must be carefully used - such that when a large number of flowers are open, a lower concentration must be used. The concentrations of 0.6 and 0.8% CH_2N_2 at 50% flowering resulted in thinning 84.4 and 84.7% of the flowers, while 0.4% CH_2N_2 at 100% flowering thinned 87.3%. These values are similar to those from manual thinning (88.0%, Figure 1A), which emerged as one of the effective thinning treatments. Concentration of 0.2% CH_2N_2 was ineffective, resulting in 72.6 and 73.3% flower fall when applied at 50 and 100% flowering, respectively, in a response similar to the control treatment.

Fruit index of 'Coral' was 26.9% in the control treatment, corresponding to the natural fruit setting (Figure 1B). In an ideal harvest, the fruiting index should be close to that of the manual thinning, which reached 12.8% to produce fruits with adequate mass and quality. Increase in flower fall assessed with the increase in CH_2N_2dose consequently resulted in a lower fruit index. Treatments with fruit index similar to that of manual thinning (12.8%) were 0.6 and 0.8% CH_2N_2application at 50% flowering and 0.4% CH_2N_2 application at 100% flowering, with percentages of 15.2, 13.4 and 10.9%, respectively (Figure 1B). FALLAHI et al. (1998) and RODRIGUES et al. (1999) reported that increasing the CH_2N_2 concentration increases flower thinning and decreases the fruit index, and our findings are in line with those previously reported. A lower fruit index at 0.6 and 0.8% CH_2N_2 application at 100% flowering is a result of the high dose when a large number of flowers are open and perhaps thinned by the chemical. LUCCHESE et al. (1994), when studying the efficiency of chemical thinners found that by applying CH_2N_2 and mineral oil seven days prior to full-bloom reduced fruiting in relation to another application that was performed 12 days before full-bloom. Fruit thinning results showed that manual thinning treatment caused 54.9% of fruit drop (Figure 1C). Treatments most similar to manual thinning were 0.4% CH_2N_2 application at 100% flowering (57.9% flower drop), followed by 0.6 and 0.8% CH_2N_2 application at 50% flowering, with 37.5 and 41.9% fruit fall, respectively.

Typically, with higher production per plant, the fruit size, mass, length and diameter tend to be smaller irrespective of treatments (Figure 2), except for manual thinning, which resulted in higher yield and quality fruits. This can be attributed to fruit selection and maintaining uniform space between the branches post-thinning. The highest production per plant was observed in treatments with CH_2N_2 applied at 50% flowering (Figure 2A). This results from the presence of a high percentage of open flowers after spraying the chemical thinner (approximately 50%), which was not covered by the product, thus ensuring a higher fruit index and production. When the product was applied at 100% flowering, the production was lower because the product covered all flowers and caused changes. In the treatment with 0.2% CH_2N_2, regardless of the season of application, production was steady, probably by the limited action of the chemical resulting in no thinning. Based on the results, we proposed that the product CH_2N_2 should be applied as a thinner at 50% flowering stage because a significant yield reduction may occur if applied at 100% flowering. Additionally, chemical thinning in flowers should be performed early on a lower number of open flowers because the unopened flowers can compensate and ensure adequate fruit production.

The production with CH_2N_2 at 50% flowering was not significantly different from the manual thinning treatment. A 0.6% CH_2N_2 dose provided the highest absolute values (Figure 2A). Fruit mass and size were slightly lower in the treatment with CH_2N_2 applications at 50% flowering than in the manual thinning treatment (Figures 2B, 2C and 2D), which could be explained by the optimal position for fruits due to manual thinning and their previous selection. However, it should be noted that the chemical treatment may be complemented by the manual thinning practice to favor production of larger fruits.

In studies using CH_2N_2 for peach flower thinning, the mean fruit mass also increased with the CH_2N_2 concentration, confirming that the increase in CH_2N_2 dose resulted in a stronger thinning effect, lower production, and larger fruits (MARODIN et al., 1994; FALLAHI, 1997; RODRIGUES et al., 1999; COUTINHO, 2001). The lower number of fruits in the plant enables production of fruits with a higher mean mass due to the increased availability and allocation of nutrients to each fruiting organ (GIOVANAZ et al., 2016). VEGO et al. (2010) reported that a decrease in the number of fruits reduced competition for carbohydrates, thereby,

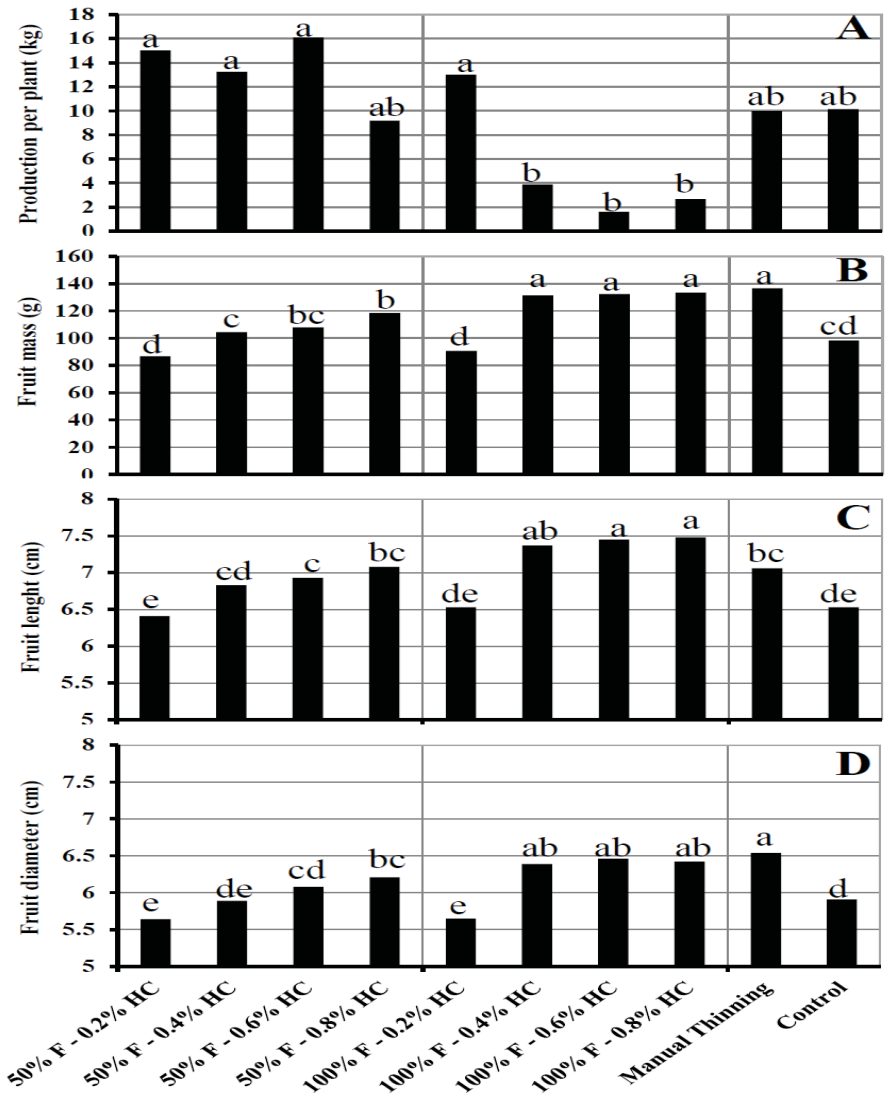

Figure 2 - Production per plant (A), fruit mass (B), fruit lenght (C) and fruit diameter (D) of the peach cultivar Coral after application of hydrogen cyanamide (HC), at 50% or 100% of flowering (F). Means followed by the same letter do not differ by Tukey's test at 5% probability. Veranópolis, RS, 2015.

improving the distribution of assimilates resulting in fruits with larger mass, diameter, and length. In the manual thinning treatment, it is possible to select remaining fruits and provide optimal conditions that can generate larger fruits, even with a good fruit load in the plant.

GREENE & COSTA (2013) reported that the thinning intensity should be decided based on the needs. For example, if the goal is to pick fruits with a larger caliber, the thinning practice should be more intense. As the practice is intensified, fruit quality improves, and conversely decreases the total production. SIMONETTO et al. (1995) reported that the 'Coral' produces peach fruits with a mean mass of 103g when manual thinning method was followed. RASEIRA et al. (2014) classified the fruit of 'Coral' as average-sized, weighing from 90 to 110g. In the present study, the mean mass obtained in the treatment with 0.6% CH_2N_2 application at 50% flowering resulted in fruits with a mass of 108g, and was equal to or greater than that described in the literature, which appears to be an acceptable fruit size considering the chemical thinner application.

The analysis of SS and AT showed a decrease in the content of soluble solids and an increase in titratable acidity in the treatments with the highest yield (Figure 3). Treatment with 0.6% CH_2N_2

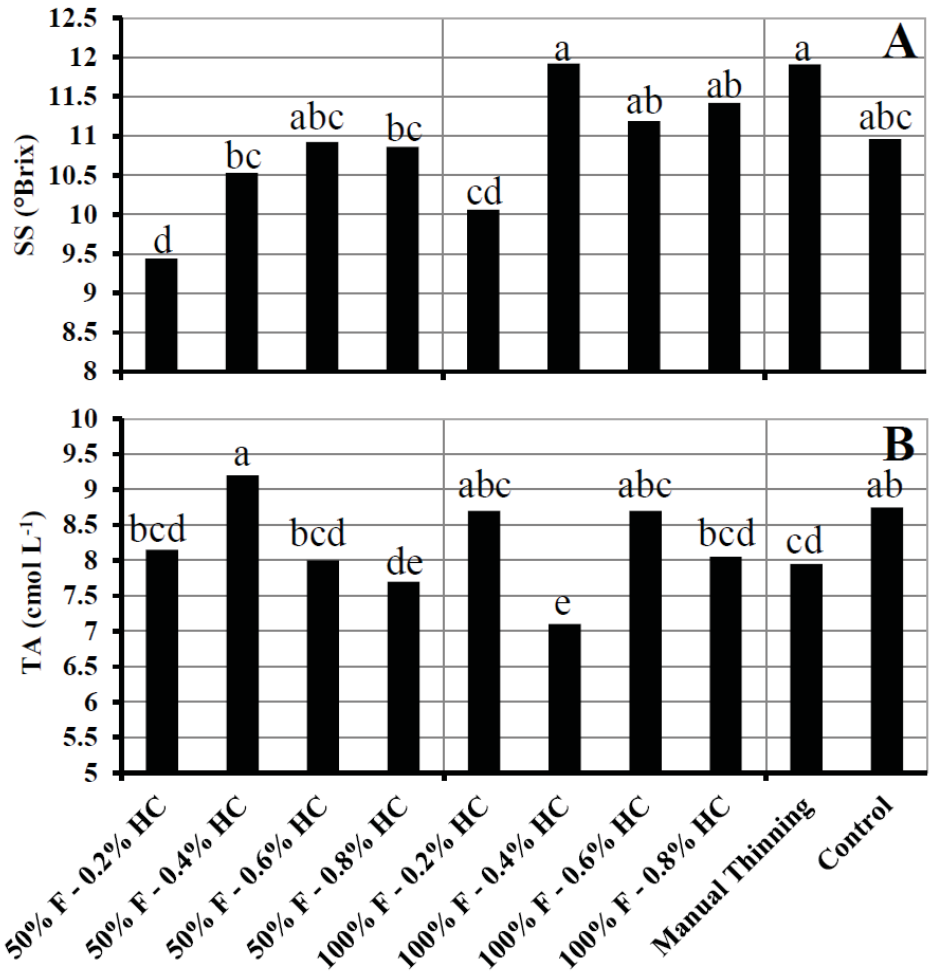

Figure 3 - Soluble solids - SS (A) and titratable acidity (TA) (B) of peach fruits cultivar Coral after application of hydrogen cyanamide (HC), at 50 or 100% of flowering (F). Means followed by the same letter do not differ by Tukey's test at 5%probability. Veranópolis, RS, 2015.

application at 50% flowering was not significantly different from manual thinning when considered qualitatively. RASEIRA et al. (2014) reported that 'Coral' fruits have a sweet taste and mild astringency. No differences in flesh firmness were observed between the treatments tested (data not shown). LUCCHESE et al. (1994) and TAHERI et al. (2012) also reported no effect of ethephon on fruit flesh firmness when applied as a fruit thinner to the BR1 and Redhaven peach cultivars, respectively.

CONCLUSION

CH_2N_2 application is effective for chemical thinning of peach flowers and fruits. CH_2N_2 should be used during early bloom (50% flowering) to ensure adequate production. The concentration of 0.6% CH_2N_2 is effective in thinning of peach flowers and fruits, specifically when applied at 50% flowering stage. The fruit load (production) of the plant directly affects the physico-chemical characteristics of fruits.

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