Production and quality of Sweet Grape tomato in response to foliar calcium fertilization[1]

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ABSTRACT

In tomato, foliar application of calcium-based nutrient solutions is used to complement soil fertilization. However, knowledge regarding the factors that influence the effectiveness of foliar fertilizer applications remains incomplete. The objective of this study was to evaluate the efficiency of foliar fertilization with calcium for improving production and quality of hydroponic Sweet Grape tomatoes. An experiment was conducted in a commercial hydroponic system in a split-split-plot scheme, with two calcium doses: 1,5 and 3 mmol L^{-1} of Ca. The solutions were sprayed on the leaves at intervals of 7 and 14 days, using commercial foliar fertilizers containing 0.3 g L^{-1} of calcium chloride or calcium acetate. The results indicate that the foliar application of calcium fertilizers, regardless of the amount of calcium provided in the nutrient solution and the frequency of applications, positively affects fruit production and quality. No difference was found between the effects of application of the two calcium sources, as well as the frequency of application.

Keywords: *Solanum lycopersicum*; supplementation; shelf-life.

INTRODUCTION

The rise in demand for tomatoes led to an increase in the world production by about 54% between 2000 and 2014 (FAO, 2017). To meet the growing demand, new high-quality and highly productive cultivars, requiring more intensive input use, have been developed.

Calcium (Ca) is an essential nutrient required for high yields (Hocking *et al.,* 2016) and, due to its important role, it is one of the most studied nutrients in tomato crop (De Freitas *et al.,* 2012). Ca acts directly on the fruit set flower number, is important in the activation and hormonal and enzymatic regulation, participates in the movement of water in and out of cells, and in cell structure and division, especially in the shoot and root apexes (Taiz *et al.,* 2017). Ca is also a quality determinant in tomato fruits. The adequate supply of the nutrient increases its firmness and prevent possible production losses due to blossom-end rot (Sturião *et al.*, 2020; Hagassou *et al.*, 2019).

Ca deficiency may occur in some parts of the plant even when is sufficient in the rhizosphere because of its low redistribution by the phloem. The movement of Ca in the plant is closely related with the water movement in the xylem, in the transpiration stream, resulting in a preferential distribution to tissues with high transpiration rates such as old leaves (Hocking *et al*., 2016).

In tomato, the high demand for Ca at the flowering and fruiting stages is met by spraying Ca-based solutions on flowers and fruits, in order to complement the soil fertilization (Coolong *et al*., 2014). In commercial crops, the cultivar Sweet Grape produces an average of 30 flowers per cluster (Heath, 2012) and is conducted with two or more stems, which further increases the number of flowers and fruits in the reproductive phase.

The use of foliar fertilization has been intensified in recent years (Fernández *et al*., 2015), as well as the availability of commercial formulations, although there are

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few controlled studies confirming the effectiveness of foliar applications of macronutrients to icrease their tissue contents during certain phases of development (Hahn *et al*., 2017). The nutrient source of foliar fertilizers can affect the efficiency and potential of the technology, since each product's performance will be, in part, determined by its physical-chemical properties, like to: water solubility, particle size, pH, deliquescence point, volatility, ionic charge and hygroscopicity (Fernández *et al*., 2015).

The spray intervals can also affect the efficiency of foliar fertilization, depending on the movement characteristics of the studied nutrient in the phloem, and the degree of the plant starvation, as well as the its phenological and physiological stage. Features related to the genotype such as growth rate and morphological characteristics of the leaves could also interfere in the plant response to foliar sprays (Fernández *et al*., 2015). Due to the low Ca flow to flowers and fruits of tomato, it is generally recommended making several leaf sprays with Ca during the production cycle (Becker *et al*., 2016; Fernández *et al*., 2015; Zamban *et al*., 2018)

The objective of this study was to evaluate the efficiency of Ca-based commercial foliar fertilizers over the production and quality of hydroponically grown Sweet Grape tomatoes, subjected to two calcium doses in the nutrient solution.

MATERIAL AND METHODS

The study was carried out from September to December, 2016 in the Agronomy Department of the Universidade Federal de Viçosa (UFV), Viçosa, Minas Gerais, Brazil (20° 45' 14" S, 42° 52' 55"; 650 m altitude), in a glass-covered greenhouse, with a 2.4-meter-tall ceiling, and side vents with anti-aphid screen in the openings. Figure 1 shows the maximum, minimum and mean temperatures recorded in the greenhouse during the experimental period.

Seedlings of Sweet Grape tomato (Heath, 2012) were produced in a commercial nursery (Agro Mudas) located in the municipality of Pará de Minas, Minas Gerais. Seeds were sown in 128-cell expanded polystyrene trays containing coconut fiber as a substrate. From 14 until 39 days after emergence the propagation trays were kept in the green house to acclimate the plants to this environment. Forty days after sowing, the seedlings, with four pairs of leaves completely expanded were transplanted into 8 L containers filled with coconut fiber (Golden Mix®): pH: 6,0±0,5; electric conductivity: 0,6±0,3; density 85 $kg.m^{-3}$; water holding capacity 55%. The plants were spaced 0.5 m between plants and 1.0 m whitin rows (2 plants/m^2), tied with string, conducted with two stems, and terminal buds pruned when each plant had three leaves above the sixth floral cluster. Pruning was carried out over the experiment to remove suckers.

The experiment was arranged in a randomized block design, and split-split-plot scheme with one plant per parcel and four replications per treatment. Ca doses in the nutrient solution (3 mmol L^{-1} – sufficient; 1.5 mmol L^{-1} - insufficient) performed the main plots. Ca sources for foliar sprays composed the sub-plots. As Ca source we have used the following compounds: calcium chloride, with 26% Ca content; 1.4 $g.cm^{-3}$ density at 20 °C; pH: 6.9; 100% solubility in water; and calcium acetate with 18% Ca content; 1.16 $g.cm^{-3}$ density at 20 °C; pH: 5.2; 100% solubility in water. Deionized water was used as the control treatment. Finally, the frequencies of application of the foliar fertilizers (at every 7 or 14 days) were allocated to the sub-sub-subplots, resulting 12 treatments and 48 experimental units.

The foliar sprays started from the beginning of flowering (22 DAT) and ended in the final week of the experimental period (112 DAT), totaling 6 and 12 applications over the experimental period for the application frequencies of 7 and 14 days, respectively.

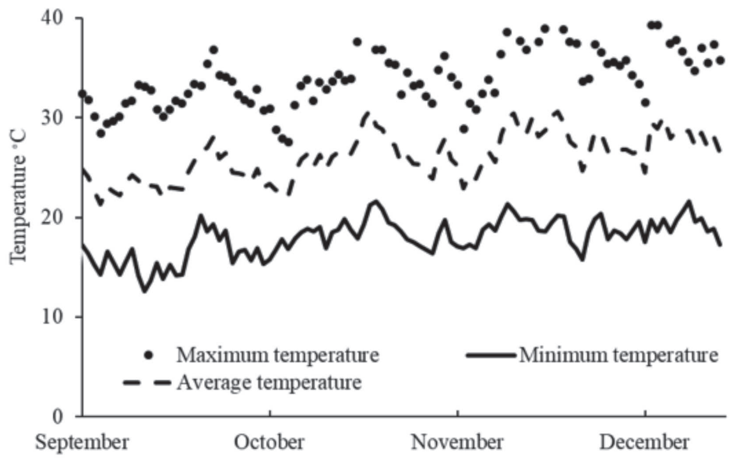

Figure 1: Maximum, minimum and mean temperatures recorded in the greenhouse during the experimental period.

The amounts of foliar fertilizers applied to the plants were calculated according to the doses and volume of solution recommended by the manufacturer. Each plant received 0.3 g L^{-1} of both Ca sources and a fixed 50 mL volume of solution per plant at each application. The foliar fertilizations were done early in the morning using a hand sprayer with a full cone nozzle. Plastic curtains were placed between the plants at spraying time to avoid spray drifting to plants that were not part of the treatment.

The nutrient solution was prepared according to Fernandes *et al*. (2002) with modifications: 8; 2; 4; 2; 1; and 1 mmol L^{-1} of N, P, K, Ca, Mg and S, and 50; 20; 7.5; 4; 0.9; and 0.7 µmol L^{-1} of Fe, B, Mn, Zn, Cu, and Mo for the vegetative phase supplied from day 1 to day 21 after transplanting (DAT), and 12; 2; 6; 1.5; and 1.5 mmol L^{-1} of N, P, K, Mg and S and 60; 10; 4; 1.3, and 0.7 µmol L^{-1} of Fe, Mn, Zn, Cu, and Mo for the reproductive phase (22 to 112 DAT). Two doses of Ca^{2+} were used in the reproductive phase as part of the experimental treatments: 3 mmol L^{-1} of Ca^{2+}, according to Fernandes *et al*. (2002) and 1.5 mmol L^{-1} of Ca^{2+} (50% of the recommended dose).

The nutrient solution circulated in the 60 L containers through a 0.25 HP pump system, feeding the irrigation lines. The pumps were controlled by an automatic timer to turn on daily at 6:00 am, 9:00 am, 11:00 am, 12:00 pm, 1:00 pm, 2:00 pm, 3:00 pm and 6:00 pm. The volume of solution applied was 520 mL per minute. From day 1 to day 40 after transplanting (DAT), the pumps were on for 2 min for each irrigation frequency; from day 41 to day 80 DAT, they were on for 3 min; and from day 81 to day 112 DAT for 4 min. The drained nutrient solution was directed back to the containers by gravity through collection pipes fixed below the benches and recirculated into the containers through the pumps.

The pH of the solution was adjusted daily to 5.5-6.5, with HCl or NaOH. Periodic replacement of nutrients was carried out, according to the reduction of electrical conductivity, admitting up to 30% depletion. Between replacements, the volume of the solution was monitored daily and replenished with deionized water, assuming a maximum reduction of 40% of the initial volume.

The phytosanitary management was carried out according to treatments recommended for crops in a protected environment (Rathee *et al*., 2018). When necessary, as a curative strategy we have used THIAMETHOXAM at the rate of 4 g/20 L, ACETAMIPRID at the rate of 5 g/20 L, ABAMECTIN at 15 mL/20 L, and TEFLUBENZURON at 5 mL/20 L for insect pest control, and TEBUCONAZOL at the rate of 20 mL/20 L for disease control.

Harvest was carried out weekly from 60 DAT, collecting ripe fruits only, as described by Heath (2012) for the cultivar Sweet Grape. Afterwards, fruits were counted, weighed, and classified into commercial and non-commercial types according to standards for commercialization determined by Sakata Sudamerica®: commercial fruits weighing 5 to 18 g, without cuticle cracking, and pests, diseases or blossom-end rot (BER). Fruits not fitting these characteristics were non-commercial. Among them, fruits with BER symptoms were counted separately in each plant.

In the fruit quality analysis, 20 commercial ripe fruits of the third and fourth floral clusters of each plant were sampled to determine firmness, soluble solids (SS), and titratable acidity (TA). Firmness was evaluated in 5 fruits using a bench penetrometer with a 4-mm diameter cone tip. A 10 mL fruit pulp sample was extracted to determine the SS content (ºBrix) with a digital refractometer. TA was measured in the pulp diluted in distilled water (1:20) and titrated with a 0.005 mol L^{-1} NaOH solution to achieve pH 8.2.

To assess the nutritional status of plants, the fourth leaf of each stem below the apex (index leaf) was sampled, when the first ripe fruits appeared, at 50 DAT. The sampled leaves were washed in distilled water, and dried in a forced ventilation oven at 65 °C to constant dry mass. At 80 DAT, 6 fruits of the third and fourth floral clusters were sampled. The sampled fruits were washed in distilled water, chopped up, placed in aluminum trays, and dried in an oven at 65 °C to constant mass. Ca contents were determined after the nitric-perchloric digestion of the plant material (Malavolta *et al*., 1997), using atomic absorption spectrophotometry.

The data were submitted to normality (Shapiro-Wilk) and homoscedasticity (Bartlett) tests, followed by variance analysis. When the F-test indicated significant interactions between the factors, the means were compared by the Tukey test at 5% probability, using the R software version 4.0.0 (R Core Team, 2018).

RESULTS AND DISCUSSION

Foliar fertilization with calcium chloride ($CaCl_2$) and calcium acetate $Ca(C_2H_3O_2)_2$ increased total production (TP), commercial production (CP), and fruit firmness (FF) (Tables 1 and 2). The increments occurred regardless of the sufficiency or insufficiency of the Ca doses in the nutrient solution (3.0 and 1.5 mmol L^{-1} respectively) and the frequencies of foliar sprays (7 or 14 days), as indicated by the lack of interactions (Table 3). Foliar fertilization with $CaCl_2$ and $Ca(C_2H_3O_2)_2$ reduced the number of fruits with blossom-end rot (NFBER) only in plants conducted with insufficient Ca in the nutrient solution (Table 4), regardless of the frequencies between foliar applications (Table 1 and 3).

A significant reduction was observed in TP, CP, FF, as well as an increase of NFBER when the recommended Ca dose in the nutrient solution was reduced by 50% (Tables 1 and 2), regardless of the two foliar fertilizers and the frequency between their applications (Table 3). These results suggest that the used Ca sources have had similar efficiencies and that the foliar application of Ca is not indicated for supplying the plant's requirement when there is severe Ca shortage in the growing medium, showing that the crop's demand is much greater than the amount that can potentially be supplied via leaf application (Fernández *et al.*, 2015).

No differences were found for fruit production and quality indices by varying the frequency of application of foliar fertilizers (Tables 1, 2 and 3). The results indicate that there is no need to carry out weekly applications of $CaCl_2$ or $Ca(C_2H_3O_2)_2$. In line with this study, Zamban *et al.* (2018) tested two frequencies of application of 0.6 g L^{-1} $CaCl_2$, at 7 or 15 days, on hybrids of the Italian tomato group (San Vito and Neptune), with applications beginning after flowering. They observed that the biweekly application was not different from the weekly application, in relation to the yield and the reduction in the number of fruits with BER.

The present study showed that both foliar fertilizers increased the Ca content of leaves and fruits (FCaC) (Table 1), regardless of the Ca dose used in the nutrient solution and the frequencies between foliar applications (Table 3). Because of being a cheap source of Ca and because there are numerous studies that demonstrate the effectiveness of Ca foliar spraying in tomatoes, $CaCl_2$, is the most used source in foliar fertilizations (Coolong *et al.*, 2014; Rab & Haq, 2012; Plese *et al.*, 1998). No studies were found in

Table 1: Total production (TP), commercial production (CP), mean fruit weight (MFW), number of fruits with blossom-end rot (NFBER), leaf calcium content (LCaC), and fruit calcium content (FCaC) of Sweet Grape tomatoes grown with sufficient or insufficient calcium in the nutrient solution and sprayed with 0.3 g L^{-1} of Ca as calcium chloride ($CaCl_2$) or calcium acetate $Ca(C_2H_3O_2)_2$, in intervals of 7 or 14 days from the flowering on

Treatments	TP	CP	MFW	NFBER	LCaC	FCaC
	g/planta				mg kg^{-1}	
(1) 3 mmol L^{-1} Ca	3179 a	2626 a	10.57 a	0.37 b	0.84 a	10.21 a
1,5 mmol L^{-1} Ca	2815 b	2161 b	10.51 a	6.08 a	0.57 b	6.32 b
CV (%)	5.44	13.20	7.70	25.70	29.56	37.13
(2) Spraying with $CaCl_2$	3102 a	2556 a	10.18 a	2.66 b	0.77 a	9.54 a
Spraying with $Ca(C_2H_3O_2)_2$	3010 a	2455 a	10.40 a	2.38 b	0.73 a	9.24 a
Spraying with water	2819 b	2169 b	10.59 a	4.55 a	0.61 b	6.02 b
CV (%)	6.80	12.46	8.50	19.29	22.80	30.77
(3) Spraying at every 7 days	3005 a	2398 a	10.40 a	3.20 a	0.73 a	8.32 a
Spraying at every 14 days	2988 a	2388 a	10.66 a	3.25 a	0.68 a	8.20 a
CV (%)	7.20	8.90	6.80	11.29	13.37	10.83

Means followed by the same letters are not significantly different by the F test at 5% probability for (1) and (3) and Tukey test at 5% probability for (2); CV = coefficient of variation.

Table 2: Firmness (FF), soluble solids (SS), titratable acidity (TA) and SS/TA ratio of Sweet Grape tomatoes grown with sufficient or insufficient calcium in the nutrient solution and sprayed with 0.3 g L^{-1} of Ca as calcium chloride ($CaCl_2$) or calcium acetate $Ca(C_2H_3O_2)_2$, in intervals of 7 or 14 days from the flowering on

Treatment	FF (N)	S S (ºBrix)	TA (% citric acid)	SS/AT -
(1) 3 mmol L^{-1} Ca	23.3 a	7.5 a	0.5 a	15.0 a
1,5 mmol L^{-1} Ca	19.8 b	7.9 a	0.5 a	15.8 a
CV (%)	9.7	8.7	4.2	7.4
(2) Spraying with $CaCl_2$	22.4 a	7.7 a	0.5 a	15.4 a
Spraying with $Ca(C_2H_3O_2)_2$	22.7 a	7.9 a	0.5 a	15.8 a
Spraying with water	19.5 b	7.5 a	0.5 a	15.0 a
CV (%)	10.6	10.2	4.7	8.2
(3) Spraying at every 7 days	21.9 a	7.7 a	0.5 a	15.4 a
Spraying at every 14 days	21.1 a	7.7 a	0.5 a	15.4 a
CV (%)	8.5	10.2	4.8	8.3

Means followed by the same letters are not significantly different by the F test for (2) at 5% probability and the Tukey test for (1) and (3) at 5% probability; CV = coefficient of variation.

the literature testing the influence of foliar application of $Ca(C_2H_3O_2)_2$ on tomato production, however positive effects of foliar sprays with this source were observed in rice cultivation (Lakaew *et al*., 2020)

Kraemer *et al*. (2009) used scanning electron microscopy and found that apple leaves can absorb Ca applied via foliar spraying in the form of $Ca(C_2H_3O_2)_2$ and $CaCl_2$, at 0,27 g L^{-1} concentration. The same authors noted that the foliar absorption of Ca applied in the form $CaCl_2$ is more efficient because of its lower deliquescence point, which promotes better dissolution and penetration through the cuticle compared with $Ca(C_2H_3O_2)_2$. According to Schönherr (2001) $CaCl_2$ was more efficiently absorbed by apple leaves because of its smaller molecule diameter comparatively to $Ca(C_2H_3O_2)_2$. Our results are in disagreement with this later result, since no differences between the two fertilizers were observed in the increase of Ca contents in tomato leaves and fruits (Table 1). However, our results are in line with the results obtained by Lotze & Tuketti (2014), who used X-ray spectrometry analysis of leaves and quantified Ca in fruits, showing that tomato has the same Ca absorption efficiency to 10 commercial foliar fertilizers of different formulations.

In both, sufficient and insufficient Ca concentration in the nutrient solution, the increments in production due to foliar fertilization were a direct result of the larger number of fruits produced, since the mean weight of the fruits (MFW) was not influenced by the treatments (Table 1). The results obtained in this study are similar to those obtained in the evaluation of Ca foliar fertilization in cherry tomatoes by Rab & Haq (2012). The authors reported that the application of 0.3 g L^{-1} $CaCl_2$ increased the number of fruits per plant in relation to the control and attributed this result to the greater flower survival. In fact the germination of the pollen grain, the development of the pollinic tube, and of the flower ovaries need Ca and B, so that, these nutrients are linked with floral setting. (Lee *et al*., 2009; Malavolta *et al*., 1997).

The increase in the FCaC derived from the application of the two foliar fertilizers (Table 1) resulted in greater fruit firmness (Table 2). These increments occurred regardless of the Ca doses in the nutrient solution) and the frequency between applications, which was confirmed by the lack of the interactions (Table 3). Ca acts on stabilization of the plasma membrane and to strengthen the cell wall through the formation of carboxylic cross-links between pectic acids and polysaccharides (Aghdam *et al*., 2012). Besides, the maintenance of this element in the tissue decreases the activity of pectohydrolytic enzymes, giving greater resistance to fruits for a longer time (Winkler & Knoche, 2019). These functions of Ca justify the results observed and justify the supplementation of Ca by fertilizer sprays.

In agreement with this study, Islam *et al*. (2016) found that the weekly spraying of 2.0 g L^{-1} $CaCl_2$ increased the accumulation of Ca in the fruits and consequently increased firmness, extending the postharvest life of cherry tomatoes. Other studies report the positive influence of $CaCl_2$ application on tomato post-harvest quality due to the greater fruit firmness (Petchhong & Khurnpoon, 2017; Coolong *et al*., 2014; Rab & Haq, 2012). However, no studies were found in the literature evaluating $Ca(C_2H_3O_2)_2$ application in tomato fruit quality. Wojcik & Borowik (2013) found that the application of $Ca(C_2H_3O_2)_2$ increases the firmness of apples.

The application of foliar fertilizers, regardless of the Ca dose in the nutrient solution and the frequencies between applications had no effect on pH, soluble solids content (SS), titratable acidity (AT), and SS/AT ratio of fruits (Table 3). These results are different from the results obtained by Coolong *et al*. (2014), who observed an increase in the SS content of hydroponic tomatoes that received 1.0 g L^{-1} $CaCl_2$. However, they are similar to those obtained by Petchhong & Khurnpoon (2017) and Islam *et al*. (2016), who reported that foliar applications of $CaCl_2$ at 0.5 and 2.0 g L^{-1} on cherry tomatoes have no effect on SS and AT.

Table 3: Indication of test F significance to the effects of the calcium dose in nutrient solution (D - sufficient or insufficient), source of calcium-based foliar fertilizer (CS - calcium chloride or calcium acetate), spraying frequency (F – intervals of 7 or 14 days) and the interactions D x CS, D x F, CS x F and D x CS x F on the production and quality attributes of Sweet Grape tomatoes

	TP[1]	CP[2]	NFW[3]	NFBER[4]	LCaC[5]	FCaC[6]	FF[7]	SS[8]	TA[9]	SS/AT[10]
D	*	*	ns	*	*	*	*	ns	ns	ns
CS	*	*	ns	*	*	*	*	ns	ns	ns
F	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
D x CS	ns	ns	ns	*	ns	ns	ns	ns	ns	ns
D x F	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
AI x F	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
D x CS x F	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

[1] Total production. [2] Commercial production. [3] Mean weight of commercial fruits. [4] Number of fruits with blossom-end rot. [5] Calcium content in leaves. [6] Calcium content in fruits. [7] Fruit firmness. [8] Content of soluble solids in fruits. [9] Titratable acidity. [10] Solids and titratable acidity ratio. * Significant by F test at 5% probability, ns = non-significant.

Plants that received an adequate dose of Ca in the nutrient solution (3 mmol L^{-1}) had a low number of fruits per plant with BER (<1 - Table 1). In turn, plants that received low dose of Ca in nutrient solution (1.5 mmol L^{-1}) showed approximately 6.0 fruits per plant with BER. The fruits of the plants that received 1.5 mmol L^{-1} of Ca in the nutrient solution had FCaC 38% lower than the plants conducted with an adequate dose of Ca in the nutrient solution (Table 1). From the results it is possible to state that, at least in this case, the main reason for BER was the amount of Ca in the fruits, and that the climatic conditions of the greenhouse (Figure 1) had a secondary effect for the appearance of the disturbance in the fruits (Hagassou *et al*., 2019).

The application of Ca foliar sprays in plants Ca-deprived (1.5 mmol L^{-1}) reduced the incidence of NFBER by 49% and 43%, using $CaCl_2$ and $Ca(C_2H_3O_2)_2$, respectively (Table 4). Schmitz-Eiberger *et al*. (2002) cultivated tomatoes with a Ca-deficient nutrient solution and found that the weekly application of 1.2 g L^{-1} $CaCl_2$ reduced the number of fruits with blossom-end rot by approximately 50%.

Comparatively to the plants that received a dose of 100% Ca in the nutrient solution, foliar sprays with Ca-based fertilizers were not capable of reducing the incidence of to blossom-end-rot of plants maintained in Ca deficient medium (Table 4), even with a higher frequency of Ca-based fertilizer sprayings (Tables 1 and 3). These results indicate that foliar application of Ca is not able to completely meet the requirements of the fruits in formation in a nutrient solution with high Ca deficiency, denoting that the demand for Ca is much greater than the amount that would possibly be supplied via leaf application (De Freitas *et al*., 2012). Besides that, foliar sprays with Ca-based fertilizers have shown a limit for efficiency, because Ca seems to have very low capacity of remobilization from the sprayed leaves to the fruits. (Marschner, 2012; Adams, 1999; Lotze *et al*., 2008).

Table 4: Unfolding of the interaction between Ca doses in the nutrient solution (3 mmol L^{-1} and 1.5 mmol L^{-1}) and Ca sources used in the foliar fertilization: 0.3 g L^{-1} Ca as calcium chloride or calcium acetate, or water (control) and their effects on the number of fruits with blossom-end rot

Ca sources	Calcium dose in the nutrient solution	
	1.5 mmol L^{-1} of calcium	3 mmol L^{-1} of calcium
Calcium chloride	4.95 Bb	0.39 Aa
Calcium acetate	4.45 Bb	0.32 Aa
Water	8.70 Ab	0.42 Aa

Means followed by the same letters. capital letters for the effect of Ca sources in foliar fertilization and small letters for Ca doses in the nutrient solution. are not significantly different by the Tukey's test at 5º probability.

CONCLUSIONS

Biweekly leaf sprayings with $CaCl_2$ or $Ca(C_2H_3O_2)_2$, at 0.3 g L^{-1} concentration, increased the Ca content of leaves and fruits, regardless of the Ca dose in the nutrient solution, increasing production and firmness of Sweet Grape tomato.

Weekly or biweekly sprays with $CaCl_2$ or Ca $(C_2H_3O_2)_2$, at a concentration of 0.3 g L^{-1}, are not able to raise the production and firmness of the fruits of plants supplied with an insufficient dose of Ca in the nutrient solution, at the same level of the production and firmness of plants supplied with an ideal dose of Ca in the nutrient solution.

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