Diversitas Journal
ISSN 2525-5215
Volume 9, Issue 3 (jul./sep. 2024) p. 1384 – 1393
https://diversitasjournal.com.br/diversitas_journal

Application of calcium nitrate in the production, rot and firmness of italian zucchini fruits

CARLOS, Roni Peterson[1]; RIBEIRO, Carlos Henrique Milagres[2]; BONIFÁCIO, Thatyelle Cristina[3]; COSTA, Lucas Ferreira[4]

[1] 0000-0002-8360-8665; Agricultural Engineer from the Federal Institute of Education, Science and Technology of Southeast Minas Gerais (IFSEMG) – Barbacena Campus. Brazil, E-mail: ronipeterson95@outlook.com
[2] 0000-0003-0850-4070; Phd student in Agronomy/Phytotechics at the Federal University of Lavras (UFLA). Brazil, E-mail: caarlos_henriquee_8@hotmail.com
[3] 0000-0001-9905-2967; Agricultural Engineer from the Federal Institute of Education, Science and Technology of Southeast Minas Gerais (IFSEMG) – Barbacena Campus. Brazil, E-mail: thaty.cris2013@yahoo.com.br
[4] 0000-0002-3001-023x; Agronomy student at the Federal Institute of Education, Science and Technology of Southeast Minas Gerais (IFSEMG) – Barbacena Campus. Brazil, E-mail: ferreiralucas0720@gmail.com

A B S T R A C T

Italian zucchini, from the Cucurbitaceae family, are a plant of great economic importance for several regions of the country, as they are an excellent source of vitamins and minerals. Because it has a short cycle, zucchini crops are very demanding in nutrients. The objective of this work was to evaluate the effect of foliar application of different concentrations of calcium, using Calcium nitrate (Calcinit®) as a source, on the production, rot and firmness of Italian zucchini fruits. Zucchini seeds of the caserta variety were used and after the plants had developed, foliar applications were carried out in three periods (before flowering, full flowering/beginning of fruiting and at the formation of the first fruits) at different concentrations (0, 3, 6, 9 and 12 g L^{-1}) of calcium nitrate. The number of rotten fruits, production, mass, length, diameter and firmness of the fruits were evaluated. The experimental design was in randomized blocks with 5 different concentrations of calcium nitrate and 5 blocks and each block containing 6 plants. Through the results obtained, it was observed that the foliar application of calcium nitrate does not influence the production, length, mass and diameter of the fruits. Regarding the number of rotten fruits, the application of 3.0 g L1 provides a smaller number of fruits with apical rot, and the application of 9.0 g L1 helps in greater fruit firmness.

RESUMO

A abobrinha italiana, da família das Cucurbitáceas, é uma planta de grande importância econômica para diversas regiões do país, devido apresentarem excelente fonte de vitaminas e minerais. Por apresentar ciclo curto, a cultura da abobrinha é muito exigente em nutrientes. O objetivo deste trabalho foi avaliar o efeito da aplicação via foliar de diferentes concentrações de cálcio tendo como fonte nitrato de Cálcio (Calcinit®), na produção, podridão e firmeza de frutos de abobrinha italiana. Utilizou-se sementes de abobrinha da variedade caserta e após seu desenvolvimento das plantas, foram realizadas aplicações via foliar em três período (antes da floração, plena floração/início da frutificação e na formação dos primeiros frutos) em diferentes concentrações (0, 3, 6, 9 e 12 g L^{-1}) de nitrato de cálcio. Foram avaliados o número de frutos podres, produção, massa, comprimento, diâmetro e firmeza dos frutos. O delineamento experimental foi em blocos casualizados com 5 diferentes concentrações de nitrato de cálcio e 5 blocos e em cada bloco contendo 6 plantas. Por meio dos resultados obtidos, foi observado que a aplicação via foliar de nitrato de cálcio não influencia na produção, comprimento, massa e diâmetro dos frutos. Já no número de frutos podres a aplicação de de 3,0 g L1 proporciona um menor número de frutos com podridão apical, e a aplicação de 9,0 g L1 auxilia em uma maior firmeza dos frutos.

ARTICLE INFORMATION

Article process:
Submitted: 10/26/2023
Approved: 07/10/2024
Published: 07/20/2024

Keywords:
Cucurbita Pepo, texture, mineral fertilizer

Palavras-chave:
Cucurbita Pepo, textura, adubação mineral

DOI: 10.48017/dj.v9i3.2933

Introduction

The Italian zucchini (Cucurbita pepo L.), also known as bush squash or marrow, belongs to the Cucurbitaceae family and is of American origin. It is a vegetable widely used in human nutrition because its fruits are sources of nutrients such as niacin and B-complex vitamins (Oliveira *et al.*, 2022). One advantage of its cultivation is that the plant adapts to different climatic conditions, making it one of the 10 vegetables with the highest economic value and domestic production (Coelho *et al.*, 2020). However, variations in the production of Italian zucchini fruits may occur due to fertilization and plant nutrition (Pôrto *et al.*, 2012), necessitating studies on the influence of macronutrients on the plant.

Studies on the nutrient absorption pattern of Italian zucchini have found that calcium is the second most absorbed nutrient by the plants in large quantities (Araújo *et al.*, 2015). Proper calcium fertilization is extremely important as it plays roles from cell elongation and multiplication to root growth, providing resistance to the plant. It can be applied pre-harvest and post-harvest, leading to firmer fruits, reducing physiological disorders, and preventing blossom-end rot (Kumar *et al.*, 2017).

Calcium is one of the elements with low mobility within the plant, where its deficiency manifests in younger leaves, causing chlorosis, reduction, and twisting of young leaves, as well as affecting root development, hindering nutrient absorption (Coelho *et al.*, 2020). In some cases, this necessitates the use of fertilizers through fertigation and foliar application to correct possible deficiencies in initial soil fertilization, as well as to physiologically stimulate certain stages of the crop, thereby improving the quality of vegetable products (Luz *et al.*, 2010).

Although there are fertilization recommendations for the commercial cultivation of zucchini, research studies relating the effects of foliar calcium application on yield improvement, as well as on fruit firmness and reduction of rot, are scarce.

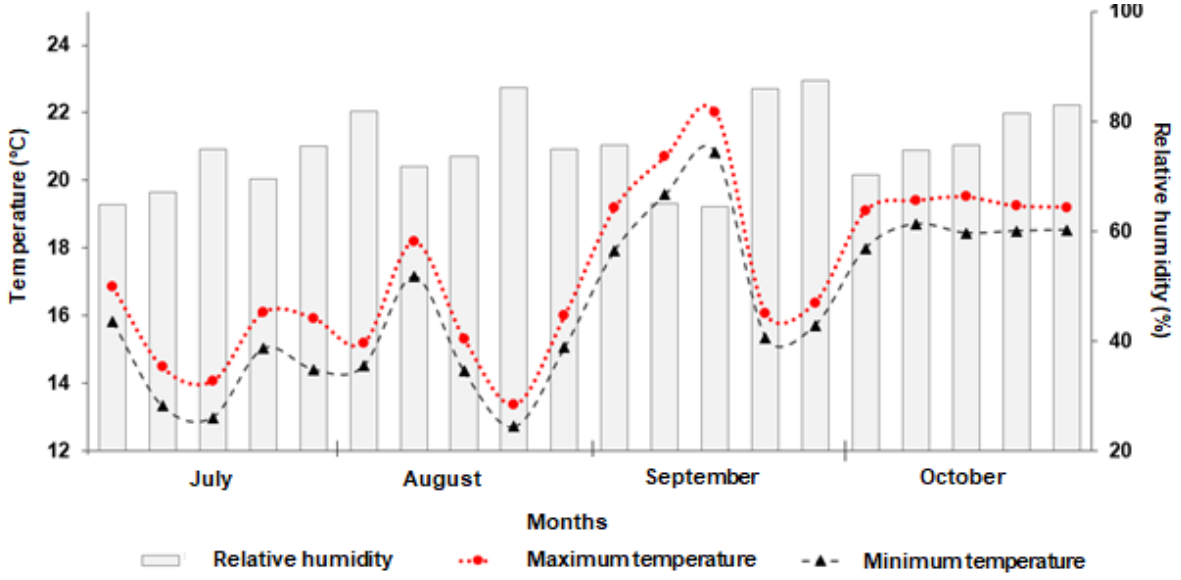
In this context, the objective of this study was to evaluate the effect of foliar application of different calcium concentrations, using calcium nitrate (Calcinit®) (26.5% calcium oxide), on the yield, firmness, and blossom-end rot of Italian zucchini fruits.

Materials e Methods

The experiment was conducted in the municipality of Barbacena, Minas Gerais (21º 22' 64" S, 43º 77' 42" W, altitude 1173 m). The climate, according to the Köppen classification of type Cwb, is a subtropical highland climate with a dry winter and mild summer. The climatic data for the experimental period are shown in Figure 1.

Figure 1.

Meteorological data collected during the execution of the experiment. Barbacena, MG, Brazil,2023.



Note: INMET data, 2024.

Before setting up the experiment, soil sampling was performed at a depth of 0.0 to 0.20 meters to characterize the chemical properties of the area. The soil chemical analysis was conducted according to the method described by Brazil (2020), and the results are shown in Table 1.

Table 1.

Chemical analysis of the soil, before installing the experiment.

Soil	ph	P	K	MO	Ca^{2+}	Mg^{2+}	H+Al	Al^{3+}	SB	M	V
	-	mg dm^{-3}		dag kg^{-1}	..... cmolc dm^{-3}.....					%	%
0 - 20	6,20	282,56	241,10	1,75	2,45	0,63	2,17	0	3,70	0	62,99

Note: Soil and leaf analysis laboratory of the Federal Institute of Southeast Minas Gerais – Campus Barbacena, 2024.

In the experiment, the Caserta Italian zucchini variety was used due to its excellent performance in autumn and spring cultivation and its high acceptance by the population.

The preliminary soil preparation involved plowing, followed by the construction of 5 raised beds using a mechanized bed former, each measuring 17 meters in length and 1.20 meters in width. For each bed, 15 holes were prepared along its length, with 3 holes designated for each plot. A spacing of 70 cm was used between holes, and a spacing of 2 meters was maintained between every three holes within each bed.

The planting rows were spaced 1.80 meters apart, measured from the center of one hole to another. Each bed contained the 5 concentrations arranged randomly, with the concentrations consisting of 15 holes with a maximum capacity of 30 plants. The beds were

covered with mulch, and basal fertilization was incorporated before planting according to technical recommendations for pumpkin and squash cultivation (Amaro *et al.*, 2021).

Direct sowing was carried out (at a depth of 2 cm), with 4 seeds per hole, and the plants were irrigated daily using sprinklers to maintain soil moisture at field capacity, avoiding both excess and lack of water. Thinning was performed in holes with more than two plants, leaving two plants per hole, which were identified with the help of tags to allow for the collection of individual production values between plants 1 and 2, and later for the randomization of each concentration.

After plant development, three applications of the concentrations 0.0g $L^{-1,}$ 3.0g L^{-1}, 6.0g L^{-1}, 9.0g L^{-1}, and 12.0g L^{-1} of Calcium Nitrate (Calcinit®), composed of 26.5% calcium oxide, 100% water-soluble and in a form assimilable by plants (Yara, 2015), were made. The calcium nitrate was diluted in distilled water and applied via foliar spraying with a manual sprayer.

The calcium nitrate applications were performed based on the observation of plant development stages, on rain-free days and during the cool part of the day (in the morning). The three calcium nitrate applications were spaced 6 days apart over the experimental period. The first application was made before flowering, the second during full bloom/early fruiting, and the third when the first fruits were already formed. The spraying was done with a manual sprayer until the leaves and fruits were fully wetted without causing runoff.

Harvesting began 55 days after sowing. The fruits were harvested immature, daily, with a harvesting standard of fruit length between 15 cm (minimum) and 20 cm (maximum). A stem length of 2 to 3 cm was maintained on all fruits, and a total of 15 harvests were made over 15 days.

The following were evaluated: fresh fruit mass (g), length (cm) excluding the stem, diameter (mm) (average of the values from the apical, median, and basal points of the fruit), and the number of rotten fruits.

The production per plant was evaluated, determined by the total weight of the fruits divided by the number of plants (kg per plant), and the variance of fruit mass (g) of the Italian zucchini as a function of the days of harvest.

The firmness of the fruits was analyzed during the first evaluation using the Stable Micro Systems ISO 1001 TA.XT Express texture analyzer, with the test parameters being a PN 2 needle of 2 mm, a speed of 2 mm/s, a penetration depth (distance) of 20 mm, a test time of 5 seconds, and a force of 5 grams (approximately 0.5 newtons). The firmness (hardness) result was given in grams, and the evaluation was performed on the median part of all fruits.

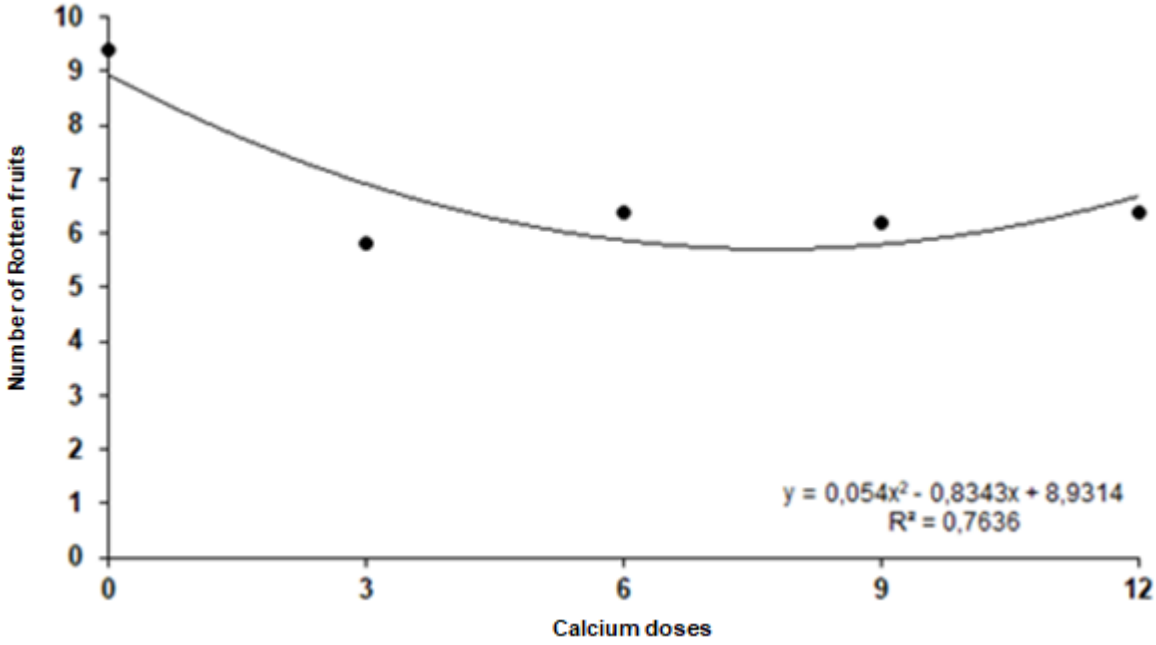
The data obtained from the respective parameters were subjected to analysis of variance using the F-test, adhering to the assumptions of the Shapiro-Wilk test model, to verify normality, and the means of the different concentrations were compared using Tukey's test at a 5% probability level. A regression test was applied to the variables that showed significant differences (Ferreira, 2011).

Results e Discussion

There was a significant difference in the parameters related to calcium nitrate concentrations concerning the number of fruits with blossom-end rot (Figure 2). The foliar application of calcium nitrate at a concentration of 3.0 g L-1 resulted in a lower number of fruits with blossom-end rot, while the concentration of 0.0 g L-1, without application, showed a higher incidence compared to the other concentrations.

Figure 2.

Number of fruits with apical rot, in italian zucchini plants subjected to different concentrations of calcium nitrate



Note: Prepared by the authors, 2024.

The sexual development of zucchini flowers can be divided into three phases: the first phase produces only male flowers, the second phase produces both male and female flowers, and the third phase produces only female flowers (Martínez *et al.*, 2013). A similar result was found by Costa *et al.* (2015), in Italian zucchini grown in a protected environment, where initially only male flowers were produced.

However, in the present study, the opposite result was obtained, with female flowers opening before the male ones. This led to a lack of pollination (Oliveira *et al.*, 2010), and the fruit rot observed at all calcium nitrate concentrations tested could be attributed to poor

pollination due to the cool temperatures in the early months (Figure 1) and short days (Amaro *et al.*, 2014).

Another factor correlated with the higher number of rotten fruits in the treatment without calcium nitrate could be a nutritional imbalance with a low calcium concentration in the plant. Since calcium is a nutrient with low mobility and Italian zucchini fruits have a high demand for this nutrient, there may have been a decrease in the structural and functional maintenance of cell membranes (Júnior *et al.*, 2011; Coelho *et al.,* 2020).

Table 2.

Fruit production (Kg), fruit fresh mass, fruit length (cm) and fruit diameter (mm) in italian zucchini plants subjected to different concentrations of calcium nitrate.

Concentrations	Production(Kg)	Mass(g)	Length (cm)	Diameter(mm)
0,0 L^{-1}	1,652 a	176,3 a	15,9 a	38,7 a
3,0 L^{-1}	1,978 a	170,5 a	15,2 a	37,5 a
6,0 L^{-1}	1,768 a	162,5 a	14,6 a	35,3 a
9,0 L^{-1}	1,740 a	174,6 a	15,6 a	38,5 a
12,0 L^{-1}	1,663 a	178,4 a	15,8 a	38,4 a
Cv (%)	22,22	12,16	10,61	11,07

Note: means of the same letters in the columns are statistically equal using the Tukey test at 5% probability.

The foliar-applied calcium concentrations did not result in increased production of Italian zucchini in the present study. In a study evaluating the productivity and economic efficiency of Italian zucchini fruits under different nitrogen concentrations (0 – 60 – 120 – 240 and 480 kg ha^{-1}) via fertigation (Oliveira *et al.,* 2022), the authors observed an increase in fruit production when a concentration of 326.64 kg ha^{-1} of nitrogen was used. A contrary result was found by Cavalcante *et al.* (2019), in fertilization with potassium and calcium in the nutrition and fertilization of the 'Paluma' guava cultivar, where the highest production gain occurred in the treatment without calcium.

However, in studies conducted by Cavalcante *et al.* (2014), on the foliar application of calcium nitrate in yellow passion fruit, a satisfactory result in production was obtained regardless of the concentrations tested. The same result was obtained by Yuri *et al.* (2012), in the production and quality of melon fruits.

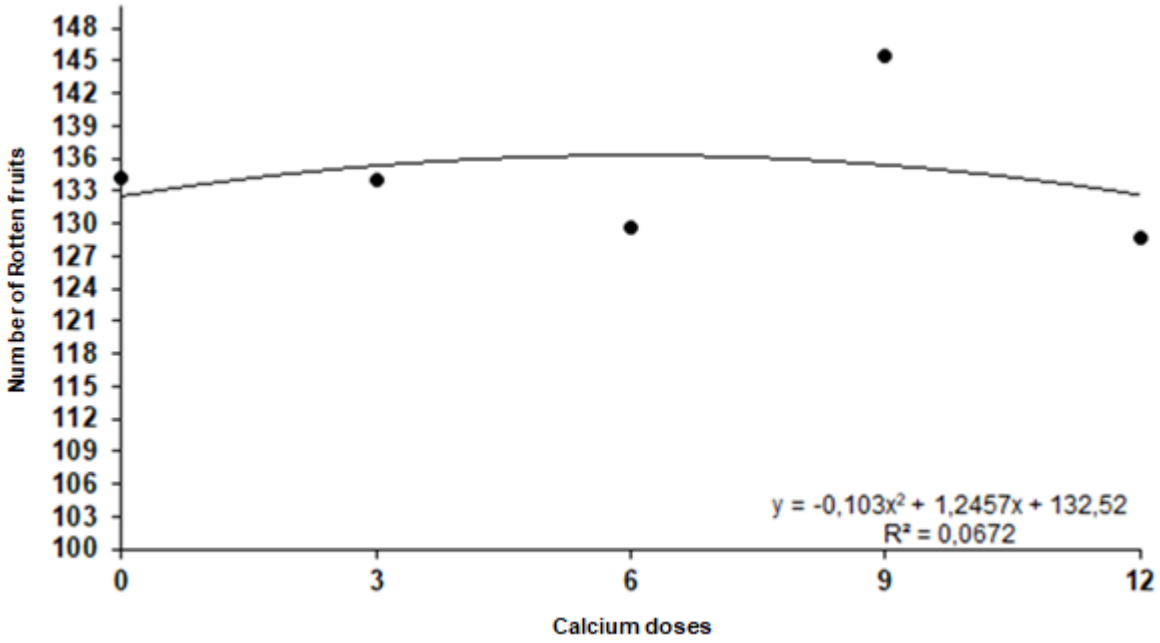
One hypothesis for the negative effect of foliar calcium application in the present study is that its transport via the phloem is limited, and the element is immobile in the plant, preventing the translocation of calcium applied to the leaf to other tissues (Cavalcante *et al.*, 2014). Calcium is an essential element for root and shoot growth, and it increases stress tolerance when applied pre-harvest, showing a more significant response in post-harvest fruit quality (Kumar *et al.*, 2017).

Regarding fruit weight, length, and diameter, there was no difference between the calcium concentrations, as zucchini yield is determined by the number and average weight of harvested fruits, resulting in production per plant (Delfim; Mauch, 2017).

Regarding fruit firmness (Figure 3), the concentration of 9 g L-1 of calcium nitrate showed higher firmness compared to the other tested concentrations, while the concentration of 12 g L^{-1} had a lower result than the other treatments.

Figure 3.

Fruit firmness (g) of italian zucchini plants subjected to different concentrations of calcium nitrate.



Note: Prepared by the authors, 2024.

In a study that analyzed the application of silicon and calcium on fruit quality and cucumber firmness (González-Terán et al., 2020), the authors observed greater firmness when calcium was applied. Similar results were found by Muñoz, Ruiz, and Bouzo (2017) in the foliar application of calcium nitrate on melon quality, with the concentrations of 1.3 and 2.6 g L-1 showing better fruit firmness.

Thus, the application of calcium, both via foliar and in the planting hole, is directly related to the maintenance of cell membrane function and structure in fruits. It is of utmost importance for the structuring and stabilization of the cell wall (Moschini et al., 2017; Vasconcelos et al., 2020), as it acts as a cementing agent and delays the ripening and senescence process, thereby extending the shelf life and marketability of the fruits (Yamamoto et al., 2011; Navarro-León et al., 2022).

Conclusions

The foliar application of calcium nitrate does not influence the production, length, mass, or diameter of Caserta Italian zucchini fruits.

The concentration of 3.0 g L^{-1} results in a lower number of fruits with blossom-end rot.

The concentration of 9 g L^{-1} of calcium nitrate shows greater firmness.

REFERENCES

Amaro, G. B., Hanashiro, M. M., Pinheiro, J. B., Madeira, N. R., & BORGES, R. (2021). Recomendações técnicas para o cultivo de abóboras e morangas. *Embrapa Hortaliças-Circular Técnica (INFOTECA-E)*.

Amaro, G. B., PINHEIRO, J. B., LOPES, J. F., de CARVALHO, A. D., MICHEREFF FILHO, M., & Vilela, N. J. (2014). Recomendações técnicas para o cultivo de abóbora híbrida do tipo japonesa.

Araújo, H. S., Cardoso, A. I. I., de Oliveira Júnior, M. X., & Magro, F. O. (2015). Teores e extração de macronutrientes em abobrinha-de-moita em função de doses de potássio em cobertura. *Revista Brasileira de Ciências Agrárias*, *10*(3), 389-395. https://doi.org/10.5039/agraria.v10i3a4937

Cavalcante, A. C. P., Cavalcante, L. F., Bertino, A. M. P., Cavalcante, A. G., Lima, A. J. D.,Ferreira, N. M. (2019). Adubação com potássio e cálcio na nutrição e produção de goiabeira'Paluma'. *Revista Ceres*, *66*, 54-62. https://doi.org/10.1590/0034-737X201966010008

Cavalcante, L. F., Mesquita, F. D. O., Nunes, J. C., Diniz, A. A., Lima Neto, A. D., Souto, A. D. L., & Souza, J. D. (2014). Produção e composição mineral do maracujazeiro amarelo com adubação foliar de cálcio após poda-segunda safra. *Revista Agropecuária Técnica*, *36*, 35-49.

Coelho, V. A. T., de Souza, C. G., de Souza Nascimento, E., Lacerda, L. G., & Cardoso, P. A. (2020). Deficiências de macronutrientes em Abobrinha Italiana (Cucurbita pepo L.): caracterização de sintomas e crescimento. *Research, Society and Development*, *9*(3), 27. http://dx.doi.org/10.33448/rsd-v9i3.2269

Costa, A. R., Rezende, R., de Freitas, P. S. L., Gonçalves, A. C. A., & Frizzone, J. A. (2015). A cultura da abobrinha italiana (Cucurbita pepo L.) em ambiente protegido utilizando fertirrigação nitrogenada e potássica. *Irriga*, *20*(1), 105-127. https://doi.org/10.15809/irriga.2015v20n1p105

Delfim, T. F., & Mauch, C. R. (2017). Fenologia, qualidade e produtividade de frutos de genótipos de abobrinha cultivado em ambiente protegido. *Tecnologia e Ciência Agropecuária*, *11*(3), 49-55.

Ferreira,DF (2011). Sisvar: um sistema computacional de análise estatística. *Ciência e agrotecnologia*, *35* , 1039-1042.

González-Terán, GE, Gómez-Merino, FC e Trejo-Téllez, LI (2020). Effects of silicon and calcium aplication on growth, yield and fruit quality parameters of cucumber established in a sodic soil. *Acta Scientiarum Polonorum Hortorum Cultus*, *19* (3), 149-158. https://doi.org/10.24326/asphc.2020.3.13.

Inmet, Instituto Nacional de Meteorologia (2024, jan, 10). Normais climatológicas do Brasil. Disponível em: http://www.inmet.gov.br/portal/index.php?r=clima/normaisclimatologicas

Júnior, S. J. A., Neto, E. B., Barreto, L. P., & Resende, L. V. (2011). Podridão apical e produtividade do tomateiro em função dos teores de cálcio e amônio. *Revista Caatinga*, *24*(4), 20-26.

Kumar, J., Kumar, R., Rai, R., Mishra, D. S., Singh, S. K., & Nimbolkar, P. K. (2017). Influence of foliar application of mineral nutrients at different growth stages of guava. *Journal of Plant Nutrition*, *40*(5), 656-661. https://doi.org/10.1080/01904167.2016.1246568

Luz, J. M. Q., Oliveira, G., Queiroz, A. A., & Carreon, R. (2010). Aplicação foliar de fertilizantes organominerais em cultura de alface. *Horticultura Brasileira*, *28*, 373-377.

Martínez, C., Manzano, S., Megías, Z., Garrido, D., Picó, B., & Jamilena, M. (2013). Involvement of ethylene biosynthesis and signalling in fruit set and early fruit development in zucchini squash (Cucurbita pepoL.). *BMC plant biology*, *13*(1), 1-14. https://doi.org/10.1186/1471-2229-13-139

Moschini, B. P., Coelho, V. A. T., Peche, P. M., Souza, F. B. M., Coutinho, G., Barbosa, C. M. A., & Freire, A. I. (2017). Crescimento e diagnose de deficiências nutricionais em Physalis peruviana L. *Agropecuária Técnica*, *38*(4), 169-176. https://doi.org/10.25066/agrotec.v38i4.30990

Muñoz, FF, Ruiz, VE e Bouzo, CA (2017). Effect of preharvest foliar sprays of calcium nitrate on melon fruit quality. *Fundácion Rómulo Raggio; Phyton*, 86(6), 131-136

Navarro-León, E., López-Moreno, F. J., Fernández, M. A., Maldonado, J. J., Yánez, J., Blasco, B., & Ruiz, J. M. (2022). A New calcium vectoring technology: Concentration and distribution of Ca and agronomic efficiency in pepper plants. *Agronomy*, *12*(2), 410. https://doi.org/10.3390/agronomy12020410

Oliveira, N. L. C., Júnior, M. H. C., Moreira, R. A., & de Oliveira, E. L. (2022). Produtividade e eficiência econômica da abobrinha italiana em função de diferentes doses de nitrogênio via fertirrigação. *Revista Ciência Agrícola*, *20*(3), 1-11. https://doi.org/10.28998/rca.v20i3.13146

Oliveira, N.L.C., Puiatti, M., Cecon, P.R., Bhering, A. S. (2010). Comportamento floral da abobrinha italiana em função da temperatura do ar. *Revista Horticultura Brasileira,* 28(2), 827-834.

Pôrto, M. L., Puiatti, M., Fontes, P. C., Cecon, P. R., Alves, J. C. (2014). Produtividade e acúmulo de nitrato nos frutos da abóbora" Tetsukabuto" em função da adubação nitrogenada. *Horticultura Brasileira*, *32*, 280-285.

Vasconcelos, L. H. C., da SIlva, F. A., Nascimento, L. M., & Vasconcelos, R. F. (2020). Avaliação pós-colheita de tangerinas 'Dekopon'submetidas a aplicação de cloreto de cálcio em pré-colheita. *Research, Society and Development*, *9*(6), e132963638-e132963638. https://doi.org/10.33448/rsd-v9i6.3638

Yamamoto, E. L. M., de Araújo Ferreira, R. M., de Oliveira Fernandes, P. L., Albuquerque, L. B., de Oliveira Alves, E. (2011). Função do cálcio na degradação da parede celular vegetal de frutos. *Revista verde de agroecologia e desenvolvimento sustentável*, *6*(2), 6.

Yara. Folheto YaraLiva-Calcinit-2015(2024, jan, 10). Disponível em: <http://yara-i.com.br/marketing/artes/folhetos/Folheto-YaraLiva-Calcinit-2015-modelo-novo.pdf>.

Yuri, J. E., Ferreira, T. S. D., GAMA, D. D. S., Resende, G. D., & Mota, J. H. (2012). Produtividade e qualidade dos frutos de melão pulverizados com cálcio. *Horticultura Brasileira*, *30*(2), S6563-S6569.