Revista ARACÊ
ISSN: 2358-2472

STAGES OF DEVELOPMENT OF THE SAN MARZANO® TOMATO VARIETY AT DIFFERENT DOSES OF UREA AND NPK

https://doi.org/10.56238/arev7n2-127

Submitted on: 11/01/2025 **Publication date:** 11/02/2025

Walysson de Oliveira Barbosa[1], Rubens Pessoa de Barros[2], Domingos Cláudio Miranda da Silva[3], Paulina Ferreira dos Santos[4], Claudia Fabrycia Macedo de Lima[5], Rubens Correia da Silva[6], Jesuit dos Santos Miranda[7] and Ian Levi Nunes Torres[8]

[1] Undergraduate Degree in Biological Sciences
State University of Alagoas – UNEAL
Email: walysson@alunos.uneal.edu.br
ORCID: https://orcid.org/0009-0000-6960-3705
LATTES: https://lattes.cnpq.br/1532627522577264
[2] Full Professor of the Department of Biological Sciences
State University of Alagoas – UNEAL
E-mail: rubens.barros@uneal.edu.br
ORCID: https://orcid.org/0000-0003-0140-1570
LATTES: http://lattes.cnpq.br/2511101759444154
[3] Undergraduate Degree in Biological Sciences
State University of Alagoas – UNEAL
Email: domingossilva@alunos.uneal.edu.br
ORCID: https://orcid.org/0000-0002-5243-9897
LATTES: http://lattes.cnpq.br/2711024066909650
[4] Undergraduate student in Biological Sciences
State University of Alagoas – UNEAL
E-mail: paulina.santos.2023@alunos.uneal.edu.br
ORCID: https://orcid.org/0009-0002-1337-5824
LATTES: https://lattes.cnpq.br/7517405965470112
[5] Undergraduate student in Biological Sciences
State University of Alagoas – UNEAL
E-mail: claudia.lima.2023@alunos.uneal.edu.br
ORCID: https://orcid.org/0009-0009-4520-4799
LATTES: https://lattes.cnpq.br/9556190912917590
[6] Master's student in Agriculture and Environment
Federal University of Alagoas – UFAL
E-mail: rubenscorreia012@gmail.com
ORCID: https://orcid.org/0000-0003-3826-8312
LATTES: http://lattes.cnpq.br/3921364670631663
[7] Undergraduate Degree in Biological Sciences
State University of Alagoas – UNEAL
Email: jesuito.miranda@alunos.uneal.edu.br
ORCID: https://orcid.org/0009-0004-5603-5090
LATTES: http://lattes.cnpq.br/0120972833669323
[8] Graduated in Agroecology Technologist
Federal University of Alagoas – UFAL
Email: ianlevinunestorres@gmail.com
ORCID: https://orcid.org/0009-0000-3529-8407
LATTES: http://lattes.cnpq.br/8588278699023849

Revista ARACÊ
ISSN: 2358-2472

ABSTRACT
Tomato (Solanum lycopersicum) is a crop of high economic and nutritional importance. The San Marzano variety is known for its quality and flavor. The objective of this study was to evaluate the effect of mineral fertilization with different doses of urea and NPK on the development of tomato plants in pots. The study was carried out at Uneal, Campus I, in Arapiraca-AL. The experimental design was completely randomized (DIC) with five treatments and four replications. The treatments included different doses of NPK and urea: T1 (control, 0g), T2 (5g of NPK + RH), T3 (6g of NPK + RH), T4 (7g of NPK + RH) and T5 (8g of NPK + RH). The plants were grown in 8L pots in a greenhouse. The results showed that mineral fertilization significantly increased tomato development and production. The NPK treatments (T2 and T3) showed a greater increase in the variables analyzed, including plant height, number of fruits, and fresh mass. The results are consistent with previous studies that demonstrated the importance of mineral fertilization for tomato development. The combination of NPK and urea proved to be effective in increasing yield and fruit quality. The optimal fertilization dose was found between 5-6g of NPK + RH.
Mineral fertilization with different doses of urea and NPK proved to be an effective practice to provide the development and production of San Marzano tomatoes in pots. Treatments with NPK (T2 and T3) stood out, showing a greater increase in the variables analyzed.

Keywords: Soil Fertility. Solanum. Physiology. Plant Nutrition.

Revista ARACÊ
ISSN: 2358-2472

INTRODUCTION

The development of the tomato plant is a complex process that goes through several phases, from seed germination to fruit maturation. Each phase, including seedling, seedling, and vegetative growth, requires specific care, especially about fertilization.

The different fertilization strategies can significantly influence the plant vigor, the quality of the fruits, and the final yield. Studies show that the proper choice and application of fertilizers during these phases are key to optimizing growth and maximizing crop yield.

Thus, it is essential to understand how different fertilizations affect each stage of tomato development to achieve the best possible results.

The phases of the tomato plant refer to the study of the plant when it is still a seed or seedling, and during development periods, revealing its vigor and response to management. As Silva (2012) points out, understanding these steps is crucial to optimize production and ensure a healthy harvest. This knowledge allows for more effective management and helps predict crop performance throughout its cycle.

The tomato crop has four stages or stages of development regarding water requirement: initial, vegetative, fruiting, and maturation. The duration of the phases varies and depends on the cultivar used and the predominant edaphoclimatic conditions (SOUSA *et al*., 2014).

The tomato species (*Solanum lycopersicum* L) belongs to the Solanaceae family; and is characterized by having a high commercial value worldwide, responsible for moving the export market to several countries. It is a plant that has Indian origins in South America, was brought to Central America, where it was domesticated in the country of Mexico and thus its consumption was popularized, soon after being introduced in Europe and then brought to Brazil through the great Italian navigations (Zayat *et al.*, 2020). In Brazil, its widespread cultivation generates a high economy at the national level, consequently becoming a source of income for several producers, whether on a large or small scale (Rodrigues *et al*., 2020).

It is a shrubby plant of the herbaceous type, with an annual cycle that varies between about 90 and 120 days, and can flower in varying periods according to the temperature of the environment, (Gomes & Castro, 2017). A person consumes an average of 5.9 g of tomatoes daily; such consumption is due not only to its flavor but also to its benefits, due to its high rate of nutrients beneficial to health (Bissacotti *et al., 2021).*

Revista ARACÊ
ISSN: 2358-2472

The species stands out for being a plant with fruit rich in vitamins, antioxidants, and carotenoids that are fundamental for the maintenance of human health, among which the ones that are shown in greater quantities are vitamins C and E, which are differentiated by being effective active ingredients in the fight against free radicals, preventing their negative effects on the body (Giraldo *et al*., 2022).

Tomatoes are a good alternative crop due to their added value in the consumer market, in addition to being a crop of high rusticity, and with high rates of fruit productivity when offered adequate conditions for their development; these conditions are fundamental from seed germination to the peak of their productivity (Soldateli *et al*., 2020).

The tomato plant is a plant that requires large amounts of nutrients for its fruiting; on the other hand, with the increase in the low productivity of Brazilian soils, the use of mineral and organometal fertilization has been progressively increasing to meet the chemical and biological needs of the plant (Galdino *et al.,* 2022), the effects of these fertilizations can provide a significant increase in tomato productivity, being able to increase the number of fruits, fresh mass and average productivity per plant, (Peres *et al*., 2020).

Some of the main minerals essential for the healthy development of the plant are P (Phosphorus), K (Potassium), Ca (Calcium), and B (Boron), especially between the flowering and fruiting period of the crop, which when properly supplied provide a significant increase in flower production and consequently fruit (De Paula *et al*., 2019).

According to Oliveira (2023), mineral nutrition enhances results when offered in an appropriate form and quantity, resulting in better quality fruits when compared to plants with the absence of mineral fertilization in similar conditions.

Based on the premise that the plant responds to fertilization doses and that one of the hypotheses affirms this assertion in this sense, the objective of this study was to evaluate the development of tomato plants of the San Marzano® variety in response to mineral fertilization of tomato with different doses of Urea and NPK in the potted system.

THEORETICAL FRAMEWORK

The tomato plant (*Solanum lycopersicum* L.) has its origins in the Andean regions of Peru, Bolivia, Ecuador, and Mexico, where it was cultivated by indigenous civilizations such as the Incas, Mayans, and Aztecs who were responsible for its domestication (Landau, 2020). In Brazil, the tomato was introduced at the end of the nineteenth century by European immigrants, especially Italians and Portuguese, who brought the vegetable to the southeast region, particularly São Paulo, since then, tomato cultivation has expanded to other regions, becoming one of the most important crops in the country (Bissacotti; Londero & Costabeber, 2021).

Its mineral nutrient absorptive mechanisms are mainly through the roots, using processes such as root interception, mass flow, and diffusion (Coelho, 2022). Nutrients are acquired in the form of inorganic ions and transported to different parts of the plant, where they are assimilated and used in essential biological functions. The efficiency of nutrient uptake can be increased by the presence of mycorrhizal fungi and nitrogen-fixing bacteria, which aid in the acquisition of nutrients (Coelho, 2022).

Minerals are fundamental for agriculture, as they provide essential nutrients for plant growth and development (Martins & Hardoim, 2023). Mineral fertilizers, such as NPK (nitrogen, phosphorus, and potassium), are widely used to improve soil fertility and increase crop yields (Costa, 2023). Additionally, mining minerals such as potash and phosphate is crucial for fertilizer production, highlighting the interdependence between the mining and agriculture sectors.

Nitrogen (N) is a mineral of paramount importance, as it is essential for the growth of leaves and stems, as it helps in the formation of proteins and chlorophyll, essential for photosynthesis, thus increasing the synthesis of sugars and other vital metabolites for the plant (Silva, 2023). Another vital mineral that enables greater water absorption is phosphorus (P), as it participates in the formation and development of roots, and also in the formation of flowers and fruits. It is also crucial for the transfer of energy within the plant (Ribeira, 2023), and potassium (K), which participates in important activities such as carbon fixation during the photosynthesis process, enzymatic activation, and also acts in the plant's defense system against possible pathogens, fungi, and other organisms that may cause damage to the plant (Ribeira, 2023).

In addition, some micronutrients are essential for the healthy and productive production of tomatoes, but even though they are needed in smaller quantities compared to macronutrients, they are essential for the plant (Monte, 2022). Such as iron, manganese, zinc, copper, boron, and molybdenum, although needed in smaller quantities, are equally vital to the normal performance of the plant. Maintaining a proper balance of these nutrients in the soil is crucial for maximizing production and ensuring plant health (Bártolo, 2026).

Revista ARACÊ
ISSN: 2358-2472

The tomato plant is a plant that requires a lot of mineral nutrients to grow and produce well. Nitrogen, phosphorus, and potassium are essential for vegetative growth, root development, and fruit quality, and also participate in other metabolic activities (Félix *et al*., 2015). Calcium, magnesium, and sulfur are also important for cellular integrity, photosynthesis, protein synthesis, and other post-synthetic nutrients (Hansel, 2021).

METHODOLOGY

LOCATION OF RESEARCH

The study was conducted in a greenhouse of the State University of Alagoas, Campus I in Arapiraca-AL, located between the geographic coordinates: 9º 75' 25" S latitude 36º 60' 11" W longitude, presenting edaphoclimatic conditions with an average temperature of 28°C and average annual precipitation of 550 mm (Alagoas-Semarh-Dmet, 2023) The climate of the region is of type As', determining tropical and warm climate according to the Köppen and Geiger classification (Köppen and Geiger, 1928).

The University's greenhouse is of the chapel type, with a specific shading screen cover for agricultural greenhouses with a 50% shade and a metal structure by Hidrogood®. The experiment was carried out with tomato Solanaceae (*Solanum lycopersicum* L).

METHODOLOGICAL PROCEDURES

Tomato seeds germinated in a commercial substrate Bioplant® incorporated with urea in 100-cell flexible polyethylene trays, with a volume of 18 ml per cell, were used for the production of the seedlings. Tomato cultivation was carried out in 8 dm^3 (8 L) plastic pots, filled with a substrate based on a dry coconut shell fiber–soilless system.

The adopted design was completely randomized (DIC) with five treatments and four replications. The treatments consisted of NPK and urea (RH) proportions with incorporation into the treatments, as follows: T1- 4g NPK + RH; T2 - 5g NPK+RH; T3 - 6g NPK+RH: T4 - 7g NPK+RH and T5 - 8g NPK+RH.

The data were discussed through analysis of variance and comparison of means of the phenological variables of the plant in pre-harvest and post-harvest (CR-chlorophyll, soil moisture, plant height, number of leaves, stem diameter, number of branches, number of flowers/flower buds, number of fruits, number of seeds, fresh weight of fruit biomass, fresh weight of the plant, fruit dry mass, root size) and bioactive compounds in the plant parts analyzed.

To determine the production variables, the plants were evaluated in the treatments, in the following characteristics in the pre-harvest (CR-chlorophyll, soil moisture, plant height, stem diameter, number of leaves, flower buds/number of flowers, number of branches, and in the post-harvest and average fruit length (cm) – CF; average fruit diameter (cm) – DF; total fruits per plant (nº) – TF; average fruit mass (g) – MF; commercial fruit production per m² (kg) – PC. Harvests were carried out from 90 DAT (days after transplanting) when the fruits were at the point of harvest.

STATISTICAL ANALYSIS OF THE DATA

The analyses were performed using the statistical program SISVAR Tukey's 5% comparison test of significance. A regression analysis will also be performed to illustrate the discrepant response of the variables in the pre and post-harvest as a function of NPK + Urea dosages (Ferreira, 2019).

RESULTS AND DISCUSSIONS

According to the data presented in Table 1, it was verified through the F* test, that the variables were significant mostly in the experimental treatments, in this study the null hypothesis for the variables in the treatments was rejected, except the variables height and number of fruits, but the coefficient of variation (CV) showed an alteration between some variables, Among them, the most prominent was the diameter of the stem. According to (Almeida *et al*., 2020), the high coefficient of variation – CV reveals that in the dispersion data, there was external interference in the data collection in the experiment, indicating a new experimental design. It can also show variations according to the availability and absorption of water from where the plant is inserted.

According to the research by Peres et al. (2020), the use of nitrogen fertilizers in the vegetative phase of tomatoes resulted in a 20% increase in productivity.

Revista ARACÊ
ISSN: 2358-2472

Table 1. Summary of the ANOVA (analysis of variance) of the variables in the treatments.

Source of Variation	GL	SQ	QM	*F	P	CV%
Chlorophyll A	4	252.789	63.197	1.625	0.207	16.41
Chlorophyll B	4	52.112	13.028	1.436	0.258	25.15
Total Chlorophyll	4	609.797	152.449	2.260	0.098	17.29
Soil moisture	4	2.302	0.575	4.414	0.010	7.33
Stem diameter	4	88.705	22.176	2.604	0.066	137.92
Height (cm)	4	203.760	50.940	0.344ns	0.845	19.78
Fresh pasta	4	708391.600	117097.900	1.096	0.385	69.16
No. of fruits	4	28.766	7.191	0.120ns	0.973	60.04
Fruit weight	4	5233.200	1308.300	3.782	0.019	29.43
No. of flower buds	4	70.800	17.700	1.432	0.260	60.60
Floral abortions	4	315.040	78.760	0.972	0.444	62.86
No. of seeds	4	2984.000	746.000	1.430	0.260	30.29
No. of branches	4	131.440	32.860	0.838	0.517	60.67
No. of Glasses	4	1.360	0.340	1.417	0.264	20.08

Legend: Mean followed by the same letter in the column does not differ statistically by the Tukey test at 5% significance. (GL) degree of freedom; (SQ) sum of squares; (QM) medium square; (*F) test at 5% probability; CV – coefficient of variation.

From the data in Table 2, by the Tukey test at 5% probability, it was found that, in general, the variables chlorophyll A (CLA), stem diameter (DC), and number of flower buds presented a higher result in the treatment (control) in which it was not submitted to mineral fertilization (T1), obtaining a partially significant development when compared to the other treatments.

The treatments in which they were submitted to fertilization with NPK+9 (T2) and (T3) showed a superior result than the others in most of the variants shown in the tables above. The results obtained in the NBF variable showed a greater increase with NPK fertilization, it was found that fertilization also influences the number of flower buds, similar results were obtained by Magalhães (2018) who obtained significant differences between the Santa Clara and IPA 6 variables.

According to Cambraia and Pinto (2015), fertilization with adequate amounts of NPK provides a greater increase in tomato production rates.

On the other hand, the treatments submitted to urea fertilization (T4) and (T5), showed significant development in the production of fruits and branches, in the fresh mass variable the treatments submitted to urea presented results similar to those obtained by De Paula, (1999) who showed differences between substrates, one of them being Plantmax®, which showed an increase in fresh mass in tomato. However, in most variants, it was inferior to the other results obtained in the other treatments.

Revista ARACÊ
ISSN: 2358-2472

Table 2. Comparison of means using the Tukey test at the level of 5% probability of the treatment variables.

Source of Variation	T1	T2	T3	T4	T5
Chlorophyll A	5,880 to	1,160 to	1,140 to	1,320 to	1,080 to
Chlorophyll B	12,600 to	11,600 to	13,920 to	12,260 to	9,520 to
Total Chlorophyll	39,580 to	44,280 to	53,240 to	49,340 to	51,040 to
Soil moisture	4,980 AB	5,200 to	4.340 b	5,020 AB	5,100 to
Stem diameter	5,880 to	1,160 to	1,140 to	1,320 to	1,080 to
Height (cm)	60,800 to	66,200 to	60,000 to	63,000 to	57,800 to
Fresh pasta	312,000 to	628,000 to	606,400 to	526,600 to	833,000 to
No. of fruits	12,600 to	12,400 to	12,000 to	15,000 to	12,460 to
Fruit weight	62,800 to	88.400 b	56,200 AB	64,400 AB	44,200 to
No. of flower buds	4,200 to	6,000 to	8,800 to	5,800 to	4,200 to
Floral abortions	10,000 to	16,200 to	19,400 to	10,600 to	15,400 to
No. of seeds	78,800 to	85,600 to	78,000 to	80,400 to	54,200 to
No. of branches	8,400 to	9,800 to	9,600 to	9,000 to	14,800 to
No. of Glasses	2,800 to	2,200 to	2,400 to	2,200 to	2,600 to

In the research conducted by Santos (2001), significant results were found for the cultivar and NPK factors about the total and commercial number of fruits, as well as the total and commercial average weight of fruits. This indicates that both the choice of variety (cultivar) and the proper application of nutrients (NPK) have a substantial impact on fruit production, both in terms of quantity and quality. These findings highlight the importance of selecting suitable varieties and applying the right nutrition to optimize fruit production.

Other similar results were observed by Porto (2014), highlighting that urea as a source of nitrogen promoted greater development and accumulation of fresh mass in the plant. This underscores the importance of nitrogen in promoting plant growth, where urea is particularly effective in the vegetative development of the plant.

During the research, physiological changes were presented in the tomato plant, such as calcium deficiency, identified through image analysis. Such a disorder presents symptoms approximately from the second week after fertilization of the flowers, and causes the apex of the fruits necrosis, thus causing the symptom known as apical rot (Júnior, *et.al*. 2011).

CONCLUSION

Mineral fertilization provided a significant increase in the development and production of tomatoes, where in general both types of fertilization presented satisfactory results, but the treatments submitted to mineral fertilization with NPK (T2) and (T3) stood out with greater emphasis, presenting in most cases a significant increase in the index in the variables analyzed.

Revista ARACÊ
ISSN: 2358-2472

As the data revealed instability in the normality of the numbers, resulting from the collections and edaphoclimatic interferences, the experiment will be installed again.

THANKS

The Foundation for Research Support of the State of Alagoas - FAPEAL, for financing research through the Institutional Program for Scientific Initiation Scholarships - PIBIC.
The State University of Alagoas – UNEAL, through the Biological Sciences Course of Campus I.
To the Environmental and Ethnobiological Studies Group – GEMBIO for all the support in the execution of the research.

Revista ARACÊ
ISSN: 2358-2472

REFERENCES

1. Alagoas. Secretary of State for the Environment and Water Resources, Directorate of Meteorology. (2017). Annual climatological data bulletin. Maceió: SEMARH. http://meteorologia.semarh.al.gov.br/relatoriospdf/ (Accessed on: 17 Jul. 2024).

2. Almeida, R. C., et al. (2020). Vegetative development of sweet heaven tomato irrigated with magnetically treated water. Brazilian Journal of Development, 6(2), 5428–5434.

3. Bártolo, I. M. M. (2016). Agricultural valorization of WWTP sludge: A study of phosphorus availability (Master's dissertation). New University of Lisbon, Faculty of Science and Technology, Lisbon.

4. Bissacotti, A. P., Londero, P. M. G., & Costabeber, I. H. (2021). Tomato: Botany, production, nutritional composition and health benefits. Cadernos de Ciência & Tecnologia, 38(2), 26643.

5. Cambraia, P. R., & Pinto, S. I. C. (2015). Enrichment of the substrate with NPK fertilization for tomato seedling production. In 7th Science and Technology Week, Bambuí (pp. 1–5). IFMG-Bambuí.

6. Coelho, V. A. T. (2022). Potassium and sodium in mineral nutrition and growth in ornamental ginger plants (PhD thesis). Presidente Antônio Carlos University.

7. Costa, J. R. A. D. (2023). Cultivation of Helianthus tuberosus L. in soil under degradation of the semi-arid region as a function of organic and mineral fertilization sources (Undergraduate final paper). [University].

8. De Paula, E. C. (1999). Production of lettuce, tomato, and cauliflower seedlings in different commercial substrates (Monograph, Bachelor of Agronomy). Federal University of Uberlândia, Uberlândia.

9. Félix, A. C. A., et al. (2015). Accumulation and export of nutrients by the tomato plant BRS Nagai. In 35th Brazilian Soil Science Congress, Natal. Brazilian Society of Soil Science.

10. Ferreira, D. F. (2019). SISVAR: A computational analysis system for split-plot experiment designs. Revista Brasileira de Biometria, 37(4), 529–535.

11. Galdino, W. de O., et al. (2022). The efficiency of the organo-mineral fertilization mix on floral biology in cherry tomato cultivars (Solanum lycopersicum L., Solanaceae) kept in a greenhouse. Diversitas Journal, 7(2). https://doi.org/10.48017/dj.v7i2.2000

12. Giraldo, I. M. G., Pineda, H. R., & Espinoza, J. A. R. (2022). Quantitative comparison of antioxidant activity in chonto and ahuyama tomatoes by ABTS, DPPH, and cyclic voltamperometry methods. Brazilian Journal of Animal and Environmental Research, 5(1), 1431–1438.

13. Gomes, S. K. S., & de Castro, M. T. (2017). Monitoring of insects in tomato plantation with silicate fertilization. Biodiversity, 16(3).

14. Hansel, F. B., et al. (2021). Mineral nutrition is an ally of plants in tolerance to environmental stresses. NPCT Agronomic Information, 1, 10–24.

15. Júnior, S. J. A., et al. (2011). Apical rot and tomato yield as a function of calcium and ammonium contents. Revista Caatinga, 24(4), 20–26.

16. Köppen, W., & Geiger, R. (1928). Klimate der Erde. Gotha: Verlag Justus Perthes.

17. Landau, E. C., et al. (2020). Dynamics of agricultural production and natural landscape in Brazil in recent decades: Products of plant origin (Vol. 2, Chap. 40, pp. 1303–1327). Brasília: Embrapa.

18. Magalhães, I. C. S., et al. (2018). Correlation between climatic factors and the development of tomato cultivars (Solanum lycopersicum L., Solanaceae) with adults of two key pests. African Journal of Agricultural Research, 13(20), 1018–1025.

19. Martins, E. de S., Martins, E. S., & Hardoim, P. R. (2023). Geochemical, mineralogical, and biological principles of soil remineralizer management.

20. Monte, A. C. da C. (2022). Determination of micronutrients and secondary macronutrients in organomineral and mixed mineral fertilizers.

21. Oliveira, L. L., et al. (2023). Response of cherry tomatoes to organomineral fertilization to increase yield. Journal of Environmental Analysis and Progress, 8(2), 54–61.

22. Peres, L. A. C., Terra, N. F., & Rezende, C. F. A. (2020). Productivity of industrial tomato submitted to organo-mineral fertilization in cover. Brazilian Journal of Development, 6, 10586–10599.

23. Pereira, A. S., & Freire, C. J. S. (2001). Cultivar and NPK fertilization in salad tomato production. Horticultura Brasileira, 19(1), 35–39.

24. Porto, J. S., et al. (2014). SPAD index and tomato growth as a function of different nitrogen sources and doses. Scientia Plena, 10(11).

25. Morais, B. G. de. (2023). Digital images for determining phosphorus concentration in soil samples through the Photometrix app [Master's thesis, UNESP]. UNESP Institutional Repository. http://hdl.handle.net/11449/244797 (Accessed on: 21 Aug. 2023).

26. Rodrigues, R. R., et al. (2020). Tomato cultivation in a protected environment under different water stresses in the soil. Research, Society and Development, 11, e2289119777. https://doi.org/10.33448/rsd-v9i11.9777

27. Santos, P. R. Z., Pereira, A. S., & Freire, C. J. S. (2001). Cultivar and NPK fertilization in salad tomato production. Horticultura Brasileira, 19(1), 35–39.

28. Silva, D. B. (2023). Foliar silicon application and nitrogen doses via soil in Arabica coffee crop as a function of water availability (Doctoral dissertation, São Paulo State University). https://repositorio.unesp.br (se disponível online)

Revista ARACÊ
ISSN: 2358-2472

29. Silva, E. C. A., & Melo, Y. A. (2012). The feasibility of organic tomato cultivation in greenhouses: A case study (Master's thesis, Universidade do Norte do Paraná).

30. Soldatelli, F. J., et al. (2020). Growth and yield of cherry tomato cultivars grown in organic substrates. Colloquium Agrariae, 1–10.

31. Zayat, J. Z. M., et al. (2022). The economic viability of salad tomato production in the south of the state of Goiás. Ibero-American Journal of Humanities, Sciences and Education, 8(6), 1455–1486.

32. Souza, V. F., et al. (2014). Irrigation and fertigation in fruit and vegetable crops (2nd ed.). Embrapa.