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DEFICIT IRRIGATION AND SOWING DENSITY IN THE CULTIVATION OF BABY BEET

IRRIGAÇÃO DEFICITÁRIA E DENSIDADE DE SEMEADURA NO CULTIVO DE BETERRABA BABY

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ABSTRACT: This research aimed to evaluate the effect of deficit irrigation rates and sowing density on the vegetative and yield performance of baby beet. The experiment wasconducted in a greenhouse at theUEG - Santa Helena de Goiás Unit. The experimental design adopted was randomized block design (DBD) arranged in a 4x2 factorial scheme, with four irrigation depths (40, 60, 80, and 100% of ETo) and two sowing densities (0.5 and 1.0 g of seeds cm-2), with three replications, making up 24 experimental units. The variables analyzed were plant height (PH), stem diameter (SD), number of plants (NP) per cm², shoot fresh mass (FM) in an area of 25cm2, dry mass of the shoot (DM), water content (WC), total titratable acidity (TTA), and water use efficiency (WUE). The data was submitted for analysis of variance. When a significant effect was found, the Tukey test was applied to compare the sowing densities and the regression analysis to adjust the data from the irrigation depths. The sowing density influenced the variables PH,FM, DM, NP, WC, and WUE, with the best performance at a density of 1.0 g cm-2. The WUE was lower as the amount of water applied increased. For the effect of the irrigation depth, it can be seen that for higher depths, the trend was towards a reduction in acidity; i.e., water availability positively affected the taste of the baby beet leaf.

Keywords: *water deficit, water use efficiency, microgreens*

RESUMO: O objetivo desta pesquisa foi avaliar o efeito de lâminas de irrigação deficitária e densidade de semeadura sob o desempenho vegetativo e produtivo de beterraba baby. O experimento foi conduzido em casa de vegetação na UEG - Unidade Universitária de Santa Helena de Goiás. O delineamento experimental adotado foi o de blocos casualizados (DBC) em esquema fatorial 4x2, sendo 4 lâminas de irrigação (40, 60, 80 e 100% da ETo) e duas densidades de semeadura (0,5 e 1,0 g de sementes cm-2), com 3 repetições, perfazendo 24 unidades experimentais. As variáveis analisadas foram: altura de planta (Alt), diâmetro do caule (DC), número de plantas (NP) por cm², massa fresca da parte aérea (MF) numa área de 25cm2, massa seca da parte aérea (MS), teor de água (TA), acidez titulável total (ATT) e eficiência do uso da água (EUA). Os dados foram submetidos à análise de variância, e quando significativa aplicou-se o teste de Tukey para o fator densidade de semeadura e teste de regressão para o fator lâminas de irrigação. O efeito de densidade de semeadura foi significativo para as variáveis Alt, MF e MS, NP, TA e EUA, apresentando a melhor performance na densidade de 1,0 g cm-2. A EUA foi menor a medida em que se aumentou a lâmina de água aplicada. Para efeito de lâmina de irrigação observa-se que para lâminas maiores a tendência foi de redução da acidez, ou seja, a disponibilidade hídrica afetou positivamente o sabor da folha de beterraba baby.

Palavras-chave: *déficit hídrico, eficiência do uso da água, microverdes*

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INTRODUCTION

Baby leaf vegetables (baby leaf) or microgreens are young vegetables consumed while still in the seedling stage, which is why they have a short production cycle and require small production spaces (WIETH et al., 2019) and have been introduced into urban agriculture as a sophisticated and exclusive food (BLISKA JÚNIOR et al., 2019). In recent years, there has been greater interest in the consumption of fruits and vegetables by the population, especially those with a high content of bioactive substances, as highlighted by Thuong and Minh (2020). Santos et al. (2020) report that microgreens have a higher concentration of antioxidants, phenols, vitamins, and minerals than mature vegetables, which is why they can be considered functional foods, which have properties that prevent diseases and promote the health of those who consume them.

Species of different botanical families such as Brassicaceae, Fabaceae, Asteraceae, Amaranthaceae, Cucurbitaceae, Apiaceae, Amaryllidaceae, and Lamiaceae are included among the microgreens (KYRIACOU et al., 2016). According to Dias et al. (2023),microgreens have gained notoriety in recent years due to their nutritional properties and good acceptance by consumers, as well as providing intense flavors and vibrant colors to prepare the most varied dishes in contemporary cuisine. In this way, beet has stood out in baby leaf production, as Santos et al. highlighted (2020).

In microgreen production, irrigation is essential for a quality and profitable crop, especially for short-cycle crops. Andrade et al. (2017) reported that in drip irrigation, water is applied directly to the root zone, with low intensity and high frequency to maintain soil moisture close to field capacity, which provides high efficiency in water application and better moisture conditions in the root zone (COELHO et al., 2006). Beet can suffer a reduction in production if irrigation is not managed correctly since crop production and development are limited when there is a water deficit (OLIVEIRA NETO et al., 2011). Linked to this, Ferreria et al. (2021) point out that water is a finite and limited resource, so it is essential to adopt sustainable irrigated agriculture that aims to increase production and yield, combined with the efficient use of this natural resource. Correct irrigation management is, therefore, a fundamental stage in the development of baby beet.

Another factor that affects crop yield is sowing density. According to Storey (2017), sowing density is among the key factors influencing microgreens yield and production efficiency. Currently, in Brazil, there is not enough evidence for growers to decide which baby beet production methods would work best for their situation, especially regarding irrigation and sowing density. Therefore, this research aimed to evaluate the effect of deficit irrigation depths and sowing density on the vegetative and productive performance of baby beet.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse at the Santa Helena de Goiás University Unit,GoiásState University (UEG). The greenhouse is located at 17°49'23" S, 50°35'18" W, and 575 meters of altitude. The region's climateis classified as Aw-type (ALVARES et al., 2013). The soil used was anOxisol with a clay texture typical of the region (SANTOS et al., 2018).

The experimental design adopted was a randomized block design (RBD) arranged in a 4x2 factorial scheme, with four irrigation depths (40%, 60%, 80%, and 100% of ETo) and two sowing densities (0.5 and 1.0 g of seeds cm-2), with four replications, making up 24 experimental units. The pots had a capacity of 4L and 19 cm in diameter. They were filled with soil sieved through a 2 mm mesh. The seeds were deposited at a depth of 1.5 cm, and the densities assessed were 0.5 and 1.0 g of seeds cm^{-2}, corresponding to 3.83 g vase-1 and 7.66 g vase-1, respectively. Fertilization with nitrogen (N) and potassium (K) was conducted in the sowing, as recommended by Filgueira (2012), applying 60kg ha-1 of N and

30 kg ha-1 of K2O. Phytosanitary and weed control was not necessary.

A localized drip irrigation system was used to apply the irrigation levels, whose emitters were of the in-line type and spaced according to the crop spacing (0.3 m between rows). Each emitter had a nominal flow rate of 1.6 L h-1, with an operating pressure of 8 mH2O (meters of water column).

The irrigation system was assessed for distribution uniformity and application efficiency. The water depthwas obtained from evaporation data from mini pan evaporimeters (EMP) made from PVC, according to Santos et al. (2017). This was calibrated in the autumn and winter according to the evaporation from the Class A evaporation pan (ECA), both installed in an area with bare soil inside the greenhouse, the calibration of which is represented by equation 1.

$$ECA = 1.4035x(EMP) + 1.2456 \quad \text{(Equation 1)}$$

Where:

ECA = evaporation from the Class A evaporation pan corrected (mm);

EMP= evaporation from the mini pan evaporimeters (mm).

Equation 2, described by Allen et al. (2006), was used to determine reference evapotranspiration (ETo), in which a Kp equal to 1.0 was adopted:

$$\text{"}ETo = Kp \times ECA\text{"} \quad \text{(Equation 2)}$$

Where:

ETo = reference evapotranspiration (mm day-1);

Kp = class A evaporation pan coefficient (dimensionless);

ECA = evaporation from the Class A evaporation pan (mm day-1).

The irrigation depth corrected for the efficiency of the system was estimated by equation 3:

$$\text{"}Di=\text{" "}ETo \times A\text{"} / AE \quad \text{(Equation 3)}$$

In which:

Di = corrected irrigation depth (mm);

ETo = reference evapotranspiration (mm day-1);

A = pot area (m2); = 0.02834 m²;

AE = application efficiency (AE =0.92).

Based on the result of ETocalculated (100%), the other values were determined by multiplying the value found by the multiplication factor for each treatment: 0.4, 0.6, 0.8, and 1.00, corresponding to 40%, 60%, 80%, and 100% of ETo respectively, with daily irrigations.

After reaching the harvesting point considered suitable for microgreens, which occurred at 15 days, the baby beets were harvested using a mold (5x5 cm) to be harvested by area, and the following variables were determined: 1- Plant height (PH), measured with a ruler graduated in centimeters. 2- Stem diameter (SD), determined in millimeters using a digital caliper. 3- Number of plants (NP) per cm² (25 cm²). 4- shoot fresh mass (FM) in an area of 25cm2 by weighing the plants harvested in each treatment on a digital balance, in grams. 5- Shoot dry mass (DM): this refers to drying in an oven at 65ºC for approximately 72 hours until it reaches a constant weight; immediately after the drying process, the plants were weighed using an analytical balance, given in grams. 6- Water content (WC) obtained using the formula (100 x (FM-DM)/FM), given in %. 7 - Total titratable acidity (TTA), obtained by titration with a standardized sodium hydroxide (NaOH) solution at 0.1N, using phenolphthalein as the turning point indicator. The values were expressed as % citric acid, according to the methodology of the Alfredo Lutz Institute (IAL, 2005). 8- Water use efficiency (WUE): the ratio between the fresh mass of plants per area (FM) and water consumption over the cycle, given in g ha-1mm-1.

The data was submitted for analysis of variance and the F-test. When a significant effect was found, the Tukey test was applied at 5% probability for the sowing density factor and the regression analysis for the irrigation depths factor, using the Sisvar software (FERREIRA, 2019).

RESULTS AND DISCUSSION

The summary of the analysis of variance is shown in Table 1. It shows the F values and the significance level for the effect of irrigation depths (Rat) and sowing density (ST) on the variables assessed for the sugar beet crop at the baby stage. The irrigation depths influenced only the total titratable acidity (TTA) and water use efficiency (WUE). The sowing density effect was significant for plant height (PH), shootfresh mass (FM), shoot dry mass (DM), number of plants per area (NP), water content (WC), and water use efficiency (WUE) at the 1% level. In this sense, the effect of the interaction between the treatment factors was only significant for WUE (5% significance level). The coefficients of variation (CV) ranged from 1.21 to 21.91%. Cruz et al. (2012) indicate that the lower the CV, the greater the precision of the evaluations, thus indicating precision in the conduct and evaluations of this trial.

Table 1. F-values for height (PH), stem diameter (SD), shoot fresh mass (FM), shoot dry mass (DM), total titratable acidity (TTA), number of plants per area (NP), water content (WC), and water use efficiency (WUE) of babybeet plants grown in a greenhouse under deficit irrigation depths (Ird) and sowing densities (Dens).

SV	DF	PH	SD	FM	DM	TTA	NP	WC	WUE
Ird	3	0.39^{ns}	1.22^{ns}	0.98^{ns}	1.65^{ns}	16.07**	3.22^{ns}	1.98^{ns}	4.79*
Dens	1	19.03^{ns}	1.97^{ns}	15.38**	9.18**	0.11^{ns}	9.66**	13.64**	17.65**
Ird x Dens	3	2.65^{ns}	1.04^{ns}	1.91^{ns}	1.41^{ns}	1.67^{ns}	1.10^{ns}	1.27^{ns}	4.68*
Block	2	1.89^{ns}	0.43^{ns}	5.91*	5.67**	1.44^{ns}	10.81^{ns}	3.22^{ns}	3.32^{ns}
Error	14	-	-	-	-	-	-	-	-
Total	23	-	-	-	-	-	-	-	-
CV (%)	-	13.07	13.74	18.57	21.09	13.92	19.91	2.21	21.91

SV: sources of variation; DF: degree of freedom; Ird: irrigation depth; Dens: sowing density; CV: coefficient of variation. ^{ns}, *, and **: not significant and significant at 5% and 1% probability, respectively, by the F-test.

Figure 1 shows the maximum and minimum temperature variation and the reference evapotranspiration estimated daily from the mini evaporimeter tank. During this period, the minimum temperatures ranged from 13.6°C to 22.6°C, and the maximum temperatures were between 45.0°C and 27.8°C.

Filgueira (2012) mentioned that the average temperature recommended for beet is between 15° and 25°C for its best development. It can be seen that from the emergence of the seedlings to the seventh day, the average temperatures were suitable for the best performance of the beet, as recommended.

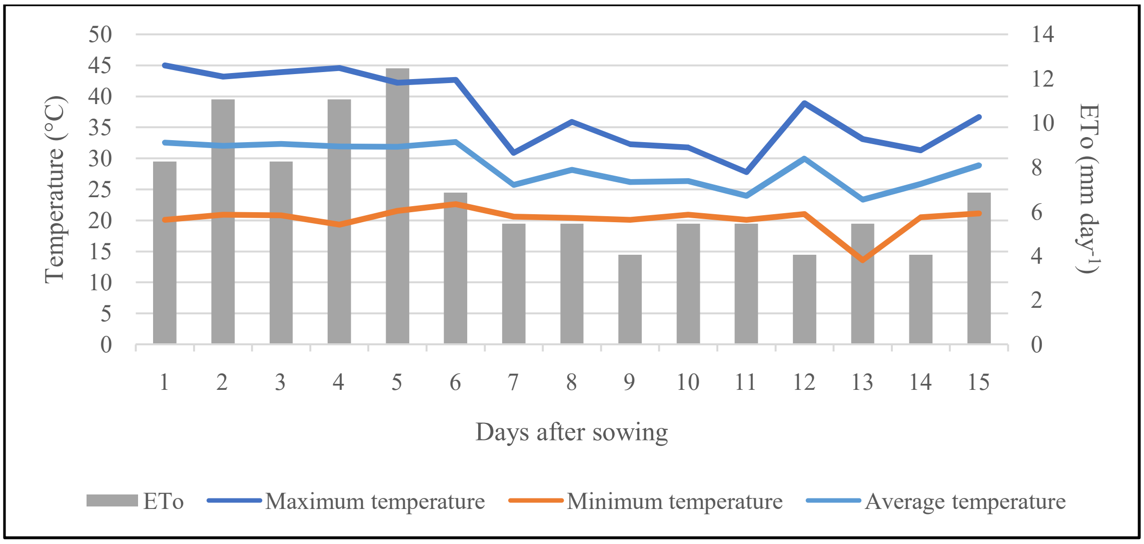

Figure 2. Reference evapotranspiration (ETo) and minimum, average, and maximum temperature inside the greenhouse where baby beet was grown in southwest Goiás.

Reference evapotranspiration (ETo) ranged from 4.05 mm on days with lower temperatures to 12.47 mm on days with higher temperatures. The observed daily average of reference evapotranspiration (ETo) was 6.95 mm day^{-1}, which represented an amount of water applied over the fifteen days of baby beet development of 104.30, 83.44, 62.58, 41.72 mm, corresponding to 100, 80, 60 and 40% of ETo. Santana et al. (2020) determined the reference evapotranspiration using different estimation models for growing beet and observed that the average ETo using the Class A evaporation pan method was 3.29 mm day^{-1}, which is lower than the value found in this study, which is probably due to the high temperatures found inside the greenhouse, as shown in Figure 1. Table 2 shows the variables significantly affected by the sowing densities in baby beet cultivation.Table 2 shows that D2 (1.0 g cm^{-2}) was superior, with better results than D1 (0.5 g cm^{-2}) for the variables plant height (PH), shoot fresh mass (FM), shoot dry mass (DM), number of plants per area (NP), water content (WC), and water use efficiency (WUE).The variables with the greatest differences between sowing densities were PH, FM, DM, NP, and WUE, with differences of 20.81%, 36.84%, 20%, 31.80% and 42.96% between D2 and D1, respectively.

Table 2. Summary of the parameters analyzed: Plant height (PH), shoot fresh mass (FM),shoot dry mass (DM), number of plants per area (NP), water content (WC), and water use efficiency (WUE) of baby beet plants under to two sowing densities (Dens).

Dens (gcm^{-2})	PH (cm)	FM (g cm^{-2})	DM (g cm^{-2})	NP (pl cm^{-2})	WC (%)	WUE (g cm^{-2} mm^{-1})
D1 (0.5)	6.47 b	0.24 b	0.04 b	2.38 b	84.79 b	141.65 b
D2 (1.0)	8.17 a	0.38 a	0.05 a	3.49 a	86.35 a	248.35 a
MSD	0.27	0.08	0.011	0.76	0.90	17.96

MSD: minimum significant difference. Means followed by the same letter in the column do not differ by Tukey test at 5% probability.

The plant height of baby beet was 6.47 cm in D1 and 8.17 cm in D2, values which were higher than those found by Santos et al. (2020) when growing beet microgreens in soil (5.86 cm) but were close to those grown in coconut fiber (7.88 cm) and worm humus (8.10 cm). Dias et al. (2023) also evaluated beet microgreens grown with zinc supplementation under hydroponic conditions and found an average plant height of 6.13 cm. The values found corroborate those of Kyriacou et al. (2016), who suggest that the ideal height for harvesting microgreens is between 5 and 10 cm.

The fresh mass of the beet microgreens in this study varied from 0.24 g cm-2 at D1 to 0.38 g cm-2 at D2, directly reflected in the plant accumulation of dry mass and water content (Table 2). Dias et al. (2023) observed fresh mass accumulation in beet microgreens of 0.1564 g cm-2 in hydroponic cultivation. The sowing density of 1.0 g cm-² for growing baby beet promoted better plant performance, making them more efficient in water use. According to experimental results by Nolan (2019), higher sowing densities resulted in higher fresh mass yields of microgreens, but the cost of seeds can be a limiting factor. Thuong and Minh (2020) reported the occurrence of radish root rot in trays where the sowing density was higher than 12 radish seeds cell-1, corresponding to 0.0164 g cm-2.

Figure 2 shows the water use efficiency (WUE) concerning irrigation depths under different densities. In D1, the behavior was linearly decreasing so that the lower the water applied, the lower the WUE; this reduction was 0.4369 g ha-1mm-1for each 1% ETo applied viairrigation depth. D2 showed the same behavior but with a reduction rate of around 3.7852 g ha-1 for each 1% of ETo appliedviairrigation depth. This behavior has already been shown in crops such as cowpeas (LOCATELLI et al., 2014) and tomatoes (SANTOS et al., 2019).

According to Campagnol et al. (2014), the WUE improves when crop yield increases, with a reduction in unnecessary expenditure on water resources, highlighting the importance of using the most efficient irrigation depth in using water resources.

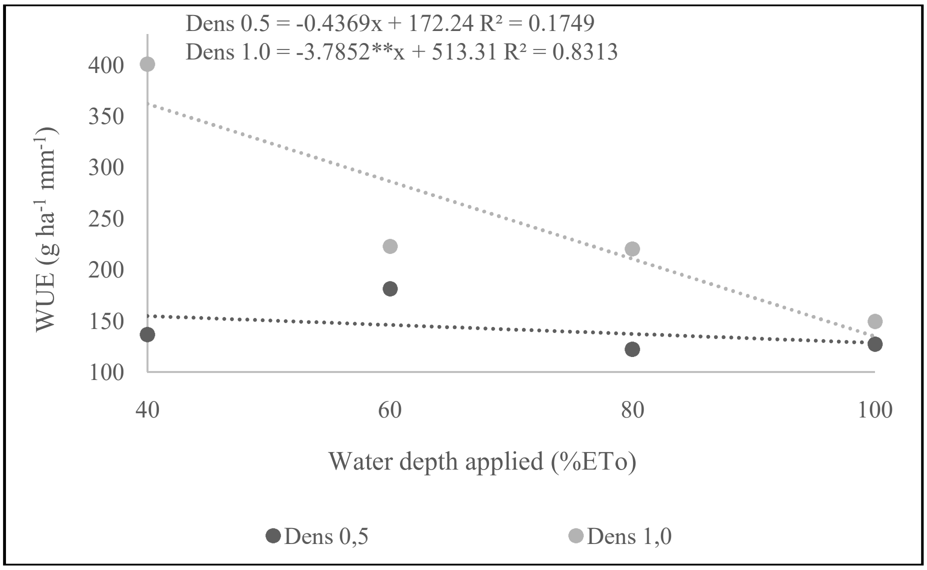

Figure 2. Water use efficiency (WUE) of baby beet under different sowing densities according to deficit irrigation depths applied based on the reference evapotranspiration (ETo). ** significant at 1% probability by the t-test.

Figure 3 shows the total titratable acidity (TTA) values of beet microgreens under the effect of irrigation rates, regardless of the sowing density adopted. A decreasing behavior can be seen, in which the TTA values decreased as the water depth increased, varying from 0.45% at 100% ETo to 0.86% at 60% ETo. The equation shows this behavior so that the rate of reduction in TTA is 0.0072% for each 1% ETo applied via irrigation depth. Santos et al. (2020) also evaluated the TTA of beet microgreens in different substrates and the results ranged from 0.4% for cultivation in soil to 0.47% in coconut fiber. According to Morais et al. (2011), titratable acidity indicates the acidic taste of vegetables and is mainly attributed to the organic acids present in plant cells, in the case of beet, the main one is citric acid. According to Alves et al. (2020), acidity in leafy vegetables is generally low, and Silva et al. (2011) indicate that the higher the TTA, the longer the product shelf life. Thus, it should be noted that when beet microgreens were cultivated with 40% of ETo, water use efficiency was higher, as was total titratable acidity, which indicates greater production efficiency and post-harvest durability.

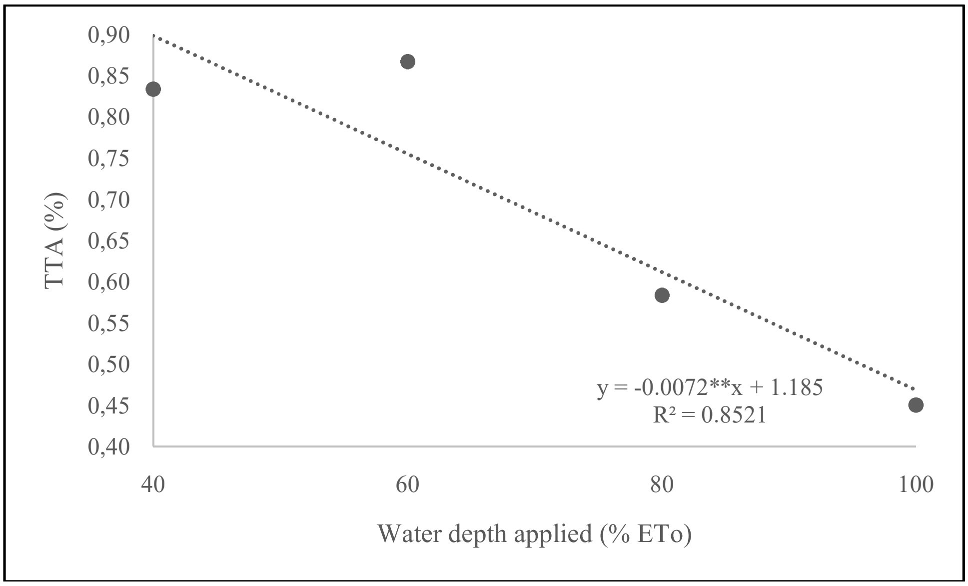

Figure 3. Titratable acidity (TTA) of beet plants, harvested at the baby stage, according to the deficit irrigation depths. ** significant at 1% probability by the t-test.

CONCLUSIONS

In the baby beet crop, the results for sowing density were significant for plant height, shoot fresh and dry mass, number of plants per area, water content, and water use efficiency, with the best performance at a sowing density of 1 g cm-2.

The parameters of total titratable acidity and water use efficiency were significantly influenced by irrigation, showing a reduction as the irrigation depth increased.

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REFERENCES

ALLEN, R. G.; PEREIRA, L. S.; RAES, D.; SMITH, M. Evapotranspiración del cultivo: guías para la determinación de los equerimientos de água de los cultivos, 2006.

ALVARES, C. A.; STAPE, J. L.; SENTELHAS, P. C.; GONÇALVES, J. L. M.; SPAROVEK G. Köppen's climate classification map for Brazil. MeteorologischeZeitschrift, Piracicaba, v. 22, nº. 6, p.711–728, 2013.

ALVES, T. N.; ECHER. M. M.; COUTINHO, P. W. R.; MACEDO JÚNIOR, E. K.; KLOSOWSKI, E. S.; SACKSER, G. A. B.; BLACK, A. V.; INAGAKI, A. M. Brazilian Journal of Development, v. 6, nº. 10, p. 79987-80001, 2020.

ANDRADE, M. C. R.; SANTOS, J. M. A.; SILVA, P. M. R.; CAMPOS, N. M. Produção de tomate rasteiro por irrigação localizada. Revista Saberes, v. 1, nº 5, p. 18-22, 2017.

BLISLA JÚNIOR, A.; BLILKA, F. M. M.; MARY, W. Demandas tecnológicas na agricultura urbana intensiva. Revista Digital de Tecnologias Cognitivas, v. 20, nº. 2, p. 77-95, 2019.

CAMPAGNOL, R.; ABRAHÃO, C.; MELLO, S. C.; OVIEDO, V. R. S. C.; MINAMI, K. Impactos do nível de irrigação e da cobertura do solo na cultura do tomateiro. Irriga, v. 19, nº. 3, p. 345-357, 2014.

COELHO, E. F.; LEDO, C. A. S.; SILVA, S. O. Produtividade da bananeira ´Prata-Anã´ e ´Grande Naine´ no terceiro ciclo sob irrigação por microaspersão em tabuleiros costeiros da Bahia. Revista Brasileira de Fruticultura. v.28, nº. 3, p.435-438, 2006.

CRUZ, E. A.; MOREIRA, G. R.; PAULA, M. O.; OLIVEIRA, A. C. M. Coeficiente de variação como medida de precisão em experimentos com tomate em ambiente protegido. Enciclopédia Biosfera, v. 8, nº 14, p.220-233, 2012.

DIAS, L. O. F.; PEIL, R. M. N.; ROMBALDI, C. V.; MARUCH, C. R.; PERIN, L. Biofortificação agronômica com zinco: respostas biométricas e fitoquímicas de microverdes de beterraba, repolho roxo e manjericão, Revista Delos: Desarrollo Local Sostenible, v.16, nº.47, p. 2719-2737, 2023.

FERREIRA, D. F. SISVAR: a computer analysis system to fixed effects split plot type designs. Revista Brasileira de Biometria, [S.l.], v. 37, nº. 4, p. 529-535, 2019.

FILGUEIRA, F. A. R. Brassicáceas: couves e plantas relacionadas. In: Novo manual de olericultura: agrotecnologia moderna na produção e comercialização de hortaliças. Viçosa-MG: UFV, p.279-299. 2012.

INSTITUTO ADOLFO LUTZ (IAL). Métodos Físicos químicos para análise de alimentos. 4. ed. São Paulo, 1018p. 2005.

KYRIACOU, M. C.; ROUPHAEL, Y.; DI GIOIA, F.; KYRATZIS, A.; SERIO, F.; RENNA, M.; SANTAMARIA, P. Micro-scalevegetableproductionandtheriseofmicr ogreens. Trends in Food Science & Technology, v. 57, p. 103-115, nº 1, 2016.

LOCATELLI, V. E, R, L.; MEDEIROS, R. D.; SMIDERLE, O. J.; ALBUQUERQUE, J. A. A.; ARAÚJO, W. F.; SOUZA, K. T. S. Componentes de produção, produtividade e eficiência da irrigação do feijão-caupi no cerrado de Roraima. Revista Brasileira Engenharia Agrícola Ambiental, v. 18, n. 6, p. 574-580, 2014.

MORAIS, P. L. D.; DA SILVA, D. N.; BEZERRA, A. M. L.; ABRANTES, S. J. D.; DE SOUSA O. N. N. Qualidade pós-colheita da alface hidropônica em ambiente protegido sob malhas termorefletoras e negra. Revista Ceres, v. 58, n. 1, p. 638-644, 2011.

NOLAN, D. A. Effects of seed density and other factors on the yield of microgreens grown hydroponically on burlap. Master, Verginia Tech., U.S.A, 2019.

OLIVEIRA NETO, D. H; CARVALHO, D. F.; SILVA, L. D. B.; GUERRA, J. G. M.; CEDDIA, M. B. Evapotranspiração e coeficientes de cultivo da beterraba orgânica sob cobertura morta de leguminosa e gramínea. Horticultura Brasileira. v. 29, nº 3, p. 330-334, 2011.

SANTANA, M. J.; CHAVES, H. H.; OLIVEIRA, M. E. F.; FERNANDES, A. L. T.; CALZADO, M. A.; FERREIRA, M. N. Estimativa da evapotranspiração e dos coeficientes de cultivo da cultura da beterraba, Revista Brasileira de Agricultura Irrigada, v. 14, n. 4, p. 4141 – 4153, 2020.

SANTOS, F. L.; COSTA, E. S.; LIMA, C. S. M. Diferentes substratos no desenvolvimento e na pós-colheita de microverdes de beterraba (Beta vulgaris L.). Revista Iberoamericana de TecnologíaPostcosecha, v. 21, n. 2, 2020.

SANTOS, H. G.; JACOMINE, P. K. T.; ANJOS, L. H. C.; OLIVEIRA, V. A.; LEMBRERAS, J. F.; COELHO, M. R.; CUNHA, T. J. F. Sistema brasileiro de classificação de solos. Embrapa Solos (5a). Brasília, DF: Embrapa Solos, 2018.

SANTOS, A. P.; COSTA, A. R.; SILVA, P. C.; MELO, M. C. R.; ARAÚJO, H. L. Influência de lâminas de irrigação e fontes de nitrogênio no crescimento vegetativo do tomate cereja cultivado em ambiente protegido. EnciclopédiaBiosfera, v.14, n.25, p. 821-831, 2017.

SANTOS, A. P.; COSTA, A. R.; SILVA, P. C.; GIONGO, P. R.; MESQUITA, M.; DRUMOND, A. A. L.Irrigation Depth and Nitrogen Fertilization on Production and Quality of Cherry Tomatoes. Journal of Agricultural Science, v. 11, n. 6, 2019.

SILVA, E. M. N. C. P.; FERREIRA, R. L. F.; NETO, S. E. D. A.; TAVELLA, L. B.; SOLINO, A. J. Qualidade de alface crespa cultivada em sistema orgânico, convencional e hidropônico. HorticulturaBrasileira, v. 29, n. 1, p. 242-245, 2011.

STOREY, A. 6 ways to grow better microgreens. In Crops & Growing Science, Upstart University, Bright Agrotech, Plenty. Upstart University, Modern Farm Education, 2017.

THUONG, V. T.; MINH, H. G. Effects of growing substrates and seed density on yield and quality of radish (Raphanussativus) microgreens, Research on Crops, v. 21, n 3, p. 579-586, 2020.

WIETH, A. R., PINHEIRO, W. D., DUARTE, T. D. S. Purple cabbage microgreens grown in different substrates and nutritive solution concentrations. Revista Caatinga, v. 32, n. 4, p. 976-985, 2019.