horticultura brasileira

Research

CRUZ FILHO, EM; SOUSA, GG; COSTA, FHR; SOUSA, HC; SILVA, FDB; SCHNEIDER, F; SILVA, EFF; LEITE, KN. Yield and physical-chemical quality of okra fruits irrigated with brackish water and phosphorus fertilization. *Horticultura Brasileira* 2024, v.42, elocation e2607. DOI: http://dx.doi.org/10.1590/s102-0536-2024-2607

Yield and physical-chemical quality of okra fruits irrigated with brackish water and phosphorus fertilization

Elizeu M Cruz Filho[1]; Geocleber G de Sousa[2]; Francisco Hermeson R da Costa[3]; Henderson C Sousa[3]; Fred Denilson B da Silva[2]; Fernanda Schneider[2]; Ênio FF e Silva[1]; Kelly N Leite[4]

[1]Universidade Federal Rural de Pernambuco (UFRPE), Recife-PE, Brasil; elizeu.cruz9@gmail.com; enio.fsilva@ufrpe.br. [2]Universidade da Integração Internacional da Lusofonia Afro-Brasileira (UNILAB), Redenção-CE, Brasil; sousagg@unilab.edu.br; freddenilson@unilab.edu.br; fernanda.schneider@unilab.edu.br. [3]Universidade Federal do Ceará (UFC), Fortaleza-CE, Brasil; hermesonrc@gmail.com; castelohenderson@gmail.com. [4]Universidade Federal do Acre (UFAC), Cruzeiro do Sul-AC, Brasil; knleite.ufac@gmail.com

ABSTRACT

Phosphate fertilization can mitigate the deleterious effects of salts in the different stages of okra. The objective was to evaluate the effect of the cyclical use of water of lower and higher ECw at different phenological stages under phosphorus fertilization on productivity and fruit quality of okra. A completely randomized design was used, in a 4 x 3 factorial scheme, with four irrigation strategies of cyclical use with water of 0.3 dS/m (W1) and 2.0 dS/m (W2) applied in different phenological stages (IS1 = W1 throughout the cultivation cycle; IS2 = W2 in the establishment phase, W1 in the vegetative phase and W2 in the reproductive and maturation phase; IS3 = W1 in the establishment phase and W2 in the vegetative, reproductive and maturation phase; and IS4 = W1 in the establishment and vegetative phase, and W2 in the reproductive and maturation phase, with three doses of phosphorus (0, 50 and 100 kg/ha), and four replications. Cyclic water use of 0.3 dS/m in the establishment and vegetative phase and 2.0 dS/m in the reproductive and maturation phase reduced the thickness of the peel, while for the length of the fruit this reduction was evidenced with the use of water 0.3 dS/m throughout the cycle. Doses of 50 and 100 kg/ha provided greater performance in fruit quality and productivity of okra.

Keywords: *Abelmoschus esculentus*, simple superphosphate, salt stress.

RESUMO

Produtividade e qualidade físico-química de frutos de quiabo irrigado com água salobra e adubação fosfatada

A adubação fosfatada poderá mitigar os efeitos deletérios dos sais nas diferentes fases de cultivo do quiabo. Objetivou-se avaliar o efeito do uso cíclico de água de menor e maior CEa em diferentes estágios fenológicos sob adubação fosfatada na produtividade e qualidade do fruto do quiabeiro. Utilizou-se o delineamento inteiramente casualizado, em esquema fatorial 4 x 3, sendo quatro estratégias de irrigação de uso cíclico com água de 0,3 dS/m (A1) e 2,0 dS/m (A2) aplicadas em diferentes estágios fenológicos (EI1 = A1 em todo ciclo de cultivo; EI2 = A2 na fase de estabelecimento, A1 na fase vegetativa e A2 na reprodutiva e maturação; EI3 = A1 na fase de estabelecimento e A2 fase vegetativa, reprodutiva e maturação; e EI4 = A1 na fase de estabelecimento e vegetativa, e A2 na fase reprodutiva e maturação, com três doses de fósforo (0, 50 e 100 kg/ha), e quatro repetições. O uso cíclico de água de 0,3 dS/m na fase de estabelecimento e vegetativa e 2,0 dS/m na fase reprodutiva e maturação reduziu a espessura da casca, enquanto para o comprimento do fruto essa redução foi evidenciada com uso de água 0,3 dS/m durante todo o ciclo. As doses de 50 e 100 kg/ha proporcionaram maior desempenho em qualidade do fruto e produtividade do quiabo.

Palavras-chave: *Abelmoschus esculentus*, superfosfato simples, estresse salino.

Received on January 16, 2023; accepted on November 23, 2023

Okra (*Abelmoschus esculentus*) is a vegetable of African origin belonging to the Malvaceae family, characterized as an annual bushy plant with indeterminate growth and sequential fruit ripening (Filgueira, 2012).

The world production in 2020 was about 10.5 million tons from a harvested area of 2.5 million hectares, mainly located in the Asian and African continents with 68.9% and 30.2%, respectively (FAOSTAT, 2020).

In Brazil, okra production is still modest; however, the southeastern and northeastern regions, especially on small farms, provide excellent climatic conditions for cultivation (Silva *et al*., 2021).

Regarding precipitation, the Brazilian semi-arid region is characterized by seasonal and uneven rainfall with high evapotranspiration rates, which favors the concentration of solutes in surface water sources, leading to soil and water salinization. This combination is a major abiotic constraint on global food production in arid and semi-arid regions (Minhas *et al*., 2020; Sales *et al*., 2021; Sousa *et al*., 2022a).

Excess dissolved salts in the soil solution inhibit plant growth by limiting water uptake through osmotic effects, altering metabolism, nutrient uptake, and ionic balance, ultimately affecting productivity and postharvest quality (Zhang *et al*., 2019; Gomes do Ó *et al*., 2020). In this context, the use of brackish water in agriculture has been adopted to mitigate salt stress on plants, optimize water resource use, and maximize agricultural productivity.

According to Neves *et al*. (2015), the use of alternating strategies with saline water in different stages of cowpea (*Vigna unguiculata*) crop reduced the consumption of good quality water by up to 47% without compromising crop yield.

Saifullah *et al*. (2018) describe that mineral nutrition enhances plant development even in unfavorable environments. Thus, chemical fertilizers have been used to alleviate salinity stress in agricultural crops. Among these macronutrients, phosphorus is the most demanded by okra, which can minimize the negative effects of saline stress on plant development by increasing the number of structural units in roots, flowers, and fruits, thus increasing productivity.

Guilherme *et al*. (2021), using lower quality water at different phenological stages of peanut crop under phosphorus fertilization, concluded that the use of higher salinity during fruiting and pod formation and lower salinity at all phenological stages, combined with 100% of the recommended dose of phosphorus, provided higher productivity of the crop.

In view of the above, the objective was to evaluate the effect of the cyclic use of water with lower and higher electrical conductivity at different phenological stages under phosphate fertilization on the productivity and quality of okra fruits.

MATERIAL AND METHODS

This research was carried out in pots, placed in full sun from July to November 2020, at the Seedling Production Unit of Auroras (UPMA), at the Universidade da Integração Internacional da Lusofonia Afro-Brasileira (UNILAB), Redenção-CE (04°14'53"S, 38°45'10"W, 240 m altitude). According to the classification of Köppen (1923), the climate of the region is characterized as Aw', tropical with dry winter. Meteorological data during the experiment were monitored by a Data logger (HOBO® U12-012 Temp/RH/Light/Ext) (Figure 1).

The substrate used consisted of local soil, coarse sand and cattle manure in a ratio of 5:3:1, respectively, adapted from Sousa et al. (2022b). The chemical analysis of the substrate before fertilization showed the following results: $pH_{(H_2O)}$ = 6.4; organic matter = 14.5 g/kg; P = 27.0 mg/kg; H+Al = 1.5 $cmol_c$/kg; K = 0.8 $cmol_c$/kg; Ca = 4.5 $cmol_c$/kg; Mg = 0.7 $cmol_c$/kg; Na = 0.7 $cmol_c$/kg; Sum of bases (SB) = 7.0 $cmol_c$/kg; ECse = 0.08; Cation exchange capacity (CEC) = 8.1 $cmol_c$/kg; Exchangeable sodium percentage (ESP) = 8.0.

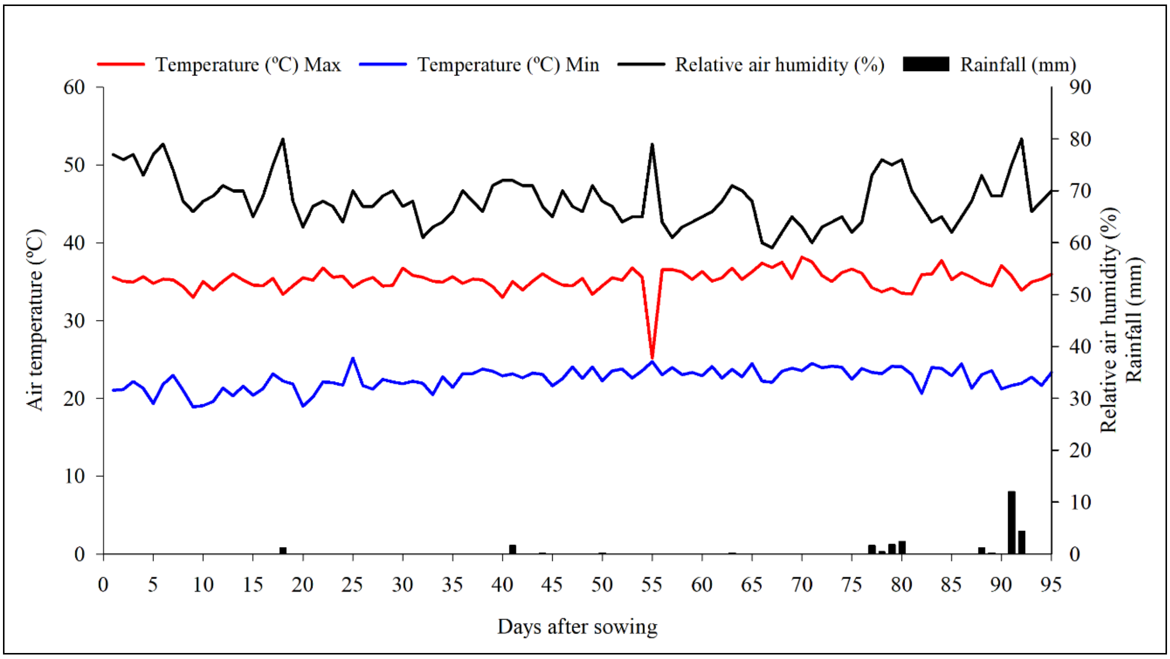

Figure 1. Average values of temperature and relative humidity during the experimental period. Recife, UFRPE, 2020.

The okra cv. Santa Cruz 47 was manually sown in styrofoam trays with 200 cells of 40 cm^3 volume, using a substrate composed of sand and charred rice husk in a 1:1 ratio. Fifteen days after seedling establishment, transplantation was carried out in 25 L pots with dimensions corresponding to a height of 35 cm and upper and lower diameters of 34 and 23 cm, respectively.

The experimental design used was completely randomized in a 4 x 3 factorial arrangement. The first factor refers to the adoption of four irrigation strategies (IS) of cyclic use with non-brackish water (W1=0.3/m) and brackish water (W2=2.0/m) applied at different phenological stages of the crop. Irrigation strategies were applied as follows: IS1 = W1 applied throughout the crop phase; IS2 = W2 applied in the crop establishment phase, W1 in the vegetative phase, and W2 in the reproductive and maturation phases; IS3 = W1 in the crop establishment phase and W2 in the vegetative, reproductive, and maturation phases; and IS4 = W1 applied in the crop establishment and vegetative phases, and W2 in the reproductive and maturation phases.

The second factor was three doses of phosphorus (0, 50, and 100 kg/ha), corresponding to 0, 50, and 100% of the recommended dose for okra crop, with four replications. The plant development scale for this work was adapted from a study developed by Paes *et al*. (2012) and includes the initial phase, corresponding to 40 days from planting to crop establishment, followed by the vegetative phase from 40 to 60 days, and ending with the reproductive and maturation phase from 60 to 100 days after sowing.

Mineral fertilization was applied in the establishment (at the time of sowing) and the rest in the topdressing (20 and 30 DAS), with 8, 10, and 6 g/pot, corresponding to 80 kg/ha N, 100 kg/ha P_2O_5, and 60 kg/ha, as recommended by Trani *et al*. (2013), in the sources urea, single superphosphate, and potassium chloride, respectively, for a stand of 10,000 plants/ha, adopting for P_2O_5 the treatments corresponding to 0, 50, and 100 kg/ha.

The amount of NaCl, $CaCl_2.2H_2O$, $MgCl_2.6H_2O$ used in the preparation of the irrigation water was prepared to obtain the ratio 7:2:1, according to the relationship between the electrical conductivity of water - ECw - and its concentration ($mmol_c/L$ = EC x 10), as described in the methodology proposed by Rhoades *et al*. (2000).

Irrigation with brackish water was initiated according to the established strategies, with a leaching fraction of 15% according to Ayers & Westcot (1999). Water was applied manually, with a daily irrigation frequency, and the irrigation depth estimated according to the drainage lysimeter principle (Bernardo *et al*., 2019), keeping the substrate close to the field capacity. The water volume to be applied to the plants was determined by equation 1:

$$VI = \frac{Vp - Vd}{1 - LF} \qquad eq.1$$

Where: VI = Volume of water to be applied in the irrigation event (mL); Vp = Volume of water applied in the previous irrigation event (mL); Vd = volume of water drained (mL) and LF = leaching fraction of 0,15.

Fruits were harvested every two days throughout the reproductive and ripening stages, during which the following variables were measured: Soluble solids, expressed in Brix degrees, measured with a refractometer; fruit pH, determined with a portable pH meter; number of fruits/plant, obtained by direct fruit counting; fruit length (cm), fruit diameter (mm), and fruit peel thickness (mm), obtained with a ruler and a digital caliper, respectively. Yield was measured on the basis of fruit mass and estimated in t/ha.

The studied and measured variables during the research were analyzed using the Kolmogorov-Smirnov test ($p \leq 0.05$) to assess normality. The data were subjected to analysis of variance and, being significant according to the F test, the means were subjected to Tukey test at 0.01 and 0.05 levels of significance using the ASSISTAT, version 7.7 Beta computer program (Silva & Azevedo, 2016).

RESULTS AND DISCUSSION

According to the analysis of variance, there was no significant interaction between irrigation strategies and phosphorus fertilization doses for any of the variables studied. However, there was an isolated effect of phosphorus doses on the number of fruits per plant, fruit diameter and yield. For fruit length, a significant effect was observed only for irrigation strategy. For fruit peel thickness, an isolated response was observed for both irrigation strategies (IS) and phosphorus doses (PD). On the other hand, there were no significant responses for soluble solids and fruit pH.

The highest values for number of fruits/plant were obtained with the application of doses of 50 and 100 kg/ha P, but values were not statistically different from each other; however, they were higher than the control treatment (Figure 2A). This result indicates that the absence of P delays plant maturity, reduces flowering and fruit set, and consequently results in a reduced number of fruits, as seen in the treatment without phosphorus fertilization.

Souza *et al*. (2023) observed that phosphorus application had a significant effect on the flowering period of okra crop, resulting in an anticipation of this phenological stage. In addition, the number of fruits was positively influenced by increasing P doses, reaching maximum values at 80 kg/ha.

For fruit diameter, the doses of 50 and 100 kg/ha of phosphorus differed from the control treatment, showing no statistical differences between them (Figure 2B). These results could be due to the positive effect of P on flowering and fruiting of plants, which contributed to the improvement of fruit diameter. According to Van Raij (2011), phosphorus plays an important role in a variety of plant compounds and is essential for various metabolic and energy transfer processes. Its presence is crucial for the proper formation of plant reproductive parts, as well as for the development and quality of fruits and seeds.

The results are consistent with those obtained by Oliveira *et al*. (2013), who studied the okra cv. Clemson Spineless 80; they observed an increase in fruit diameter with increased phosphorus fertilization.

The mean values presented in Figure 2C show that irrigation strategies IS2, IS3, and IS4 are statistically different from IS1. This effect could be due to the nutrients present in the salts, that is, $MgCl_2$ could have had a synergistic effect with phosphorus, contributing to an increase in this variable. As pointed out by Malavolta *et al*. (1997), the presence of magnesium in the environment can affect the uptake of phosphorus (P) by plants, since magnesium can play the role of transporting P into plant tissues.

The results obtained, together with the absence of adverse effects on okra crop for the other variables analyzed during the experiment, indicate that irrigation strategies can be effective. Water can be used cyclically in okra, at phenological stages, with an electrical conductivity of 2.0 dS/m.

Regarding the fruit peel thickness (Figure 3A), irrigation strategies IS1, IS2 and IS3 do not show a statistically significant difference from each other. However, they differ from strategy IS4, which consists of irrigation with water at 2.0 dS/m in the reproductive phase of the crop, showing tolerance to brackish water in the initial and vegetative phases and greater sensitivity to this variable in the reproductive phase.

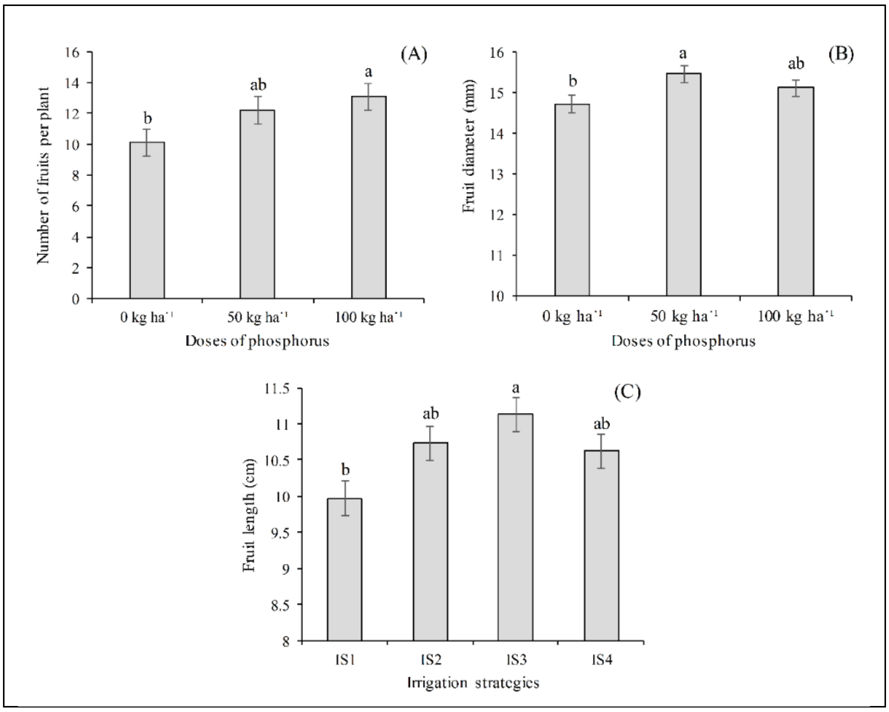

Figure 2. Number of fruits per plant (A) and fruit diameter (B) of okra as a function of different doses of phosphorus fertilization. Fruit length (C) subjected different irrigation strategies. Means followed by the same lowercase letters on the bars are not significantly different by Tukey test ($p < 0.05$). Redenção, UNILAB, 2020.

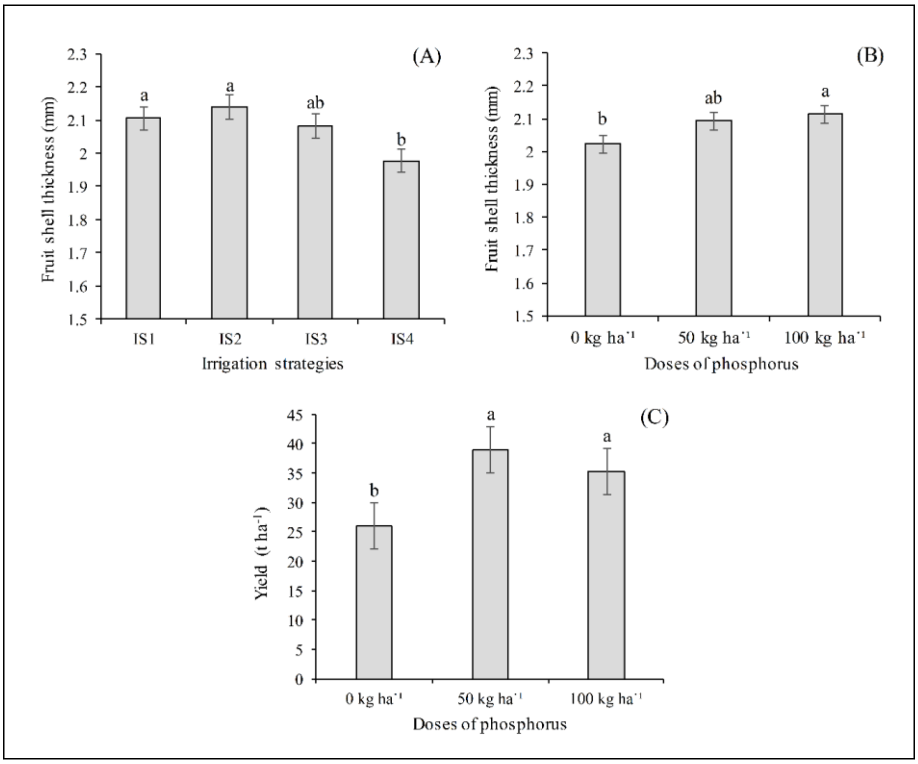

Figure 3. Effect of irrigation strategies on okra fruit peel thickness (A). Peel thickness (B) and yield (C) of okra as a function of different doses of phosphorus. Means followed by the same lowercase letters on the bars are not significantly different by Tukey test ($p < 0.05$). Redenção, UNILAB, 2020.

Pereira *et al*. (2018) found that salt stress negatively affected the thickness of melon fruit rinds. Gomes do Ó *et al*. (2021) observed a decrease in mini watermelon fruit rind thickness with increasing salinity, a trait that may affect fruit quality and shelf life as it reduces resistance to transport and preservation.

The fruit peel thickness showed superiority when fertilized with doses of 50 and 100 kg/ha compared to the control (Figure 3B), where the lowest average values were obtained. These results are due to the fact that phosphorus performs the function of storing and providing chemical energy such as ATP, which is used in processes and reactions such as photosynthesis, cell growth and division, protein biosynthesis, starch, and respiration (Chitarra & Chitarra, 2005; Marschner, 2012). For phosphorus fertigation, Azevedo *et al*. (2016) also found a positive effect on watermelon flesh thickness.

There is a significant response of yield to phosphorus fertilization (Figure 3C), with greater expressiveness at the dose of 50 kg/ha, which provided a productivity of around 39 t/ha, an increase of 50.5% compared to the control treatment (25.9 t/ha), which is not statistically different from the dose of 100 kg/ha, which had an increase of 35.9% (35.2 t/ha), highlighting an alternative to reduce expenses with phosphorus fertilizers for the producer in situations similar to this work.

According to the study conducted by Uddin *et al*. (2014), phosphorus application had a positive effect on increasing the yield of okra crop. The results showed that the dose of 80 kg/ha of phosphorus provided the maximum productivity values, while the treatment without phosphorus fertilization showed minimum productivity values. Oliveira *et al*. (2013), working with the Clemson Spineless 80 cv., also found positive effects of P on increasing okra yield.

The cyclical use of water with lower salinity in the establishment and vegetative stages and higher salinity in the reproductive and ripening stages reduced fruit peel thickness, while for fruit length, this reduction was only evident with the use of lower salinity water throughout the cycle.

Doses of 50 and 100 kg/ha provided better performance in number of fruits per plant, fruit diameter, fruit peel thickness and okra yield.

ACKNOWLEDGMENTS

To the Universidade da Integração Internacional da Lusofonia Afro-Brasileira for the support granted for the realization of this study. To the Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco (FACEPE), for the grant of the master's degree scholarship to the first author.

REFERENCES

AYERS, RS; WESTCOT, DW. 1999. *A Qualidade da Água na Agricultura*. 2.ed. Campina Grande: UFPB. Brasil. 153p.

AZEVEDO, BM; FERNANDES, CNV; NASCIMENTO NETO, JR; VIANA, TVA; VASCONCELOS, DV; DIAS, CN. 2016. Frequência da fertirrigação fosfatada na produtividade da cultura da melancia. *Irriga* 21: 257-268.

BERNARDO, S; MANTOVANI, EC; SILVA, DD; SOARES, AA. 2019. *Manual de Irrigação*. 9. ed. Viçosa: UFV. Brasil. 545p.

CHITARRA, MIF; CHITARRA, AB. 2005. *Pós-colheita de frutos e hortaliças. Fisiologia e Manuseio.* 2 ed. Lavras: FAEPE. Brasil. 783p.

FAO - FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS – FAOSTAT. 2020. Production crops. Available at: <https://www.fao.org/faostat/en/#data/QCL>. Accessed November 15, 2022.

FILGUEIRA, FAR. 2012. *Novo manual de olericultura: Agrotecnologia moderna na produção e comercialização de hortaliças*. 3 ed. Viçosa: UFV. Brasil. 421p.

GOMES DO Ó, LM; COVA, AMW; AZEVEDO NETO, ADD; SOUZA, MG; SANTOS, AL; GHEYI, HR. 2021. Production, water-use efficiency and post-harvest quality of hydroponic mini watermelon under salinity stress. *Pesquisa Agropecuária Tropical* 51: e67054.

GOMES DO Ó, LM; COVA, AMW., GHEYI, HR; SILVA, NDD; AZEVEDO NETO, ADD. 2020. Production and quality of mini watermelon under drip irrigation with brackish water. *Revista Caatinga* 33: 766-774.

GUILHERME, JMS; SOUSA, GG; SANTOS, SO; GOMES, KR; VIANA, TVA. 2021. Água salina e adubação fosfatada na cultura do amendoim. *Irriga* 1: 704-713.

KÖPPEN, WP. 1923. *Die Klimate der Erde: Grundriss der Klimakunde*. Walter de Gruyter & *Co*. Berlin. 369p.

MALAVOLTA, E; VITTI, GC.; OLIVEIRA, SA. 1997. *Avaliação do estado nutricional das plantas: Princípios e aplicações*. Piracicaba: Potafós. 319p.

MARSCHNER, P. 2012. *Marschner´s mineral nutrition of higher plants*.3ed. Academic Press: Londres. 649p.

MINHAS, PS; RAMOS, TB; BEN-GAL, A; PEREIRA, LS. 2020. Coping with salinity in irrigated agriculture: Crop evapotranspiration and water management issues. *Agricultural Water Management* 227: 105832.

NEVES, ALR; LACERDA, CFD; SOUSA, CHCD; SILVA, FLBD; GHEYI, HR; FERREIRA, FJ. 2015. Growth and yield of cowpea/sunflower crop rotation under different irrigation management strategies with saline water. *Ciência Rural* 45: 814-820.

OLIVEIRA, ECA; SILVA, GP; OLIVEIRA, RI; CUNHA FILHO, M; LIRA JUNIOR, MA; FREIRE, FJ. 2013. Crescimento, produtividade e nível crítico de fósforo para o quiabeiro em relação à adubação fosfatada. *Revista Brasileira de Ciências Agrárias* 8: 89-594.

PAES, HMF; ESTEVES, BS; SOUSA, EF. 2012. Determinação da demanda hídrica do quiabeiro em Campos dos Goytacazes, RJ. *Revista Ciência Agronômica* 43: 256-261.

PEREIRA, ED; QUEIROGA, RCF; SILVA, ZL; ASSIS, LE; SOUSA, FF. 2018. Produção e qualidade do meloeiro sob osmocondicionamento da semente e níveis de salinidade da água. *Revista Verde de Agroecologia e Desenvolvimento Sustentável* 13: 8-15.

RHOADES, JP; KANDIAH, A; MASHALI, A. M. 2000. *Uso de águas salinas para a produção agrícola*. Estudos FAO 48, Campina Grande: UFPB. Brasil. 117p.

SAIFULLAH, DS; NAEEM, A; IQBAL, M; FAROOQ, MA; BIBI, S; RENGEL, Z. 2018. Opportunities and challenges in the use of mineral nutrition for minimizing arsenic toxicity and accumulation in rice: A critical review. *Chemosphere*. 194: 171-188.

SALES, JRDS; MAGALHÃES, CL; FREITAS, AG; GOES, GF; SOUSA, HCD; SOUSA, GGD. 2021. Índices fisiológicos de quiabeiro irrigado com água salina sob adubação organomineral. *Revista Brasileira de Engenharia Agrícola e Ambiental* 25: 466-471.

SILVA, FAS; AZEVEDO, CAV. 2016. The Assistat Software Version 7.7 and its use in the analysis of experimental data. *Africa Journal and Agriculture Researche* 11: 3733-3740.

SILVA, SN; OLIVEIRA, KCL; BARCELOS, AIH; GUEDES, SF. 2021. Produtividade e análises físico-químicas do quiabeiro em diferentes tipos de coberturas em sistema agroecológico. *Revista Ibero-Americana de Ciências Ambientais* 12: 204-212.

SOUSA, GGD; SOUSA, HC; SANTOS, MFD; LESSA, CIN; GOMES, SP. 2022a. Saline water and nitrogen fertilization on leaf composition and yield of corn. *Revista Caatinga* 35: 191-198.

SOUSA, HC; SOUSA, GGD; CAMBISSA, PB; LESSA, CI; GOES, GF; SILVA, FD; VIANA, TVDA. 2022b. Gas exchange and growth of zucchini crop subjected to salt and water stress. *Revista Brasileira de Engenharia Agrícola e Ambiental* 26: 815-822.

SOUZA, ADJ; WAMSER, AF; SILVA, VB; NASCIMENTO, S; GRANGEIRO, LC; CECÍLIO FILHO, AB. 2023. Adubação fosfatada e teor crítico foliar de fósforo para o quiabeiro. *Revista Caatinga* 36: 479-485.

TRANI, PE; PASSOS, FA; TEODORO, MCCL; SANTOS, VD; FRARE, P. 2013. *Calagem e adubação para a cultura do quiabo*. Instituto Agronômico de Campinas.

UDDIN, MJ; AKAND, MH; ISLAM, S; MEHRAJ, H; UDDIN, AFMJ. 2014. Phosphorus levels on growth and yield of okra (*Abelmoschus esculentus*). *Bangladesh Research Publication Journal* 10: 120-124.

VAN RAIJ, B. 2011. *Fertilidade do solo e manejo de nutrientes*. International Plant Nutrition Institute. Piracicaba. 420p.

ZHANG, T; ZHANG, Z; LI, Y; HE, K. 2019. The effects of saline stress on the growth of two shrub species in the Qaidam Basin of Northwestern China. *Sustainability* 11: 828.

Author's ORCID:

Elizeu M Cruz Filho – http://orcid.org/0000-0002-6208-3521
Geocleber G de Sousa – http://orcid.org/0000-0002-1466-6458
Francisco Hermeson R da Costa – http://orcid.org/0000-0002-9276-8177
Henderson C Sousa – http://orcid.org/0000-0001-6588-6832
Fred Denilson B da Silva – http://orcid.org/0000-0002-6365-6045
Fernanda Schneider – http://orcid.org/0000-0002-0134-314X
Ênio F F e Silva – http://orcid.org/0000-0002-8652-503X
Kelly N Leite – http://orcid.org/0000-0003-1919-9745