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PRODUCTION AND WATER CONSUMPTION OF EGGPLANT UNDER SALT STRESS AND CONTINUOUS DRIP AND PULSE DRIP IRRIGATION[1]

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ABSTRACT - Eggplant is a vegetable considered as moderately sensitive to salinity, and its production is affected by water deficit in the soil, mainly in the reproductive phase of the crop. The objective of this study was to evaluate the use of irrigation with brackish water using continuous drip and pulse in production, water consumption, water use efficiency, and soil salinization. The experimental design was in randomized blocks, in a 4 × 4 factorial scheme, with five replicates, totaling 80 plots. The treatments consisted of four forms of water application, continuous drip, and pulse throughout the cycle; continuous drip in the vegetative phase and pulse in the reproductive phase, and pulse in the vegetative phase and drip in the reproductive phase and four levels of irrigation water salinity - ECw (0.3; 1.5; 3.0; 4.5 dS m^{-1}). The inversion of irrigation treatments occurred 65 days after transplanting. Increase in water salinity from 0.3 to 4.5 dS m^{-1}, the total production (-11.96%), fruit length (-5.05%), and water use efficiency (-7.01%) reduced while there was no significant effect for the forms of water application and interaction between the studied factors. Pulse irrigation provided greater water savings and resulted in higher electrical conductivity in the soil saturation extract. The efficiency of water use did not show statistical difference when continuous drip or pulse irrigation was used throughout the cycle.

Keywords: Water use efficiency. Phenological phases. Salinity. *Solanum melongena* L.

PRODUÇÃO E CONSUMO HÍDRICO DA BERINJELA SOB ESTRESSE SALINO IRRIGADA POR GOTEJAMENTO CONTÍNUO E PULSOS

RESUMO - A berinjela é uma hortaliça considerada moderadamente sensível à salinidade e sua produção é afetada pelo déficit hídrico no solo, principalmente na fase reprodutiva da cultura. Objetivou-se avaliar a influência do uso da irrigação com água salobra utilizando o gotejamento contínuo e pulsos na produção, consumo hídrico e eficiência do uso da água da berinjela e na salinização do solo. O delineamento experimental foi em blocos casualizados, arranjado em esquema fatorial 4 × 4, com cinco repetições, totalizando 80 parcelas. Os tratamentos foram compostos pela combinação de quatro formas de aplicação de água: gotejamento contínuo e pulsos durante todo o ciclo; gotejamento contínuo na fase vegetativa e por pulsos na fase reprodutiva e pulsos na fase vegetativa e gotejamento na reprodutiva; e quatro níveis de salinidade de água de irrigação - CEa (0,3; 1,5; 3,0; 4,5 dS m^{-1}). A inversão das formas de irrigação ocorreu aos 65 dias após o transplantio. Com o aumento da salinidade da água de 0,3 a 4,5 dS m^{-1}, a produção total (-11,96%), comprimento do fruto (-5,05%) e eficiência do uso da água (-7,01%) reduziram enquanto, não se verificou efeito significativo para a forma de aplicação de água e interação entre os fatores estudados. A irrigação por pulsos proporcionou maior economia de água, e resultou em maior condutividade elétrica do extrato de saturação do solo. O gotejamento contínuo ou por pulsos durante todo o ciclo não apresentaram diferenças estatísticas quanto a eficiência do uso de água, mas a irrigação por pulsos é a mais indicada por proporcionar economia de água.

Palavras-chave: Eficiência do uso da água. Fases fenológicas. Salinidade. *Solanum melongena* L.

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INTRODUCTION

The Solanaceae family has important plant species such as tomato, bell pepper, potato, scarlet eggplant among others, including eggplant, which has great socioeconomic importance (LIMA et al., 2015). This Solanaceae species used to be considered a vegetable of secondary importance. However, its consumption has been increasing, due to its antioxidant, anti-inflammatory, cardioprotective, anti -obesity and anticancer properties, and because it helps reducing cholesterol and the risk of coronary diseases, besides being a source of various vitamins and minerals (PLAZAS et al., 2013; GÜRBÜZ et al., 2018).

Eggplant is a vegetable that has high production and adapts to hot and humid environments (GÜRBÜZ et al., 2018). However, the quantity and quality of the water used in the cultivation affect its production. Water deficit in the soil is particularly harmful to the crop during the production formation stage, as it causes the abortion of flowers and fruits and reduces fruit growth (BILIBIO et al., 2010). In relation to water quality, especially in arid and semi-arid regions, the water may contain high concentrations of salts that cause gradual soil salinization and may hamper the germination, development, and yield of eggplant, considered to be moderately sensitive to salinity (ÜNLÜNKARA et al., 2010; LIMA et al., 2015; HANNACHI; van LABEKE, 2018). However, there are differences in salinity tolerance between genotypes. Hannachi and van Labeke (2018) considered the cultivars Bonica and Galine to be more tolerant, while the most sensitive cultivars were Adriatica and Black Beauty.

Soil salinization affects plants due to increased concentration of salts in the soil solution, which compromises water absorption due to the reduction in the osmotic potential of the soil, in addition to specific ions causing toxicity to plants when absorbed, interfering in physiological processes and nutritional imbalance (DIAS et al., 2016). Thus, strategies are needed to mitigate the effects of salinity when using brackish water.

Irrigation associated with different forms of application can be fundamental to meet the water needs of crops when using brackish water. These forms include pulse drip irrigation, which according to Almeida et al. (2018) consists of a short period of water application, followed by an interval without irrigation and again another short period of application. This cycle repeats until the entire water depth required is applied. This technique has been studied in several crops in different regions of the world, for instance with potatoes in Egypt (ABDELRAOUF et al., 2012) and tomato in Saudi Arabia (ELNESR et al., 2015), and in Brazil, in cucumber (MALLER et al., 2016), lettuce (ALMEIDA; LIMA; PEREIRA, 2015), green beans (ALMEIDA et al., 2018) and eggplant (ARRIERO et al., 2020). In these studies, positive results were observed when comparing continuous drip with pulse drip irrigation, such as water-saving, increased yield, improvement in product quality, and delay in the negative effects of salinity.

In this context, the present study aimed to evaluate the influence of the continuous drip and pulse drip irrigation systems on the production and yield components, water consumption, and water use efficiency of eggplant using brackish water in irrigation and in soil salinization.

MATERIAL AND METHODS

The experiment was conducted from April to July 2019 in a protected environment, belonging to the experimental area of the Soil and Water Engineering Nucleus of the Federal University of Recôncavo da Bahia, located in the municipality of Cruz das Almas (12º40’39” S, 39°40’23” W, average altitude of 212 m), Bahia, located in the Recôncavo region of Bahia, Brazil. Air temperature values during the experimental period ranged from 24.8 to 25.2 ºC in the greenhouse, and the average relative humidity of air was 79%.

The experimental design used was randomized blocks, in a 4 × 4 factorial scheme, with five replicates, totaling 80 experimental units. The treatments were two forms of water application in the vegetative and reproductive stages of eggplant, referring to the application by continuous drip (C) and pulse drip (P) throughout the cycle; continuous drip in the vegetative stage, followed by pulse drip in the reproductive stage (C/P); and pulse drip in the vegetative stage and continuous drip in the reproductive stage (P/C). The inversion of the form of water application between continuous drip and pulse drip was performed at 65 days after transplanting (DAT). These treatments were combined with four levels of electrical conductivity of irrigation water (ECw): 0.3 (control - local-supply water), 1.5, 3.0, and 4.5 dS m^{-1}. Brackish water was prepared by adding NaCl to the local-supply water. After preparation, the electrical conductivity was measured and adjusted accordingly. These ECw levels were based on the study conducted by Arriero et al. (2020), who reported that irrigation with brackish water (electrical conductivity = 2.5 dS m^{-1}) prepared with the addition of NaCl did not affect the yield of eggplant when irrigated by pulse or continuous drip systems.

Commercially acquired seeds of the eggplant cultivar Florida Market from the company Isla were sown in polyethylene trays with 50 cells, containing coconut fiber and earthworm humus at a 2:1 ratio (v:v). After 30 days of sowing, the seedlings with four true leaves were transplanted into 100-L polyethylene containers filled with a 0.05-m-thick layer of crushed stone and 150 kg of soil from the 0-0.20 m layer, which was properly pounded to break up clods and homogenized. The crushed stone layer and the soil were separated by a screen, and a 16-mm-diameter tube was also installed at the bottom of each container for drainage. Each plot consisted of one polyethylene container with one plant.

The soil used was classified as *Latossolo Amarelo Ditrocoeso típico* (Oxisol), with low fertility and cohesive subsurface horizons. The physical-chemical characteristics of soil are presented in Table 1, determined according to the methodology described by Teixeira et al. (2017).

Table 1. Chemical and physical attributes of the soil used in the experiment.

Chemical characteristics											
ECse	pH	P	K	Ca	Mg	Al	H+Al	Na	SB	CEC	V
dS m^{-1}		mg dm^{-3}		--------------------cmol$_c$ dm^{-3}--------------------							%
1.28	5.1	13	48	1.0	0.5	0.2	3.0	0.04	1.66	4.66	35.6

Physical characteristics							
FC	PWP	Sand	Silt	Clay	Texture	OM	SD
---cm^3 cm^{-3}---		-------g kg^{-1}-------				g kg^{-1}	kg dm^{-3}
0.451	0.185	682.5	202.2	115.3	Sandy loam	1.18	1.5

ECse – Electrical conductivity of saturation extract; pH – Hydrogenic potential in water; SB – Sum of bases; CEC- cation exchange capacity; V – Base Saturation; FC –Field capacity (10 kPa); PWP –permanent wilting point (1500 kPa); OM – Organic matter; SD - Soil density.

From the chemical analysis of the soil and following the recommendations of Trani (2014) for the crop, 60 days before transplanting, liming was performed with 65 g of dolomitic limestone, and basal fertilization was applied with 46 g of monoammonium phosphate (MAP) and 13 g of potassium chloride (KCl) per container, in addition to 2 L of well decomposed manure. Top-dressing fertilization was performed at 30, 60, and 90 DAT, with 3.3 g of urea and 2.5 g of KCl per plot. Fertilization was calculated considering the area of the polyethylene container, 0.5 m^2. Cultural practices consisted of periodic scarification of the soil, preventive application of insecticide and fungicides, removal of the lateral branches from the main stem before the first flower, and staking of the plant to support the fruits.

The characteristic curve of soil water retention was used to calculate the irrigation depth, according to the model of van Genuchten (1980) represented by Equation 1.

$$\theta = 0.101 + \left(\frac{0.486 - 0.101}{\left[1 + (0.056\ |\Psi|)^{1.345}\right]^{0.256}} \right) \quad (1)$$

Where θ is soil moisture (cm^3 cm^{-3}) and Ψ is the matrix potential (kPa).

Soil moisture was monitored with a tensiometer installed at 0.15 m depth, in three replicates of each treatment. The tensiometer readings were performed daily at the pre-fixed times. Irrigation was carried out when the average tension obtained was greater than or equal to 15 kPa, and the moisture content was elevated to field capacity (10 kPa). The gross depth was determined considering the effective depth of the root system as equal to 0.30 m.

Irrigation was applied by a drip system, with one emitter per container of the conventional type with a flow rate of 2.1 L h^{-1} and Christiansen Uniformity Coefficient of 91% (value observed under experimental conditions). The emitters were connected to 5-mm-diameter microtubes in 0.020-m-diameter polyethylene tubes. Pulse drip irrigation was performed as follows: after determining the irrigation time, it was split equally into six times (pulses), with an interval of 30 minutes between pulses. A digital controller with four outputs and 24 programs was used to control pulse drip irrigation.

In the period from 65 to 100 DAT, eight harvests of eggplant fruits were performed, considering the criteria of bright purple color, soft pulp, firm peel and green calyx. Together with the harvest of marketable fruits, fruits that had suffered some kind of injury and/or malformation were also harvested.

Number of fruits (NFR), fruit length (FRL, cm), fruit diameter (FRD, cm), total production (TOTP, g $plant^{-1}$), and water consumption (WC, L $plant^{-1}$) were evaluated. Fruit length was measured with a graduated ruler, fruit diameter was measured with a digital caliper, water consumption was determined by the difference between the amounts of water applied and drained during the cycle, and water use efficiency (WUE, kg m^{-3}) was calculated using Equation 2.

$$\text{WUE} = \frac{\text{TOTP}}{\text{V}} \quad (2)$$

Where TOTP is the total production of the crop (kg $plant^{-1}$), and V is the volume of water applied by irrigation (m^3 $plant^{-1}$).

After harvest, the pH and electrical conductivity of the soil saturation extract were analyzed using the methodology of Teixeira et al. (2017); soil samples were collected at two points of the wet bulb, 0.10 m away from its center, at 0-0.30 m depth in each plot.

The collected data were subjected to analysis of variance. When significant by the F test, the mean data of the forms of application were compared by Tukey test at a 0.05 probability level. Salinity levels, when significant ($p<0.05$), were analyzed by regressions, and the models were selected based on the significance of their terms, on the coefficient of determination, and on the biological significance of the behavior. In the case of significant effect of the interaction, it was decomposed and the means of different forms of water application were compared based on the models obtained. All statistical analyses were performed with the help of the statistical program SISVAR version 5.6 (FERREIRA, 2019).

RESULTS AND DISCUSSION

The number of fruits (NFR) and fruit diameter (FRD) did not show significant effect of any of the treatments, obtaining means of 4.42 plant $fruits^{-1}$ and 6.6 cm, respectively (Table 2). However, water consumption (WC) was significantly influenced by the interaction between water salinity levels and forms of water application. When analyzing the factors separately, salinity had a significant effect on fruit length (FRL), total production (TOTP), and water use efficiency (WUE), which was also significantly affected by the forms of water application factor (Table 2).

Table 2. Summary of analysis of variance for the number of fruits (NFR), fruit length (FRL, cm), fruit diameter (FRD, cm), total yield (TOTP, g), water consumption (WC, L), and water use efficiency (WUE, kg m^{-3}) of eggplant grown in a protected environment with different forms of irrigation (I) under salt stress (ECw).

SV	DF	Mean squares					
		NFR	FRL	FRD	TOTP	WC	WUE
Irrigation (I)	3	12.08^{ns}	2.14^{ns}	1.71^{ns}	$84{,}590.98^{ns}$	$1{,}154.07^{**}$	18.62^{**}
ECw	3	2.18^{ns}	21.66^{**}	1.29^{ns}	$626{,}860.77^{**}$	$9{,}728.04^{**}$	22.40^{**}
I*ECw	9	6.39^{ns}	2.87^{ns}	1.26^{ns}	$49{,}997.37^{ns}$	247.49^{**}	1.73^{ns}
Block	4	5.42^{ns}	1.30^{ns}	1.62^{ns}	$66{,}696.97^{ns}$	0.26^{ns}	2.26^{ns}
Error	60	4.53	1.54	0.64	58,838.20	0.25	1.27
CV (%)		48.07	12.80	12.14	42.61	0.55	17.50
Mean		4.42	9.71	6.6	569.22	91.11	6.45

SV- Source of variation; DF- Degrees of freedom; ECw- Electrical conductivity of irrigation water; * and ** significant at the 0.05 and 0.01 level of probability, respectively; ^{ns} – not significant by the F test, CV = Coefficient of variation.

For FRL, there was a negative linear response to ECw, indicating a 5.05% reduction per unit increment in the electrical conductivity of irrigation water, decreasing from 10.84 cm (ECw = 0.3 dS m^{-1}) to 8.50 cm (ECw = 4.5 dS m^{-1}), which corresponded to a total reduction of 21.5% (Figure 1A). These results corroborate those reported by Oliveira et al. (2014), who observed losses of 22.1% with water salinity ranging from 0.5 to 6.0 dS m^{-1}, and by Santos et al. (2018), who found a 15.71% reduction when comparing the lowest salinity level (ECw = 0.5 dS m^{-1}) with the highest salinity level (ECw = 5.0 dS m^{-1}). Salinity affects plant growth, especially eggplant fruits as reported by Lima et al. (2015) when analyzing the dry mass partition in different parts of the plant.

However, even when local-supply water (ECw = 0.3 dS m^{-1}) was used, FRL was lower than that reported by Arriero et al. (2020), who considered marketable fruits of the cv. Florida Market as those with FRL above 13 cm. However, Costa et al. (2019), for the same cultivar, found lengths ranging between 10.42 and 12.23 cm in three forms of cultivation - conventional, organic, and hydroponic. Thus, the results of the present study are within the size range found in other studies.

Total fruit production was also affected by the increase in water salinity, so that the highest TOTP was achieved at ECw of 0.3 dS m^{-1} (760.31 g), and for each increment in the ECw unit there was a reduction of 11.96% (Figure 1B), a value close to those found for eggplant by Lima et al. (2015) and

Santos et al. (2018), which were 13.5 and 12.32%, respectively. For Acosta-Motos et al. (2017), salt stress initially induces osmotic stress, causing lower water availability to plants and, in the long term, induces ion toxicity due to nutrient imbalances, limiting plant yield. According to Lima et al. (2015), eggplant under salt stress significantly reduces the translocation of photoassimilates to fruits, due to lower absorption of water and nutrients.

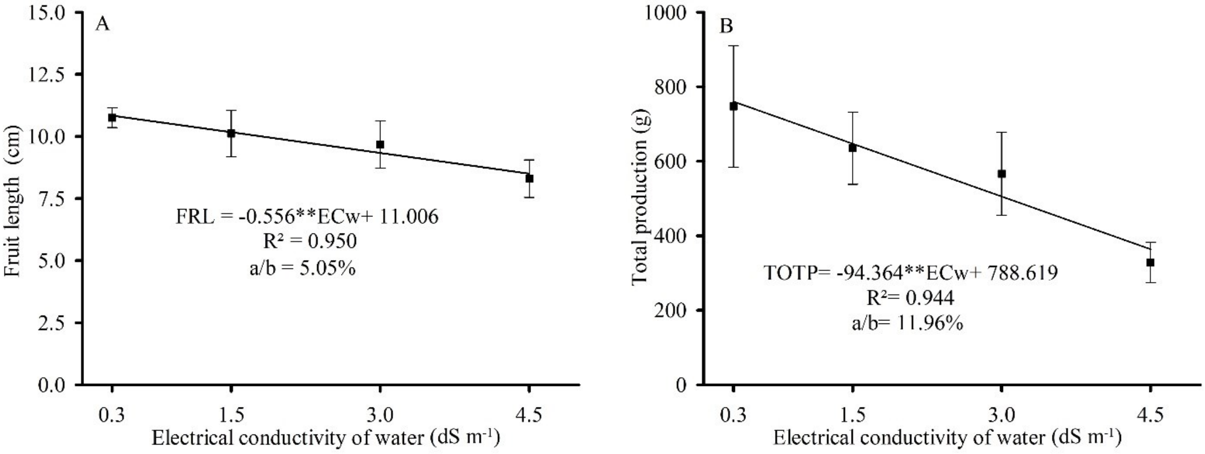


Figure 1. Average fruit length – FRL (A) and total production – TOTP (B) of eggplant as a function of the electrical conductivity of the irrigation water.

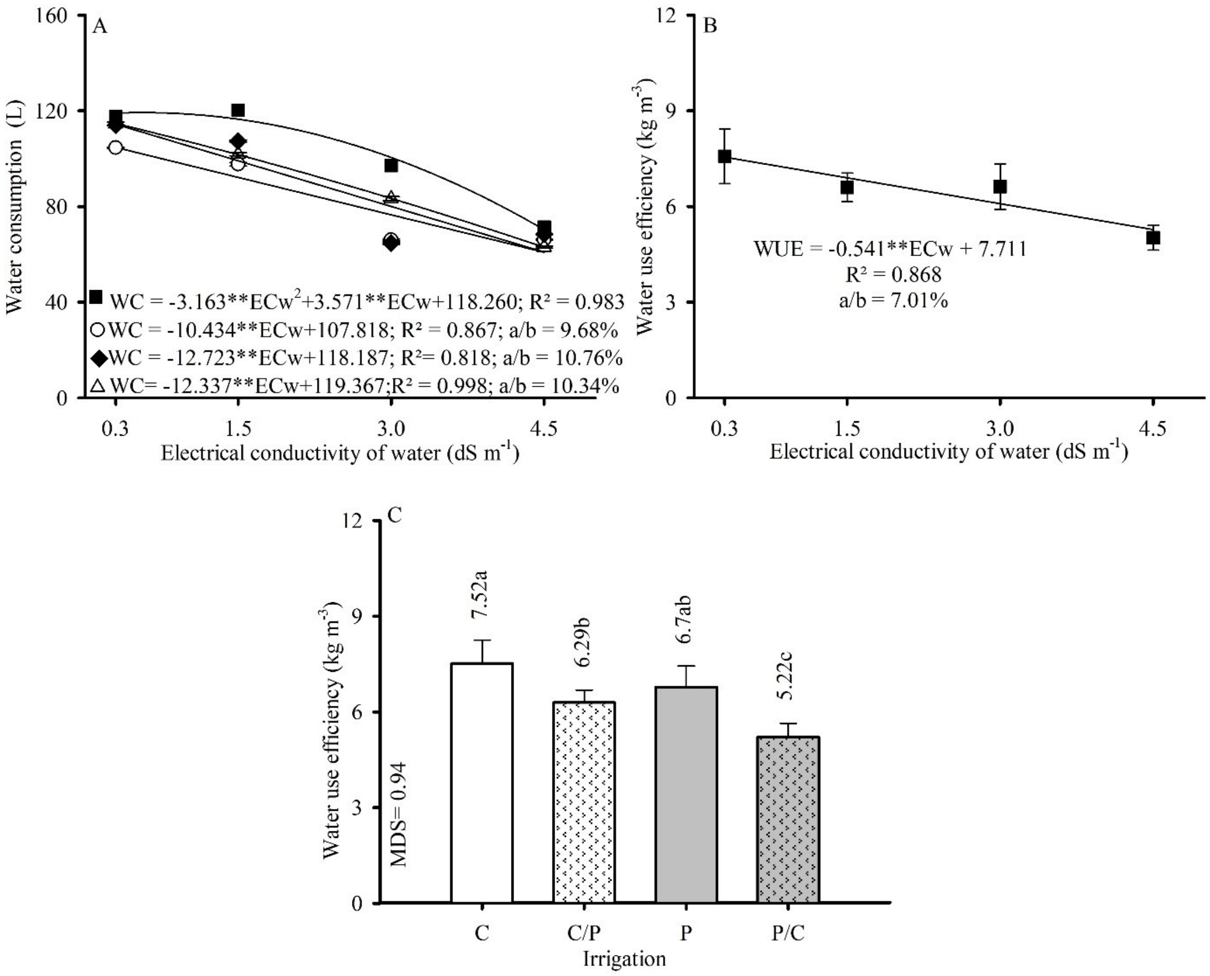
However, even with the use of local-supply water, the production was lower than that observed by Costa et al. (2019), who found a production of 2.50 kg plant^{-1}, using the same cultivar under open field conditions. This variation may have occurred due to the edaphoclimatic conditions of cultivation. In the present study, there was also an excessive fall of flowers (not quantified), which is a characteristic of eggplant under thermal stress conditions according to Dhatt and Kaur (2017).

Another aspect to consider is performing pollination, especially when working under greenhouse conditions and with open-pollinated cultivars such as cv. Florida Market. Silva, Oliveira and Hrncir (2016), studying different types of pollination in a greenhouse, observed that in the cultivation of the eggplant variety Embu, which is also open-pollinated, plants with free pollination did not produce fruits, while among the other treatments only plants with manual cross-pollination showed better results. Thus, the low fruit production can probably be due to the absence of pollinating agents in the greenhouse.

The decomposition of the interaction for water consumption pointed to a linear reduction of consumption with the increase of salinity in the treatments with pulse drip irrigation (P), pulse drip followed by continuous drip (P/C), and continuous drip followed by pulse drip (C/P), showing total reductions along the crop cycle of 41.8, 44.8 and 46.7% when comparing the lowest with the highest salinity level. However, in the treatment with continuous drip irrigation (C), in which a quadratic response was observed, there was a reduction only from the salinity level of 0.56 dS m^{-1} (Figure 2A). The decrease in water consumption is related to the accumulation of salts in the soil along the crop cycle, which contributed to reducing the osmotic potential of the soil and, consequently, plants under salt stress had restrictions to absorb water (DIAS et al., 2016).

In the case of water application by continuous drip irrigation, there was higher water consumption compared with pulse drip irrigation, regardless of the stage in which it was used. According to the regression equation, increases of 13.72, 26.40, 31.35, and 15.47% were estimated when compared with pulse drip irrigation at salinity levels of 0.3, 1.5, 3.0, and 4.5 dS m^{-1}, respectively (Figure 2A). Therefore, the use of pulse drip irrigation promoted greater water saving, probably because the irrigation depth was split, which allowed maintaining soil moisture for a longer time.

Almeida, Lima and Pereira (2015) observed water saving of 25% with the use of pulse drip irrigation as compared with continuous drip irrigation in lettuce cultivation. For Maller et al. (2016), pulse drip irrigation has the potential to save about half of the irrigation water in the greenhouse compared with conventional drip irrigation.



Continuous drip - C (■) and pulse drip P (○) throughout the cycle; continuous drip in the vegetative stage, followed by pulse drip in the reproductive stage - C/P (◆); and pulse drip in the vegetative stage and continuous drip in the reproductive stage - P/C (△).

Figure 2. Unfolding of the interaction between the forms of water application and the electrical conductivity of water for water consumption - WC (A), water use efficiency - WUE, as a function of the electrical conductivity of water (B) and in relation to form of water application (C) of eggplant.

WUE as a function of water salinity obtained an estimated value of 7.55 kg m^{-3} with local-supply water (0.3 dS m^{-1}), decreasing by 0.54 kg m^{-3} (7.01%) per unit increase in ECw, reaching a value of 5.28 kg m^{-3} at the highest level of water salinity (4.5 dS m^{-1}), totaling a relative decrease of 30.1% when comparing the two salinity levels (Figure 2B).

For the form of water application factor, the highest mean of WUE was obtained in the C treatment, 7.52 kg m^{-3}, but it did not differ statistically from the P treatment (6.78 kg m^{-3}). The P/C treatment had the lowest mean (5.22 kg m^{-3}), differing statistically from the others (Figure 2C). These results corroborate those reported by Arriero et al. (2020), who found higher WUE (7.31 kg m^{-3}) for continuous drip irrigation, using local-supply water (0.3 dS m^{-1}), but observed no statistical difference from pulse drip irrigation (5.92 kg m^{-3}).

Despite the low production, as water consumption was lower, WUE became high, with values close to those found by Arriero et al. (2020), who used a similar eggplant cultivation system. However, the WUE values obtained in the present study were higher than those found by some authors who also used drip irrigation in eggplant cultivation, for instance, Almasraf and Salim (2018) (3.71 kg m^{-3}), in sandy loam soil under greenhouse conditions, and Mohawesh (2016), working in the field in two different environments, one with temperature and precipitation of 25 °C and 83 mm and the other with 18 °C and 250 mm, respectively, finding corresponding values of 5.13 and 2.78 kg m^{-3} when applying a 100% evapotranspiration depth, respectively.

The electrical conductivity of the soil saturation extract (ECse) at the end of the experiment was significantly influenced by the studied factors and by the interaction between water salinity levels and forms of water application ($p<0.01$). For the pH of the saturation extract (pHse), there was a significant effect ($p<0.05$) of the individual factors salinity and forms of water application (Table 3).

Table 3. Summary of analysis of variance for electrical conductivity and pH of the saturation extract (ECse, pHse) of soil at a depth of 0-0.30 m under eggplant cultivation irrigated by different combinations of dripping and pulses (I) under saline stress (ECw).

SV	DF	Mean squares	
		ECse	pHse
Irrigation (I)	3	13.07**	0.19*
ECw	3	593.13**	0.17*
I* ECw	9	11.18**	0.03ns
Block	4	2.01ns	0.04ns
Error	60	1.37	0.05
CV (%)		15.36	3.45
Mean		7.63	6.84

SV- Source of variation; DF- Degrees of freedom; ECw- Electrical conductivity of irrigation water; * and ** significant at the 0.05 and 0.01 level of probability, respectively; ns – not significant by the F test, CV = Coefficient of variation.

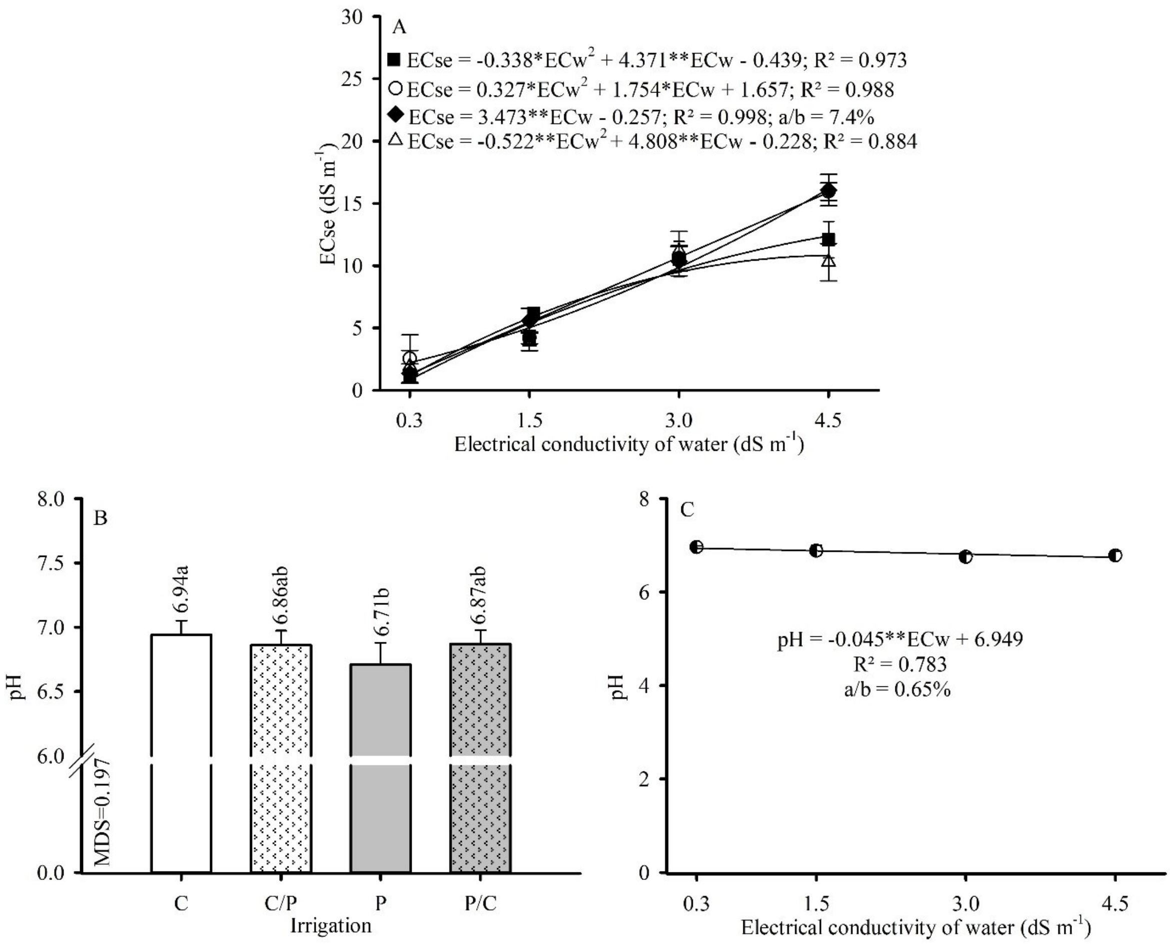
The decomposition of the interaction for ECse in the 0-0.30 m layer (Figure 3A) showed a positive response with the increase of salinity in the irrigation water. The form of water application C/P showed a linear relationship, and for the other forms of application, the model was quadratic, all with coefficients of determination (R^2> 0.88), allowing estimation of ECse based on ECw. It can be observed that the mean concentration factor (ECse/ ECw) was relatively high (>3) compared to that reported by Ayers and Westcot (1999), since the leaching fraction was not contemplated in the applied depth. Thus, the results indicate that the use of a leaching fraction is necessary to reduce the concentration factor and consequently control the accumulation of salts in the soil. Regardless of the form of irrigation, ECw above 1.0 dS m^{-1} caused soil salinization (ECse ≥ 4.0 dS m^{-1}) for the conditions under which the present study was carried out.

When analysing the effect of forms of irrigation at each water salinity level, it was observed that up to ECw = 3.0 dS m^{-1} there were no differences between forms of water application; however, under ECw = 4.5 dS m^{-1} the mean ECse of the treatments P and C/P was 35.82% higher than those of the treatments C and P/C (Figure 3A).

In pulse drip irrigation, the width of the wet-bulb increases horizontally and decreases vertically with depth as the operating time decreases for the same water depth applied, while in continuous drip irrigation the wet bulb has greater depth and smaller width, and this vertical increase may be undesirable because water moving below the root zone can result in waste of water, loss of nutrients and groundwater pollution (ABDELRAOUF et al., 2012). According to Andrade, Almeida and Lima (2014), pulse drip irrigation promotes a more uniform distribution of soil moisture in the surface layer, whereas continuous drip irrigation concentrates soil moisture in the 0.20-0.40 m layer. Considering the results found by these authors, it can be inferred that the use of pulse drip irrigation promoted higher moisture in the 0-0.30 m layer, with lower depth and greater width of the wet-bulb, and consequently accumulated more salts in this layer. On the other hand, continuous drip irrigation probably led to higher moisture content in the soil for a layer below 0.20 m, which allowed dilution of salts, so ECse was lower at 0-0.30 m depth.

The reduction in ECse values can be attributed to the shape of the wet-bulb and the site where the sample was collected, approximately 0.10 m away from its center, as continuous drip irrigation promotes lower width of the wet-bulb compared with pulse drip irrigation, which possibly allowed the displacement of salts to greater depths. When comparing the results under the forms of water application P/C and C/P, this fact can be confirmed, because the value of ECse was higher for C/P (when pulse drip irrigation was used in the reproductive stage) as compared with P/C.

Regarding the form of water application, the pHse reached its highest absolute value (pHse = 6.94) when continuous drip irrigation - C was used along the entire crop cycle, differing statistically only from the application by pulse drip irrigation - P (pHse = 6.71) (Figure 1B). In turn, for the water salinity factor, the pHse was higher (6.93) with the local-supply water (0.3 dS m^{-1}) and decreased by 0.65% per unit increase in ECw to a value of 6.75, at the highest salinity level (4.5 dS m^{-1}) (Figure 3C). These values were close to the optimal pH range for nutrient absorption by eggplant plants, from 5.5 to 6.8 (FILGUEIRA, 2007). Therefore, the pH did not interfere in the absorption of nutrients in the cultivation of eggplant under different forms of water application.



Continuous drip - C (■) and pulse drip P (○) throughout the cycle; continuous drip in the vegetative stage, followed by pulse drip in the reproductive stage - C/P (◆); and pulse drip in the vegetative stage and continuous drip in the reproductive stage - P/C (△); minimum significant difference- MSD.

Figure 3. Unfolding of the interaction between the forms of water application and the electrical conductivity of water for the electrical conductivity of the saturation extract (ECse) of soil in layer 0-0.30 m (A), pH in layer 0-0, 30 m in relation to the form of water application (B) and the electrical conductivity of the water (C).

According to Dias et al. (2016), as water salinity increases, the pH decreases, and this phenomenon is similar in the soil solution. Thus, the increase in ECw caused a reduction in pH, and when pulse drip irrigation was used there was a higher concentration of salts and consequently a lower pH value compared with the other types of irrigation. In addition, according to Sandri and Rosa (2017), higher soil water contents and temperatures up to 25 °C favor the nitrification process, which releases hydrogen into the soil solution, contributing to the reduction of pH.

CONCLUSIONS

An increase in the electrical conductivity of irrigation water reduces fruit length, total production, and water use efficiency of eggplant.

Pulse drip irrigation promotes greater water savings, but increases the risk of soil salinization compared with continuous drip irrigation.

Changing the forms of water application from continuous drip to pulse drip or from pulse drip to continuous drip at 65 days after transplanting does not influence eggplant yield.

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