ISSN 1807-1929
Revista Brasileira de Engenharia Agrícola e Ambiental
Brazilian Journal of Agricultural and Environmental Engineering
v.25, n.6, p.422-428, 2021
Campina Grande, PB – http://www.agriambi.com.br – http://www.scielo.br/rbeaa

DOI: http://dx.doi.org/10.1590/1807-1929/agriambi.v25n6p422-428

Water yield and consumption of cauliflower plants grown in a hydroponic system using brackish waters and different flow rates[1]

Produtividade da água e consumo hídrico pela couve-flor utilizando águas salobras e diferentes vazões

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HIGHLIGHTS:

Raising the flow rate of the nutrient solution with brackish water results in less water consumption in cauliflower.
The water yield in cultivation of cauliflower depends on the chemical composition of the water used in the nutrient solution.
The cauliflower production is viable in hydroponics using waters with electrical conductivities of up to 5.88 dS m^{-1}.

ABSTRACT: Studies related to the use of natural brackish waters, water consumption, and flow rates of nutrient solutions applied to cauliflower plants are incipient in Brazil. The objective of this study was to evaluate the water yield and consumption by cauliflower plants grown under the use of brackish waters based on chemical characteristics of waters from wells of the Brazilian semiarid, grown in nutrient film technique (NFT) hydroponic system. A completely randomized design with four replicates was used, in a 6 × 2 factorial arrangement, consisted of six different waters to prepare the nutrient solution and two flow rates. The waters were formulated based on a simulation of brackish waters from wells of different communities of the municipality of Ibimirim, state of Pernambuco, Brazil, which presented electrical conductivities of 1.67, 3.30, 4.71, 5.88, and 13.84 dS m^{-1}, and municipal public water. The flow rates of the nutrient solution used were 1.5 and 2.5 L min^{-1}. The use of brackish waters to prepare the nutrient solutions and refilling the solutions lost by evapotranspiration decreased the water consumption and cauliflower yields, with higher magnitude for the flow rate of 2.5 L min^{-1}. The highest water yield values of the shoot fresh and dry biomasses were found for the calcium chloride water. The best water for the cauliflower production was the calcium sulphate water, and the worse was the S2 magnesium chloride water. The use of all waters is viable for cauliflower production, except the S2 magnesium chloride water; however, the use of the flow rate of 2.5 dS m^{-1} results in higher decrease in crop yield.

Key words: *Brassica oleracea*, water quality, salinity, nutrient film technique

RESUMO: Estudos relacionando à utilização de águas salobras naturais, consumo hídrico e vazões de aplicação da solução nutritiva aplicados a couve-flor são incipientes no Brasil. Objetivou-se avaliar a produtividade da água e o consumo hídrico da couve-flor condicionada à utilização de águas salobras provenientes da simulação das características químicas de águas de poços subterrâneos do semiárido brasileiro, em sistema hidropônico NFT (fluxo laminar de nutrientes), utilizando-se delineamento inteiramente casualizado, esquema fatorial 6 x 2, correspondente a seis tipos de águas, uma de abastecimento e as demais formuladas a partir da simulação de águas salobras de poços subterrâneos de diferentes comunidades do município de Ibimirim, PE, de condutividade elétricas de 1,67; 3,30; 4,71; 5,88 e 13,84 dS m^{-1} e duas vazões de aplicação da solução nutritiva (1,5 e 2,5 L min^{-1}), com quatro repetições. A utilização das águas salobras para preparo da solução nutritiva e reposição do volume evapotranspirado reduziu o consumo hídrico e o rendimento da couve-flor, com maior magnitude na vazão de 2,5 L min^{-1}. Os maiores valores de produtividade da água da biomassa verde e seca da parte aérea foram obtidos com água cloretada cálcica (CC). A melhor água para a produção de couve-flor foi a sulfatada cálcica (SC) e a pior a cloretada magnesiana S2 (CMS2). À exceção da CMS2, é possível utilizar as demais águas para produção da couve-flor; porém a utilização da vazão de 2,5 dS m^{-1} proporciona maior redução na produtividade da cultura.

Palavras-chave: *Brassica oleracea*, qualidade da água, salinidade, fluxo laminar de nutriente

• Ref. 232001 – Received 10 Dec, 2019
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• Accepted 03 Feb, 2021 • Published 10 Mar, 2021
Edited by: Hans Raj Gheyi

Introduction

The energy reordering that the presence of salts triggers in plants is among the main problems of using brackish waters for agricultural production; it causes changes in water consumption, carbon assimilation and, consequently, in the water use yield (Bosco et al., 2009).

Some regions usually undergo water shortages, such as the Semiarid region of the Northeast of Brazil, where agricultural crops are often grown using irrigation with underground brackish waters (Albuquerque et al., 2015). The need of using technologies compatible to this situation is evident in these regions (Paulus et al., 2012; Silva Júnior et al., 2019).

Nutrient film technique (NFT) hydroponics is among the technologies that can be used for the production of crops irrigated with brackish waters. It generates products with high quality and provides high crop yields in short times (Paulus et al., 2012; Santos Júnior et al., 2015) and results in plants with higher resistance to salt stress than conventional crops (Soares et al., 2007).

However, despite NFT hydroponics is used for crops that are relatively tolerant to salt stress, such as cauliflower (Giuffrida et al., 2016), it presents specificities regarding the use of brackish waters that still require studies. These specificities include the frequency and flow rate of the circulation of the nutrient solution (Silva Júnior et al., 2019; Soares et al., 2020), and the chemical composition of the waters used for the crops (Martins et al., 2019).

In this context, the objective of this study was to evaluate the water yield and consumption by cauliflower plants of the cultivar Sarah-1169 grown under the use of brackish waters prepared based on chemical characteristics of waters from wells of the Semiarid region of Brazil, grown in nutrient film technique (NFT).

Material and Methods

The experiment was conducted in a greenhouse at the Department of Agricultural Engineering (DEAGRI) of the Federal Rural University of Pernambuco (UFRPE), in Recife, state of Pernambuco (PE), Brazil (08° 01' 05" S, 34° 56' 48" W, and mean altitude of 6.5 m).

A completely randomized design with four replicates was used, in a 6 × 2 factorial arrangement, consisted of six different waters for the nutrient solution and two flow rates. The waters were formulated based on a simulation of brackish waters from wells of different communities of the municipality of Ibimirim, PE, Brazil, which presented electrical conductivities of 1.67, 3.30, 4.71, 5.88, and 13.84 dS m^{-1}, and municipal public water (ECw = 0.2 dS m^{-1}).

The waters were classified according to the Piper diagram (Piper, 1944) as: calcium sulphate water (CSW); S1 magnesium chloride water (MCW-S1); calcium chloride water (CCW); sodium chloride water (SCW); S2 magnesium chloride water (MCW-S2), and municipal public water (MPW) (Table 1).

The electrical conductivities of the waters from the wells used as reference were 1.67, 3.30, 4.71, 5.88, and 13.84 dS m^{-1}, corresponding to the CSW, MCW-S1, CCW, SCW, and MCW-S2, respectively. The municipal public water presented electrical conductivity of 0.12 dS m^{-1}. The two flow rates used for the application of the nutrient solution were 1.5 and 2.5 L min^{-1}.

The salt proportion and concentration in the waters used for the preparation of the solutions nutritious were simulated under laboratory conditions to coincide with the salt concentrations of the waters of wells in the Moxotó River basin (Soares et al., 2020), specifically in the municipality of Ibimirim, PE, Brazil, and due characterized as described in Table 1.

The brackish waters from the wells were simulated by performing a chemical analysis of the waters and adding a mixture of salts ($CaCl_2$, $NaHCO_3$, Na_2CO_3, KCl, $MgSO_4$, NaCl, and $MgCl_2$). The nutrient solution was prepared as recommended by Furlani (1998), using calcium nitrate, potassium nitrate, monoammonium phosphate, magnesium sulfate, copper sulfate, zinc sulfate, manganese sulfate, boric acid, sodium molybdate, and Fe EDTA 13%.

Cauliflower plants of the cultivar Sarah-1169 was grown in a nutrient film technique (NFT) hydroponic system; each plot consisted of a 3.0 m long independent hydroponic set with trapezoidal profiles, using spacing of 0.6 m between profiles and 0.5 m between plants. The mean height used for the installation of the profiles was 1.0 m from the soil, using a slope of 5%.

Each plot had a 220-V, 32-W circulation electric pump and a 50-L reservoir for the nutrient solution per flume, a float and an automatic replenishing system for the refilling of the solution lost by evapotranspiration through the plants in each flume. The nutrient solution was managed using a closed system, with recirculation of water and nutrients.

Cauliflower seedlings were acquired from a specialized plant nursery at 20 days after the sowing (DAS). The seedlings

Table 1. Chemical composition waters prepared based on a simulation of chemical characteristics of waters from wells of different sites of the municipality of Ibimirim, PE, Brazil, which were classified according to the diagrams of Piper (Piper, 1944) and Richards (1954) and used to prepare the nutrient solutions and for the refilling of water lost by evapotranspiration

Waters		ECw (dS m^{-1})	pH	Ca^{+2}	Mg^{+2}	K^+	Na^+	Cl^-	CO_3^{-2}	HCO_3^-	SO_4^{-2}
Piper (1944)	Richards (1954)		(mg L^{-1})								
MPW	C_1S_1	0.12	6.30	0.90	0.60	2.50	5.40	15.40	0.0	21.45	0.0
CSW	C_3S_1	1.67	7.23	90.09	71.66	2.73	176.86	349.70	52.85	361.24	133.40
MCW-S1	C_4S_2	3.30	6.72	207.48	147.89	37.07	295.27	1105.55	36.79	500.94	65.00
CCW	C_4S_2	4.71	7.08	436.80	185.86	18.00	476.24	1927.20	118.86	689.70	47.40
SCW	C_4S_3	5.88	7.39	300.30	202.95	10.54	665.44	2230.53	0.00	419.82	0.00
MCW-S2	C_4S_4	13.84	7.67	60.06	1146.69	10.54	1283.89	4893.56	82.07	755.04	137.69

MPW - Municipal public water; CSW - Calcium sulphate water; MCW-S1 - S1 magnesium chloride water; CCW - Calcium chloride water; SCW - Sodium chloride water; MCW-S2 - S2 magnesium chloride water; ECw - Electrical conductivity of water; C_1S_1 - Water with low salinity and low sodium content; C_3S_1 - Water with high salinity and low sodium content; C_4S_2 - Water with very high salinity and mean sodium content; C_4S_3 - Water with very high salinity and high sodium content; C_4S_4 - Water with very high salinity and sodium content were maintained in a 200-cell tray filled with coconut fiber up to 30 DAS; during this period, they were irrigated with a nutrient solution, as recommended by Furlani et al. (1998) with 50% dilution. The transplant of seedlings to the profile was carried out at 30 DAS, when the seedlings had four definitive leaves; then, the application of the treatments was started.

Pests and diseases were controlled by applications of neem oil, a natural repellent; and deltamethrin (Decis 25 EC; Bayer, Leverkusen, Germany), a contact insecticide from the pyrethroid group, at the rate of 30 mL per 100 L of water, to control *Plutella xylostella*, using two applications (35 and 45 DAS) over the crop cycle.

The pH and the electrical conductivity of the nutrient solution (ECsol) were read in alternate days throughout the crop cycle. The nutrient solution of the control treatment was refilled, following the methodology proposed by Martinez & Silva Filho (1997), at 15 DAT, when the electrical conductivity reached values lower than 1.0 dS m^{-1}, corresponding to a decrease of 30% from the initial value.

The water consumption (WC) was determined over the crop cycle through daily readings of the solution levels in the reservoirs and calculation of the volume lost by evapotranspiration, according to the following equation of Soares et al. (2010) (Eq. 1).

$$V_{ETc} = \frac{\left[(Lf - Li)\pi D^2\right]}{(4n\Delta T)} \qquad (1)$$

where:

V_{ETc} - volume lost by evapotranspiration (m^3 plant^{-1} day^{-1});
Lf - final reading of the water level in the storage (m);
Li - initial reading of the water level in the storage (m);
D - internal diameter of the reservoir (m);
ΔT - time interval between readings (days); and,
n - number of plants in the profile in the time interval ΔT.

The plants were harvested at 90 DAS (60 days after the transplant); the shoot fresh (SFB) and dry (SDB) biomasses of the plants were determined in a precision balance (0.001 g) immediately after the harvest. The plants were dried until constant weight and placed in forced air-circulation oven to obtain the SDB.

The water yield of the shoot fresh (WY-SFB) and dry (WY-SDB) biomasses were also determined. The WY-SFB was calculated by the relation between SFB of the last harvest and the total water consumption (TWC), according to Silva et al. (2012) (Eq. 2). WY-SDB was obtained by the relation between SDB of the last harvest and TWC, according to Jabro et al. (2012) (Eq. 3).

$$WY - SFB = \left(\frac{SFB}{TWC}\right) \qquad (2)$$

$$WY - SDB = \left(\frac{SDB}{TWC}\right) \qquad (3)$$

where:

WY-SFB - water yield of the shoot fresh biomass (g L^{-1});
WY-SDB - water yield of the shoot dry biomass (g L^{-1});
SFB - total shoot fresh biomass (g);
SDB - total shoot dry biomass (g); and,
TWC - total water consumption (L plant^{-1}).

The data obtained were subjected to analysis of variance, and the means compared by the Scott-Knott test at $p \leq 0.05$.

Results and Discussion

The electrical conductivity (ECsol) and pH (pHsol) of the nutrient solutions throughout the crop cycle (60 DAT) as a function of the different waters used for the preparation of the nutrient solution and the two flow rates of the nutrient solution applied (1.5 and 2.5 L min^{-1}) is shown in Figure 1.

The ECsol (Figures 1A and B) in treatments with brackish water increased for both flow rates (1.5 and 2.5 L min^{-1}), except for the treatment with municipal public water (MPW). This increase was probably due to the refilling of the water lost by evapotranspiration, which was done with the respective brackish waters of the treatments.

The ECsol of the treatment with nutrient solution prepared with MPW (0.2 dS m^{-1}) decreased over time for both flow rates. This decrease was due to the refilling of the water lost by evapotranspiration in this treatment (MPW), which presented low salinity (0.2 dS m^{-1}); thus, as the plants absorbed the nutrients from the solution, the EC of the solution decreased.

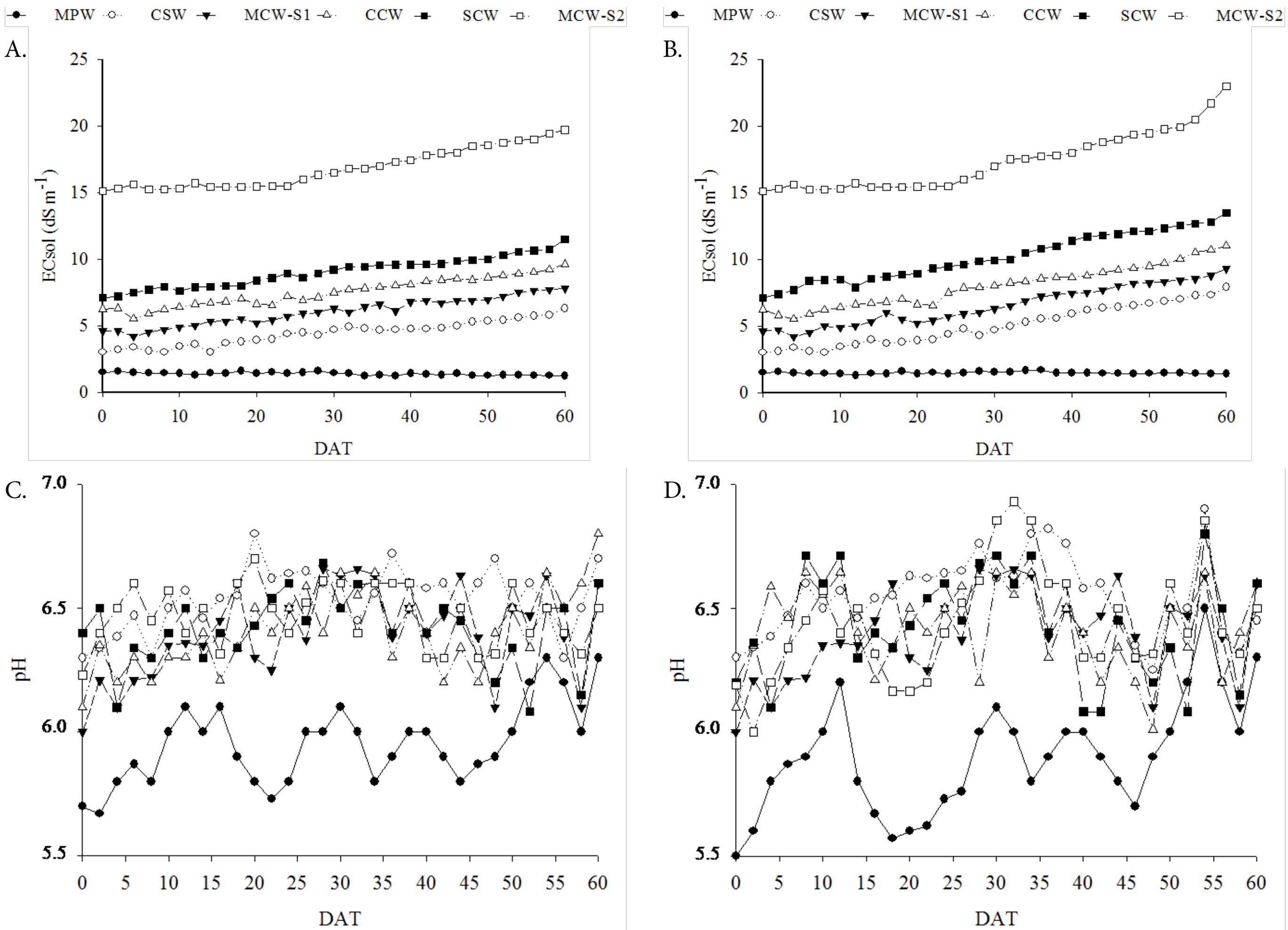
Similar results were found by Lira et al. (2018), when evaluating hydroponic production of watercress using brackish waters; and by Soares et al. (2010) and Alves et al. (2011), when evaluating hydroponic production lettuce crop using brackish waters.

The pHsol (Figures 1C and D) of all the treatments were within the range of 5.5 and 7.0, i.e., within the pH range that do not negatively affect hydroponic crops. According to Furlani et al. (1999), pHsol between 4.5 and 7.5 do not affect the development of hydroponic crops; however, solutions with acidity lower than 4 may hinder the cell membranes, and solution with alkalinity higher than 8 may cause deficiency of some nutrients to plants, such as iron and phosphorus.

According to the analysis of variance, the effect of the interaction between the treatments evaluated was significant ($p \leq 0.01$) for the shoot fresh (SFB) and dry (SDB) biomasses, water consumption (WC), and water yield of the shoot fresh biomass (WY-SFB). The water yield of the shoot dry biomass (WY-SDB) was affected only by the waters of the nutrient solution (Table 2).

The SFB decreased mainly for the flow rate of 1.5 L min^{-1} (Table 3). The SFB found for the treatment with magnesium chloride water (MCW-S2), the treatment with the highest salinity, was 74.19% lower than that of the treatment with MPW, the treatment with the lowest salinity. This SFW decrease found for treatments with flow rate of 2.5 L min^{-1} was even more pronounced, with 91.82%.

The treatment with EC of 1.67 dS m^{-1} (CSW) resulted in 18.40 and 10.46% lower SFB and SDB, respectively, than those of the treatment with EC of 0.2 dS m^{-1} (MPW), when using the flow rate of 2.5 L min^{-1}. These differences were 13.05 and 6.89% for SFB and SDB, respectively, when using the flow rate of 1.5 L min^{-1}.



MPW - Municipal public water; CSW - Calcium sulphate water; MCW-S1 - S1 magnesium chloride water; CCW - Calcium chloride water; SCW - Sodium chloride water; MCW-S2 - S2 magnesium chloride water

Figure 1. Mean electrical conductivity (ECsol) and pH (pHsol) of nutrient solutions applied at the flow rates of 1.5 L min^{-1} (A and C) and 2.5 L min^{-1} (B and D) throughout the cauliflower crop cycle

Table 2. Analysis of variance for shoot fresh (SFB) and dry (SDB) biomasses, water consumption (WC), water yield of the shoot fresh (WY-SFB) and dry (WY-SDB) biomasses of cauliflower plants as a function of different brackish waters and flow rates

Source of variation	F calculated				
	SFB	SDB	WC	WY-SFB	WY-SDB
Waters	299.651*	1975.737*	1850.161**	18.507**	30.140**
Flow rates	32.330*	203.664*	122.035**	3.410^{ns}	3.916^{ns}
Waters × Flow rates	3.893*	28.739*	16.223**	7.441**	1.360^{ns}
Coefficient of variation (%)	8.82	2.47	4.04	10.91	13.5

*, **, and ns - Significant at p ≤ 0.01, p ≤ 0.05, and not significant by F test, respectively

Table 3. Analysis of the interaction between shoot fresh (SFB) and dry (SDB) biomasses of cauliflower crops and brackish waters for different flow rates

	Flow rate L min^{-1}	Water use to prepare the nutrient solution					
		MPW	CSW	MCW-S1	CCW	SCW	MCW-S2
SFB (g)	1.5	1157.50 aA	1006.50 bA	842.75 cA	712.00 dA	402.25 eA	298.75 fA
	2.5	1189.00 aA	970.25 bA	697.00 cB	567.50 dB	302.00 eB	97.25 fB
SDB (g)	1.5	102.03 aA	95.00 bA	80.18 cA	76.75 dA	51.25 eA	40.23 fA
	2.5	103.25 aA	92.45 bB	74.88 cB	68.88 dB	40.13 eB	22.68 fB

Means followed by the same lowercase letter in the rows, or uppercase letter in the columns, are not different by the Scott Knott test at p ≤ 0.05; MPW - Municipal public water; CSW - Calcium sulphate water; MCW-S1 - S1 magnesium chloride water; CCW - Calcium chloride water; SCW - Sodium chloride water; MCW-S2 - S2 magnesium chloride water

Decreases in plant growth due to increases in salinity of the nutrient solution may be due to the osmotic effect of the higher ion concentrations in the nutrient solutions on the plants (Soares et al., 2020). The high Na^+ and Cl^- concentrations in the brackish waters (Table 1) probably caused imbalances in the plant nutrient absorption, since excess Na^+ and Cl^- ions in the nutrient solution can cause imbalances in the absorption of essential nutrients, such as nitrogen, calcium, and potassium (Abbasi et al., 2016).

Decreases in plant growth due to different cationic origin of waters (NaCl, KCl, Na_2SO_4, and K_2SO_4) was also found by Aghajanzadeh et al. (2018) for *Brassica rapa* L. seedlings, showing the effect of these salts on glucosinolate contents, composition and expression of genes of the glucosinolate biosynthetic route and transcription factors associated; they also found different response of different plant parts to the salts evaluated.

The highest SFB were found for the lowest flow rate used to apply the nutrient solution for all treatments, except the treatments MPW and calcium sulphate water (CSW) (Table 3). These results may be due to the higher salt availability to plants subjected to the flow rate of 2.5 L min^{-1}, caused by the mass flow in the rhizosphere, when compared to plants subjected to the flow rate of 1.5 L min^{-1}.

Therefore, it is possible that the lowest flow rate used to apply the brackish nutrient solution provided a higher water (Table 4) and nutrient absorption to the crop, resulting in a higher fresh biomass accumulation by the plants than the flow rate of 2.5 L min^{-1}.

According to Mendonça et al. (2017), increasing flow rate of the nutrient solution decreases the absorption of solutes from it, since the low exposure time of roots to ions does not allow these nutrients to bound to all available absorption sites in the roots.

The flow rates had no significant effect on the SDB when using MPW to prepare the nutrient solution (Table 3). The treatment with nutrient solution prepared with magnesium chloride water (MCW-S2) resulted in 60.57% lower SDB for the flow rate of 1.5 L min^{-1} and 78.03% lower SDB for the flow rate of 2.5 L min^{-1}, when compared to the treatment MPW.

The water consumption of plants treated with nutrient solution prepared with the highest salinity water (13.84 dS m^{-1}; MCW-S2) was 80% (flow rate of 1.5 L min^{-1}) and 89.63% (flow rate of 2.5 L min^{-1}) lower than those of plants in the treatment MPW (Table 4).

According to Paulus et al. (2012), decreases in water consumption in crops subjected to salt stress are due to the osmotic effect caused by the salts, which results in a lower water absorption, increases water stress, and decreases of transpiration.

Similar results of water consumption were found by Cruz et al. (2018) for cauliflower crops grown in NFT hydroponic system with different salinity levels; and by Soares et al. (2010) and Paulus et al. (2012) when evaluating the use of brackish waters in hydroponic lettuce crops.

Regarding the flow rates used, the best results were found for the lowest flow rate (1.5 L min^{-1}); it was probably due to the greater water stress of plants in treatments with the highest flow rate, caused by the higher flow of salts in the rhizosphere of plants (Cruz et al., 2018).

The highest WY-SFB were found for the treatment with calcium chloride water (CCW), in both flow rates used to apply the nutrient solutions, showing a mean production of 51.8 and 56.91 g L^{-1} for the flow rates of 1.5 and 2.5 L min^{-1}, respectively (Table 4).

This result can be attributed to the water chemical composition, which had higher quantity of calcium (Ca) than the other waters, despite presenting an EC of 4.71 dS m^{-1}. Ca is an essential nutrient for the plant development; high Ca concentrations can decrease deleterious effects of sodium under salt stress (Lahaye & Epstein, 1969; Ribeiro et al., 2015). The treatment CCW had the second highest bicarbonate (HCO_3^-) to chloride (Cl^-) ratio (0.45). This ratio is important to evaluate the quality of brackish waters for irrigation and prepare nutrient solutions for hydroponic crops, due to the effects of these anions in the nutrient solution.

The WY-SFB with the use of S2 magnesium chloride water (MCW-S2), in the flow rate of 1.5 dS m^{-1}, were similar to those of the treatments MPW, CSW, S1 magnesium chloride water (MCW-S1), and SCW. It is associated to the low water consumption caused by the salt stress of plants subjected to the treatment MCW-S2, which had the highest EC and the lowest HCO_3^- to Cl^- ratio (0.15).

The higher EC of treatments with brackish waters was, among other factors, due to the lower HCO_3^- to Cl^- ratio, which were 1.03 for (CSW), 0.45 (MCW-S1), 0.35 (CCW), 0.18 (SCW), and 0.15 (MCW-S2). These results corroborate those found by Maia et al. (2012), who evaluated the HCO_3^- to Cl^- ratio of waters of wells of the Northeast region of Brazil for irrigation purposes.

Regarding the effect of the water used to prepare the nutrient solutions on the water yield of the shoot dry biomass (WY-SDB), the highest WY-SDB means were found for the treatments with CCW and MCW-S2, which showed 6.19 and 6.79 g L^{-1}, respectively (Figure 2).

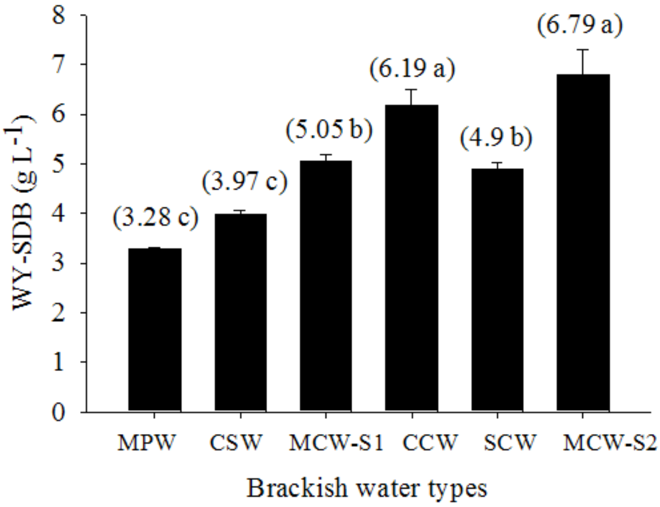


Figure 2. Water yield of the shoot dry biomass (WY-SDB) of cauliflower crops as a function of use of different brackish waters used to prepare the nutrient solution

Table 4. Analyses of the interaction between water consumption (WC) and water yield of the shoot fresh biomass (WY-SFB) of cauliflower and brackish waters used to prepare nutrient solutions, for different flow rates

	Flow rate L min^{-1}	Water use to prepare the nutrient solution					
		MPW	CSW	MCW-S1	CCW	SCW	MCW-S2
WC (L $plant^{-1}$)	1.5	30.30 aB	25.10 bA	16.87 cA	12.66 dA	10.87 eA	6.05 fA
	2.5	32.30 aA	22.25 bB	14.03 cB	9.98 dB	8.05 eB	3.35 fB
WY-SFB (g L^{-1})	1.5	38.19 bA	40.11 bA	50.03 bA	51.80 aA	35.68 bA	49.57 bA
	2.5	36.87 cA	43.66 cA	49.90 bA	56.91 aA	37.60 cA	29.25 dB

Means followed by the same lowercase letter in the rows, or uppercase letter in the columns, are not different by the Scott Knott test at $p \leq 0.05$; MPW - Municipal public water; CSW - Calcium sulphate water; MCW-S1 - S1 magnesium chloride water; CCW - Calcium chloride water; SCW - Sodium chloride water; MCW-S2 - S2 magnesium chloride water

The lowest mean WY-SDB were found for the treatments with MPW (3.28 g L^{-1}) and CSW (3.97 g L^{-1}). This result can be attributed to the chemical composition of the waters used, which resulted in a low deleterious effect of salt stress due to the high concentrations of nutrients in these waters, as seen in the calcium chloride water (CCW), which has high calcium concentration.

Conclusions

1. The use of brackish waters for the preparation of nutrient solutions and refilling of the water volume lost by evapotranspiration resulted in lower water consumption and cauliflower yield, with higher magnitudes for the flow rate of 2.5 L min^{-1}.

2. The highest water yield of the shoot fresh biomass was found for the treatment with calcium chloride water, and the highest shoot dry biomass was found for the treatment with calcium chloride water and S2 magnesium chloride water.

3. The best water for cauliflower production was the municipal public water; among the brackish waters, the best was the calcium sulphate water and the worse was the S2 magnesium chloride water.

4. All waters evaluated can be used for cauliflower productions, however, the use of a flow rate of 2.5 dS m^{-1} results in higher decreases in crop yield.

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