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Growth and Production of Cultivars Ornamental Sunflower Irrigated With Water of Different Salinities

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Abstract

The sunflower (*Helianthus annuus* L.) appears as an income alternative to the producers of the northeastern region of Brazil, however limited by the salinity present in the waters of the region, which makes it necessary to select cultivars that are more adaptable to this situation. On this, the objective was assessing the development of two cultivars of cutting ornamental sunflower with waters of different salinities. The experiment was performed in conditions of protected environment at UFCG, CCTA-Pombal-PB. It was performed in outline of blocks in factorial scheme 5 × 2, being five saline levels (N1 = 0.3, supply water; N2 = 1.5; N3 = 2.7; N4 = 3.9; and N5 = 5.1 dS m^{-1}) and two cutting ornamental sunflower cultivars (Red Sun and Vincents II), with four repetitions and two plants by portion, with a total of 80 experimental units. The irrigation water salinity affected all the analyzed variables, up to estimate level of 2.7 dS m^{-1} acceptable reductions happen of 10% in the inflorescence and stem of cultivars of ornamental sunflower. The Red Sun cultivar when compared with cultivar Vincents II demonstrated better results in the studied variables.

Keywords: floriculture, *Helianthus annuus* L., saline stress

1. Introduction

The sunflower (*Helianthus annuus* L.) is a yearly dicotyledonous plant originated in the north American continent that, due to its high adaptation to edafoclimatic conditions has been gaining prominence in the Brazilian agribusiness (Caldeira et al., 2017). This fact was associated mainly to the most various purposes of cultivation: from grains production to oil extraction and animal feeding, as in the production of cutting flowers and vase (Brito et al., 2017). Flower and plant trade has been consolidating as economic activity relevant in all national territory, mainly by the decentralization off the South of the country, being produced by big and small owners (Junqueira & Peetz, 2014).

As a way to follow up the development of this sector, it comes as an alternative the cultivation of cutting ornamental sunflower that, besides the high adaptation to the environment conditions, present short cycle and inflorescences lush leading to a high acceptance by consumers, mainly for production of arrangements and decorations (Andrade et al., 2017). This situation makes these cultivars an alternative to the socioeconomic development of the northeastern region of Brazil.

As main barrier to the sector development in this region is the restriction of good quality water for irrigation, leading producers to adopt water resources with high concentration of salts (Silva et al., 2015). This condition leads to a reduction of the soil water potential, leading to a decrease of absorption of water by the plant, and therefore, the nutritional unbalance, by the accumulation of ions as Na^+ and Cl^-, that over time provide a toxic effect leading to restrictions of plant metabolism (Souza et al., 2017; Zhang et al., 2017).

Thus, the use of saline Waters for irrigation for plant production is a challenge that has been overcome in different parts of the world through the adoption of adequate practices of culture handling of soil and water (Medeiros et al., 2017), amongst them, we highlight the use of plants tolerant to salinity and sodicity (Brito et al., 2015). For Pivetta et al. (2012), the success of production of certain culture starts with the choice of a cultivar adapted to the region conditions, thus, studies that assess the agronomic development of culture when subject to the environment conditions of cultivation place are necessary.

In view of this, the objective was to assess the development of two cultivars of cutting ornamental sunflower irrigated with waters of different salinities.

2. Method

2.1 Location and Description of Experiment Area

The experimented was performed in conditions of protected environment, vegetation house at Universidade Federal de Campina Grande, Center of Science and Agrifood Technology of Pombal Campus-PB, located at 6°47′3.87″ S and 37°48′5.75″ W, with average altitude of 170 meters, from November 2017 to February 2018. The climate according to the Köppen classification is type Aw, hot and damp with summer and fall rains and yearly average rainfall of 800 mm (Moura et al., 2011).

2.2 Description of Handling

The experiment was performed in outlining of block (DBC), presenting a factorial scheme of 2 × 5, two cultivars of cutting ornamental sunflower (red Sun and Vincents II), and five levels of irrigation water salinity (ECw) (0.3; 1.5; 2.7; 3.9 and 5.1 dS m^{-1}), with four repetitions and two plants by portion, with a total of 80 experimental units. The solutions were obtained through addition of sodium chloride (NaCl) and local supply water (0.3 dS m^{-1}).

The used cultivars presented characteristics of height from 1 to 3 meters, vigorous and of early cycle, hairy leaves, different in color: a red one with dark core (Red sun) and a yellow one with dark core (Vincents II).

2.3 Setup and Experiment Steps

Plastic Vases with capacity of 15 liters were used, with holes in the base for free drainage, filled with 0.8 kg of gravel, which covered the base of the vase and followed by 14.2 kg soil material provided from UFCG campus in Pombal-PB. Before seeding, a volume of water necessary for the soil to reach field capacity, through a saturation method by capillarity followed by free drainage.

The physicochemical characteristics of the soil used (Table 1) were determined by the method described by Texeira et al. (2017) at Universidade Federal da Paraíba (UFPB), Center of Agro Science, Campus II Areia, PB, Soil Science department.

Table 1. Physicochemical Characteristics of the substrate used in the experiment

Chemical Features									
pH	P	K^+	Na^+	Ca^{2+}	Mg^{2+}	SB	CTC	Al^{3+}	$H + Al^{3+}$
$CaCl_2$ 1:2.5	mg dm^{-3}	---------- $cmol_c/dm^3$ ----------							
6.5	536.6	143.67	0.07	1.20	0.71	2.34	3.15	0.10	0.81
Physical Features									
MO		Sand		Silt		Clay		Texture Class	
---------- g kg^{-1} ----------									
4.79		851		99		50		Free Sand	

Note. pH: hydrogen potential; Ca^{2+} and Mg^{2+} extracted with 1 M KCl at pH 7.0; Na^+ and K^+ extracted using 1 M NH_4OAc at pH 7.0; $Al^{3+} + H^+$ extracted using 0.5 M CaOAc pH 7.0.

Seeding was performed in plastic cups of 100 mL, one seed per recipient, 7 days after germination when they presented two final leaves; they were transplanted to the 15 L vases, at the end of the afternoon.

On day 30 after the transplantation (DAT), the plants were tutored and fertilized with macro and micro nutrients (N, P_2O_5, K_2O, Ca, Mg, S, B, Co, Cu, Fe, Mn, Mo, Zn), via leaf, following the specific need for cultivation (Sfredo et al., 1984).

The application of saline water started at 30 DAT, with daily manual irrigations, the applied volume was determined by the lysimetric process of drainage, calculated in function of the applied water volume drained from previous irrigation (Bernardo et al., 2006).

Every 15 days, a 10% leaching fraction was applied based on the volume applied in this period, which purpose was to reduce the accumulation of substrate salts.

During the experiment, the following cultivation handling was performed: manual elimination of spontaneous plants and weekly scarification before each soil irrigation.

2.4 Assessed Variables

In order to assess the effect of treatments over the plants growth, the absolute growth rate (AGR) for plants height (AGR_{PH}) and stem diameter (AGR_{SD}) were measured from 15 to 60 DAT. The determination of absolute growth rate (TCA) and relative growth rate was obtained employing the method proposed by Benicasa (2003), as described in the Equations 1 and 2, respectively:

$$TCA = (A2 - A1)/(t2 - t1) \quad (1)$$

where, AGR = Absolute Growth Rate; A2 = plant growth at time t2; A1 = plant growth at time t1; t2 – t1 = difference of time between samples

The relative growth rate was obtained by Equation 2, in which it was measured the growth in function of preexisting matter, adapting to plants height and diameter.

$$TCR = (\ln A2 - \ln A1)/(t2 - t1) \quad (2)$$

where, RGR = relative growth rate; A2 = plant growth at time t2; A1 = plant growth at time t1, t2 – t1 = difference of time between samples and; ln = natural logarithm.

The determination of phytomass was performed at 60 DAT through a destructive assessment of the experiment, the plants were collected, washed (the roots), and then fractioned in leaf, steam, inflorescence and root. Later, the material was conditioned in paper bags previously identified and put in an air circulation greenhouse at 65ºC for 48 hours. After obtaining the constant weight, the determination of dried phytomass leaves (LDP), inflorescences (IDP), roots (RDP) and stem dried phytomass (SDP), besides the dried phytomass of above-ground (ADP) (LDP+IDP+SDP), and total dried phytomass (TDP) (ADP + RDP) on a precision scale of 0.01g.

2.5 Statistics Analysis

The variables were assessed through variance analysis by F test and, in the cases of significative effect, performed the analysis of linear and quadratic polynomial regression for water conductivity (dS m^{-1}), and conclusive for acultivars of ornamental cut of sunflower, using the statistics software SISVAR (Ferreira, 2014). The choice of regression was performed through better adjustment based on the coefficient of determination (R^2) and taking in to account a probable biological explanation.

3. Results e Discussion

According to the summary of variance analysis (Table 2), it is verified the significative effect in the interaction between electrical conductivity of irrigation water and cultivars of sunflower over the plant absolute growth rate (AGR_{PH}) in the period of 15-60 DAT. While the other growth rated had a significative effect for irrigation water salinity and cultivars of sunflower, in isolation.

Table 2. Summary of variance analysis for absolute (AGR_{PH}) and relative (RGR_{PH}) growth rates of plant height and absolute (AGR_{SD}) and relative (RGR_{SD}) growth of plant of stem diameter, for two cultivars of cutting ornamental sunflower irrigated with saline waters in the period 15-60 DAT

Variation Resource	Average Square				
	GL	AGR_{PH} 15-60	RGR_{PH} 15-60	AGR_{SD} 15-60	RGR_{SD} 15-60
Cultivars (C)	1	2.36**	0.001**	0.002**	0.0000**
Saline levels (S)	4	0.22**	0.0000**	0.001**	0.0000**
Linear regression	1	0.75**	0.0000^{ns}	0.002**	0.0000*
Quadratic regression	1	0.096^{ns}	0.0000**	0.0000^{ns}	0.0000^{ns}
Interaction (C × S)	4	0.087*	0.0000^{ns}	0.0000^{ns}	0.0000^{ns}
Blocks	3	0.046^{ns}	0.0000^{ns}	0.0000^{ns}	0.0000^{ns}
CV(%)	-	9.58	7.93	15.63	12.68

Note. ^{ns}, **, * respectively not significant, significative to 1% and 5%

The increase of irrigation water salinity exerted negative effect over the absolute growth rate of plant height (AGR_{PH}) in which, according to linear regression equation (Figure 1), it is observed unit reductions of 4.48% and 6.62% for unit increase in ECw in the cultivars of cutting ornamental sunflower Vincents II and Red Sun, respectively. Leading to ECw of irrigation of 5.1dS m^{-1} depreciations of 21.52% in cultivar Vincent II and 31.76% in cultivar Red Sun, when compared to ECw of 0.3 dS m^{-1}. Even presenting greater losses in this variable, Red Sun cultivar presented better results in AGR_{PH} when compared to cultivar Vincents II. It is noted that the inhibition of plant growth by salinity happened as the excess of salts in the soil solution changes the metabolic activities of cells in the process of cell stretching, restricting the elasticity of cell wall, reducing the cell stretching and, as consequence, the plant growth (Taiz et al., 2017).

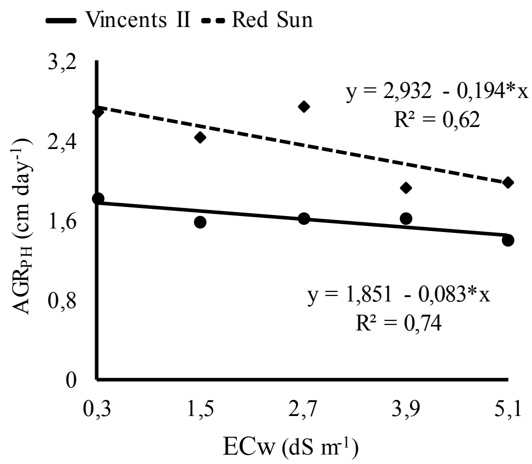

Figure 1. Interaction of two cultivars of cutting ornamental sunflower in function to the saline levels of irrigation water under the absolute growth rate of plant height (AGR_{PH}) in the period 15-60 DAT

The relative growth rate of plant height (RGR_{PH}) was adjusted to the quadratic model (Figure 2A), it was noted the increase of 8.11% when the plants were irrigated with ECw water of 2.7 dS m^{-1}, when compared to salinity of 0.3 dS m^{-1}. This situation shows a certain tolerance of sunflower plants to irrigation water salinity, may be related to compartmentalization of salts in the interior of the vacuoles (Willadino & Camara, 2010).

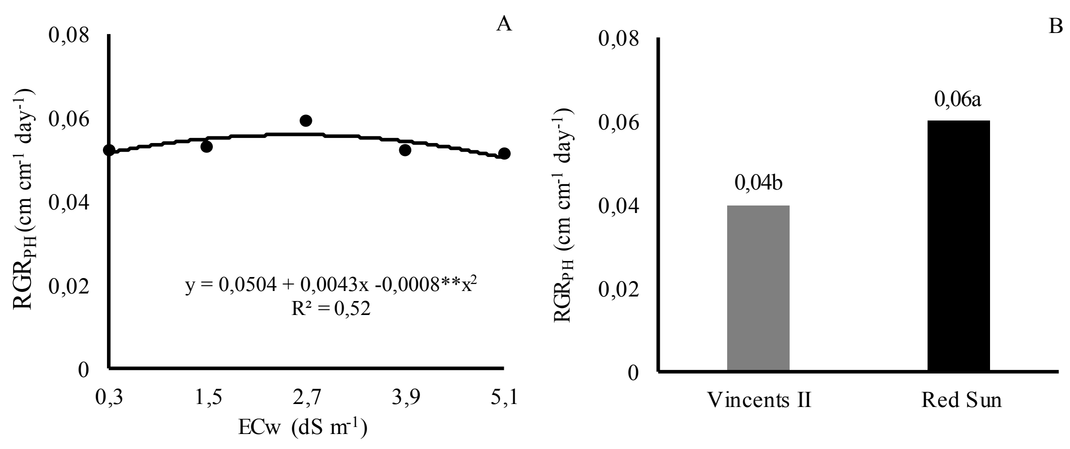

Figure 2. Isolated effect factors to saline levels of irrigation water (A) and of two cultivars cutting ornamental sunflower (B) under the relative growth rate of plant height (RGR_{PH}) in the period 15-60 DAT

The cultivar of cutting ornamental sunflower Red Sun was superior, when compared to cultivar Vincents II (Figure 2B), showing a growth of 33.3% in the plants height. This behavior may be related to a better use of environment conditions by plants with increase of material along the development stage of cultivation cycle (Lustri et al., 2017).

As regards absolute growth rate for stem diameter (Figure 3A), the additions of irrigation water salinity result in linear reductions of AGR_{SD} of 5.77% in each ECw unit increase, leading to a total reduction of 27.7% when compared to salinity of 5.1 with the 0.3 dS m^{-1}. Torres et al. (2014) attributed such reduction to energy consumption for organic compounds synthesis osmotically active, and necessary for processes of compartmentalization in the regulation of ions transportation.

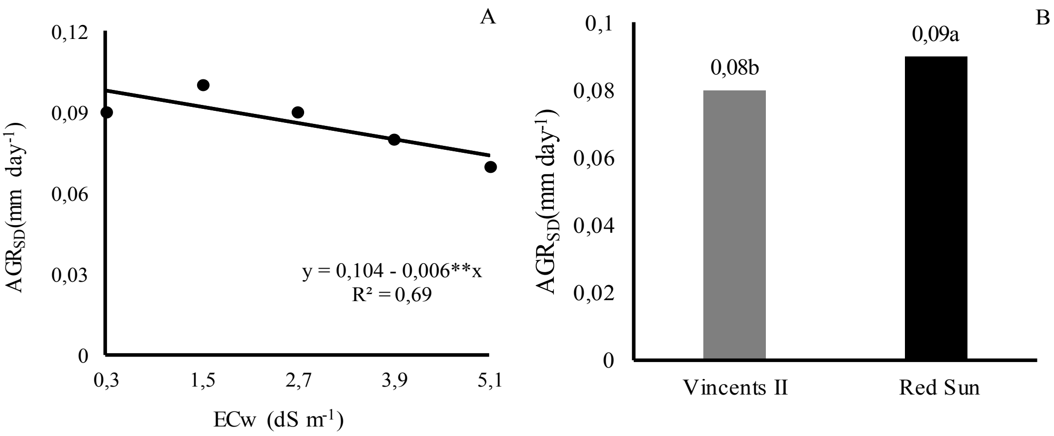

Figure 3. Isolated effect factors to saline levels of irrigation water (A) and of two cultivars cutting ornamental sunflower (B) under the absolute growth rate of stem diameter (AGRSD) in the period of 15-60 DAT

The cultivar of cutting ornamental sunflower Red Sun showed superiority when compared to cultivar Vincents II (Figure 3B), presented increase of 11.1% in $AGR_{SD.}$ A possible explanation for this fact would be that such cultivar could keep the increase in the concentration of CO_2, which led to increase of plant photosynthetic rated (Gomes et al., 2018).

In relation to relative growth rate of steam diameter, it was noted that it would present similar behavior to TCAdh, where the second model of linear regression (Figure 4A) showed decrease of 8.18% by unit increase of electrical conductivity of irrigation water, reaching saline level of 5.1 dS m^{-1}, leading to a decrease of 39.26% in RGR_{SD} compared to plants irrigated with local supply water (0.3 dS m^{-1}). According to Freire et al. (2010), it causes damages to pressure of turgescence in the cells due to decrease of water content in the tissues, resulting in decrease of cell wall expansion, causing lower growth in the plants.

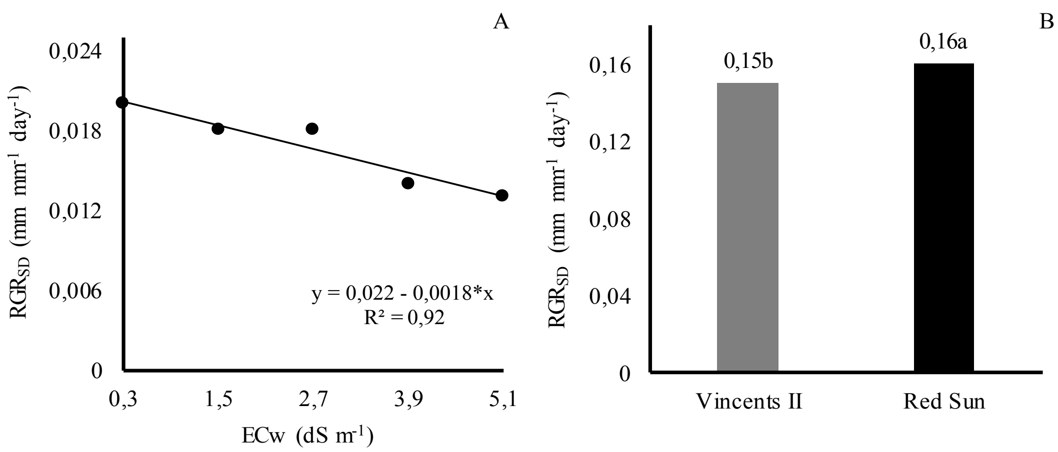

Figure 4. Isolated effect factors to saline levels of irrigation water (A) and of two cultivars cutting ornamental sunflower (B) under the relative growth rate of plant height (RGRSD) in the period of 15-60 DAT

The cultivar of cutting ornamental sunflower Red Sun continued superior when compared to cultivar Vincent II (Figure 4B), showing an increase of 6.25% in the diameter relative growth rate. Certainly, this advantage in relation to Vincents II is due to better vegetal material characteristics, and as it is a hybrid, consequently, it presented better force, due to heterozygous.

In Table 3, it is noted significative effect of cultivars isolated factors of cutting ornamental sunflower and saline levels of irrigation water over the phytomass variables of leaves (LDP), inflorescence (IDP), above-ground (ADP) and total (TDP). It is also noted the effect of factors interaction for stem dried phytomass variables (SDP) and roots (RDP).

Table 3. Summary of variance analysis for variables of dry phytomass of leaves (LDP), inflorescence (IDP), roots (RDP), stem (SDP), and for dry phytomass above-ground (ADP) and total (TDP), for two cultivars of cutting ornamental sunflower irrigated with saline waters

Variation Resource	Average Square						
	GL	LDP	IDP	RDP	SDP	ADP	TDP
Cultivars (C)	1	7.25**	7.77*	0.54^{ns}	64.36**	1099.03 **	103.97**
Saline levels (S)	4	6.76**	7.54**	1.78**	38.42**	1228.30**	138.01**
Linear regression	1	9.41**	9.58*	3.71**	134.65**	3442.03**	333.58**
Quadratic regression	1	3.55*	0.01^{ns}	0.14^{ns}	2.52^{ns}	192.54^{ns}	3.38^{ns}
Interaction (C x S)	4	1.91^{ns}	3.84^{ns}	0.58*	13.37*	269.05^{ns}	25.91^{ns}
Blocks	3	0.09^{ns}	0.36^{ns}	0.21^{ns}	0.76^{ns}	63.33^{ns}	10.98^{ns}
CV(%)	-	14.19	22.69	15.67	18.06	11.16	14.46

Note. ^{ns}, **, * respectively not significative, significative to $p < 0.01$ and $p < 0.05$.

Irrigation water provided quadratic behavior of leaves dry phytomass (Figure 5A), with accented reductions from the ECw of 2 dS m^{-1}. Up to this level, there was an increase of 21% in FSF, when compared to plants irrigated with supply water (0.3 dS m^{-1}). It is associated with strategies to reduce the effect of salinity by the plant, with accumulation of different types of organic substances and inorganic myocytes in the cytosol in response to stress by salts, as a form of regulation of cell processes (Khan et al., 2014).

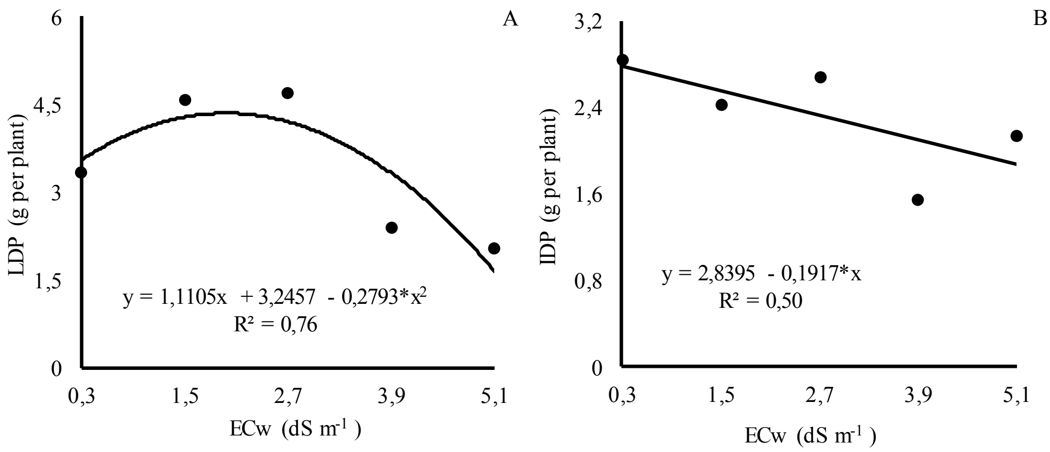

Figure 5. Dried Phytomass of leaves-LDP (A) and inflorescence-IDP (B) of two cultivars of cutting ornamental sunflower, under different saline levels of irrigation waters

The increase of irrigation water salinity significantly affected ($p < 0.05$) the production of dried phytomass of inflorescence (DPI) for factor isolated, and according to regression equation (Figure 5B), it was noted that the model which the data better adjusted was the linear, decrease of 6.75% with unit increase of ECw of irrigation, and reaching a total reduction of 32.4% in ECw of 5.1 dS m^{-1} compared to 0.3 dS m^{-1}. Fact explained by nutritional unbalance in the plants subject to salinity, which limits the translocation of nutrients for inflorescence, decreasing the development (Souza et al., 2017).

The increase of salinity of irrigation water exerted negative effect over the dried phytomass of roots, in which, according to linear regression equation (Figure 6A), resulting in unit reductions of 12.03% and 15.03% for cultivars of cutting ornamental sunflower Vincents II and Red Sun, respectively. It happened in the ECw of irrigation of 5.1 dS m^{-1} a total decrease of 57.74 in cultivar Vincents II and 72.14% in cultivar Red Sun when compared to ECw of 0.3 dS m^{-1}. Consequence of the stomatal closing and reduction in the speed of leaf elongation which limits the supply of photo-assimilates for root system, decreasing the formation of new roots and root growth (Kawavata et al., 2017).

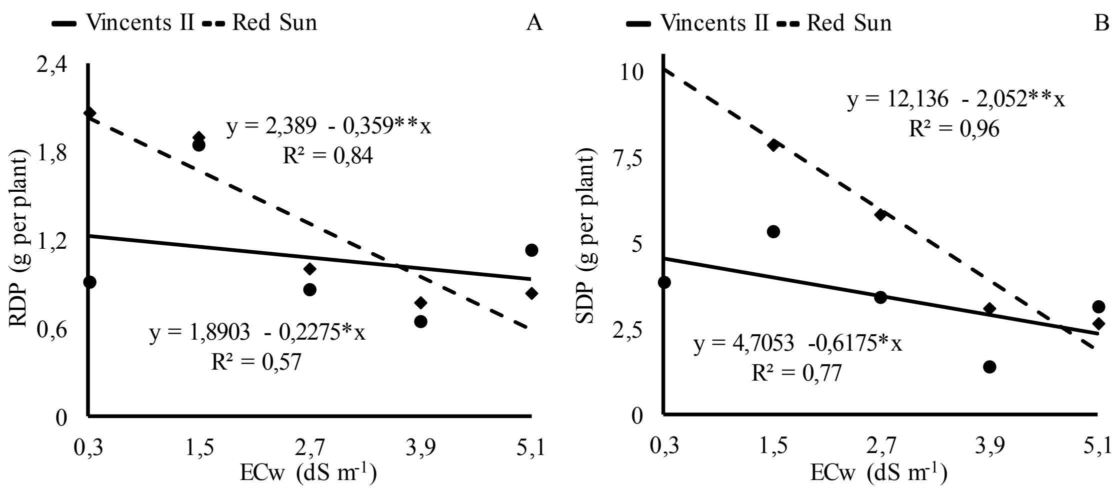

Figure 6. Interaction of two cultivars of cutting ornamental sunflower (*Helianthus annuus* L.), in function of saline levels of irrigation water under the dried phytomass of roots (RDP) and stems (SDP) of the plant

In relation to stem dried phytomass, the high level of salinity in the irrigation water exerted negative effect over this variable, where, according to linear regression equation (Figure 6B), presented a decrease of 13.12% to 16.90% for cultivars of cutting ornamental sunflower Vincent II and Red Sun, respectively. It caused decreases of 62.97% on ECw irrigation of 5.1 dS m^{-1} on cultivar Vincent II and 81.16% on Red Sun, when compared to ECw 0.3 dS m^{-1}. Willadino and Camara (2010) assign this reduction to osmotic, toxic and nutritional effects arising from the accumulation of salts in the root zone of the plant.

The phytomass of air part (Figure 7A), the data adjusted to a decreasing linear relation, for dried phytomass of above-ground reduced in 13.00% for unit increase of electrical conductivity of irrigation water (ECw), total reduction of 62.33% in the air part, when compared to higher and lower saline level (0.3 dS m^{-1} and 5.1 dS m^{-1}). Travassos et al. (2011), in research of aquarium of irrigated sunflower with brackish water, obtained a dried phytomass variable of above-ground, decreases of 13.56% for unit increase of electrical conductivity of irrigation water.

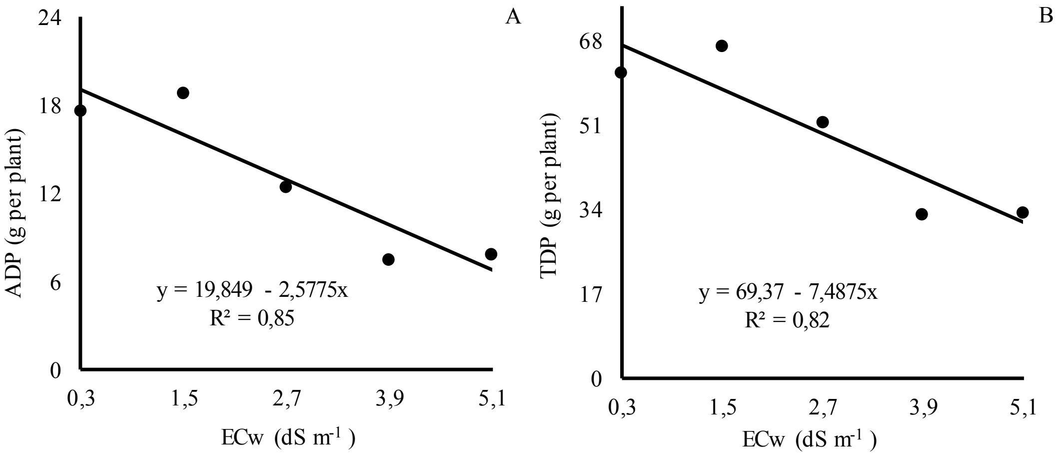

Figure 7. Isolated effect of conductivity of irrigation water in the dried phytomass of above-ground-ADP (A) and total-TDP (B) under two cultivars of cutting ornamental sunflower

While for total dried phytomass (Figure 7B), presented similar behavior to ADP, presenting a reduction of 10.8% by unit increase in the ECw, resulting in a total reduction of 51.8% in total phytomass, when compared to higher saline level (5.1 dS m^{-1}). According to Taiz et al. (2017), the decrease of TDP by increasing the salinity may be associated with inefficiency of roots in preventing the excessive accumulation of Na^+ and Cl^- in the air part, where the accumulation of them affect the activity of several enzymes, causing quantity and quality changes in the plant metabolism, resulting in low production of energy, besides causing disturbances in the assimilation of N and protein metabolism, reflecting in the reduction of TDP production.

Assessing the cultivars of sunflower isolated (Figure 8), it was noted that the Red Sun was superior in relation to variables analyzed compared to Vincents II. Presenting increase of 25.21% for dried phytomass of leaves, 28.11% dried phytomass of inflorescence, 25.05% for dried phytomass of above-ground (stem and leaves) and 21.33% of total dried phytomass of plants.

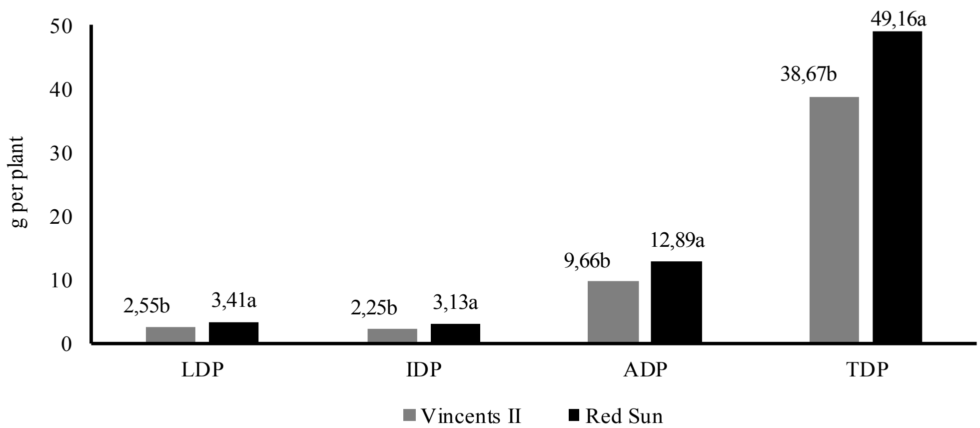

Figure 8. Isolated effect of two cultivars of cutting ornamental sunflower under dried phytomass of leaf (LDP), inflorescence (IDP), above-ground (ADP), and total dried phytomass (TDP), in different levels of conductivity of irrigation water

A possible explanation for this happening may be related to the capacity of this cultivar to adapt better to present environment conditions, as well as an increase in the efficiency of water use, making the plants better use this resource, with lower hydric loss through perspiration (Travasso et al., 2012).

4. Conclusions

The salinity of irrigation water affected all the analyzed variables, up to the estimate level of 2.7 dS m^{-1}, acceptable reductions of 10% in the inflorescence and stems of cultivars of ornamental sunflower.

The cultivar Red Sun when compared to cultivar Vincents II showed better results in studied variables.

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