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# Production of sunflower under saline water irrigation and nitrogen fertilization

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**The aim of the present study was to evaluate the production components of sunflower Embrapa 122-V2000, as a function of irrigation water salinity and nitrogen doses. The experiment was conducted in plastic pots with a capacity of 100 L under greenhouse conditions in Federal University of Campina Grande, during the period of April-July 2012, in an experimental design adopting factorial arrangement of 5 x 5, with five levels of irrigation water salinity, expressed by electrical conductivity of 0.7, 1.7, 2.7, 3.7 and 4.7 dS $m^{-1}$ (25°C) and five nitrogen rates of 50, 75, 100, 125 and 150 mg N $kg^{-1}$ soil, with three repetitions, totaling 75 experimental units. The evaluated parameters were: total number of achenes, percentage of viable achenes, percentage of biomass of viable achenes, the biomass and diameter of chapter, dry weight of 1000 seeds and production of achenes. Although, the interaction of water salinity and nitrogen levels did not show significant effects on the components of production, increase in the salt content of the water inhibited all the variables while elevation of nitrogen rates stimulated emission of achenes, chapter biomass and production of achenes.**

**Key words:** Marginal quality water, productivity, *Hellianthus annus* L.

## INTRODUCTION

The continuous population growth in the world requires the availability of food in the same proportions, which leads to the need for producing more food to meet the demand of human consumption. This demand has been met by the production of food through rainfed agriculture and the use of irrigation systems in arid and semiarid

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regions, which has allowed the expansion of agricultural areas worldwide (Machado et al., 2007).

Sunflower (*Helianthus annuus* L., Asteraceae family) is a plant native to Mexico and currently a viable option among oilseed crops, due to the quality of its oil, in polysaturated fatty acids and vitamin E, besides high protein digestibility (Grompone, 2005). According to Machado and Carvalho (2006), sunflower has the advantage of having tolerance to adverse weather conditions and wider thermal range of exploration than other oilseed crops of commercial importance. Thus, it can be an alternative in the diversification of family farming activities, because, besides grain production for oil extraction, it can be used in apiculture for the good quality of pollen and nectar.

The advance in sunflower cultivation in the last years has shown that this crop may be an alternative to various agribusiness segments, evidencing a sustainable option for the composition of production systems in the many producing regions of Brazil (Vieira, 2005). Among the factors justifying sunflower cultivation, there is an increasing demand for edible oil and biofuels, besides the possibility of using the bran as a complement in animal ration (Ferrari, 2004).

Nitrogen (N) is the second most required nutrient by sunflower and the one that most limits its production, causing yield reduction of up to 60% due to its deficiency (Castro and Farias, 2005). N plays an important role in sunflower metabolism and nutrition, and its deficiency causes nutritional disorders. This nutrient in excess causes a reduction in the percentage of oil and can increase the incidence of pests and diseases, compromising grain production (Biscaro et al., 2008). Nobre et al. (2011) evaluating sunflower cv. 122 Embrapa 122-V2000, under irrigation with waters of different salinities (0.5 to 4.9 dS $m^{-1}$) and doses (50 to 125% of the N recommendation), concluded that the duration of crop cycle and the time interval between the formation and physiologic maturity of seeds reduces its mass and increases with the dose of N. Ribeiro et al. (2015) studying the effects of irrigation with saline water and nitrogen on growth and production components of sunflower cv. Embrapa 122-V2000, found no siginificant influence on biometric indices and production.

The negative effects of irrigation water salinity in oilseed crops have been observed by many researchers (Silva et al., 2008; Correia et al., 2009), including the sunflower crop (Silva et al., 2009; Nobre et al., 2010; Guedes Filho et al., 2015).

The irregularity of rains, the lack of good quality water for agriculture, inadequate irrigation management and the low tolerance of economically important plants to salinity has compromised food production worldwide (Hans et al., 2015). These problems are more frequent in arid and semiarid areas of the world and in Brazil, where more than 30% of the soils in irrigated lands are affected by salts (Lopes et al., 2008; Smith et al., 2009; Leite et al., 2010) and require the adoption of practices that economically justify the use of high salinity water in agriculture in order to overcome the lack of food for the increasing global population (Rhoades et al., 2000). Thus, several studies have pointed out that there is evidence of competition in uptake of nitrate and chloride, so that an increase in the nitrate concentration in the root zone may inhibit greater absorption of chloride by the plant (Flores et al., 2002).

The knowledge of the effects of salts on this crop and on the soil, as well as the involved phenomena, are extremely important for an adequate management of irrigation and cultivation and the use of saline water (Dias and Blanco, 2010). Therefore, the sunflower crop has stood out in researches with low quality water (Rodrigues et al., 2010; Nobre et al., 2011; Travassos et al., 2011; Guedes Filho et al., 2015), due to the possibility of the production of edible oil, biodiesel and as an ornamental plant and material.

In this context, this study aimed to evaluate the productive behavior of Embrapa 122-V2000 sunflower under irrigation with water of increasing salinity levels and N fertilization.

## MATERIALS AND METHODS

The experiment was conducted in a screened shelter at the Center of Technology and Natural Resources of the Federal University of Campina Grande (UFCG), from April to July 2012, located at the geographic coordinates of 07° 13′ 11′′ S and 35° 53′ 31′′ W, and an altitude of 550 m. The climate in the region, according to Köppen's classification, adapted to Brazil, is Csa (humid temperate climate with dry and hot summer), which represents a semi-humid mesothermal climate, with hot and dry summer (4 to 5 months) and rains from autumn to winter; the months of June and July are the coldest ones, with mean temperatures less than 20°C.

The experimental design was completely randomized using a 5 x 5 factorial scheme with three replicates, totaling 75 experimental units. The treatments corresponded to five levels of irrigation water electrical conductivity – ECw (0.7; 1.7; 2.7; 3.7 and 4.7 dS $m^{-1}$), prepared through the addition of non-iodized NaCl to the water from the local supply system (ECw = 0.7 dS $m^{-1}$), combined with five N doses, corresponding to 75, 100, 125 and 150 mg of N $kg^{-1}$ of soil.

The experiment was conducted using the Embrapa 122-V2000 sunflower cultivar, which stands out for its precocity as compared to the hybrids currently cultivated in Brazil. It can reach mean yield of 1,700 kg $ha^{-1}$ and mean oil content of 43.5%. It has a cycle of approximately 100 days and its flowering starts at 53 days (Embrapa , 2002).

Seventy five plastic pots with capacity of 100 L of soil were used and distributed at spacing of 1.5 m between rows and 1.0 m between plants. The bottom of the pots was connected to a 5-mm-diameter plastic tube, for the drainage of the leachate, and had a nylon screen, on which 1 kg of crushed stone (no. zero) was placed. Two plastic containers were placed below the pots for the collection of drained water.

The substrate consisted of material from a soil classified as non-saline Yellow Argisol, according to the Brazilian Soil Classification System - SiBCS (Embrapa, 2013), collected in the district of São José da Mata, in the municipality of Campina Grande-PB, in the layer of 0-20 cm, which was pounded to break up clods, sieved and placed in the plastic pots. During the period of September 2011 to

**Table 1.** Characteristics of soii in the layer of 0-20 cm, in relation to the chemical and salinity properties before application of treatments.

| Soil properties | Values | Saturation extract | Values |
|---|---|---|---|
| pH ($H_2O$) | 6.17 | $pH_{sp}$ | 5.97 |
| OM (g $kg^{-1}$) | 19.1 | ECse (dS $m^{-1}$) | 2.03 |
| P (mg $dm^{-3}$) | 56.2 | Chloride ($mmol_c$ $L^{-1}$) | 12.5 |
| $Ca^{2+}$ ($cmol_c$ $kg^{-1}$) | 3.88 | Bicarbonate ($mmol_c$ $L^{-1}$) | 5.00 |
| $Mg^{2+}$ ($cmol_c$ $kg^{-1}$) | 2.86 | Calcium ($mmol_c$ $L^{-1}$) | 10.37 |
| $K^+$ ($cmol_c$ $kg^{-1}$) | 0.30 | Magnesium ($mmol_c$ $L^{-1}$) | 9.63 |
| $Na^+$ ($cmol_c$ $kg^{-1}$) | 0.47 | Potassium ($mmol_c$ $L^{-1}$) | 0.38 |
| $Al^{3+}$ ($cmol_c$ $kg^{-1}$) | 0.00 | Sodium ($mmol_c$ $L^{-1}$) | 4.86 |
| $H^+$ ($cmol_c$ $kg^{-1}$) | 1.62 | SAR (mmol $L^{-1})^{1/2}$ | 1.54 |
| SB ($cmol_c$ $kg^{-1}$) | 7.51 | ESP (%) | 5.15 |
| CEC ($cmol_c$ $kg^{-1}$) | 9.13 | Degree of salinity | Slight |
| V (%) | 82.25 | Soil of classification | Non saline non sodic |

OM- Organic matter; CEC- cation exchange capacity [SB + ($H^+$ + $Al^{3+}$)]; SB- sum of bases ($Ca^{2+}$ + $Mg^{2+}$ + $K^+$+ $Na^+$); V- base saturation% = (SB/CEC) x 100; $pH_{sp}$ – pH of the saturation paste; ECse- electrical conductivity in the saturation extract; ESP- exchangeable sodium percentage ($Na^+$/CEC x 100).

February 2012 castor bean crop was cultivated in the pots under same treatments of water salinity and N rates (Alves et al., 2012). The chemical characteristics (Table 1) refer to the mean results of the soil analysis after leaching with local supply water (ECw = 0.7 dS $m^{-1}$) until the draining water in each pot had an electrical conductivity around 0.9 dS $m^{-1}$. Chemical parameters related to fertility were determined according to the methodologies proposed by Donagema et al. (2011) and salinity according to Richards (1954), at the Laboratory of Irrigation and Salinity of the UFCG.

Before sowing, soil water content was increased to field capacity through irrigation. Irrigation management during the cultivation was performed based on water balance, following an irrigation frequency of two days. Thus, the water depth in each treatment was calculated as a function of the applied water volume and the volume of water drained in the previous irrigation, adding a leaching fraction of 10%.

Fertilization followed the recommendations of Novais et al. (1991) for experiments in protected environments. Basal fertilization was performed using 300 mg of $P_2O_5$ and 4 mg of boron $kg^{-1}$ of soil, as single superphosphate and boric acid, respectively. Potassium fertilization consisted of 150 mg of $K_2O$ $kg^{-1}$ of soil, as potassium chloride. Nitrogen fertilization, as urea, was applied according to the treatments. Both potassium and nitrogen, were applied one third at sowing (basal dose) and two thirds as top-dressing in equal doses at 20 and 40 days after sowing (DAS). Sowing was performed at a depth of 2 cm, using ten seeds per pot. Seedlings emergence started on the fourth day and continued until the $13^{th}$ day; at 15 DAS, the first thinning was performed, leaving three plants with the best vigor per pot and, at 20 DAS, the second thinning was performed, leaving one plant per pot.

As plants reached the state of physiological maturation of achenes, that is, when they showed a hard mass, referring to the “R9” phenological stage (Silva et al., 2007), irrigation was suspended. At this stage, the capitula inclined downward, with their back and bracts showing yellow and brown color. In this period, 75 DAS, plants were at the end of the cycle, when the evaluation of sunflower production components started. At 85 DAS, harvest was performed by cutting the stem of each plant close to the soil and then separating the different parts (stem, leaf, capitulum and root) and placing them in kraft paper bags. Every part of plant was dried in a forced-air oven at 65°C until constant weight, to determine the following parameters: total number of achenes (TNA), percentage of viable achenes (VA%), percentage of viable achene weight (VAW%), phytomass of capitulum (PCAP), diameter of capitulum (DCAP), weight of 1000 achenes (M1000A) and production of achenes (PROD). The achenes of each capitulum were manually threshed and then separated into viable and non-viable achenes. Non-viable achenes were considered as those that did not develop or were empty. The TNA refer to manual count of all achenes in the chapter; the percentage of viable achenes (AV%) was calculated by relating number of viable achenes - NVA to TNA - NVA/TNA x 100; the VAW was cauculated by the relationship VAW/PROD x 100; the PCAP was obtained by manual threshing of the achenes from receptacle of sepals and bracts and subsequently placed (receptacle, sepals and bracts) for drying in an oven with forced air ventilation at temperature of 65°C, for a period 48 h. The diameter of the chapter (DCAP) was measured with a millimetric ruler; the M1000A was determined by weighing 1000 viable achenes and the production of achenes was calculated based on the weight of achenes of each plot (one plant), considering the moisture content of the achenes of 13%.

The obtained data were subjected to the analysis of variance by F test at 0.01 and 0.05 probability levels; when significant, polynomial regression analysis was performed using the statistical program SISVAR (Ferreira, 2011).

## RESULTS AND DISCUSSION

According to the results of the F test (Table 2), the interaction between water salinity levels and N doses did not affect significantly any of the evaluated parameters, but salinity had significant effects on all the production components, and N doses on the total number of achenes, phytomass of capitulum and production of achenes of sunflower. Similar results were reported by several authors (Nobre et al., 2010, 2011; Oliveira et al., 2010; Freitas et al., 2012; Guedes Filho et al., 2015), who observed isolated effects of irrigation water salinity and N

**Table 2.** Summary of the F test and regression for the total number of achenes (TNA), percentage of viable achenes (%VA), percentage of viable achene phytomass (VAP%), phytomass of capitulum (PCAP), diameter of capitulum (DCAP), mass of 1000 achenes (M1000A) and production of achenes (PROD) of sunflower as a function of irrigation water salinity and nitrogen fertilization, evaluated at harvest, 85 days after sowing.

| Variation source | F TEST | | | | | | |
|---|---|---|---|---|---|---|---|
| | TNA | VA% | VAP% | PCAP | DCAP | M1000A | PROD |
| Salinity (S) | ** | ** | ** | ** | ** | ** | ** |
| Linear regression | ** | ** | ** | ** | ** | ** | ** |
| Quadratic regression | * | ns | * | ** | ns | ** | * |
| Nitrogen (N) | ** | ns | ns | ** | ns | ns | * |
| Linear regression | ** | ns | ns | ** | ns | ns | ** |
| Quadratic regression | ns | ns | ns | ns | ns | ns | ns |
| Interaction (S x N) | ns | ns | ns | ns | ns | ns | ns |
| CV (%) | 15.46 | 6.66 | 3.55 | 13.31 | 20.50 | 8.75 | 15.21 |

CV = coefficient of variation; ns = not significant; * = significant (p < 0.05); ** = significant (p < 0.01).

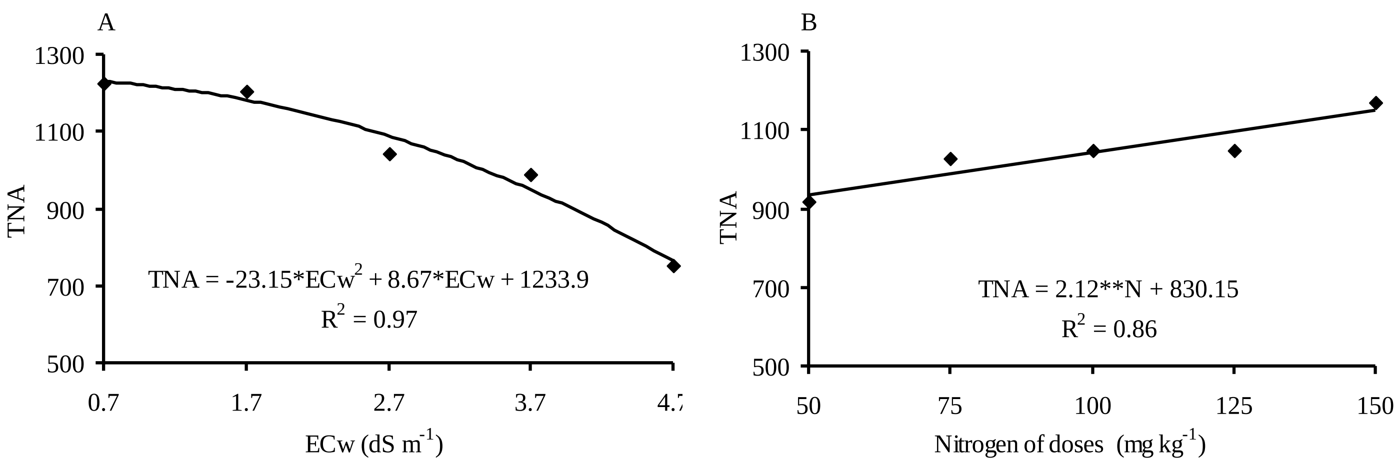


**Figure 1.** Total number of achenes– TNA of sunflower as a function of irrigation water salinity (A) and nitrogen fertilization (B) evaluated at harvest, 85 days after sowing.

on sunflower growth and production, but, in general, without significant effects of the interaction between both on plant vegetative and productive behaviors. The lack of significant effect of the interaction can be a response of the adequate N supply to plants, which contributed to the attenuation of the effects of increasing water salinity, as observed for the total number of achenes, phytomass of capitulum and production of achenes, for which the increase in salinity was inhibited and the increase in N stimulated each studied variable.

The increase in water salinity compromised the emergence of sunflower achenes and, according to the regression (Figure 1A), the data adjusted to a quadratic model (p<0.05). TNA obtained by irrigation waters were: 1217, 1182, 1089, 949 and 682 for the salinity levels of 0.7; 1.7; 2.7; 3.7 and 4.7 dS $m^{-1}$, respectively, comparison of TNA obtained in due to lower and higher salinity level, point that there was 44% reduction in the total number of achenes. According to Assis et al. (2007), the reduction in the production in plants cultivated under saline water irrigation can be due to the delay in net carbon assimilation, associated with osmotic effects and accumulation of potentially toxic ions ($Na^+$ and $Cl^-$) in leaf tissues. Likewise, despite evidencing the harmful effect of salinity on the number of achenes, the decrease also indicated that the variable is important for the evaluation of the crop under saline stress.

Nobre et al. (2010), evaluating production of sunflower cultivar Embrapa 122-V2000 under different levels of irrigation water salinity (ECw from 0.5 to 4.9 dS $m^{-1}$), in experiment conducted in a greenhouse, concluded that the production of achenes decreased linearly from the irrigation water salinity of 0.5 dS $m^{-1}$.

For N fertilization, the increase in the doses stimulated the emergence of achenes (Figure 1B), the number of achenes obtained under different N doses were: 936,

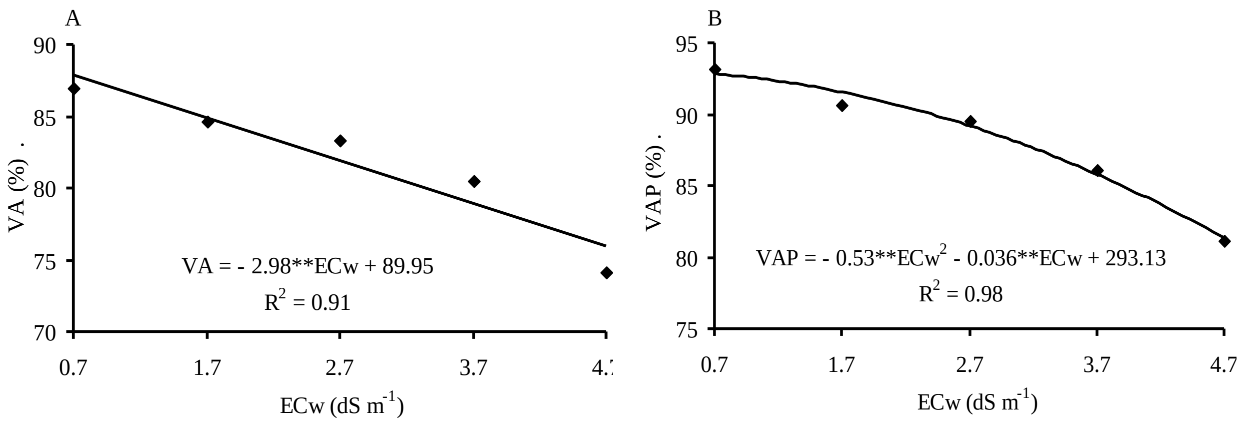


**Figure 2.** Percentages of viable achenes– %VA (A) and viable achene phytomass– %VAP (B) of sunflower as a function of irrigation water salinity, evaluated at harvest, 85 days after sowing.

989, 1042, 1095 and 1148 achenes for the levels of 50, 75, 100, 125 and 150 mg N $kg^{-1}$ of soil, respectively, the number of achenes obtained under highest N level (150 mg N $kg^{-1}$ of soil) were 22.64% more than that of lowest level (50 mg $kg^{-1}$ of soil). The increment in TNA can be related to the functions performed by this nutrient in plant metabolism, since it is a constituent of chlorophyll molecule, nucleic acids and proteins, besides being an activator of various enzymes. Furthermore, it participates in vital processes in the plant, such as synthesis of protein, ionic absorption, photosynthesis, respiration, multiplication and differentiation of cells (Malavolta, 2006). Abbadi et al. (2008), studying the effects of N on growth, yield and production components of safflower and sunflower, observed increases in the number of achenes per capitulum and concluded that the direct effects are smaller for safflower than sunflower.

According to the regression equation (Figure 2A), the effect of irrigation water salinity on the percentage of viable achenes was linear and decreasing, with reductions of about 3.31% in percentage of VA per unit increase in ECw. For water salinity levels of 0.7; 1.7; 2.7; 3.7 and 4.7 dS $m^{-1}$, the obtained percentage of viable achenes were 87.86; 84.88; 81.90; 78.92 and 75.94%, respectively, indicating that there was a reduction of 11.92% in the percentage of viable achenes between the lower and higher levels of irrigation water salinity. As for nitrogen levels, no significant effect was observed. The decrease in VA can be attributed to the reduction in water availability to plants, because of the osmotic effects resulting from the accumulation of salts in the root zone under saline stress, which require higher energy to absorb water (Leonardo et al., 2007) with consequent negative effects on yield. Travassos et al. (2011), evaluating production components and achene production of sunflower under irrigation with differrent water salinity levels (0.5 to 5.0 dS $m^{-1}$) in protected environment, concluded that the number of viable achenes decreased by 9.64% per unit increase in ECw. Chen et al. (2009) in a drip irrigation system with saline water of electrical conductivity ranging from 1.6 to 10.9 dS $m^{-1}$, reported linear reduction of 5.5% in viable achenes of sunflower per unit increase in irrigation water salinity.

Viable achene phytomass (VAP) (Figure 2B) adjusted to a quadratic regression model. Considering the equation, the biomass obtained for viable achenes in function of the salinity levels of irrigation water were: 92.85; 91.54; 89.17; 85.74 and 81.25% for levels 0.7; 1.7; 2.7; 3.7 and 4.7 dS $m^{-1}$, respectively, causing decrease of 12.49% in biomass of viable achenes between the lowest and highest level of salinity. These results indicated that salinity levels in the irrigation water from 4.7 dS $m^{-1}$ on cause low production of viable achenes, making the production less profitable in salinized areas. Santos Júnior et al. (2011), studying the sunflower cv. Embrapa 122-V2000 in semi-hydroponic system, using coconut fiber as a substrate, irrigated with nutrient solutions of EC from 1.7 to 11.5 dS $m^{-1}$, observed a decrease of 11.3% in the phytomass of achenes with unit increase in salinity. Studies conducted by Escalante and Rodríguez (2010), on sunflower in Mexico, reported that the number and phytomass of achenes were affected by irrigation water salinity.

As for the phytomass of capitulum (Figure 3A), the regression equation fitted to a quadratic model. It is observed that when plants were exposed to water salinities 0.7; 1.7; 2.7; 3.7 and 4.7 dS $m^{-1}$, the biomass of the chapter was 124.8; 113.2; 96.2; 73.7 and 45.8 g, respectively, indicating a reduction of 63.3%, between the lowest and the highest level of the irrigation water salinity. Such reduction is strongly related to the effects of salinity on plants, which lead to loss of yield and/or quality.

For the factor N doses, the data of phytomass of capitulum adjusted best to a quadratic model (Figure 3B); where it is noted that the values increased with

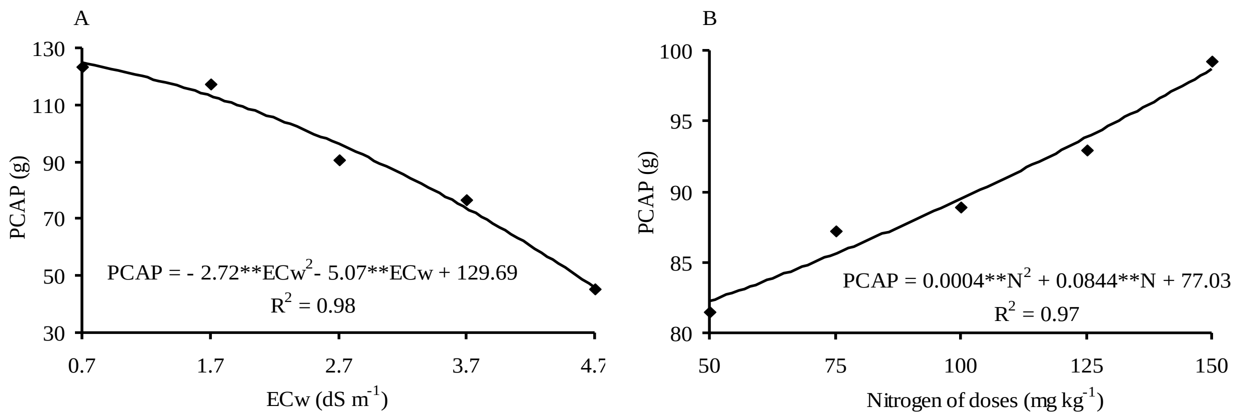


**Figure 3.** Phytomass of capitulum– PCAP of sunflower as a function of irrigation water salinity (A) and nitrogen fertilization (B), evaluated at harvest, 85 days after sowing.

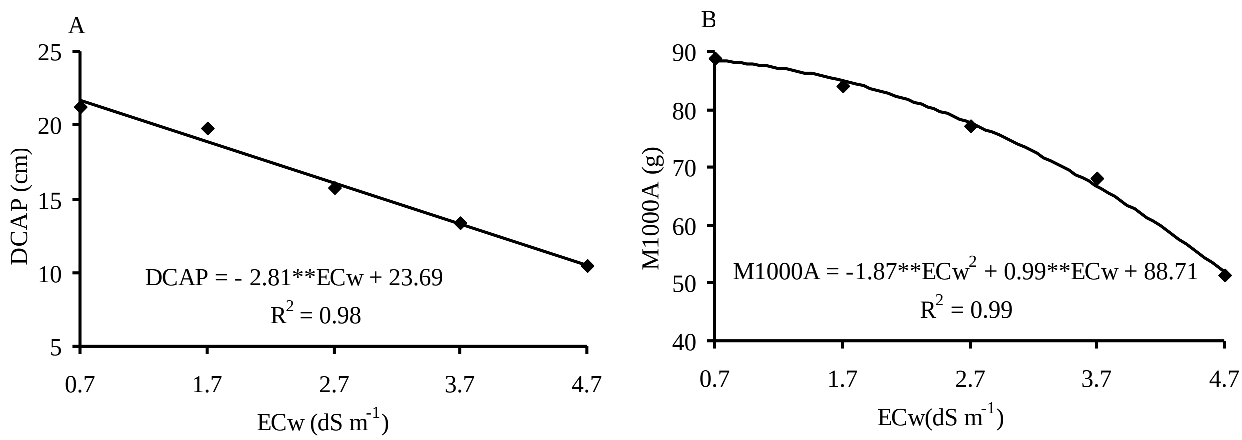


**Figure 4.** Diameter of capitulum– DCAP (A) and weight of 1000 achenes (M1000A) (B) of sunflower as a function of irrigation water salinity, evaluated at harvest, 85 days after sowing.

increasing doses of nitrogen, the values being 82.3; 85.6; 89.5; 93.8 and 98.7 g of dry matter, depending on levels of nitrogen, respectively, 50, 75, 100, 125 N and 150 mg $kg^{-1}$ of soil. By regression equation, it is also observed that the plants fertilized with the highest dose N obtained an increase of 19.99% in FCAP, in relation to that fertilized with the lower dose. According to Biscaro et al. (2008), N plays an important role in sunflower metabolism and nutrition, and is the nutrient that most limits its production. Excess of N may cause a decrease in oil percentage and high doses N can increase the incidence of pests and diseases, affecting grain production.

Sunflower capitulum diameter was also negatively affected by the different levels of irrigation water salinity and, according to the regression equation (Figure 4A), there was a linear negative effect, with estimated reduction of about 11.86% per unit increase in ECw. The plants subjected to salt stress with water 0.7; 1.7; 2.7; 3.7 and 4.7 dS $m^{-1}$ have had their head diameter: 21.72; 18.91; 16:10; 13:29 and 10:48 cm, indicating a reduction in the order of 51.75% in chapter diameter, between the highest and lowest salinity treatment. This reduction in DCAP as a function of water salinity can also be explained by the osmotic stress caused by the decrease in the external water potential and by the ionic effect, resulting from the accumulation of ions in plant tissues (Munns and Tester, 2008). Silva et al. (2009), evaluating ornamental sunflower cultivated under different levels of electrical conductivity and fertigation, observed that the increase in EC of the nutrient solution significantly reduced capitulum diameter between the salinity levels of 3.5 and 6.5 dS $m^{-1}$. Travassos et al. (2011), working with salinity levels from 0.5 to 5 dS $m^{-1}$, observed diameters much lower (ranging from 5.47 to 7.41 cm) than those obtained in the present study.

For weight of 1000 achenes, according to the regression equation (Figure 4B), the increasing irrigation water salinity promoted a quadratic response. For water salinity levels of 0.7, 1.7; 2.7, 3.7 and 4.7 dS $m^{-1}$, the

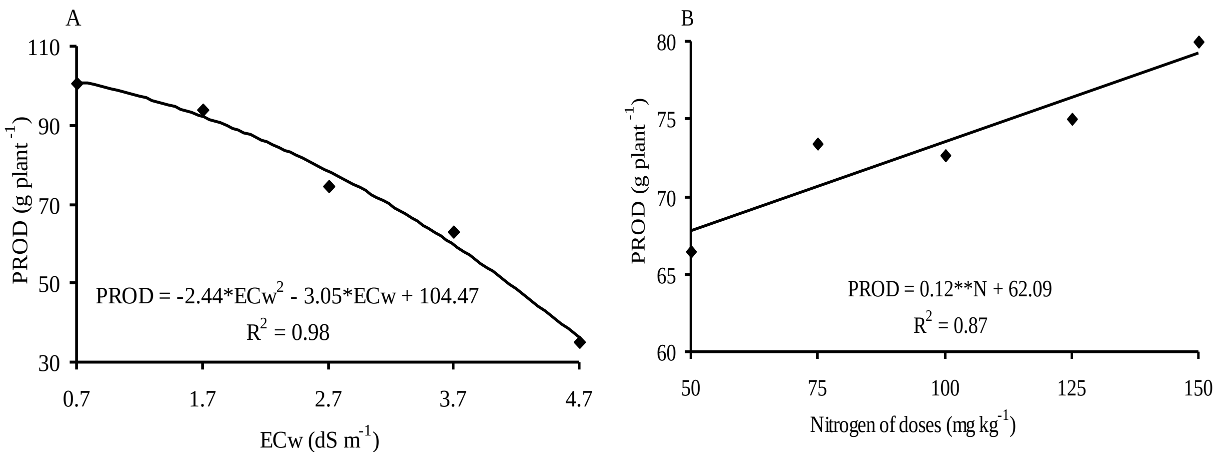


**Figure 5.** Production of achenes (PROD) of sunflower as a function of irrigation water salinity (A) and nitrogen fertilization (B), evaluated at harvest, 85 days after sowing.

mass of 1000 achene obtained was 88.5, 84.9, 77.6, 66.8 and 52.1 g, respectively, when comparing the plants irrigated with water dS 4.7 m$^{-1}$ with those that were under ECw 0.7 dS m$^{-1}$, a reduction of approximately 41.13% in weight of 1000 achenes was observed. The negative effect of salinity on the weight of 1000 achenes was expressive, which shows that the production is affected by the presence of salts in the water. Nobre et al. (2010), studying sunflower, cultivar Embrapa 122-V2000, irrigated with saline water (ECw of 0.5 to 4.9 dS m$^{-1}$), concluded that the weight of 1000 achenes decreased linearly from the salinity level of 0.5 dS m$^{-1}$ in the irrigation water.

As for the total number of achenes and capitulum phytomass, the increases in water salinity and N doses, respectively, inhibited and promoted sunflower production (Figure 5). According to the regression equation, the production of achenes (Figure 5A) fitted to a quadratic model, wherein, when the plants were irrigated with water of salinities 0.7, 1.7, 2.7, 3.7 and 4.7 dS m$^{-1}$, the production of achenes was 101.14, 92.23, 78.44, 59.78 and 36.24 g plant$^{-1}$. These results indicate a decrease of 64.17% in the production of achenes between the lower and higher levels of irrigation water salinity. Saline stress tends to affect plant physiology, causing metabolic disorders, especially due to the reduction in the absorption of water and nutrients in the soil, which leads to lower development and, consequently, lower crop production. Nobre et al. (2011), in a study with sunflower, cultivar Embrapa 122-V2000, irrigated with saline water, observed that the production decreased by approximately 14.55% per unit increase in the electrical conductivity of the irrigation water from the 0.5 dS m$^{-1}$ upwards. Travassos et al. (2011), working with sunflower in greenhouse irrigated with water of EC levels from 0.5 to 5.0 dS m$^{-1}$, observed that the production of achenes decreased by 10.6% per unit increase in irrigation water EC.

As for the N fertilization, the effect on the production of achenes was linear and increasing (Figure 5B), with production of 68.09; 71.09; 74.09; 77.09 and 80.09 g plant$^{-1}$ at doses of 50, 75, 100, 125 and 150 mg N kg$^{-1}$ of soil. respectively, which is equivalent to increase of 4.83% for every increase of 25 mg of N kg$^{-1}$ of soil. According to Khalil et al. (2008) and Babaiy et al. (2009), increasing N levels for many crops, including sunflower, significantly increased the production characteristics of the crop, such as the production of achenes and oil.

## Conclusions

The interaction between irrigation water salinity and nitrogen doses did not have significant effects on any of the studied variables, while the increases in water salinity and nitrogen doses, respectively, inhibited and stimulated the emergence of achenes, capitulum phytomass and the production of achenes.

The total number of achenes, capitulum phytomass and production of achenes were more compromised by water salinity than the number and phytomass of viable achenes, capitulum diameter and mass of a thousand viable achenes. Nitrogen promoted the linear increase in the production of achenes, total number of achenes and capitulum phytomass, attenuating the harmful effects of water salinity on sunflower.

## Conflict of Interests

The author have not declared any conflict of interests.

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