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Original Research Article

Phytomass and components of sesame production cultivated under salinity of the soil and nitrogen fertilization

Introduction: The sesame possesses productive potential mainly job in areas semiarid, that are usually attacked by abiotic factors limiting to the production of agricultural cultures, as it is the case of the salinity. Techniques that seek reduction of the salinity are essential, one of them supply of nitrogen fertilization.
Aims: To evaluate phytomass and production of sesame plants submitted the salinity of the soil under nitrogen fertilization.
Place and Duration of Study: The experiment was led in the months of December 2016 to April of 2017, in experimental area belonging to the Federal University of Campina Grande, in the Center of Sciences and Food Technology located in the municipal district of Pombal-PB.
Methodology: The treatments were composed by five levels of salinity of the saturation extract (0.9; 1.7; 2.5; 3.3 and 4.1 dS m^{-1}) and five doses of nitrogen (40; 70; 100; 130 and 160%) constituting factorial 5x5, with three repetitions and in experimental design of randomized blocks. To cultivate used was the BRS silk, with sow accomplished in polypropylene vases with capacity for 18 Liters, filled out with 22 kg of soil originating from of the place. To the 110 days after sow proceeded him her the analyses of the following parameters: mass dries of the aerial part, mass dries of the root and mass total drought, electric conductivity of the saturation extract, number of fruits, mass of fruits and mass of seeds.
Results: There was significant effect for all the analyzed variables. To leave of those factors was determined that the salinity of the soil affected the sesame production negatively.
Conclusion: High doses of nitrogen provoke reduction in the income of the culture and they potentiate the harmful effects of the salinity in the soil. The nitrogen fertilization with 70% of the recommendation was the best for reduction of the saline stress in the studied conditions.

Keywords: Sesamum indicum L., stress saline, mineral nutrition, income.

1. INTRODUCTION

The sesame (*Sesamum indicum* L.) is a species belonging to the family Pedaliaceae, being one of the oldest cultures, cultivated along the tropics and subtropics and considered an oleaginous one relevant for productive potential of oil with high quality, scentless and eatable, presenting excellent nutritional characteristics and properties for industrial ends [1].

In the area of the Brazilian Northeast cultivation is accomplished by small and medium producers, mainly for subsistence, with few marketed surpluses, being the production by few incentive measures to the producer under the conditions of the semiarid, that it possesses physical-environmental characteristics that can reduce the productive potential of several cultures owed: the high evapotranspiration, rainfall unevenly badly distributed during the year, soils reduced depth, low capacity of retention of water or still salinized [2].

The osmotic effect promoted by the salts reduces the capacity of absorption of water for the plants, besides the effect of some specific ions that cause functional disturbances and offenses mainly in the leaves, promoting modifications in the physiologic and metabolic processes of the plants, what can be thought about the quality of that that is produced in the plant [3].

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The salinity is one of the abiotic factors that more causes limitation in the production of cultures, because, it provokes nutritional unbalance, inhibition of the absorption of other cations, decrease of the osmotic potential and toxicity of specific ions (mainly Na^+ and Cl^-), to the point of to commit vital physiologic activities the plant [4]. Though, through the correct handling in field, it is possible to reach satisfactory productive incomes, tends as base the demands of consumption of water and nutritious for the culture. The use of fertilizers, for instance, mainly nitrogen sources are shown as viable alternatives to lessen harmful effects of present salts in the soil, as affirmed for [5, 6] in castor oil plant and [7] with sunflower.

For the nitrogen (N) the macronutrient to be considered in larger demand by the plants, mainly for participating directly in the metabolism, composition of biomolecules (ATP, NADH, NADPH), proteins and countless enzymes, however, usually less than 50% of the applied nitrogen under the fertilizer form it is used by the cultures, being the losses caused by countless processes which the same is subject. The nitrogen is lost mainly by the nitrate leaching, volatilization of ammonia and emission of N_2, N_2O and other oxides of nitrogen. The deficiency or excess of this can cause nutritional disorder, with production fall and reduction in the oil tenor [8, 9].

This way, the appropriate supply of N for that oleaginous one can be from great relevance to productivity in atmosphere with higher amounts of salts, because, the efficiency of this added to the soil refers to the recovery degree for the plants, considering the losses that usually happen, making possible like this larger economical returns to the producer, for the decrease of production costs and favoring productivity. Before this, it was aimed at the phytomass and the components of production of the sesame cultivated under salinity of the soil and nitrogen fertilization.

2. MATERIAL AND METHODS

The experiment was carried in experimental area of the Federal University of Campina Grande, in the Center of Sciences and Food Technology (UFCG/CCTA), located in the municipal district of Pombal, PB, located to 6º48'16" S, 37º49'15" W and medium altitude of 144 m.

The treatments consisted of five levels of salinity of the saturation extract with the following electric conductivities - CEes: 0.9; 1.7; 2.5; 3.3 and 4.1 dS m^{-1} and five nitrogen doses (40; 70; 100; 130 and 160%) based on the recommendation of [10]. The salinity levels were obtained starting from the dissolution of the chloride of sodium (NaCl), being considered the initial salinity of the soil (0,9 dS m^{-1}), the soil weight for vase (22 kg) and the saturation percentage (32%). The statistical design was a randomized complete block design in factorial outline 5 x 5, with three repetitions.

Seeds of cultivating of sesame BRS Seda were sowed in polypropylene vases with capacity for 18 Liters, filled out with 22 kg of soil, originating from of the place. 30 seeds were deposited by container to a medium depth of 0,5 cm, these properly distributed in spacing of 0,9 m between lines and 0,7 m among plants. To the 15 days after sow - DAS, it was made the first rough-hewing leaving 6 plants for vase; to the 20 days occurred the second, staying two plants and to the 30 it was accomplished the third party and last rough-hewing staying the most vigorous plant.

The soil used for completion of the vases was collected in a depth of 0-20 cm, later smashed and sieved. The chemical characteristics (Table 1) they were certain in the Laboratory of Irrigation and Salinity of UFCG, as methodologies proposed for [11].

Table 1. Chemical characteristics of the soil used in the experiment.

	Chemical characteristics		
Chemical characteristics of the soil	Values	Extract of Saturation of the soil	Values
pH (H_2O) (1:2,5)	6.46	pH	6.44
MO (g kg^{-1})	21.20	CEes (dS m^{-1})	0.90

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P (mg dm^{-3})	2.40	Chloride ($mmol_c$ L^{-1})	4.75
Ca^{2+} ($cmol_c$ kg^{-1})	9.07	Carbonate ($mmol_c$ L^{-1})	0.00
Mg^{2+} ($cmol_c$ kg^{-1})	3.47	Bicarbonate ($mmol_c$ L^{-1})	7.50
K^+ ($cmol_c$ kg^{-1})	0.60	Calcium ($mmol_c$ L^{-1})	5.50
Na^+ ($cmol_c$ kg^{-1})	0.10	Magnesium ($mmol_c$ L^{-1})	4.62
Al^{3+} ($cmol_c$ kg^{-1})	0.00	Potassium ($mmol_c$ L^{-1})	0.86
H^+ ($cmol_c$ kg^{-1})	1.52	Sodium ($mmol_c$ L^{-1})	1.73
SB ($cmol_c$ kg^{-1})	13.24	RAS (mmol L^{-1})$^{1/2}$	0.76
CTC ($cmol_c$ kg^{-1})	14.76	Saturation percentage	32.00
V (%)	89.70	Salinity	No saline
PST (%)	0.68	Class of the soil	Normal

MO - Organic matter; CTC - Cation exchange capacity - [SB + (H^+ + Al^{3+})]; SB - Sum of bases (Ca^{2+} + Mg^{2+} + K^++ Na^+); V - Saturation for bases = (SB/CTC) x 100; CEes - electric Conductivity of the saturation extract; PST - Percentage of exchangeable sodium (Na^+ x 100/CTC)

Still according to the recommendation of [10], manuring was accomplished with simple superphosphate, in the dose of 300 mg of P_2O_5 kg^{-1} of soil, applied in foundation one day before sow and potassium nitrate as potassium source, in the dose of 150 mg of K_2O kg^{-1} of soil, being this last one parceled out in three applications, corresponding to a room in sow and three rooms in two portions same to the 20 and 40 DAS. As the nitrogen fertilization, this was applied according to the treatments and divided in three applications in a similar way the potassium fertilization, using as source sulfate of ammonium.

The irrigation was accomplished being considered the daily sheet of water through the hydric balance in the root zone, being subtracted the drained volume of the applied volume (VI = VA - VD) in the previous irrigation.

To the 110 DAS was determined the following variables:

Number of fruits for plant (NFP): through the counting of the total number of fruits for plant; Mass of fruits for plant (MFP): taking place the weighting of all of the fruits, in analytical scale of precision (0.001); Mass of seeds for plant (MSP): certain after the manual retreat of the seeds of the interior of the green bean and weighting in analytical scale; Mass dries of the aerial part (MDAP), root (MDRP) and total (MTDP) for plant: the plants were separate partly aerial and root, put in paper bags kraft, separate for treatment, previously identified and dried in greenhouse regulated 65 °C, until reaching constant weight (48 hours), elapsed that period, the samples were heavy in analytical scale accurately of 0.001 g, being the mass total drought determined by the sum of the mass dries of the aerial part and mass dries of the root, all the results were expressed in grams by plant.

Electric conductivity of the extract of saturation soil: was certain through the methodology of [12], where initially for preparation of the saturation paste 300 g of the sample of the soil was used, being added distilled water, until that if it reached the paste point. Later, the samples stayed in rest for 24 h and soon afterwards they were conditioned in vacuum system for obtaining of the extracts, when then, was certain CEes of each solution, with aid of a conductivity meter and for the automatic correction of temperature.

The data were submitted to the variance analysis by the test 'F' in level of 0.01 and 0.05 of probability and when significant, took place regression analysis using the statistical software SISVAR 5.6 [13].

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3. RESULTS AND DISCUSSION

To the 110 days after the sowing, it was verified that the electric conductivity of the saturation extract, mass dries root and total, mass of fruits and number of fruits were influenced significantly ($p < 0.05$) for the interactive effect of both factors (salinity of the soil and doses of nitrogen), in other words, both act simultaneously in the sesame plants, while, the mass dries of seeds was significant ($p < 0.01$) in function of the isolated factors (Table 2).

Table 2. Summary of the test F for electric conductivity of the saturation extract (EC), number of fruits for plant (NF), mass of fruits for plant (MFP), mass of seeds for plant (MSP), mass dries of the aerial part (MDAP), mass dries of the root for plant (MDRP) and mass total drought for plant (MTDP) of sesame to the 110 days after the sowing (DAS), under salinity of the soil and nitrogen fertilization.

Variation source	Test F						
	EC	NF	MFP	MSP	MDAP	MDRP	MTDP
Salinity (S)	**	**	**	**	ns	**	**
Linear Reg.	**	**	**	**	ns	**	**
Quadratic Reg.	ns	ns	ns	ns	ns	ns	ns
Detour	ns	ns	ns	ns	ns	ns	ns
Nitrogen (N)	**	ns	ns	**	ns	ns	ns
Linear Reg.	**	ns	ns	**	ns	ns	ns
Quadratic Reg.	ns	ns	ns	**	ns	ns	ns
Interaction (S x N)	**	*	*	ns	ns	**	**
Block	ns	ns	ns	ns	*	ns	*
CV (%)	8.72	18.06	20.35	22.38	18.54	33.77	21.58

ns, **, * respectively no significant, significant $p < 0.01$ and $p < 0.05$; CV = variation coefficient

The electric conductivity of the saturation extract (CEes) in the end of the cycle of the sesame obtained larger increase (116,68%) with the use of the manuring of 160% of N, when comparing the largest (4.1 dS m^{-1}) and smaller (0.9 dS m^{-1}) saline level (Figure 1). At the time that the dose of 40% of N also presented proportional increment to the increase of the salinity of the soil corresponding to 94% if compared the conductivity 0.9 to 4.1 dS m^{-1}. In the other dosages of N (70, 100 and 130%) the minimum values were verified 3.59, 4.17 and 4.71 dS m^{-1} in the salinities of the soil of 2.32, 2.24 and 2.02 dS m^{-1}, respectively.

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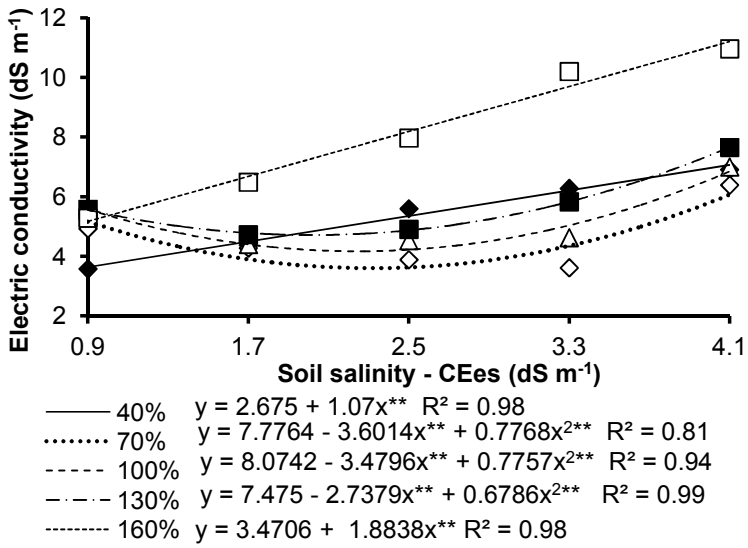

Figure 1. Electric conductivity of the extract of saturation of the soil in the end of the cycle of the sesame submitted to the salinity of the soil and the nitrogen fertilization. UFCG, Pombal, 2018.

Therefore, the electric conductivity of the soil rose because of the increase in the use of N, what is explained by the presence of salts also in the fertilizer, provoking the accumulation of toxic ions, being the alterations of the electrolytic concentration of the proportional solution to the increase of ions [14]. Ammoniacal sources, can also acidify the soil through the located application and consequent interference in the nitrification process, because, that generated acidity attacks the activity of the responsible bacteria for the nitrification, reducing the conversion of the ammonium to nitrate, that is the assimilable form of N for the plants [15]. Similar effect was observed for [16], evaluating the electric conductivity of the saturation extract under salinity and doses of nitrogen, in the cultivation of the mamoneira. Being like this, the minimum values of conductivity mainly in the dose of 70% N, possibly it can be explained by this concentration not to have interfered so much in the acidification of the soil.

For the mass dries of the root of the sesame in function of the growing doses of nitrogen and of the salinity of the soil (Figure 2A), was observed that doses them of 40 and 100% of N presented decreasing lineal behavior with respective reductions of 42 and 67% if compared among the largest (4.1 dS m^{-1}) and the smallest (0.9 dS m^{-1}) saline level of the soil. In the doses of 70 and 160% of N, it was verified that the data were adjusted to quadratic equations reaching esteemed of 95 maximum values and 105 g of dry mass of root in the salinity of the soil of 1.7 and 1.2 dS m^{-1}, respectively, reducing drastically in function of the addition of salts. While the dose of 130% of N, quadratic tendency was verified with minimum of 41 g in the salinity of the soil of 4.1 dS m^{-1}.

The mass total drought was also influenced by the appraised treatments, which the dose of 40 and 130% of N presented decreasing lineal behavior with reduction of 25.14 and 95.85%, reached dear minimum of 146.8 and 129.07 g in the concentration of 4.1 dS m^{-1}, respectively (Figure 2B). while, in the doses of 70 and 100% quadratic behavior was verified, reaching values minimum of 125.15 and 111g in the salinity 4.1 dS m^{-1}. In compensation the dose of 160 g of N presented positive effect to the salinity of 1.7 dS m^{-1} with maximum of 212g, however, the unitary increase of the salinity of the soil presented negative effect, so that in the salinity of 4.1 dS m^{-1} was obtained the least values (100 g).

The reduction observed in the mass dries of the root and total is related as much the salinity of the soil as the elevation of the doses of N, which, it can also elevate the salinity of the soil, or to increase the concentration of ions of ammonium quickly in the soil, causing toxicity to the plant and provoking physiologic disorders, committing this way the cellular division, the growth and consequently reduction in the accumulation of photoassimilates for the plant, interfering in the production [17].

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[18] studying the influence of the saline water in the culture of the sesame, cultivated in vase, they verified that the unitary increase of the salinity causes decrease in the biomass accumulation with reduction of 59.78% for the mass dries from the root and 56.96% to the mass total drought among the intervals from 0.8 to 4.5 CEes. [19], they concluded that the manuring with nitrogen doesn't lessen the harmful effects of the saline stress on the growth and production in cotton plants, cv. 'BRS Rubi', it just increases the development of the same ones.

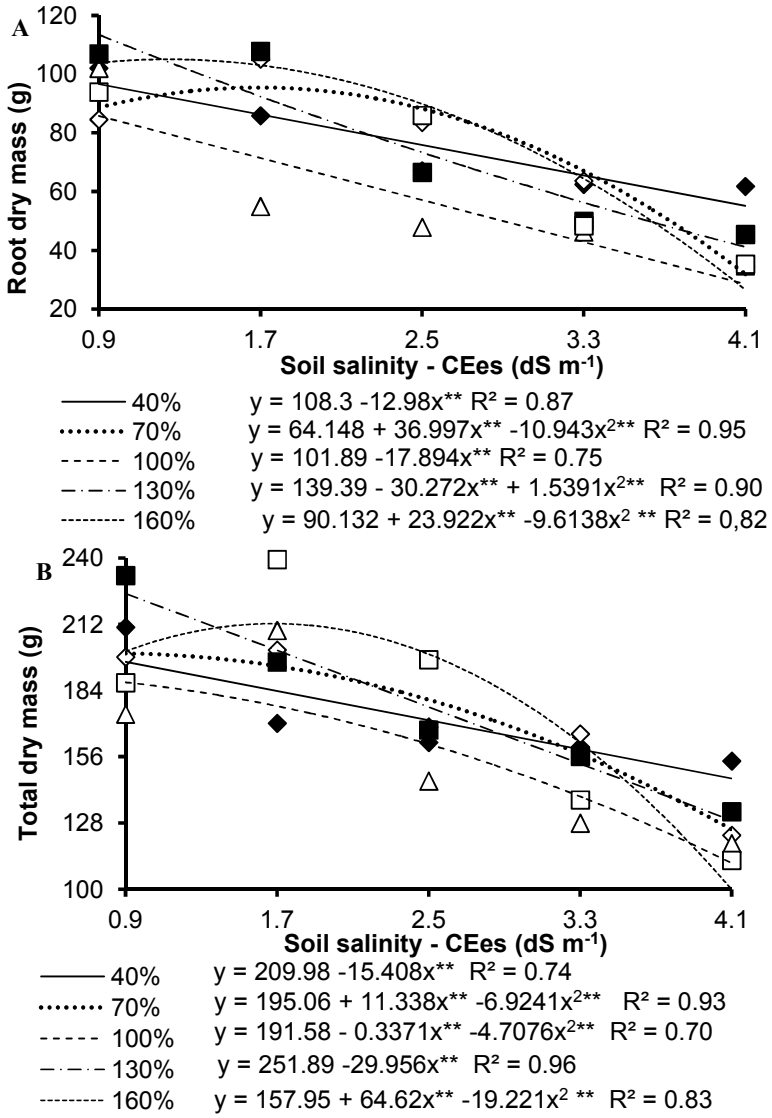

Figure 2. Mass dries of the root (A) and mass total drought (B) of sesame submitted to the salinity of the soil and doses of nitrogen fertilization. UFCG, Pombal, 2018.

The production of the fruits was interfered significantly with addition of salts and doses of N, in the mass of the fruits the use of 40, 100, 130 and 160% of N behaved inversely proportional to the increment of salts in the soil, refusing from 39.89 to 26.91g (40% N), 48.24 against 30.81 g (100% N), 49.67 for 20.01g (130% N), 44.85 against 29.99g (160% N) between the smallest and larger saline level (Figure 3A). In compensation, the use of the dose of 70% of N demonstrated increment of 3.98% in the conductivity 1.65 dS m^{-1} CEes, refusing starting from these saline levels in the soil. In

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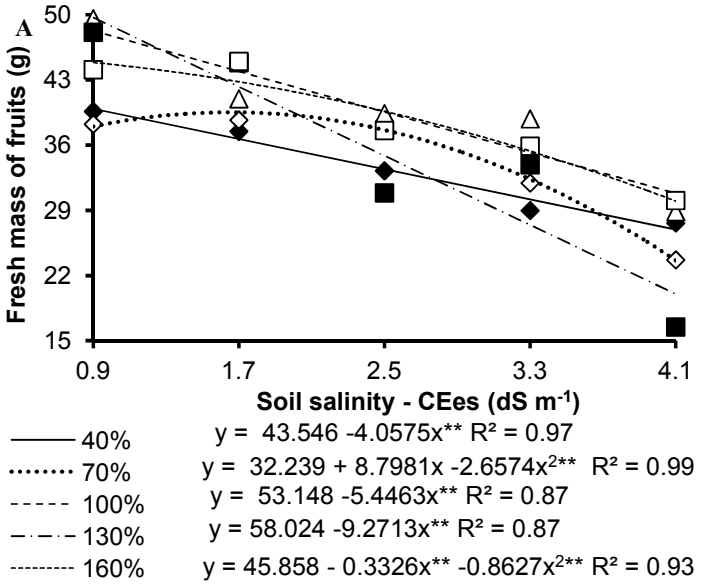
agreement with [20] the competition possibility exists in the absorption for the plant of the nitrate and chloride, so that an increase in the concentration of nitrate in the root zone can inhibit larger absorption of chloride, optimizing like this, the production of the plant even under stress conditions, explaining such fact happened in the dose of 70% of nitrogen.

Similarly, the number of sesame fruits decreased 30.17; 32.75; 56.26 and 23.58%, respectively, in the doses of 40, 100, 130 and 160% of N, in the interval between 0,9 and 4,1 dS m^{-1} of the extract of saturation of the soil (Figure 3B). However, the nitrogen fertilization of 70% behaved quadratically with increment until the dear conductivity of 1.43 dS m^{-1} corresponding to 129.54 fruits for plant, decreasing in larger saline levels of the soil.

The reduction in the number of fruits, is related with physiologic disturbances, caused by the increase of the salinity, where which, alters the osmotic potential, reducing the consumption of water consequently for the plant and the absorption of nutrients, affecting the fixation index of the fruits directly [21]. [22], evaluating the influence of the saline stress and different proportions of nitrate and ammonium about the emergency, the growth and the sesame production, they observed reduction of 31.45% in the number of fruits for unitary increase of the electric conductivity of the irrigation water, however they didn't verify beneficial effect in the studied doses of N.



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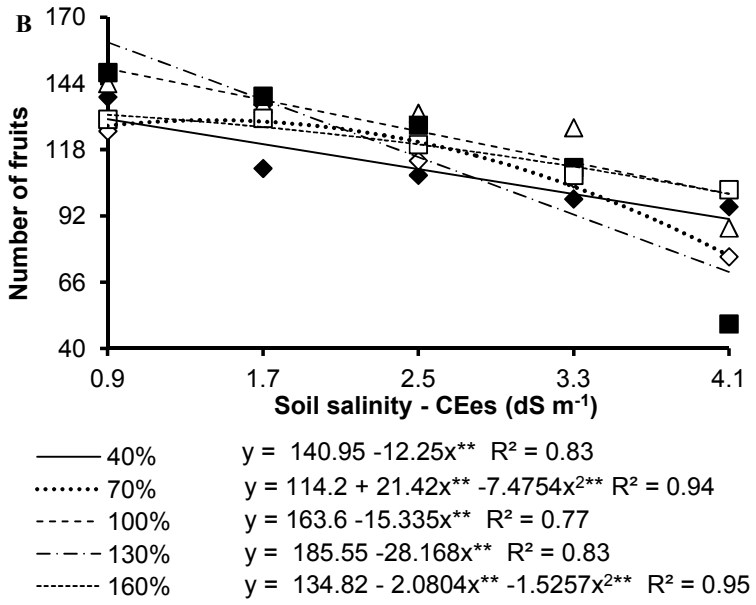
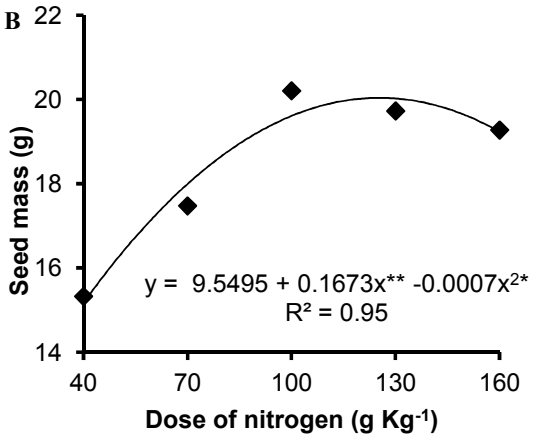


Figure 3. Fresh mass of the fruits (A) and number of fruits (B) of sesame submitted to the salinity of the soil and doses of nitrogen fertilization. UFCG, Pombal, 2018.

Analyzing the salinity of the soil separately in the mass of seeds, a decreasing lineal behavior was verified with reduction of 28.1% for the plants cultivated with salinity of the soil of 4.1 dS m^{-1} (CEes), compared with the plants cultivated with 0.9 dS m^{-1}, reaching dear minimum of 15.38 g of seeds for plant when submitted to 4.1 dS m^{-1} (Figure 4A).

That reduction in function of the increase in the electric conductivity of the saturation extract is related with the inhibition of the growth and consequently with the biomass accumulation that is caused by the poisonous effects of the absorbed salts by the plants, consequent of the low capacity of osmotic adjustment of the species and for the reduction of the total potential of water provoked by the increase of the saline concentration, carting in losses in the production of seeds [23].



Similar behavior was observed for [22], that evaluating the sesame production under saline stress, verified reduction of 26.04 g in the mass of seeds when the plants were submitted to 4.4 dS m^{-1} of CEes, compared with cultivated them with salinity of 0.4 dS m^{-1}, therefore, the salinity causes harmful effects in the production of seeds for plant of this species.

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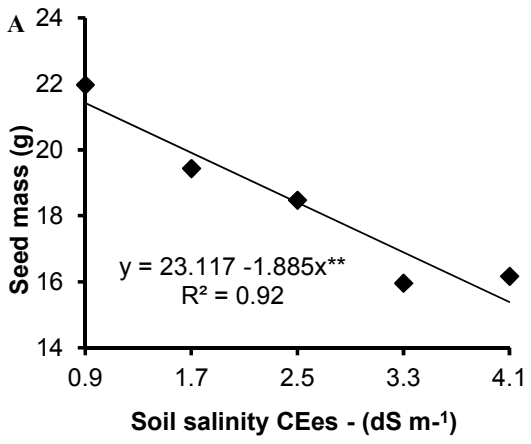

Figure 4. Mass of sesame seeds submitted to the salinity of the soil (A) and doses of nitrogen fertilization (B). UFCG, Pombal, 2018.

The use of the nitrogen fertilization provided quadratic behavior in the mass of seeds, with maximum point in the dear dose of 119.5 g Kg^{-1} of Nitrogen, with 19.54 g, refusing 5.87% starting from this concentration of N (Figure 4B). Consequently that dose tends to favor the production of seeds, because the nitrogen besides elevating the capacity of osmotic adjustment of the plants to the saline stress, favors the resistance of the different cultures the other abiotic stresses [24]. Therefore, use of the nitrogen fertilization increased the production corroborating with [25] to the they evaluate irrigation with saline water and nitrogen fertilization in the production of the sunflower which verified that the increase in the supply of nitrogen provided larger production in achenes.

4. CONCLUSIONS

The salinity of the soil affected the accumulation of phytomass and sesame production negatively;

High doses of nitrogen provoke reduction in the income of the sesame and they potentiate the harmful effects of the salinity of the soil;

The nitrogen fertilization with 70% of the recommendation was the best for reduction of the saline stress in the analyzed conditions.

BIBLIOGRAPHICAL REFERENCES

1. Euba Neto M, Pereira WE, Souto JS, Arriel NHC. Growth and productivity of sesame in Flossic Neosol as a function of organic and mineral fertilization. *Revista Ceres*. 2016; 63(4):568-575. http://dx.doi.org/10.1590/0034-737X201663040018.Portuguese

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2. Pedrotti A, Chagas RM, Ramos VC, Prata APN, Lucas AAT, Santos PB. Causes and consequences of the soil salinization process. *Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental*. 2015; 19 (2):1308-1324. Portuguese

3. Nobre RG, Lima GS, Gheyi HR, Lourenço GS, Soares LAA. Emergence, growth and production of castor bean under saline stress and nitrogen fertilization. *Revista Ciência Agronômica*. 2013; 44(1):76-85. Portuguese

4. Taiz L, Zeiger E, Moller IM, Murphy A. *Physiology and Plant Development.* 6ª eth. Porto Alegre: Artmed; 2017. Portuguese

5. Anjos LA, Nobre RG, Gheyi HR, Lima GS, Silva AO, Silva SSS. Growth components of castor bean cultivated with saline waters and nitrogen doses. *Irriga*. 2012; 1:40-54. Portuguese

6. Lima GS, Nobre RG, Gheyi HR, Soares LAA, Silva AO. Production of castor bean cultivated with salt water and nitrogen doses. *Revista Ciência Agronômica*. 2015; 46(1):1-10. Portuguese

7. Nobre RG, Gheyi HR, Soares FAL, Cardoso JAF. Production of sunflower under saline stress and nitrogen fertilization. *Revista Brasileira de Ciência do Solo*. 2011; 35:929-937. Portuguese

8. Nobre RG, Lima GS, Gheyi HR, Soares LAA, Silva AO. Growth, consumption and efficiency of water use by castor bean under saline and nitrogen stress. *Revista Caatinga*. 2014; 27(2):148 - 158. Portuguese

9. Santos MG. *Sesame irrigated due to nitrogen fertilization in two agricultural crops. Dissertation (Master in Plant Science). Postgraduate Program in* Fitotecnia da Universidade Federal Rural do Semiárido, Mossoró; 2017. Portuguese

10. Novais RF, Neves JCL, Barros NF. Controlled environment test. In: Oliveira AJ, Garrido WE, Araújo JD, Lourenço S. (Eds.). *Métodos de Pesquisa em Fertilidade do Solo*. Brasília: EMBRAPA-SEA;1991. Portuguese

11. Donagema GK, Campos DVB, Calderano SB, Teixeira WG, Viana JHM. *Manual of soil analysis methods*. 2 eth. Rio de Janeiro:Embrapa Solos; 2011. Portuguese

12. Richards LA. *Diagnosis and improvement of saline and alkali soils*. Washington, USDA Agriculture Handbook; 1954.

13. Ferreira DF. Sisvar: A Guide for Its Bootstrap Procedures in Multiple Comparisons. *Ciência e Agrotecnologia*. 2014; 38(2):109-112.

UNDER PEER REVIEW

14. Kawavata CKH, Fois DAF, Coppo JC, Alves Neto A. Influence of doses and of two sources of potassium in corn root system and electric conductivity in soil.*Investigación Agraria*. 2017; 19(1) 28-34. Portuguese

15. Souza TR, Bardiviesso DM, Andrade TF, Bôas RLV. Nutrients in soil and soil solution in fertigated citrus drip irrigation. *Revista de Engenharia Agrícola*. 2015; 35 (3):484-493. http://dx.doi.org/10.1590/1809-4430-Eng.Agric.v35n3p484-493/2015 Portuguese

16. Lima GS, Nobre RG, Gheyi HR, Soares LAA, Silva AO. Growth and production components of castor bean under saline stress and nitrogen fertilization. *Engenharia Agrícola*. 2014; 34 (5):854-866. Portuguese

17. Caproni CM, Ramos DJ, Vieira Neto J, Silva LFO, Simões JC, Pereira WR. Substrates and nitrogen fertilization in the production of yellow passion fruit seedlings. *Scientia Agraria.* 2013; 14:69-75. Portuguese

18. Sousa GG, Fiusa JN, Leite KN, Soares SC, Silva GL. Saline water and biofertilizer of cattle manure in sesame crop. *Revista Agropecuária Técnica*. 2017; 38(3):116-125. https://doi.org/10.25066/agrotec.v38i3.33694 Portuguese

19. Lima GS, Dias AS, Gheyi HR, Soares LAA, Andrade EMG. Saline water irrigation and nitrogen fertilization on the cultivation of colored fiber cotton. *Revista Caatinga*. 2018; 31(1): 151–160. http://dx.doi.org/10.1590/1983-21252018v31n118rc

20. Silva MVT, Lima RMS, Silva NKC, Oliveira FL, Medeiros JF. Production of pumpkin under different levels of saline water and nitrogen doses. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*. 2014; 9(1):287-294. Portuguese

21. Oliveira FA, Medeiros JF, Alves RC, Linhares PSF, Medeiros AM, Oliveira MKT. Interaction between salinity of irrigation water and nitrogen fertilization in eggplant culture. *Revista Brasileira de Engenharia Agrícola e Ambiental*. 2014;18(15):480-486. Portuguese

22. Dias AS, Lima GS, Grey HR, Nobre RG, Santos JB. Emergence, growth and sesame production on saline stress and proportions of nitrate and ammonium. *Revista Caatinga*. 2017; 30(2):458-467. http://dx.doi.org/10.1590/1983-21252017v30n221rc. Portuguese

23. Lúcio WS, Lacerda CF, Mendes Filho PF, Hernandez FFF, Neves ALR, Gomes Filho E. Growth and physiological responses of melon inoculated with arbuscular mycorrhizal fungi under saline stress. *Revista Semina*. 2013; 34(4):1587-1602. http://dx.doi.org/10.5433/1679-0359.2013v34n4p1587. Portuguese

UNDER PEER REVIEW

24. Silva PJ, Souza Filho JF. *Production of Organic Sesame in the Communities of Family Producers of São Francisco de Assis do Piauí*. Campina Grande: EMBRAPA-CNPA; 2008. Portuguese

25. Santos JB, Guedes Filho DH, Gheyi HR, Lima GS, Cavalcante LF. Irrigation with saline water and nitrogen in production components and yield of sunflower. *Revista Caatinga.* 2016; 29(4):935–944. http://dx.doi.org/10.1590/1983-21252016v29n419rc