

Vegetable ash as attenuate of saline stress in peanut (*Arachis hypogaea* L.)

ABSTRACT

Aims: This work was developed with the aim to evaluate the development of irrigated peanut with salt water and application of vegetable ash doses.

Study design: The experiment installed was in a completely randomized design, in a 5x4 factorial scheme, with five replicates.

Place and Duration of Study: The experiment was conducted between January and April 2015, in a greenhouse of the Federal University of Paraíba, in Bananeiras, PB, Brazil.

Methodology: Peanut seeds. cultivar BR-1 were planted in pots (5 dm³). Irrigation with different electrical conductivities of irrigation water (0.5, 1.5, 2.5, 3.5 and 4.5 dS m⁻¹) was used 20 days after emergence until the end of the cultivation and the four doses of vegetable ash (0.0 1.5, 2.5 and 3.5 g kg⁻¹ soil) were applied at the beginning of the crop. Were evaluated: plant height, leaf area index, root length, number of pods, number of branches, number of seeds, root dry matter, shoot, pods and seeds and total chlorophyll.

Results: The use of saline water influenced all variables analyzed in peanut regardless of the use of vegetal ash.

Conclusion: The use of vegetable ash was not efficient as an attenuating agent of the deleterious effect of irrigation water salinity on peanut.

Keywords: Fertilization; water quality; salinity.

1. INTRODUCTION

Peanut (*Arachis hypogaea* L.) is one of the most cultivated oilseed crops in the world. Showing great economic and social importance to many farmers living in the semi-arid regions of the planet [1]. In the year 2016, the world production of peanut was 36 million tons obtained in 23 million hectares [2].

The salinity of water is one of the most abiotic factors that contribute to the reduction of growth and development of cultivated plants and its effect is more prominent in the arid and semi-arid regions. High salt concentrations, in addition to reducing the water use potential, can cause toxic effects on plants, leading to functional disturbances and metabolic damage [3].

The responses to the plants subjected to saline stress comprise changes in metabolism and growth, as in biochemical and physiological processes. Thus, the plant needs to adjust to survive under adverse conditions and may require adaptation processes in the absorption, transport and distribution of ions, in addition to the compartment of mineral nutrients in the cells. These changes can be expressed in plant morphology, growth and physiology and consequently in crop productivity [4].

The peanut tolerates irrigation with water with the electrical conductivity of up to 3.3 dS m⁻¹, without losses in yield [5]. In the literature, several studies on the effect of water salinity in the crop are found [6,7,8]. These authors found that increased salinity of irrigation water significantly reduced the development of peanut crop.

Faced with this problem, many studies have been carried out to attenuate the effects of saline stress in several crops, with the emphasis on the use of alternative sources of nutrients such as vegetable ash. It may contain essential nutrients such as K, P, Ca, Mg and Si that are directly related to the increase in the plant resistance to abiotic stresses [9]. Some authors have already reported beneficial effects of potassium, silicon and phosphorus nutrients as attenuators of salt stress [10,11,12]. In view of this, this work was developed with the aim of evaluating the cultivation of peanut (*Arachis hypogaea* L.) irrigated with salt water and application of vegetable ash doses.

2. MATERIAL AND METHODS

The experiment was conducted in a protected environment (greenhouse) between January and April 2015 in the Agriculture sector of the Center for Social and Agricultural Human Sciences (CSAHS) of the Federal University of Paraíba (UFPB) in Bananeiras, PB. A municipal district inserted in the micro-region of the Brejo Paraibano, located by the geographical coordinates 6° 45 '00 "of South latitude, 35° 38' 00" of West longitude of Greenwich and 520 m high.

The experimental design was completely randomized 5x4 with factorial scheme consisting of five electrical conductivities of irrigation water (ECw - 0.5, 1.5, 2.5, 3.5 and 4.5 dS m⁻¹) and four doses of vegetable ash (VA - 0.0, 1.5, 2.5 and 3.5 g kg⁻¹ of soil) with five replicates, totaling 100 experimental units. The electrical conductivity of 0.5 dS m⁻¹ was chosen because it is the average conductivity of irrigation water used in the study region.

Peanut seeds cultivar BR-1 were used, placing four seeds in each pot at two centimeters depth. Five days after sowing (DAS) the emergence of seedlings began. After the emergence, thinning was done leaving only the most vigorous plant. The experimental units were represented by polyethylene pots with capacity of 5.0 dm³ (with one plant per experimental unit), filled with 0.3 kg of gravel + 1 kg of sand + 3.7 kg of soil. The peanut plants were initially irrigated with water without restriction of use (≤0.5 dS m⁻¹), 20 days after emergence, the plants received on average 400 mL of water, with respective saltiness. For irrigation management, the drainage method was used.

Water used for irrigation came from the reservoirs of the CSAHS/UFPB with 0.5 dS m⁻¹. From this water, the salt concentrations were formulated by addition of the salt complex. For this, an instrutherm[®] microprocessed portable conductivimeter (model CD-860) was used. The ash used in the substrate was derived from firewood of algaroba plants (*Prosopis juliflora* (Sw) DC) and was placed, as the substrate was prepared in the corresponding proportions (0.0, 1.5, 2.5 and 3.5 g kg⁻¹).

Table 1. Chemical properties of irrigation water.

	ECw	pH	SO ₄ ⁻²	Mg ⁺²	Na ⁺	K ⁺	Ca ⁺²	CO ₃ ⁻²	HCO ₃	Cl ⁻	SAR	ESP	Clas
	dS m ⁻¹		mg L ⁻¹				mmol _c dm ⁻³						
T _{0.5}	0.5	7.8	2.65	0.11	2.24	0.06	0.10	0	0.9	2.8	6.92	8.21	C ₂ S ₂
T _{1.5}	1.5	7.1	19.4	0.13	8.9	0.06	0.11	0	1.2	12	23.79	25.28	C ₃ S ₄
T _{3.0}	3.0	7.3	3.69	0.16	15.2	0.07	0.11	0	0.8	21	40.69	37.01	C ₃ S ₄
T _{4.5}	4.5	7.6	5.24	0.17	28.9	0.08	0.12	0	1.0	40.9	81.86	54.44	C ₄ S ₄

ECw = Electrical conductivities of irrigation water; SAR = Sodium adsorption ratio; ESP = Exchangeable sodium percentage

Peanut plants were collected and analyzed at 95 days after sowing. The following variables were determined: plant height (PH), using millimetre ruler, by measuring the distance between the soil surface and the apex of the plant; leaf area index (LAI) using an AccuPAR[®] linear ceptometer (model LP-80); total chlorophyll (TC), with ClorofiLOG[®] portable chlorophyllometer (model CFL1030); root length (RL) using millimeter ruler; number of pods per plant (NP); number of branches per plant (NB); number of seeds per plant (NS); shoot dry mass (SDM), root (RDM), pod (PDM) and seeds (SEDM). To determine dry masses, the fresh material was packed in paper bags and set to dry in an oven with forced air circulation, at a temperature of 65 °C until reaching a constant mass, being determined in a precision scale (0.001 g). Data were analyzed by analysis of variance (ANOVA) and t-test are conducted, when significant, regression analysis was performed using the statistical program SISVAR version 5.6 [13].

3. RESULTS AND DISCUSSION

The electrical conductivities of irrigation water (ECw) statistically influenced the variables analyzed, as described in ANOVA (Table 2). Regarding the vegetable ash (VA) application, a significant effect was observed only for leaf area index (LAI). In relation to the interaction between the ECw x VA levels, it was verified that there was significance for plant height (PH), number of branches (NB), number of pods per plant (NP), root dry mass (RDM) and dry seed mass (DSM).

Table 2. Summary of ANOVA for plant height (PH), number of branches (NB), number of pods per plant (NP), number of seeds per plant (NS), root length (RL), total chlorophyll (TC), shoot dry mass (SDM), pod (PDM), seed (SEDM), root (RDM) and leaf area index (LAI) of peanut (*Arachis hypogaea* L.) submitted to irrigation with salt water (ECw) and application of vegetal ash (VA).

SV	DF	Mean Square					
		PH	NB	NP	NS	RL	TC
ECw	4	125.11**	22.28**	148.42**	2479.18**	57.61**	552.34**
VA	3	4.86 ^{ns}	0.77 ^{ns}	24.91 ^{ns}	112.81 ^{ns}	17.22 ^{ns}	11.54 ^{ns}
ECw * VA	12	46.48**	3.06**	20.62*	83.31*	7.85 ^{ns}	13.74 ^{ns}
Error	80	15.09	1.02	10.15	58.95	4.51	7.52
CV (%)		21.28	14.54	22.32	24.83	18.87	7.32
		SDM	PDM	SEDM	RDM	LAI	
ECw	4	93.74**	643.96**	461.81**	117.35**	1.23**	
VA	3	13.60 ^{ns}	7.08 ^{ns}	4.06 ^{ns}	14.04 ^{ns}	0.95**	
ECw * VA	12	7.44 ^{ns}	10.09 ^{ns}	9.31*	12.69*	0.52**	
Error	80	5.35	5.85	4.04	6.36	0.06	
CV (%)		22.12	22.91	27.12	31.94	23.58	

CV(%): Coefficient of variation; DF: Degrees of freedom; *: $P < 0.05$. **: $P < 0.01$ and ns: $P > 0.05$ by the F test.

It was observed that the height of plants was negatively affected as the salinity increases irrigation water, except for the plants that received 1.5 g kg⁻¹ of ash, which maintained a height of 18.98 cm. It is verified that the plants submitted to the amount 2.5 g kg⁻¹ of ash had a marked decrease in height increment of the water salinity, decreasing from 27.44 cm in ECw from 0.5 dS m⁻¹ to 14.64 cm in the ECw of 4.5 dS m⁻¹ (Fig. 1), similar results were found by other authors [4].

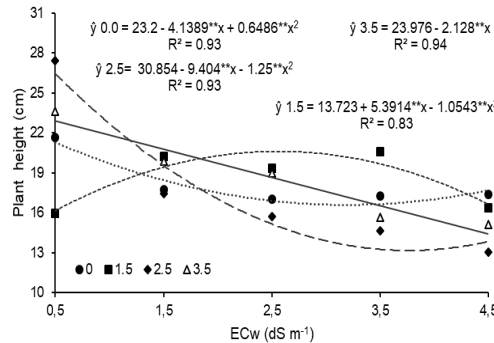


Fig. 1. Plant height of peanut (*Arachis hypogaea* L.) submitted to irrigation with salt water and application of vegetal ash
** $P < 0.001$

Studies with peanut BR-1 submitted to ECw 1.0, 3.5, 6.0 and 8.5 dS m⁻¹, showed a negative compromise in plant height, reducing the height up to 62.4%. ECw of 4.0 dS m⁻¹ affects the height values of peanut plants, the difference is 28.25% when compared to the low conductivity treatment (0.8 dS m⁻¹) [14]. It was observed that the plants submitted to 3.5 g kg⁻¹ of ash had a linear decrease in height when the amount of irrigation increased of saline waters, decreasing drastically from 23.4 cm in 0.5 dS m⁻¹ to 16.2 cm at the salinity by 4.5 dS m⁻¹. Plants that received 2.5 g kg⁻¹ of ash obtained the highest height when they received water of 0.5 dS m⁻¹, but as observed in the other doses of ash, the height was negatively affected in ECw of 1.5 dS m⁻¹.

The plants with the highest number of branches (NB) were those exposed to the control treatment (0 g kg⁻¹ ash) and irrigated with conductivity water of 0.5 dS m⁻¹ (Fig. 2). It is possible that the superiority of the control treatment is related to the absence of toxic effects caused by the salinity caused by the accumulation of salts in the root zone of the plants [15].

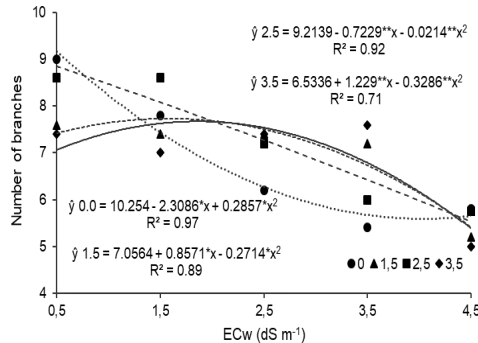


Fig. 2. Number of branches of peanut (*Arachis hypogaea* L.) submitted to irrigation with salt water and application of vegetal ash
* $P < 0.05$; ** $P < 0.001$

The numbers of branches were affected with greater intensity in the ECw of 4.5 dS m⁻¹. However, plants that received the amount 3.5 g kg⁻¹ ash at the salinity of 3.5 dS m⁻¹ perform a higher NB value, justifying that ash application can mitigate the aggravating effects of salinity of the water the number of branches. The superiority presented by the vegetal ash confirms that this alternative fertilizer can increase soil fertility and acts as a plant growth promoter [16].

The amount of pods was affected by increasing salts in irrigation water (Fig. 3). The plants with the amounts of ash 1.5 and 3.5 g kg⁻¹ had higher number of pods (NP) when irrigated with water of 0.5 dS m⁻¹, however, with the increase by conductivity to 4.5 dS m⁻¹. NP significantly decreased to less than 10 pods plant⁻¹.

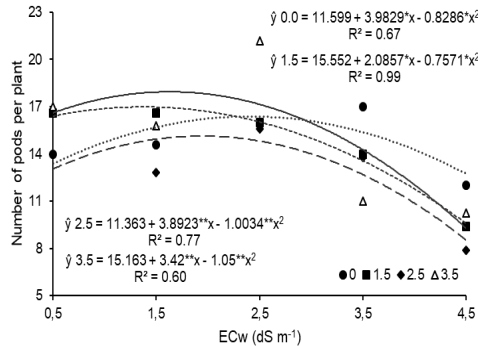


Fig. 3. Number of pods of peanut (*Arachis hypogaea* L.) submitted to irrigation with salt water and application of vegetal ash
* $P < 0.05$; ** $P < 0.001$

Plants which did not receive ash (0 g kg⁻¹) had better response to NP, presenting 13 pods plant⁻¹, even irrigated with salinity water of 4.5 dS m⁻¹. The addition of ash did not influence the number of pods in the conductivity treatment 4.5 dS m⁻¹. [17] Observed different results, studying the effect of wood ash and sewage sludge on cotton, found that the number of fruits was positively affected by the increase of the ash.

Fig. 4 shows the significant difference between treatments, especially when the water saline content is high. Plants that had the amounts of ash 0.0, 1.5 and 2.5 g kg⁻¹ added on the substrate and exposed to salinity of 0.5 dS m⁻¹ and obtained practically the same values of leaf area index (LAI). However, from the salinity of 2.5 dS m⁻¹ the LAI values decrease drastically. However, the plants that received the amount 3.5 g kg⁻¹ of ash reached a higher value of LAI (1.8 cm²), which maintained the LAI of 1.5 cm² even when submitted to salinity of 4.5 dS m⁻¹, justifying that the application of 3.5 g kg⁻¹

of ash can mitigate the aggravating effects of irrigation water salinity to leaf area of peanut plants. The lowest LAI values were identified in the treatment of 4.5 dS m⁻¹, ranging from 0.5 to 0.8 cm² for the plants that received the amounts of ash 0.0, 1.5 and 2.5 g kg⁻¹. [8] Identified a decrease in the leaf area of the peanut plants, maintained under different salinities in the presence and absence of bovine biofertilizer.

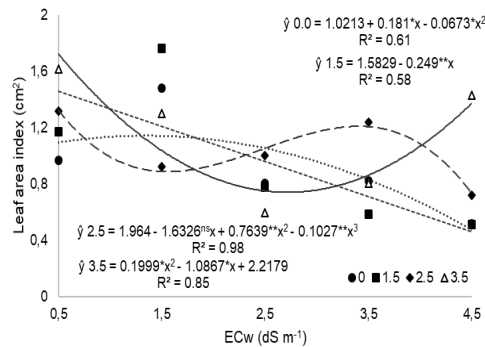


Fig. 4. Leaf area index of peanut (*Arachis hypogaea* L.) submitted to irrigation with salt water and application of vegetal ash
 * $P < 0.05$; ** $P < 0.001$; ^{ns} $P > 0.05$

Fig. 5 shows that the root length of the peanut plants was affected as the salinity of the irrigation water was increased. The highest value was observed in the ECw of 1.5 dS m⁻¹ (12.7 cm) and the lowest in the ECw of 4.5 dS m⁻¹ (8.5 cm), representing a decrease of 49.4%.

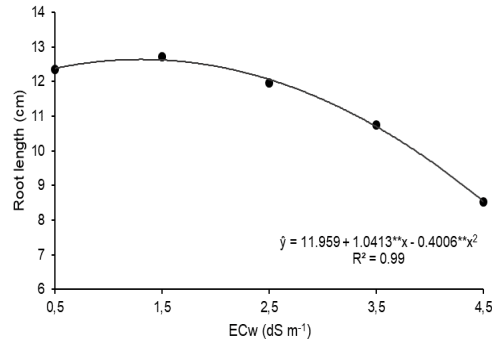


Fig. 5. Effect of electrical conductivity of irrigation water in the root length of peanut (*Arachis hypogaea* L.)
 ** $P < 0.001$

The electrical conductivity of 4.5 dS m⁻¹ caused a decrease in the length of the roots of the peanut, which determines that the cultivar does not tolerate high salt levels in irrigated water, causing root atrophy of the excess salts. The high concentration of salts in the cells provoke the unbalance of the biochemical reactions and physiological alterations, consequently being able to worsen circumstantially in the growth of the tissues [15]. The decrease in the root length of the plants irrigated with saline water may also be interconnected with the increase to soil osmotic pressure, implying a greater difficulty for the plant to absorb water and reach the process of cell division and stretching [20].

It is observed that the number of seeds per plant was affected as the salinity of irrigation water was elevated (Fig. 6). The maximum value of seeds/plant was 40.8 and the minimum of 14.4. found in the salinities of 0.5 and 4.5 dS m⁻¹, respectively, representing a decrease of 183.3%. These results corroborate with those found by [18] who worked with the same crop and showed that the increase in salinity interferes negatively with the number of seeds produced. The high concentration of salts in the soil solution impairs the absorption of nutrients, causing abnormalities in plant metabolism, directly influencing the production of the crops [19].

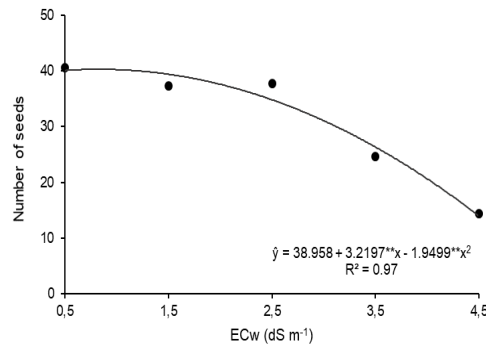


Fig. 6. Effect of electrical conductivity of irrigation water in the number of seeds of peanut (*Arachis hypogaea* L.)
**** $P < 0.001$**

The total chlorophyll index (TC) decreased as the salt concentration was elevated, the maximum value was 42.6 and the minimum of 31 FCI (Falker chlorophyll index), found in the salinities of 0.5 and 3.5 dS m⁻¹, respectively (Fig. 7). In studies carried out by [7], these authors point out that the chlorophyll content was linearly affected by the increase in the electrical conductivity of the soil saturation extract, proving the sensitivity of the crop to high levels of salts in the water. Also according to these authors, the decrease of chlorophyll indices may be related to the disorganization of the cells and the degradation of the chlorophyll by NaCl, reducing their synthesis. Consequently, the radiation rate can be affected and there is interference in productivity.

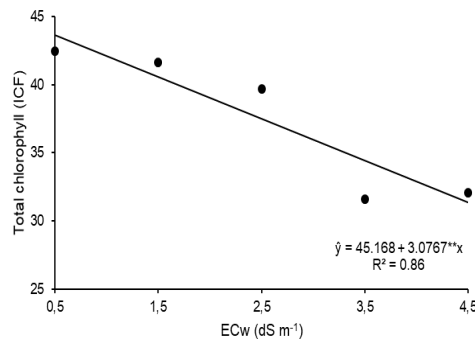


Fig. 7. Effect of electrical conductivity of irrigation water in the total chlorophyll of peanut (*Arachis hypogaea* L.)
**** $P < 0.001$**

All biomass variables were significantly reduced when the plants were submitted to saline stress (Fig. 8A-B and 9A-B). This is a classic response that was verified in other studies when plants are submitted to saline stress [7.21.22]. These results are associated with the salinity effects of irrigation water on the physiology of the plant, promoting metabolic disorders, mainly in relation to the absorption of water and soil nutrients and the reduction of leaf area, which implies a smaller surface area photosynthesizing and. Consequently, the low yield of the crop [6].

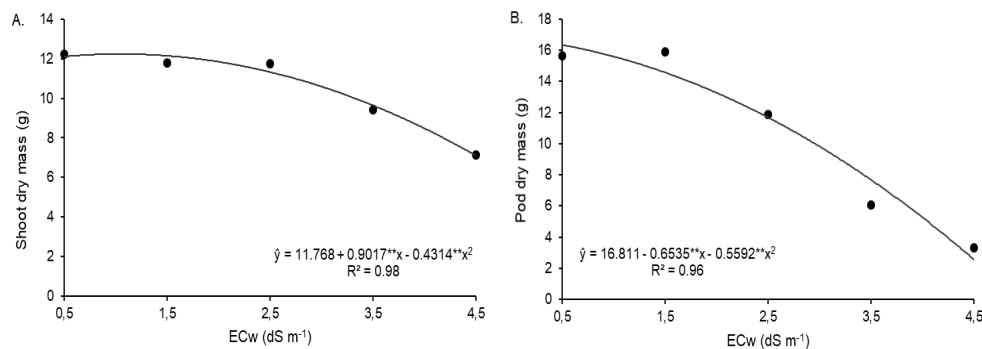


Fig. 8. Effect of electrical conductivity of irrigation water in the shoot dry mass (A) and in the pod dry mass (B) of peanut (*Arachis hypogaea* L.)
**** $P < 0.001$**

The shoot dry mass (SDM) was affected as the salinity of irrigation water increased from 2.5 dS m⁻¹. It is observed that there was a significant reduction of 41.8% when irrigated with water with ECw of 4.5 dS m⁻¹ (Fig. 8A). These decreases agree with [8] when reporting that the increase in the saline concentration of the irrigation water progressively decreases the biomass production in peanuts. [4] Argue that the reduction of the growth parameters of the crop may be related to the restriction of the osmotic potential of the soil solution due to the increase in the high levels of salinity.

Fig. 8B shows a negative effect on the dry mass pod (DPM), when the salt content is high, and the highest dry matter deposition was found in the treatments of 0.5 dS m⁻¹ and 1.5 dS m⁻¹. Plants kept under the salinity of 4.5 dS m⁻¹ obtained the lowest MSV value, demonstrating the sensitivity of the culture to the higher salts. [23] Working with string beans under saline irrigation and potassium fertilization, identified a reduction in dry biomass of the pods from the salinity of 2.2 dS m⁻¹.

Seed dry mass (SEDM) was affected drastically with salinity increase on the irrigated water (Fig. 9A). The highest value of SEDM was observed in plants that received the amount of ash 2.5 g kg⁻¹ when subjected to the salinity of 0.5 dS m⁻¹, adjusting linearly decreasingly from the increase by ECw. This may be associated with the osmotic potential of the soil solution that makes it difficult for the plant to absorb water. [7] Also observed a reduction in this variable with the increase in the irrigation water salinity.

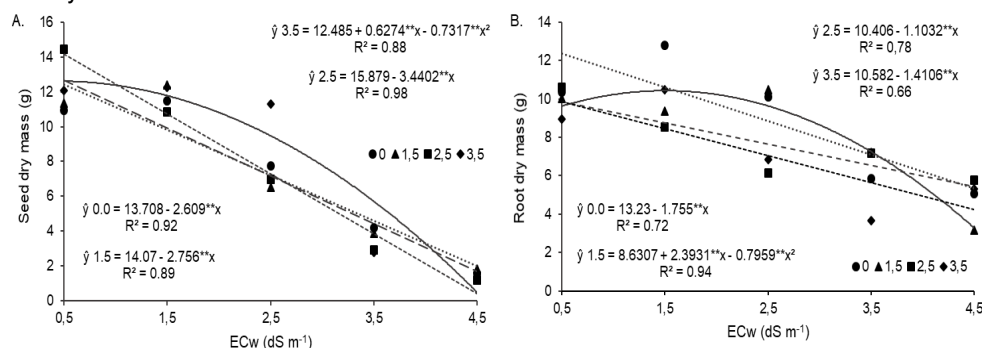


Fig. 9. Seed dry mass (A) and root dry mass (B) of peanut (*Arachis hypogaea* L.) submitted to irrigation with salt water and application of vegetal ash
**** $P < 0.001$**

The root dry mass (RDM) of the peanut plants were negatively affected as the salt contents were increased (Fig. 9B). Plants that did not receive ash (0 g kg⁻¹) had the highest accumulation of dry matter in the root, however, the MSR values were decreased as the water salinity was increased. Studies performed by [10] evidenced that the dry mass of the root of oiticica (*Licania rigida* Benth.) seedlings irrigated with saline water and fertilized with potassium was reduced with the increase of salts in irrigate water.

217 4. CONCLUSION

- 218 • The use of saline water influenced all variables analyzed in the peanut (*Arachis hypogaea* L.)
- 219 crop regardless of the use of vegetal ash;
- 220 • The use of vegetable ash until 3.5 g kg⁻¹ of soil was not efficient as an attenuating agent of
- 221 the deleterious effect of saline water in the peanut crop.

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