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Evaluation of the Consortium with Salicornia Neei for use in the Semi-Arid of Pernambuco. III - Pennisetum Glaucum L. (Millet)

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ABSTRACT

Northeast Brazil is a region that faces serious problems related to rainfall irregularity, resulting in severe and prolonged droughts, specifically in the semi-arid region. The Pernambuco semi-arid region presents great spatial and temporal variability of rainfall, with irregular rainfall concentrated in a few days and months, considerably limiting the planting of crops for animal and human food; in addition to the scarcity of rainfall, there is a high level of salinity in the soil and water and such characteristics require an adaptation in agriculture: implementation of new technologies, cultivation of halophytes and drought-resistant plants. It is of fundamental importance to search for low cost and efficient alternatives that are adapted to the peculiarity of the environment and that can bring benefits to the local farmer. The objective of this work was to evaluate the effect of the consortium between Salicornia neei and Pennisetum glaucum on growth and productivity in greenhouse cultivation, submitted to irrigation with desalinator reject. The experiment was carried out with three soil textures, in a randomized block design, with Salicornia neei and millet, individualized and in consortium and irrigated with water (control) and with desalination waste, with three replications. After 180 days, it was observed that Salicornia neei showed a better production of green matter (123.64kg/ha) and dry (24.73kg/ha) when irrigated with desalination waste and cultivated in the soil with medium texture. The consortium of Salicornia neei and Pennisetum glaucum, in soil with a clayey texture, presented better results for TF (27.87%), TP (13.69%) and TN (2.19%), when irrigated with water; and greater sodium absorption (5.79%), when irrigated with desalinator reject. For the absorption of calcium (2.53%) there was a response for the soil with sandy texture, irrigation with water and only for Salicornia neei.

Keywords: *Halophyte;saline water;plant growth; millet.*

INTRODUCTION

The northeastern semiarid has its peculiar characterization. It is usually affected by droughts, causing several socioeconomic and environmental impacts due to the occurrence of poorly distributed and unpredictable rainfall, compromising the growth and development of animals, due to the scarcity and low nutritional value of forages in the dry period of the year. Millet is a promising alternative for the production of forage in the semi-arid region, as it is a grass of easy installation and management, short cycle, high nutritional value and adapted to different conditions of climate and soil, resistant to high temperatures and water deficit, besides having capacity for intense regrowth and nutrient extraction and recycling. It is a xerophytic culture with a hot climate that has efficient drought resistance characteristics and mechanisms [1, 2].

Pennisetum glaucum (millet) is an annual grass of African origin from the *Poaceae* family, known as “corn of pearls”, of erect size, with uniform development that presents great forage potential, high biomass production, versatility of use, low cost of implantation, being able to be used in human and animal feeding, serving as grazing or silage and production of grains in the manufacture of animal feed, as soil cover in no-tillage systems. The production of annual grasses is an effective alternative that ensures the availability of food to meet nutritional requirements in the most critical periods of the year in the Brazilian semiarid region.It is an interesting alternative that can integrate agriculture and livestock [3, 4, 5]

The culture of millet has been gaining prominence in Brazilian agriculture due to its forage characteristics, tolerance to water stress, high rusticity, rapid growth, adaptation to low fertility soils and excellent production capacity for dry matter and biomass. It is a species that serves for the recovery and renewal of perennial pastures, whose grains are used for human consumption; it is a plant rich in omega-3, it fights heart disease and diabetes, helps in the treatment of cancer and enhances brain activities.Millet flour can be used in baking, it does not contain gluten and is very nutritious [6, 7, 8].

Millet (*Pennisetum glaucum*) is a plant with a lot of photosynthetic efficiency and tolerance to high temperature and drought, as it is a short-cycle forage (60 to 90 days), rich in starch, soluble and insoluble dietary fiber, minerals and antioxidants, source of phytochemicals and micronutrients, being widely grown in the off-season.It is one of the most cultivated crops in the arid and semi-arid regions of Africa and India, as it sustains itself under adverse conditions and can be produced with a low rainfall, about 250-350 mm of precipitation, using water efficiently compared to other plants such as corn and sorghum, and has high mass production per unit area (60t of green matter per hectare) and good nutritional value. Drought and salinity are two major restrictions that have an impact on crop growth and productivity; therefore, the cultivation of millet is positive for agriculture as it promotes soil restructuring, as it has vigorous roots and good nutrient cycling capacity [9, 10,11, 12].

The semi-arid region of Pernambuco is usually affected by droughts, causing several socioeconomic and environmental impacts, its soils are affected by salts, which limits the planting of cultivars. It is important to emphasize the correct choice of the crop used, since not all species tolerate salinity and produce satisfactorily in semi-arid regions. The accumulation of salts is a problem that leads to soil degradation and deterioration of its physical, chemical and biological properties; hence the importance of cultivating halophyte plants, which represent the only group capable of living in soils with high concentrations of salts. In this scenario, there is a halophyte belonging to the class *Equisetopsida*, subclass *Magnoliidae*, to the order *Caryophyllales*, to the family *Amaranthaceae*, to the genus *Salicornia* and to the species *Salicornia neei* [13].

Salicornia neei is an example of a halophyte used for phytoremediation of waste / saline effluents, production of plant biomass for different purposes and restoration of coastal environments. The species *Salicornia neei* has aroused great interest in recent years because in addition to its nutritional power in terms of minerals, antioxidants and vitamins, it has a perennial life cycle, survives for several years, and can be propagated by seeds or through vegetative growth, due to the its cauline capacity for regrowth [14,15,16, 17, 18, 19].

According to [20],the cultivation of two or more cultures of different species simultaneously in the same area, called the system of intercropping, consists of a considerable reduction in the risks arising from irregular rainfall in the region, reaching high crop yields.

In view of the above, the objective of this study was to evaluate the effect of the consortium between *Salicornia neei* and *Pennisetum glaucum* on growth and productivity in greenhouse cultivation, submitted to irrigation with desalinator reject.

Material and Methods

Obtaining Seedlings

The production of seedlings by vegetative propagation of *Salicornia neei* Lag. was performed directly on the vessels to be used in the experiment.10cm long stem fragments (cuttings) were removed from the matrix plants, with the lower part in bevel.These cuttings were placed in pots with clay, medium and sandy textures. For 30 days, the plants were irrigated with drinking water, and every three days they were sprayed with desalinator rejectto acclimatize them until rooting.

Millet seeds (*Pennisetum glaucum*) were supplied by the Seed Chamber of the Agronomic Institute of Pernambuco (IPA), Recife, Pernambuco.

Conducting the Experiment

The experiment was carried out under greenhouse conditions, located at the IPA headquarters, using black polyethylene pots, with eight kilograms of soil with clayey, medium and sandy textures, coming from the São Bento do Una Experimental Station, from

IPA , air-dried, stripped, homogenized and sieved in 2mm mesh for fertility analysis, according to Table 1.

Table1. *Soil fertility analysis used in the experiment*

Determination	Texture Soil		
	Sandy	Average	Clay
pH (H_2O)	6.40	5.50	7.40
P, mg/dm^3	13	105	209
Ca, $cmol_c/dm^3$	0.40	0.90	12.40
Mg, $cmol_c/dm^3$	0.60	0.60	2.20
Na, $cmol_c/dm^3$	0.05	0.11	4.09
K, $cmol_c/dm^3$	0.08	0.05	0.60
Al, $cmol_c/dm^3$	0.00	0.30	0.00
H, $cmol_c/dm^3$	0.33	1.35	0.25
S, $cmol_c/dm^3$	1.1	1.7	19.3
CTC, $cmol_c/dm^3$	1.5	3.3	19.5
V, %	77	50	99
m, %	0	15	0

Where: *S = Sum of Bases; CTC = Cation Exchange Capacity; V = Percentage of Saturation by Base; m = Percentage of Saturation by Aluminium.*

Source: *Soil Fertility Laboratory of the Agronomic Institute of Pernambuco* - *IPA, Recife, Pernambuco (2019).*

The treatments consisted of the individual planting of Salicornia and Millet, as well as intercropping, in the three types of soil textures, with irrigation with water (control) and with the desalinator reject, observing the development of the plants for up to 180 days.

The experimental design used was a randomized block, with the treatments: Salicornia and Millet individualized and the consortium of Salicornia with Millet, three soil textures (clayey, sandy and medium), with two types of irrigation (water and desalinator reject), with three repetitions, totaling 54 experimental units.

Throughout the experiment, humidity was maintained in the pot capacity, by weighing the pots and daily watering with drinking water and with the desalinator reject from the municipality of Riacho das Almas, Pernambuco, to complement the water lost through evapotranspiration, with the following features: Electrical conductivity = 11.54 mS/cm at 25ºC; Ca^{2+} = 403.00 mg/L; Mg^{2+} = 393.09 mg/L; Na^{+} = 200.00 mg/L; K^{+} = 40.00 mg/L; Sodium Adsorption Ratio (SAR) = 23.67; pH = 7.9;Classification for irrigation = C4S4 (Very high salinity water and high sodium concentration).

Collection of the Experiment

After the experimental period, the aerial part of the millet and the salicornia were collected, separating them at the height of the plants' neck and washed with deionized water. To evaluate the yield of the cultivated plants, the weight of fresh matter (FMW) was determined on the day of collection. That done, all the material was packed in paper bags, dried in an air circulation oven, at 600C, for 72 hours, to determine the dry matter weight (DMW).

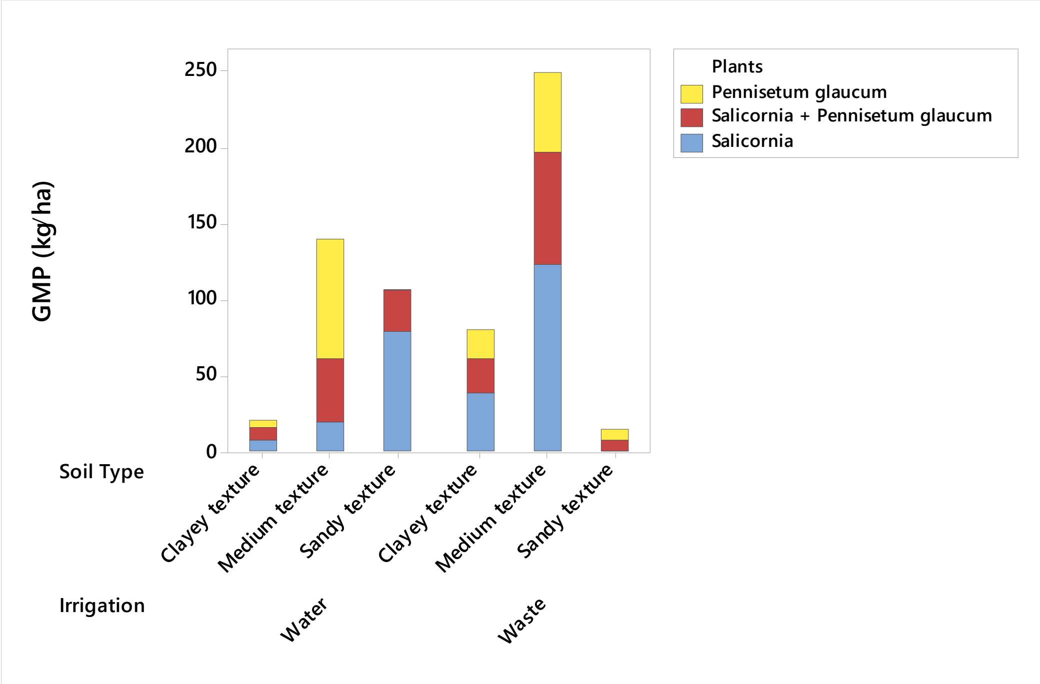
Soon afterwards, the material was milled, in a Wiley mill, provided with a 42mm sieve to, by means of nitroperchloric digestion [21], the contents of the absorbed elements (K^{+}, Ca^{2+}, Mg^{2+} , Na^{+}) and total nitrogen were determined by the microkjeldhal method, as well as bromatological analysis[21]. A soil sample was also collected for complete chemical analysis [22].

Statistical Analysis

The data obtained were submitted to individual and joint statistical analysis, relevant to the variables studied, using appropriate mathematical models. The variance was tested by the F test, using the statistical program MINITAB US.2018.

Results and Discussion

In Fig. 1 (a) and (b) which presents the results obtained for the weight of green (a) and dry matter (b) and in Fig.2 (a) and (b) which shows the respective ascending curves, it is it is possible to observe that the treatment with only Salicornia neei showed a better production of green matter (GMP), equal to123.64kg/ha, and dry matter production (DMP), equal to 24.73kg/ha, when irrigated with desalinator reject and grown in soil with medium texture, compared to clayey texture soil, water irrigation, only *Pennisetum glaucum* (0.00kg/ha) and to soil with clayey texture, irrigation with waste, only *Salicornia neei* (0.00kg/ha).



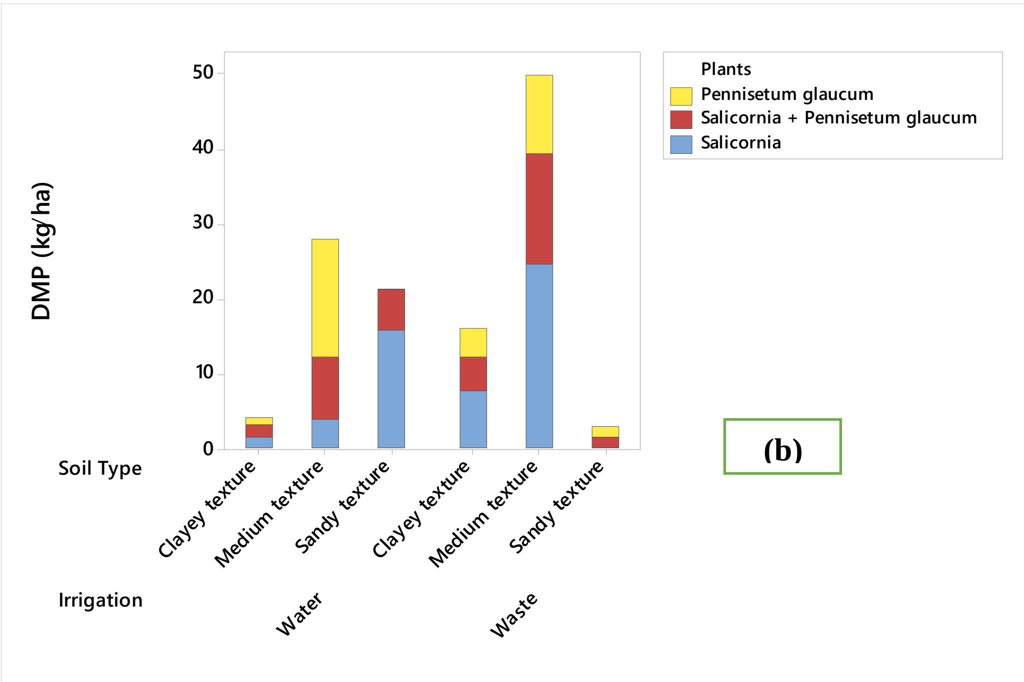


Fig1. *Results obtained for the production of green matter - GMP (a) and dry - DMP (b) from Salicornia neei intercropped, or not, with millet (Pennisetum glaucum), in three different textures of soil and irrigated with water and desalinator reject*

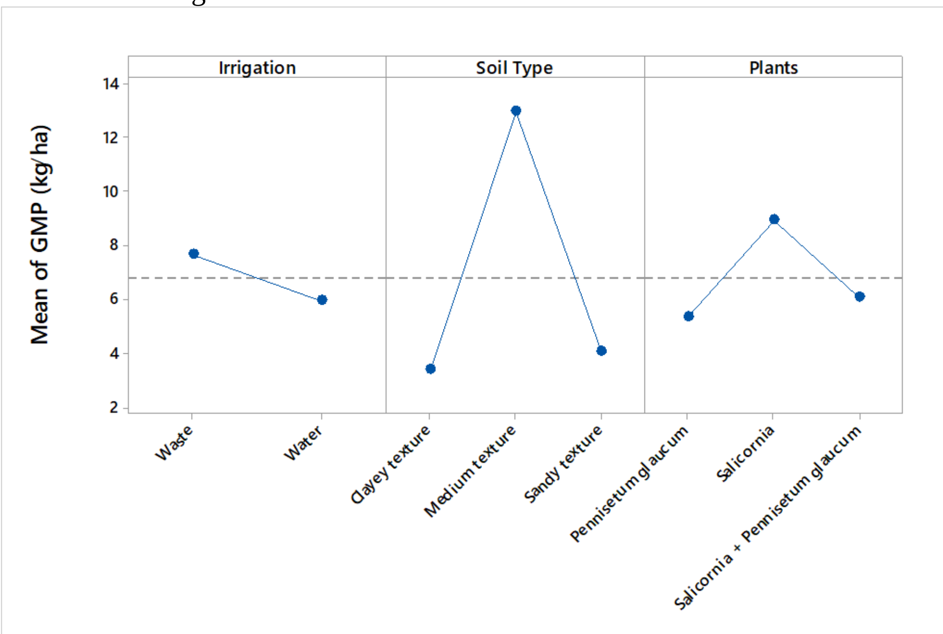
According to [6], *Pennisetum glaucum* is an important option among the plant species used for soil coverage , as it has a dry matter production capacity of 9.65t/ha at full bloom and has a C/N ratio of 30 or greater in the rubber and flowering phases, reaching up to 20 t/ha of DMP, lower values than that found in this research.

According to [23] the bromatological composition of genomic combinations of elephant grass and millet showed an average production of total green matter (GMP) of the millet genotypes of 28.63t/ha/cutting, and the elephant grass cultivar stood out with a production of 55.03t/ha/cutting. The results for GMP demonstrated that the different genomic combinations have productive potential for the development of forage cultivars.

In the experiment by [24], millet showed high conversion to green and dry matter when subjected to the 275mm blade of irrigation with wastewater. The intercropping of millet with lab-lab beans did not interfere with the production of millet.

According To [25], there was a significant effect in relation to the green matter, which presented an estimate for each increment of 1 mm of irrigation blade than the green matter of the millet, being obtained the average of 47.06 t/ha. Work [26] shows that millet had a satisfactory production in 67 days after sowing (DAS), with an average of2, 223.7kg.

The experiment by [27], for 90 days, was in a completely randomized design, consisting of millet cultivars (ADR-300; ADR-500; BRS-1501 and BN-2) where the DM contents differed between cultivars, varying from 50.18 to 60.56% for ADR-300 and BRS-1501, respectively. The average production was 2,055.62 kg/ha of dry matter.



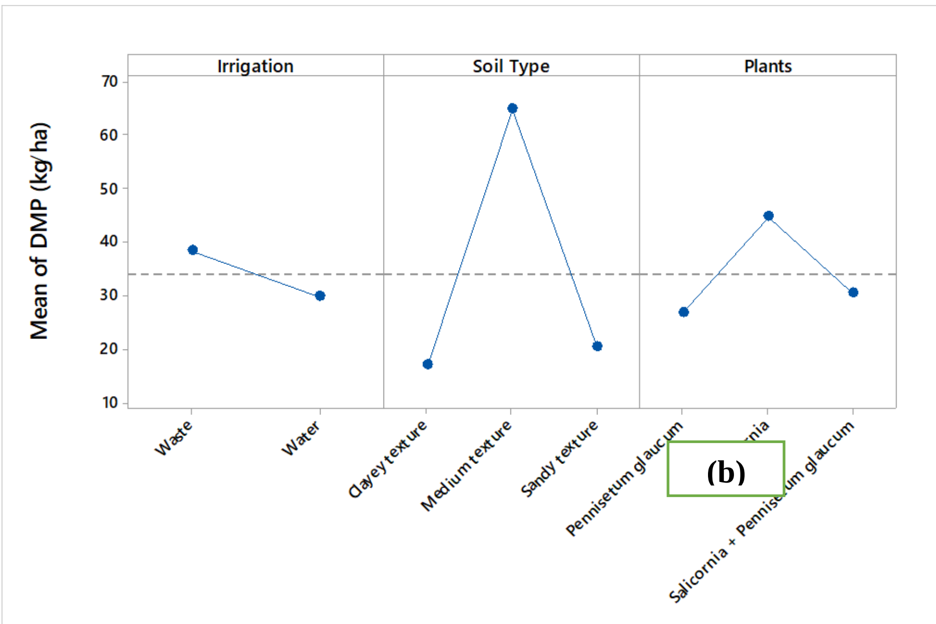


Fig2. *Results obtained for the upward effect of green matter production - GMP (a) and dry - DMP (b) from Salicornia neei intercropped, or not, with millet (Pennisetum glaucum), in three different textures of soil and irrigated with water and desalinator reject*

It can be seen from Fig.2 (a) and (b) the upward effect on plant growth, increased production of green matter - GMP (a) and dry - DMP (b) starting from the soil with clayey texture, reaching its peak in the medium texture and decreasing in the sandy texture. Similarly, analyzing the plant factor: the use of the consortium of *Salicornia neei* and *Pennisetum glaucum* did not show any greater growth; however, with the use of only Salicornia neei there is a greater growth in GMP and DMP. Finally, analyzing the use of water or desalinator reject, there is a greater production of DMP and GMP with the use of the waste.

In Fig. 3, it is observed, by the simultaneous optimization of the studied variables that the millet responded satisfactorily to the Na^+ absorption (5.79%) in the soil with a clayey texture, irrigated with desalinator reject and in the consortium of *Salicornia neei* and *Pennisetum glaucum*. The most satisfactory results for total protein - TP (13.69%), total nitrogen - TN (2.19%) and total fiber - TF (27.87%) were in clayey soil, irrigated with water and in the consortium of *Salicornia neei* and *Pennisetum glaucum*. For Ca^+ (2.53%), the best absorption was in the soil with a sandy texture, irrigated with water and only *Salicornia neei*. All of these results, therefore, favored the production of green matter (GMP) and the consequent production of dry matter (DMP).

In a study by [8], to determine plant species with potential for phytoextraction in the soil, millet was indicated. In the determination of K^+ it was noted that millet was the plant that most phyto extracted this element and was statistically similar to alfalfa; this can be attributed to the preferential absorption of monovalent ions by grasses/*poaceae*. In the case of $Ca^{2+}$and Mg^{2+},the greatest extraction also occurred when the soil was cultivated with millet and alfalfa, demonstrating the great extraction power of these crops.

To [28], TP levels were similar for all millet cultivars, with an average value of 7.78%, lower than that found in this research (13.69%).TN doses did not influence (P> 0.05) on TF levels.There was a difference in TF levels between cultivars (P <0.05), ranging from 36.10 to 41.91% for cultivars ADR-300 and BN-2, respectively, values higher than those found in this experiment (27.87%).

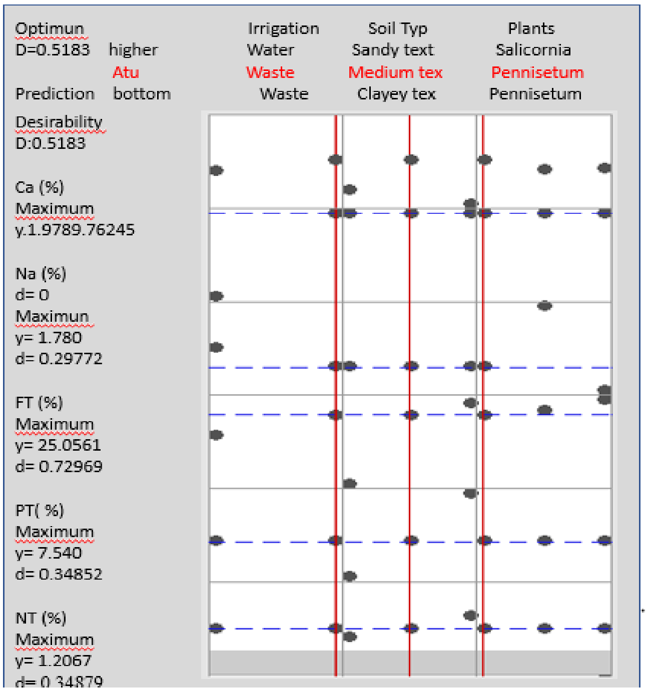


Fig3. *Results obtained for absorption of nutrients by Salicornia neei intercropped, or not, with millet (Pennisetum glaucum), in three different textures of soils and irrigated with water and desalinationwaste*

Conclusion

Salicornia neei presented a better production of green matter (123.64kg/ha) and dry (24.73kg/ha), when irrigated with desalination waste and cultivated in the soil with medium texture. The consortium of *Salicornia neei* and *Pennisetum glaucum*, in soil with a clayey texture, presented better results for TF (27.87%), TP(13.69%) and TN (2.19%)when irrigated with water; and greater sodium absorption (5.79%) when irrigated with desalinator reject. For the absorption of calcium (2.53%) there was a response for the soil with sandy texture, irrigation with water and only for *Salicornia neei*.

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