YIELD RESPONSES OF SALTBUSH IRRIGATED WITH EFFLUENTS FROM RAISING TILAPIA IN BRINE OF DESALINIZATION BRACKISH WATER

Everaldo R. Porto[*], Luiza T.L. Brito, Fernanda R. Porto

Introduction

The increasing expansion of the desalinization will be able to bring environmental severe impacts due to the subproducts or effluents, in other words, waters with elevated tenors of salts that are, most times, poured on the soil. Data concerning this fact can be seen in studies of Amorim et al. (1997). The irrigation of halofit plants with saline effluent has been suggested as an alternative for reduction of the negative impacts caused by this subproduct of the desalination (Miyiamoto et al., 1996; Glenn et al., 1998; Brown et al., 1999; Montenegro et al., 2000; Porto et al., 2001).

Halofits are plants with the skill of supporting not only high levels of salinity of the complex soil-water, but also the skill of accumulating significant quantities of salts in his tissue (Miyamoto et al., 1994). Among the halofits, the saltbush (Atriplex nummularia) is one of the most important because of having specialized mechanisms for accumulation of salts in its interior and for its elimination through the leaves. In fact, the plant acts in this way not with the objective of becoming specialized in the absorption of salts, but with the objective of being adjusted to the environment when this one has high levels of salinity.

Even the literature showing saltbush up like a biological desalinator of the soil (Glenn et al., 1998; O'Leary, 1986; Porto et al., 2001), its effectiveness increases when it is cultivated with lower volumes of effluent (Brown et al., 1999). On the other side, the predominance of the problems with irrigated areas salinization originates by the excessive use of water on irrigation

[*] Embrapa Semi-Arid, Soil Water Management, Petrolina, Pernambuco, Brazil,. email: erporto@cpatsa.embrapa.br

(Rhoades, 1998), but it is also important to recognize the fraction of lixiviation like recommendation of good practices in the irrigated agriculture; however, in treating brackish water, the incorporation of salt in the profile of the soil is straightly connected to the volume of water applied in the irrigation.

The present study has the objective of evaluating the influence on saltbush yield and at some characteristics of the soil, when irrigated with four volumes of effluent of the pink-colored raisement tilapia (Oriochromis sp.) in brine of the desalination of brackish water.

Material and methods

The experiment was introduced in the Experimental Field of the Embrapa Semi-Árido, in Petrolina, PE where effects of four volumes of water of irrigation were observed: T1=75; T2=150; T3=225 and T4=300 L $week^{-1}$ $plant^{-1}$, applied at a time. The soil of the experimental area was classified as "Argisolo amarelo eutrófico abruptico plíntico" (EMBRAPA, 1999).

Cuttings of saltbush with 30 days of age, original from the same plant by vegetative propagation, they were trasplanted for pits with 0,4 x 0,4 x 0,4 m, with the space between the pits of 4,0 x 4,0 m, in a randomized complete block design with four treatments and three reapplications. Each treatment corresponds to 16 plants. The total area of the experiment had 3.072 m^{2}. The irrigation system used was furrows and water applied was brine from a desalting plant in which was raised pink-colored tilapia (Oriochromis sp.). The density of settlement of the Tilapia in the tank was 4 alevinos/m^3 and the cycle of the fish, was six months. The edge of each furrow, which wet area was $20m^2$, was containing four plants. The transplant of the cuttings was carried out on 06/16/2000 in pits that they received 5L of dung of caprine and 150g of simple super phosphate. The harvest was on 05/31/2002. During this period, two cycles of Tilapia were cultivated and when 35 irrigations were carried out. The monitoring of the effluent salinity and of soil salinity was carried out weekly before each irrigation when the electric conductivity (dS/m) is determined, and also were determined the pH and the moisture (%) of the soil. Such analyses were done following the methodology of the soil laboratory of Embrapa (Classen, 1997). The samples of soil were collected before the application of the respective volume of water in each treatment, taken to depth 0-30 cm, 30-60 cm, 60-90 cm, and to a distance 0,20m of the plant. The data of total yield for plant by treatment were analysed statistically, valued with Duncan's test, and subjected to analyses of regression. In both proceedings, were in use modules of SAS (1989). The quantity of dry matter (MS) was estimated, following techniques described by Silva (1990), besides the estimates of the quantitative of salts accumulated in the tissue of the saltbush, through the determination of total ashes. In the harvest, the whole vegetable material was withdrawn with height equal or superior to 50 cm from the surface of the ground. Such materials were classified like firewood, thick stem, fine stem and leaves. Like firewood, it was considered the whole woody material with diameter equal or superior to 10 mm; like thick stem, the material of diameter between 8 and 10 mm and, like fine stem, the material with inferior diameter to 8 mm. Finally, it was called a foraging material the set of stems and leaves.

Results and Discussion

In Table 1 there show up the results of the physical analyses of the soil in the experimental area, before the planting of the saltbush. The soil was described how as sand/ clay texture; The mean pH of the profile, of 5,7, is considered typical for this type of soil and the electric conductivity of the saturation extract of the soil profile was 0,40 dS / m allowing to qualify the soil as not saline. The available water capacity of the profile, determined on basis of mass, is 6,1 %.

Table 1. Some of the physical properties of the soil before irrigation.

	Soil depth cm)			
	0-30	**30-60**	**60-90**	**Mean**
Sand (%)	76	63	57	
Silt (%)	14	14	17	
Clay (%)	10	23	26	
pH (H_20 – 1:2,5)	6,1	5,8	5,2	5,70
Electrical Conductivity (dSm^{-1})	0,24	0,37	0,6	0,40
Particle Density (g/cm^3)	2,58	2,63	2,61	
Bulk Density (g/cm^3)	1,37	1,35	1,39	
Field Capacity (%)	8,49	14,35	20,86	14,56
Wilting point (%)	4,38	8,82	12,19	8,46

Table 2 shows the data of pH and of electric conductivity for three layers of the soil profile, in accordance with the treatments. A light increase is observed in the mean values of pH of the profiles, while the volume of water was higher. As for the electric conductivity, the increases were significant and reversely proportional to the increases of the volumes of water, but still very far from the limits for compromising the saltbush production, which is 31,25 dS/m (20g/L), according to results got by Myiamoto et al. (1996). It is important to observe that, already for the first year, the electric mean conductivity of the profile of the treatment T1 brings near to the mean conductivity of the effluent which was 7,2. In function of elapsed two years, the biggest concentrations took place in the superior layers for all the treatments; however, it is shown up the possibility to have been lixiviation in the treatment T4, owing to a minor diversion between the values of the electric conductivity of three layers of the profile, because of the excess of water on the first layer of the profile (0-30 cm) to have transported part of the salts to the lower layers, which did not happen with the treatments irrigated with less volumes than the T4; on the contrary, through the process of evapotranspiration the solution of the soil was becoming concentrated on the period for the treatments that received less volumes of water.

Table 2. Change in pH and electrical conductivity of the soil solution in the irrigated Atriplex field after two years.

	Depth of the soil (cm)							
	pH				C.E. (dSm-1)			
	0 - 30	30 - 60	60 -90	Mean	0 - 30	30 - 60	60 -90	Mean
T1	6,3	6,1	4,6	**5,67**	17,45	7,76	7,4	**10,87**
T2	6,4	5,8	5,6	**5,93**	12,39	7,62	11,86	**10,62**
T3	7,7	8,2	7,3	**7,73**	4,35	4,66	10,38	**6,46**
T4	7,4	7,7	6,3	**7,13**	4,80	6,07	6,34	**5,74**

The weekly electric conductivity of the soil extract is introduced in the Figure 1, in which the values represent weekly averages of three layers of the profile. The values for all the treatments followed the same tendency, presenting higher values on the last week of September and on the first one of October, when the taxes of evaporation were higher in the tank class "A". Since it was expected, the treatment T1 reached the highest levels of salinity, being able to have a mean value of 13,43 ds/m, showing the concentration of the salts up in function of the reduced moisture in the soil in the layer of 0-30 cm. The electric conductivity of this layer for this treatment reached 17,67 dS/m.

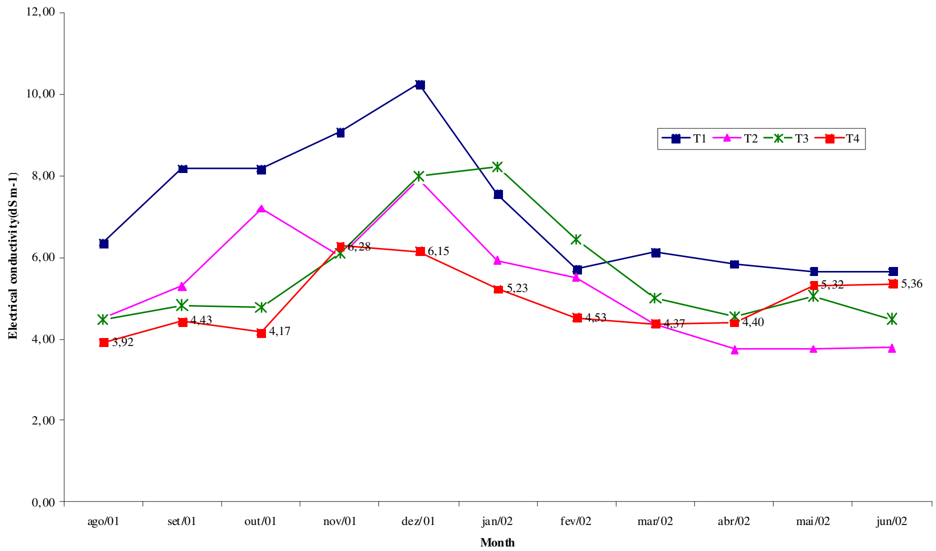

Figure 1 – Variation of the mean electrical conductivity of the three layers of soil profile according to the treatments.

Table 3 shows the mean weight of fresh matter by plant, for the different treatments. Each data represents the average of four plants. According to the statistical analysis, there are significant differences in level of 1 %, proved by Duncan's test. The coefficient of variation was 12,53 % and R^2 was 0,97.

Table 3. Treatments and yields of Atriplex nummularia for the cycle 2000-2001 (kg of fresh matter/plant).

Treatment	**T1**	**T2**	**T3**	**T4**
Yield	**34,7a**	**45,5a**	**61,6b**	**63,0b**

*Values followed by the same latter are not significant at 1-recent level.

The regression analysis is shown on Figure 2, correlating total yield by plant and the volumes of water applied on the irrigations. According to this information, the best result was got by the treatment T4, in other words, irrigating the saltbush with the volume 300 L/week^{-1} plant^{-1}; corresponding to 45mm/week/plant this value is near to the one of the weekly evaporation, rate measured at the experimental area, with tank class 'A', what was 46,9 mm. The existing difference of yield between the treatments T3 and T4, statistically it is not significant.

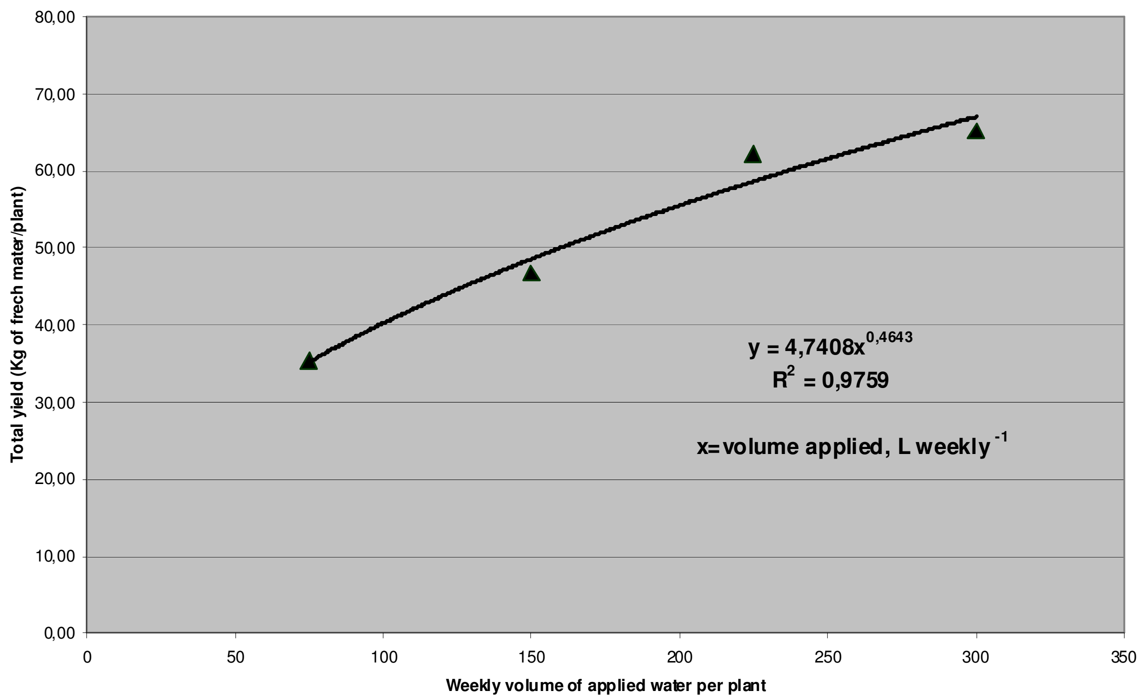

Figure 2. Correlation of yield response of Atriplex with applied volume of water.

Considering a stand of 625 plants^{-1} ha^{-1} and the proportion of each harvested part of the plant in relationship to the total, the Table 4 presents the results of the dry matter for each treatment.

Table 4. Yield estimative for the total plant and parts (dry matter/ha)

	Harvested parts					
				Fodder		
Treatment	**Total**	**Fire wood**	**Thick stem**	**Fine stem**	**Leaves**	**Total**
T1	8.254,3	2.330,3	1.798,0	1.521,8	2.604,2	4.126,0
T2	10.895,8	3.963,0	2.217,8	1.578,9	3.136,2	4.715,1
T3	14.399,4	5.656,3	2.376,0	1.846,8	4.520,3	6.367,1
T4	15.006,2	6.078,5	2.536,0	1.888,7	4.503,0	6.391,7

From the point of view of production of fodder, these results can be considered good, since the yield in dry matter are quite superior to the one got with the leucena (Leucaena leucocephala), which is 3,0 t ha^{-1} cut^{-1} (Oliveira, 2000) being able to be compared to the alfalfa irrigated with water with superior quality (O'Leary et al., 1985).

On the other side, it is convenient to emphasize that one of the limitations of the potential of underground water in the crystalline rock is the low flow of the wells. In this perspective the yields of the saltbush was calculated, for each treatment, the yield of saltbush per liter of water. The treatment T1 was the one that more produced biomass for unity of water, reaching 4,84 g of dry matter L^{-1}. Myiamoto et al. (1994), found yields of atriplex that they varied between 1,4 and 2,6 h L^{-1}.

The data of the Table 5 present the estimate of the quantity of existent ash in the different parts of the plant, according to the treatments. The totals of ash varied between 15,0 and 16,0 g 100 g^{-1} of dry matter not being. The biggest concentration was found in the leave that is the most expressive component of the foraging material. In agreement with Myiamoto et al. (1994), the limit of salt in diets for goat and lamb is 10g of salts per 100 of dry matter, being this one the limitations for the use of the saltbush as foraging. So, the recommendation is to mix it with other foods in the formation of the diet.

Table 5. Estimative of quantity of ash existing in the different parts of the plant tissue, according to the treatments (kg/ha).

	Harvested parts					
				Fodder		
Treatment	Total	Fire wood	Thick stem	Fine stem	Leaves	Total
T1	1.027,7	62,9	57,6	105,7	801,5	907,2
T2	1.325,2	108,5	88,0	115,9	1.012,8	1.128,8
T3	1.906,3	155,8	102,0	155,4	1.493,1	1.648,5
T4	1.946,0	167,6	108,5	160,2	1.509,8	1.670,0

Being considered the total of water of irrigation applied and the mean salinity of the effluent one, what was 7,2 dS/m (4,6 g/L) it concludes that the treatment T1 was the most efficient in the retreat of salts of the soil, having in mind that the ash content is an estimate approached the desalinization of the soil. In this work, the treatment T1 withdrew 13,6 % of the total of salts that were incorporated to the soil by the irrigation, while the treatment T4 withdrew only 6,4 %.

Conclusions

1- The salinity of the soil increased in all the treatments.

2- The best yield of the saltbush was obtained by managing weekly application of 300 liters of effluent per plant.

3- For the treatment T4, which it received weekly 300L of effluent / plant, the yield was superior to what it received 225L, however they are not deferential statistically.

4- The treatment T1 presented the best yield of biomass per unit of applied water, producing 4,84g of dry matter/L of effluent, while the treatment T4 produced only 1,71 g of dry matter/L.

5- Considering the incorporation of salts to the soil for the irrigation and its retreat for the plant, the treatment T1 was the most efficient one, with a retreat of 13,6 % of the total incorporated, while the percentage of retreat for the treatment T4 was of only 6,4 %.

Literature Cited

Amorim, M. C. C. de; Porto, E. R.; Silva Júnior, L. G de A.; Liberal, G. de S. 1997. Efeito de sais no solo provenientes de rejeitos da dessalinização por osmose inversa, no semi-árido pernambucano. In: Congresso Brasileiro de Engenharia Agrícola, 26,1997, Campina Grande. Anais... Campina Grande: SBEA;UFPB, CD-Rom.

Araújo, G. G. L de; 2006. Produção e uso do feno da erva sal na alimentação de caprinos e ovinos no semi-árido. Petrolina, PE: Embrapa Semi-Arido, 33 p. il (MMA/SRH, Embrapa Semi-Árido. Cartilha do PAD).

Brown, J.J.; Glenn, E.P.; Fitzsimmons, K.M.; Smith, S.E. 1999. Halophytes for treatment of saline aquaculture efluent. Aquaculture, Amsterdam, v. 175, p. 255-268.

Claessem, M.E.C. (Org.) 1997. Manual de métodos e análises de solo, 2. ed. rev. atual. Rio de Janeiro: EMBRAPA–CNPS, 212 p. (EMBRAPA–CNPS; Documentos, 1).

EMBRAPA. Centro Nacional de Pesquisa de Solos (Rio de Janeiro, RJ). 1999. Sistema brasileiro de classificação de solos. Brasília: EMBRAPA-SPI, 412P.

Glenn, E.; Tanner, R.; Miyamoto, S.; Fitzsimmons, K.; Boyer, J. 1998. Water use, productivity and forage quality of the halophyte atriplex nummularia grown on saline waste water in desert environment. Journal of Arid Enviroments, London, v. 38, 9. 45-62.

Miyamoto, S.; Glenn, E.P.; Singh, N.T. 1994. Utilization of halophytic plants fpr fodder production with brackish water in subtropic deserts. In: SQUIRES, V.R.; AYOUB, A.T. (Ed:) Halophyte as a resource for livestock and for rehabilitation of degraded lands. Amsterdam: Kluwer Academic, p. 43-75.

Miyamoto, S. 1993. Water use and potential irrigation scheduling of halophytes. In.: Halophyte Utilization in Agriculture, pp. 99-146. Agadir, Morocco: Bari-Institute.

Miyamoto, S.; Glenn, E.P.; Olsen, M.W. 1996. Growth, Water use and salt uptake of four halophytes irrigated with highly saline water. Journal of Arid Environments, London, v. 32, p. 141-159.

Montenegro, A.; Montenegro, S.; Silva, V.P.; Marinho, I.; Silva, J.G.; Bezerra, R.; Barros, M.K. 2000. "Uso múltiplo da água subterrânea nas áreas de domínio do Programa Xingó, com ênfase no desenvolvimento de halófitas. In.; I CONGRESSO MUNDIAL DE ÁGUAS SUBTERRÂNEAS, Fortaleza. **Anais**...Fortaleza: Associação Brasileira de Águas Subterrâneas, 1CD-ROM.

Moore, R.T.; White, R.S.; Calowell, M.M. 1972. Transpiration of atriplex confertifolia and eurotia lantana in relation to soil, plant and atmospheric moisture stress. Canadian Journal of Botany, Ottawa, v. 50, p.1411-1418,

O'leary, J.W.; Glenn, E.P.; Watson, M.C. 1985. Agricultural production of halophytes irrigated with seawater. Plant and Soil, Dordrecht, v. 89, p. 311-321.

O'leary, J. W. 1986. A critical analysis of the use of Atriplex species as crop plant for irrigation with highly saline water. In: AHMAD, R.; SAN PIETRO, A.(Ed.). Prospects for biosaline research. Karachi: Karachi University, p. 416-432.

Oliveira, M.C. de. 2000. Leucena: suplemento protéico para a pecuária do semi-árido no período seco. Petrolina, PE: Embrapa Semi-Árido. Circular Técnica, 51)

Porto, E.R.; Amorim, M. C. C. de; Silva Júnior, L. G. de A. 2001. Uso do rejeito da dessalinização de água salobra para irrigação da erva-sal (*Atriplex nummularia*). Revista Brasileira de Engenharia Agrícola e Ambiental, Campina Grande, v. 5, n. 1, p. 111-114.

Rhoades, J.D. 1998. Use of saline and brackish water for irrigation: implications and role in increasing food production, conserving water, sustaining irrigation and controlling soil and water degradation. In: INTERNATIONAL EXECUTIVE COUNCIL MEETING, 49.; ICID AFROASIAN REGIONAL CONFERENCE, 10.; INTERNATIONAL WORKSHOP ON THE USE OF SALINE AND BRACKISH WATER FOR IRRIGATION: IMPLICATIONS FOR THE MANAGEMENT OF IRRIGATION, DRAINAGE AND CROPS, 1998, Bali, Indonesia. **Proceedings**...Bali: ICID-CIID, p. 261-304.

Silva, D.J. 1990. Análise de alimentos (métodos químicos e biológicos). 2ª Edição. Viçosa: Universidade Federal de Viçosa, 165 p.

SAS INSTITUTE. 1989. SAS/FSP user's guide: release 6.03 edition. Cary, 331 p.