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Desalinization of saline soils by *Suaeda salsa*

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Abstract

The halophyte, *Suaeda salsa*, was grown in saline soil in pots and watered with a NaCl solution containing 0.2 g L^{-1} Na-ions. *S. salsa* accumulated Na during a 120-day growing period and caused a net reduction in the Na content of the soil. *S. salsa* also decreased the Na content of saline soil in a field experiment. The Na content of the soil at depth 20–30 cm was reduced by 4.5% with *S. salsa* at a density of 15 plants m^{-2} and by 6.7% with a density of 30 plants m^{-2}. In contrast, the Na content was decreased by only 1% with *Medicago sativa* at 15 plant m^{-2} and increased by 3.8% with bare soil. The results confirm that *S. salsa* is an effective salt absorber in saline soils.

Introduction

Suaeda salsa is a halophyte which can absorb salts from saline soils and accumulate them within the plant. Analyses have shown that the shoot and root salt contents of *S. salsa* can be 23–27% and 10–12% of dry weight, respectively (Hou, 1952; Hou et al., 1959; Jia and Liu, 1977; Zhao, 1984). *S. salsa* grows normally in highly saline soils and the accumulation of salt in the plant tissue may significantly decrease the salt content of these soils (Liu, 1974; Sharma and Gupta, 1986; Staples and Toenniessen, 1984; Zhao, 1984). A reduction in the salt content of soil would increase the area of land available for cultivation and would raise the yield of crops grown on marginal saline soils.

Materials and methods

Experiments were carried out in the area of Yu Cheng, East China, 36°55′N 116°40′E, for a period of 120 days commencing 14 May. Twenty seedlings of *Suaeda salsa* (L.) Pall. were transplanted from a seedbed into salinized fluvo aquic soil in each of five porcelain pots (diameter 23 cm, height 22 cm, 11 kg soil). Five pots without seedlings were used as controls. All pots received 1 L of NaCl solution, containing 0.2 g Na-ions, every third day, in order to replace salt absorbed by the plants. The NaCl solution was applied through three glass tubes penetrating the soil to different depths. The pots were placed outside and covered with thin, transparent plastic sheets as protection against rain. Temperatures under the plastic sheets were approximately 2°C higher than above and light intensity was approximately 10% lower.

S. salsa seeds were also sown in saline soil in the field. Plots with an area of 10 m^2 were sown with *S. salsa* seeds at 15 or 30 m^{-2}, with alfalfa (*Medicago sativa* L.) at 15 m^{-2}, or left unsown. Each treatment was replicated four times in a Latin square design. The soil of adjacent plots was separated by a plastic sheet to a depth of 1 m.

The dry weight and Na content of representative samples of plants from pots, and the Na content of soil from pots and field plots, were measured at the beginning and end of the experiments. Na-ions were extracted from soil with water and from dried plants by heating with 5 *M* HCl at 100°C until dry and redissolving in deionized water. Quantitative analysis of Na was made by atomic absorption spectrophotometry. The field trial results were subjected to two-way analysis of variance and least significant differences calculated using Tukey's t value (Li, 1964).

Results

Pot experiment

Table 1 shows the dry weight and Na content of the *S. salsa* plants increased during the 120-day experimental period. Table 2 shows that the Na content of the soil in pots without *S. salsa* increased during the experiment by an amount approximately equal to that added as NaCl in the irrigation water. In contrast, the Na-ion content of soil in pots with *S. salsa* decreased, despite the addition due to irrigation with the NaCl solution. Table 2 shows, that there was a mean net loss of 10.6 g Na-ions pot^{-1}, possibly accounted for by uptake by the *S. salsa* plants. This suggestion is confirmed by the data in Table 1 which shows that the Na content of the *S. salsa* plants increased by 10.94 g pot^{-1} during the experiment. *S. salsa* was clearly capable of taking up salt from the soil.

Table 1. Changes in dry weight and Na content of *Suaeda salsa* plants in pots (mean of five replicates ±95% confidence interval)

Initial dry weight (g pot^{-1})	Initial Na content (g pot^{-1})	Final dry weight (g pot^{-1})	Final Na content (g pot^{-1})
0.62 ± 0.03	0.16 ± 0.04	42.3 ± 1.2	11.1 ± 0.5

Field experiment

Table 3 shows that the Na content of soil in which *S. salsa* was grown decreased and that this decrease was greater with a higher plant density. The reduction in soil Na content by *S. salsa* was greatest in the 20–30 cm soil horizon. *M. sativa* also reduced the Na content of the soil, be it less effectively than did *S. salsa*. The Na content of soil with no plant cover increased, especially in the 0–10 cm horizon, presumably due to evaporation of saline groundwater which can lead to a long-term accumulation of salts at the soil surface.

Discussion

S. salsa growing in saline soil can absorb and accumulate considerable amounts of salt within one growing season, thereby decreasing the salt content of the soil. In the pot experiment, on average 10.9 g of Na-ions were absorbed by plants with a total final dry weight of 42.33 g. The dry weights of individual *S. salsa* plants in the field typically reach 80 or 100 g during the growing season. On this basis it would be theoretically possible for *S. salsa* at 15 plants m^{-2} to remove 3090–3860 kg of Na from 1 ha of the field soil. From the field trial data in Table 3 it can be calculated that the average Na-ion content of the 0–60 cm soil horizon decreased by 0.13 g kg^{-1} with 15 *S. salsa* plants m^{-2} and by 0.20 g kg^{-1} with 30 plants m^{-1}. If it is assumed that this soil has a bulk density of 1600 kg m^{-3} then the decrease in Na content observed in the field represents a reduction of 1248 and 1920 kg Na-ions ha^{-1} with 15 and 30 plants m^{-2} respectively.

Table 2. Changes in Na-ion content of soil in pots with and without *Suaeda salsa* (mean of 5 replicates ±95% confidence interval)

Treatment	Initial Na content (g pot^{-1})	Na-ions added by irrigation (g pot^{-1})	Final Na content (g pot^{-1})	Change in Na content (g pot^{-1})
+*S. salsa*	12.6 ± 0.4	8.0	10.0 ± 0.6	−10.6 ± 0.4
−*S. salsa*	12.8 ± 0.4	8.0	21.0 ± 0.8	+0.2 ± 0.6

Table 3. Changes in Na content at different depths of soil in plots sown with *Suaeda salsa* or *Medicago sativa*, or left unsown. Values are the means of four replicates

	Initial Na content ($g\,kg^{-1}$ DW)			Final Na content ($g\,kg^{-1}$ DW)			Change in Na content (% of initial)		
	Depth (cm)			Depth (cm)			Depth (cm)		
	0–10	20–30	50–60	0–10	20–30	50–60	0–20	20–30	50–60
M. sativa 15 plants m^{-2}	4.50	4.12	3.83	4.42	4.08	3.81	−1.8	−1.0	−0.5
S. salsa 15 plants m^{-2}	4.60	4.21	4.00	4.49	4.02	3.90	−2.4	−4.5	−2.5
S. salsa 30 plants m^{-2}	4.70	4.16	3.92	4.52	3.88	3.78	−3.8	−6.7	−3.6
Unsown	4.56	4.22	3.83	4.97	4.38	4.02	+9.0	+3.8	+3.9
LSD ($p < 0.05$)	(-------0.13-------)			(-------0.11-------)			(-------4.13-------)		

If *S. salsa* were harvested at the end of the growing season, a significant reduction in soil salinity might be achieved. It is possible that many other halophytes, including species of the genera Atriplex, Salicornia and Aster could also be used in soil improvement (Flowers, 1986; Staples and Toenniesson, 1984).

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