ABILITY OF SESUVIUM PORTULACASTRUM TO REMOVE SALT FROM SALINE MEDIA

Ho Bich Lien[(1)]
(1) Thu Dau Mot University
Corresponding author: lienhb@tdmu.edu.vn

DOI: 10.37550/tdmu.EJS/2025.01.608

Article Info

Volume: 7
Issue: 1
March: 2025
Received: Nov. 14th, 2024
Accepted: Jan. 15th, 2025
Page No: 38-44

Abstract

Sesuvium portulacastrum was shown to absorb sodium (Na+) and clor (Cl-) from the soil and accumulate it within its tissues. Therefore, it was chosen as a good plant for the phytodesalination of saline soils. The present study aimed to evaluate plant capacity to accumulate cloride ions and the potential to desalinize in saline soil medium of this halophyte. The results show that S. portulacastrum has a high tolerance at salt concentrations from 0.5% - 5% in growth terms of stem height, number of branches level 1, root length, and fresh biomass. Plants absorb a marked Cl- ions content clorideine and accumulate in roots, stems, and leaves. The efficiency of salt removal is 92% in the treatment of NaCl 1%. These results contribute to reducing soil salinity, so it is possible to apply sea buckthorn to treat saline soil environments.

Keywords: halophyte, phytodesalination, saline soils, *sesuvium portulacastrum*

1. Introduction

Currently, the situation of saltwater intrusion is more and more serious due to the increasing temperature of the earth. In Vietnam, the soil affected by saltwater is about 1 million hectares, about 3% of the total natural soil area. Saline soil is a major threat to agricultural production. It is caused by high concentrations of Na+, Cl^-, and SO_4^{2-} ions. High soil salinity will reduce the permeability of the soil solution, causing an imbalance in nutrient absorption. These factors affect plant growth, causing poor plant growth and development, reducing productivity and quality of agricultural products, and even causing plant death (FAO, 2005).

Numerous approaches were established to reclaim including soils physical, chemical, and biological. In biological methods, desalination of salt-affected soils by halophytes is of great interest (Mokded Rabhi et al., 2010). To adapt to a saline soil medium, halophytes have many protective mechanisms to grow and develop well in a saline medium such as changes in morphology, osmotic pressure adjustment, accumulation of ions (Na^+, Cl^-, K^+, Ca^{2+}, SO_4^{2-}...), and soluble organic compounds (proteins, sugars, amino acids...) (Messed et al., 2004). The accumulation of these compounds is not only important for the regulation of the osmotic pressure of cells but also for protecting cell structure.

S. portulacastrum is a herbaceous, perennial, psammophytic, dicotyledonous, and facultative halophyte belonging to the family Aizoaceae (Lokhande et al., 2009) that grows in coastal and mangrove areas throughout much of the world. It grows in sandy clay, coastal limestone and sandstone, tidal flats and salt marshes (Đang Thai Minh, 2011). *S. portulacastrum* is a vine with thick, smooth stems and fleshy, glossy green leaves. *S. portulacastrum* was shown to be tolerant to saline soils. S. portulacastrum has been explored for the desalination of saline soils and the phytoremediation of metals from contaminated soils and nitrogen and phosphorus from eutrophic water (Jianjun Chen et al., 2024). A study conducted in India showed that plant growth steadily increased when irrigated with nutrient solutions containing NaCl in the range from 100 to 500mM (Wang et al., 2022). *S. portulacastrum* can absorb sodium (Na^+) from the soil and accumulate it within its shoot tissues. It can detoxify salt by secreting salt through the leaves (Lokhande et al., 2012). In addition, *S. portulacastrum* is also known to survive in harsh environmental conditions such as heavy metal pollution and drought. Research on the ability of *S. prtulacastrum* to remove salt from saline media can be considered an important step for finding solutions to improve salinity in the situation of increasing salinity intrusion and to respond to the problem of climate change that is strongly affecting the environment in Vietnam.

2. Methods

S, portulacastrum used in this study was collected from the Can Gio district, Ho Chi Minh City. After mother plants were cut into equal sections and cultivated under non-saline distilled water for 14 days. After rooting, seedlings were grown on a control sand medium or subjected to NaCl salt. Plants were subjected to 6 different treatments (20 plants per treatment) of 0%, 0.5%, 1%, 2%, 3%, and 5%. Each treatment is repeated three times. The soil used in this experiment was coarse sand (100%), taken from a sand mining farm in Binh Duong.

Figure 1. Morphology of *S. portulacastrum* showing plants with pink- and white-colored flowers and seeds (Lokhande et al., 2009)

On the 10, 20, and 30th day of treatment, the growth parameters of plants were analyzed as stem height, number of branches, root length, and fresh weight. On the 30th day of treatment, plants were harvested and cut into leaves, stems, and roots, and the salt accumulated content of 2.5g of root, stem, or leaf samples were ground with 25ml of deionized water, then filtered extraction, and collected. Put 10ml of extraction into a conical flask, add 2-3 drops of 5% K_2CrO_4, titrate with 0.02N $AgNO_3$, and calculate the salt content accumulated (% Cl^-).

Cl^- concentration (%) in soil was also determined on the 30th day of the experiment. Collect soil in each treatment and mix well. Take 2.5g of soil, add 25ml of deionized water, and shake well for one hour. Then, filter the sample, and take the extraction. Take 10ml of the extraction and titrate with 0.02N $AgNO_3$ with 5% K_2CrO_4 reagent.

The data are presented as the means ± standard deviations (SDs) of triplicates. Analysis of variance (ANOVA) and post hoc comparisons of means to determine significant differences ($p < 0.05$). The chemicals in the experiment are pure and of German origin.

3. Results and discussion

3.1. Plant growth in saline medium

Under salt stresses *S. portulacastrum* exhibits various adaptations through morphological growth. The growth of the stem height, number of branches level 1**,** root length, and fresh biomass is shown in Figure 2, Figure 3, Figure 4, and Figure 5. NaCl treatment at concentrations of 0.5%, 1%, 2%, 3%, and 5% did not affect the growth of *S. portulacastrum.* Compared with the control, plant growth of *S. portulacastrum* in the treatment treatments was higher. This suggests that this halophyte is tolerant to saline medium. According to Toth and Kertesz (1997), because of the saline tolerance of *S. portulacastrum*, it increased plant height in the salt-supplemented environment more than in the salt-free environment. A study in India showed that plant growth increased when irrigated with nutrient solutions containing NaCl in the range from 100 to 500mM (Kannan et al., 2013).

Responses of plants in each treatment concentration showed that the highest plant growth occurred at 1% NaCl and lower at concentrations of 0.5%, 2%, 3%, and 5%. This suggests that 0.5%, 2%, 3%, and 5% NaCl are not suitable for plant growth. With the NaCl concentration of 1%, stem height, number of branches level 1, root length, and fresh biomass grew more than the remaining treatments, possibly because the salt concentration added was the appropriate concentration for plant growth. When the concentration gradually increased to 2%, 3%, and 5%, the plant growth tended to decrease, possibly because the plant was salt poisoned. Current results suit previous findings found that in irrigation water with high salt concentration, the ability of *S. portulacastrum* to adapt to salty soil is limited (Daoud, 2001). Venkatesalu (1994) also demonstrated that at 1% NaCl concentration, the root size of *S. portulacastrum* increased significantly. On the contrary, at a salt concentration of 0.5%, plant height still did not grow as much as 1% treatments, possibly because this was not the appropriate concentration for plant growth.

The growth reduction in plants exposed to 2%, 3%, and 5% NaCl suggests that there is an osmotic effect at these NaCl concentrations. This means that the harmful effects of high concentrations of NaCl on certain organs are nutritional, toxic, or oxidative (Isayenkov, 2012).

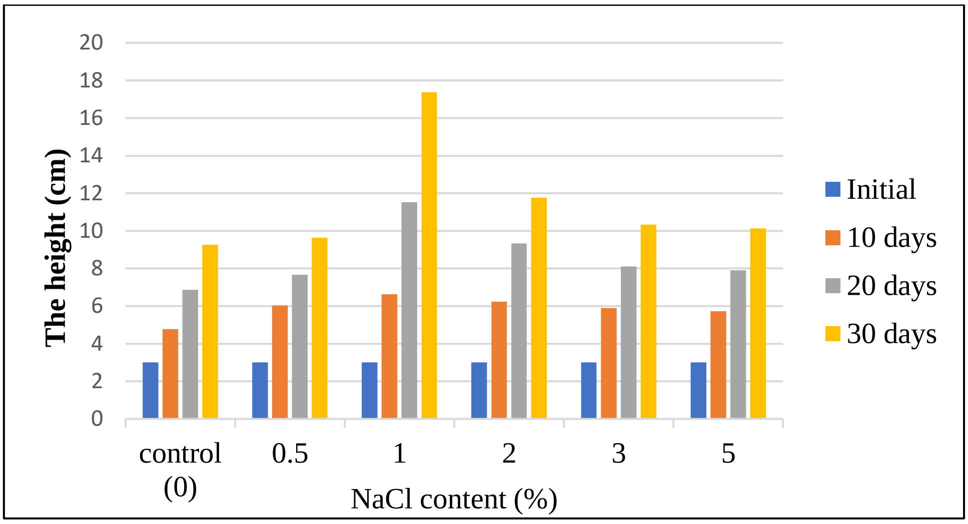

Figure 2. The growth of stem height (cm) of *S. portulacastrum*

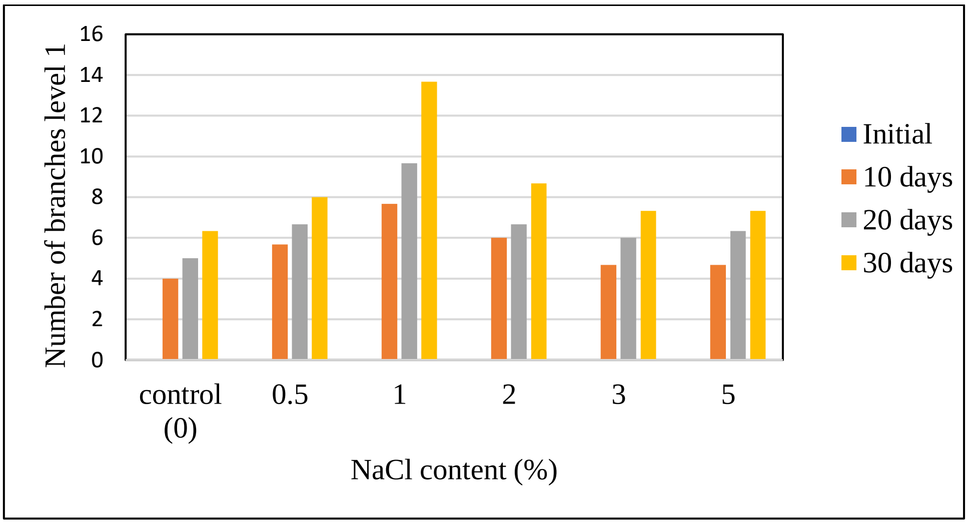

Figure 3. The growth of the number of branches level 1 of *S. portulacastrum*

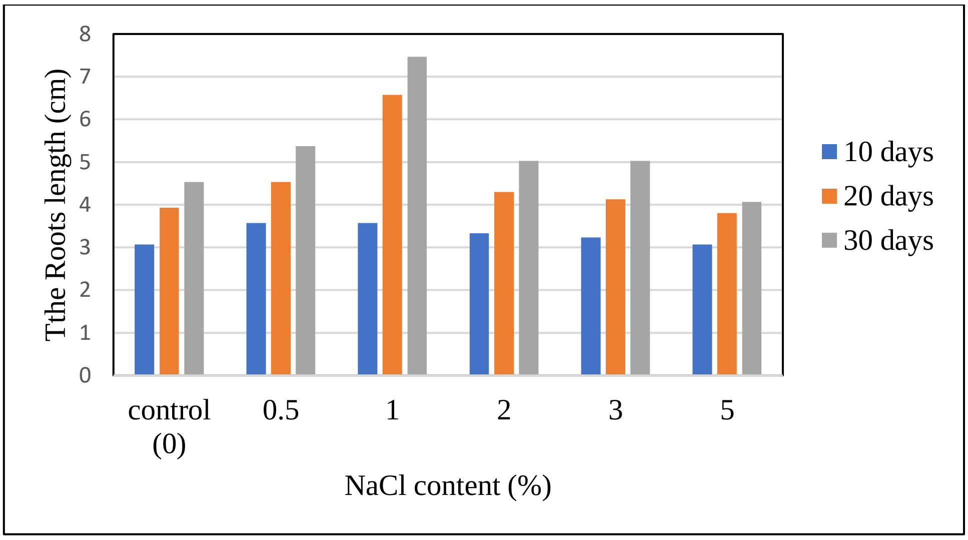

Figure 4. The growth of root length (cm) of *S. portulacastrum*

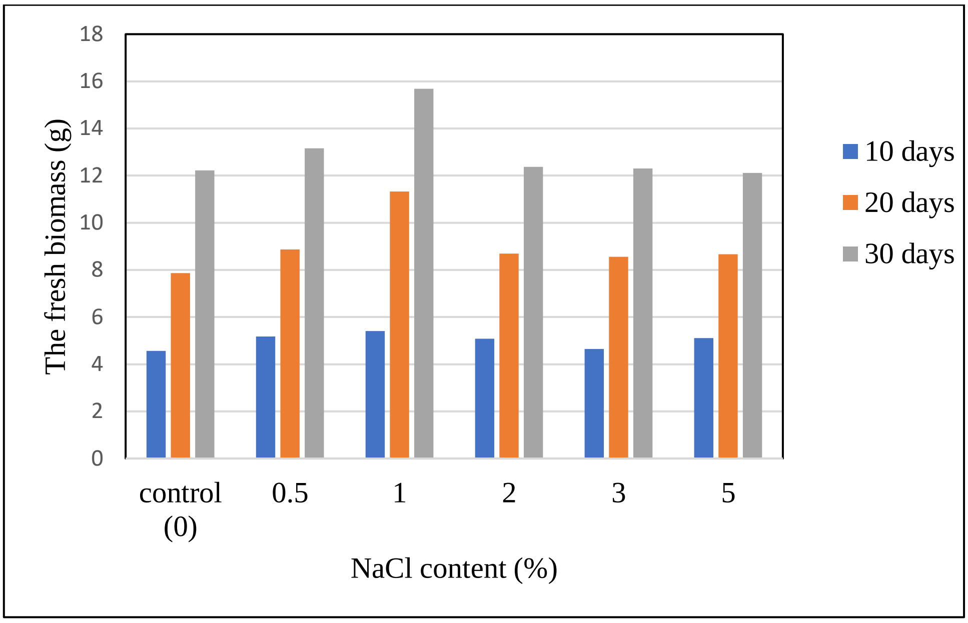

Figure 5. The growth of fresh biomass (cm) of *S. portulacastrum*

3.2. Salt absorption of S. portulacastrum

S. portulacastrum is a halophyte that requires salt for optimal growth. It is known for its high salt tolerance (Rabhi et al., 2010) and its ability to accumulate enormous Na^+, K^+, and Cl^- quantities within plants. The study results showed that after 30 days of the experiment, salt content in the roots, stems and leaves of *S. portulacastrum* plants had a statistically difference between treatments *($p<0.05$)* (Table 1). Cl^- accumulation in *S. portulacastrum* plants tends to increase when NaCl concentration increases in the medium. Except for the Na^+ ion, Cl^- is also the dominant ion in *S. portulacastrum* plants, the Cl^- content increases as the salinity increases (Daoud, 2001). Therefore, the higher the salt content, the higher the Cl^- accumulation in the roots, stems and leaves. The high Cl^- accumulation in the roots, stems, and leaves in 2%, 3%, and 5% NaCl concentrations may be the cause of plant growth inhibition.

Cl^- concentrations increased in all organs under saline conditions. The highest concentration was found in leaves (0.18-1.27%), followed by stems (0.12-0.78%) then roots (0.13-0.45%) (Table 1). Thus, under saline conditions, a preferential Cl^- allocation towards leaves was observed. This Cl^- accumulation allowed *S. portulacastrum* to be one of the most efficient halophytes in phytodesalination.

TABLE 1. Accumulated Cl^- concentration in *S. portulacastrum* for 30 days of experiment

Cl^- concentration (%)	**Roots**	**Stems**	**Leaves**
0 (control)	$0{,}11\pm 0{,}01^d$	$0{,}04\pm 0{,}01^f$	$0{,}05\pm 0{,}01^f$
0.5	$0{,}13\pm 0{,}01^d$	$0{,}12\pm 0{,}01^e$	$0{,}18\pm 0{,}01^e$
1	$0{,}24\pm 0{,}01^c$	$0{,}18\pm 0{,}02^d$	$0{,}31\pm 0{,}02^d$
2	$0{,}29\pm 0{,}03^c$	$0{,}32\pm 0{,}01^c$	$0{,}53\pm 0{,}01^c$
3	$0{,}37\pm 0{,}02^b$	$0{,}45\pm 0{,}02^b$	$0{,}70\pm 0{,}01^b$
5	$0{,}45\pm 0{,}02^a$	$0{,}78\pm 0{,}01^a$	$1{,}27\pm 0{,}02^a$

Different alphabetical letters in the same column exhibit a different significant level ($p<0.05$); Mean ± SD

3.3. Salt removing ability from soil of S. portulacastrum

S. portulacastrum showed a high phytodesalination capacity by removing high Cl^- quantities from the soil. The change of Cl^- concentration in soil after 30 days of treatment had a statistically significant difference *($p<0.05$)* (Table 2). Cl^- concentrations of 3% and 5% was different from Cl^- concentrations of control, 0.5%, 1%, and 2%. Compared to the first day of the experiment, Cl^- concentration in the soil after 30 days decreased by 0.02%, 0.07%, 0.08%, 0.35%, 0.75%, and 1.08% respectively for the treatments control, 0.5%, 1%, 2%, 3%, and 5% (Table 2). The decrease in soil salt content means that the treatment ability of *S. portulacastrum* was effective in all treatments infected with different salinity concentrations. This proves that *S. portulacastrum* has good NaCl saline treatment ability in soil environments supplemented with NaCl concentrations of 0.5 - 5%. Contribute to the application of *S. portulacastrum* to treat salinity in increasingly saline soil environments like in Vietnam today.

TABLE 2. Variation Cl^- concentration in soil

Cl^- concentration (%)	Initial	10 days	20 days	30 days	Treatment efficiency (%)
0 (control)	0,06 ± 0,01	0,04 ± 0,01	0,03 ± 0,01	0,02± 0,01^{c}	66.7
0.5	0,50 ± 0,03	0,35 ± 0,02	0,22 ± 0,01	0,07± 0,01^{c}	86
1	1,00 ± 0,03	0,61 ± 0,02	0,42 ± 0,01	0,08± 0,04^{c}	92
2	2,00 ± 0,06	1,16 ± 0,09	0,75 ± 0,01	0,35± 0,05^{bc}	82,23
3	3,00 ± 0,05	1,71 ± 0,06	1,09 ± 0,08	0,75± 0,05^{ab}	74,92
5	5,00 ± 0,03	3,07 ± 0,09	1,71 ± 0,05	1,08± 0,05^{a}	78,23

Different alphabetical letters in the same column exhibit a different significant level ($p<0.05$); Mean ± SD.

Treatment efficiency of treatments with added salt was higher than the control, the highest being at 1% NaCl treatment with 92%. It may be due to *S. portulacastrum* is phytodesalination. When it lives in a saline environment, the treatment efficiency of treatments of 0.5; 1; 2; 3; and 5 is higher than the control.

1% NaCl concentration is the suitable saline environment for growth of the plant. The better the plant's ability to grow, the higher the efficiency of treating salt in the soil. Therefore, with 92% treatment efficiency, using *S. portulacastrum* plants in treating 1% salinity soil is very feasible.

4. Conclusions

S. portulacastrum grows well at all four concentrations of NaCl 0.5, 1, 2, 3, and 5%. Of which, the tree grows best at a concentration of NaCl 1%. *S. portulacastrum* has the ability to withstand saline soil by storing salt in its body. *S. portulacastrum* accumulates NaCl in the roots, stems, and leaves, of which the highest Cl% is accumulated in the leaves. The highest efficiency of NaCl treatment is at a salt concentration of 1% (92%). The accumulation of salt in the roots contributes to reducing soil salinity, so it is possible to apply *S. portulacastrum* to treat saline soil environments.

References

Đang Thai Minh (2011). Dictionnaire vietnamien - français. Les mots vietnamiens d'origine française. *Synergies Pays riverains du Mekong*, special, ISSN: 2107-6758.

Daoud S., Harouni M.C., Bengueddour R. (2001). *Biomass production and ion composition of some halophytes irrigated with diffirent seawater dilutions*. Faculty of Science – Ibnou Zohr university.

FAO (2005). *Global Network on Integrated Soil Management for Sustainable Use of Salt-affected Soils*. FAO Land and Plant Nutrition Management Service, Rome, Italy.

Isayenkov, S.V. (2012). Physiological and molecular aspects of salt stress in plants. *Cytol. Genet*, 46, 302-318.

Kannan, P. R., Deepa, S., Kanth, S. V., Rengasamy, R. (2013). Growth, osmolyte concentration and antioxidant enzymes in the leaves of *Sesuvium portulacastrum L.* under salinity stress. *Appl. Biochem. Biotechnol*, 171, 1925-1932.

Lokhande V.H., Gor B.K., Desai N.S., Nikam T.D., Suprasanna P. (2012). Sesuvium portulacastrum, a plant for drought, salt stress, sand fixation, food and phytoremediation. *A review. Agron. Sustain. Dev*, 33, pp.329-348.

Lokhande VH, Nikam TD, Patade VY, Suprasanna P. (2009). Morphological and molecular diversity analysis among the Indian clones of *Sesuvium portulacastrum L. Genet Res Crop*, 56, 705-717.

Messed D., Labidi N., Grignon C., Abdelly C. (2004). Limits imposed by salt to the growth of the halophyte *Sesuvium portulacastrum. Plant Nutrition Soil Sicence*, 167, pp. 720-725.

Mokded Rabhi, Siwar Ferchichi, Jihène Jouini, Mohamed Hédi amrouni, Hans-Werner Koyro, Annamaria Ranieri, Chedly Abdelly, and Abderrazak Smaoui (2010). Phytodesalination of a salt-affected soil with the halophyte *Sesuvium portulacastrum L.* to arrange in advance the requirements for the successful growth of a glycophytic crop. *Bioresource Technology*. *101*(17), 6822-6828.

Rabhi, M.; Giuntini, D.; Castagna, A.; Remorini, D.; Baldan, B.; Smaoui, A.; Abdelly, C.; Ranieri, A. (2010). *Sesuvium portulacastrum* maintains adequate gas exchange, pigment composition, and thylakoid proteins under moderate and high salinity. *J. Plant Physiol*, *167*, 1336-1341.

Wang, D., Yang, N., Zhang, C. Y., He, W. H., Ye, G. P., Chen, J. J., et al. (2022). Transcriptome analysis reveals molecular mechanisms underlying salt tolerance in halophyte Sesuvium portulacastrum. *Front. Plant Sci.* 13. doi: 10.3389/fpls.2022.973419.