EFFECTS OF SEA WATER SALINITY ON THE GROWTH OF VETIVER GRASS (*CHRYSOPOGON ZIZANIOIDES* L.)

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ABSTRACT

Vetiver grass (*Chrysopogon zizanioides*) has the ability to adapt and develop in many different environments and to recover quickly from the disadvantaged conditions of the environment. It can absorb large amount of nitrogen, phosphorus and dissolved heavy metals in the environment. To date studies on salt tolerance of vetiver grasses have been conducted mainly in the soil environment, and very limited in the aquatic environment. Therefore, a full study on sea water salinity tolerance of vetiver is needed to solve problems of pollution in estuaries - where water quality is often affected by the activities of human and industrial, agricultural productions, which have increasingly become more acute. This paper presents results of research on the growth of vetiver affected by the level of sea water salinity. The research results showed that vetiver grass is capable of growing in sea water salinity ranging from 0-19.64 dS/m (0-11 ‰).

Key words: salt tolerance; vetiver grass; estuary; Da Nang Bay

1. Introduction

An estuary is a partially enclosed coastal body of water that is either permanently or periodically open to the sea and it receives at least periodic discharge from a river (Potter, Chuwena et al. 2010). Estuarine ecosystem plays a very important role for human activities, from the purpose of economic development to recreation. The pursuit of economic development is frequently related to phenomena such as increasing industrialization and urbanization, which, in turn, cause negative environmental impacts caused by pollution. Despite its ecological and economic importance to the region, estuarine ecosystem has suffered considerable degradation due to intensive and continuous industrial; domestic contamination; pesticides from runoff of agriculture, and transportation activities (Irabien, Cearreta et al. 2008).

Until now, there are many methods used to treat contaminated water and phytoremediation is one of techniques referring to the use of plants and associated soil microbes to reduce the concentrations of contaminant in the environment. It is a novel treatment, cost effective, efficient, environmentally friendly and in situ applicable. The study results of Huaiman Chen (Huaiman 1999); Shu Weiguo (Weiguo, Lixiang et al. 1999); Paul Truong (Truong 1999); Lieth (Koyro, Lieth et al. 2008) showed that vetiver grass have many pre-eminent properties for phytoremediation technology. It can be used for removal of contaminants such as heavy metals and radionuclides as well as for organic pollutants and broad adaptation to different environmental conditions. In particular, according to Truong (Truong 1994), vetiver grass can grow on relatively highly saline soil environment.

Therefore, studies on sea water salt tolerance of vetiver grass have enormous significance in the application of phytoremediation technology to solve the issues of water pollution in estuaries.

2. Material and methods

2.1. Preparation of test plants

Seedlings of vetiver grass were collected from experimental plot of the Faculty of Bio-Environment, Da Nang University, Vietnam. All seedlings were raised for 15-20 days in tap water, cleaned with distilled water, cut and separated into roots (7 cm long) and shoots (40 cm high) and transplanted to containers (20 cm high, 18cm in diameter) with different salinity levels.

2.2. Experimental design

This study was performed as a glasshouse experiment and vetiver grass (*Chrysopogon zizanioides* L.) was used to investigate the level salt tolerance. Water samples taken from Da Nang Bay and Phu Loc River were combined according to the following 11 treatments (Table 1).

Table 1. *Dilution proportion and salinity levels of 11 treatments*

Formula	Ratio		Salinity	
	Water taken from Da Nang Bay (%)	Water taken from Phu Loc river (%)	‰	dS/m
CT1	100	0	29	51.79
CT2	90	10	26	46.43
CT3	80	20	23	40.07
CT4	70	30	20	35.72
CT5	60	40	17	30.35
CT6	50	50	14	25
CT7	40	60	11	19.64
CT8	30	70	8	14.28
CT9	20	80	5	8.92

CT10	10	90	2	3.57
CT11	0	100	0	0

Samples of shoot height; root length and new shoot number were taken and measured after 15 days (short-term experiment) and 30 days (long-term experiment).

2.3. Statistical analysis

Data were analysed with a one-way ANOVA. Comparison among means were done using Duncan's test. All test of significance were carried out using the 5% probability level.

3. Results and discussion

3.1. The growth of vetiver grass after 15 days

The results in terms of shoot height, root length and the number of new shoots of vetiver after 15 days are presented in Table 2.

Table 2. *Effect of salinity on the growth of vetiver grass after 15 days*

Formula	Salinity		Height of shoots (cm)	No. new shoots	Length of roots (cm)	Changes in length	
	‰	dS/m				Shoots	Roots
CT1	29	51.79	-	-	-		
CT2	26	46.43	30.33±2.58	2.67±0.68	8.00±1.76	-	+
CT3	23	40.07	34.00±1.40	3.33±0.48	8.50±1.82	-	+
CT4	20	35.72	36.33±1.53	4.03±0.37	8.83±1.76	-	+
CT5	17	30.35	38.67±2.03	4.13±0.55	9.33±1.29	-	+
CT6	14	25	41.67±2.15	4.32±0.78	9.67±1.58	+	+
CT7	11	19.64	43.67±1.29	4.25±0.54	9.33±1.15	+	+
CT8	8	14.28	46.33±2.58	4.01±0.41	9.67±1.27	++	+
CT9	5	8.92	50.67±3.04	4.43±0.53	10.00±1.40	++	++
CT10	2	3.57	51.67±2.17	4.67±0.34	10.17±1.86	++	++
CT11	0	0	61.67±1.53	5.33±0.58	11.33±1.85	+++	++

changes in height of shoots (cm):
< 0 → –; 0 – 5 → +; 6 – 15 → ++; 16 - 30 → +++; and > 30 → ++++

changes in length of roots (cm):
≤ 2 → +; 3 – 7 → ++; and > 7 → +++

Results after 15 days experiment showed that the tallest growth was 61.67 cm (at 0 salinity) and the shortest growth was 30.33 cm (at 46.43 dS/m salinity); number of new shoots increased from 2.67 to 5.33; root length from 8.00 to 11.33 cm respectively *($p \leq 0.05$)*.

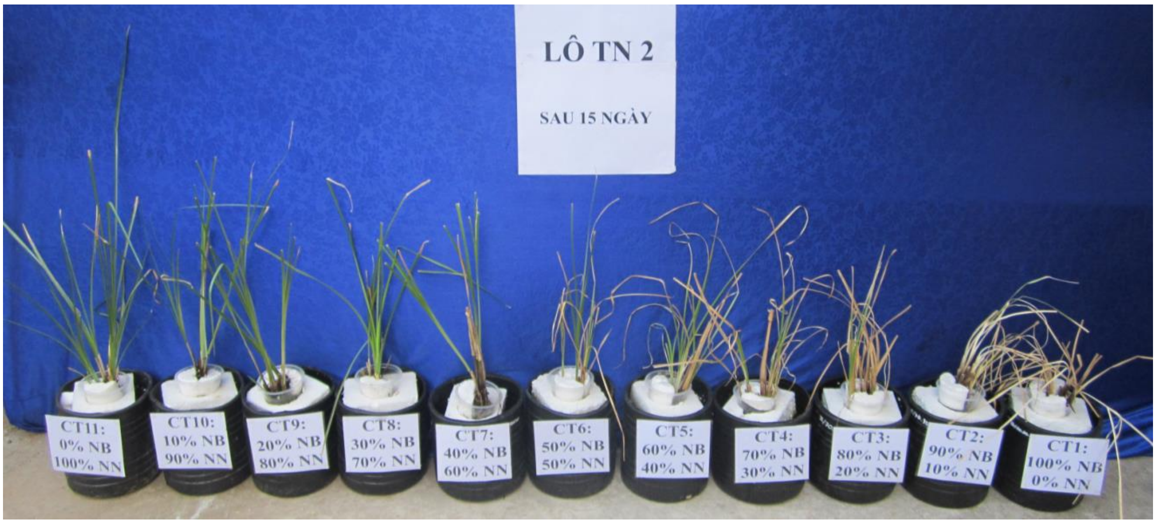

Figure 1. *Vetiver grass after 15 days, treatments 1(L) - 11(R)*

In general, the height of vetiver grass increased sharply when salinity was reduced from 14.28 to 0dS/m, gradually increased in the range between 25.00 to 19.64dS/m and sharply from 46.43 to 30.35dS/m, and eventually died when salinity exceeded 46.43dS/m.

Meanwhile, the number of new shoots increased in the range of 35.72 to 0dS/m, decreased gradually in the range of 46.43-35.72dS/m and died at 46.43dS/m.

In contrast with its height and development of new shoots, the length of vetiver roots appeared to be less affected by the salinity level in the water. It decreased gradually in the range of 0-30.33dS/m salinity and completely died at 46.43dS/m.

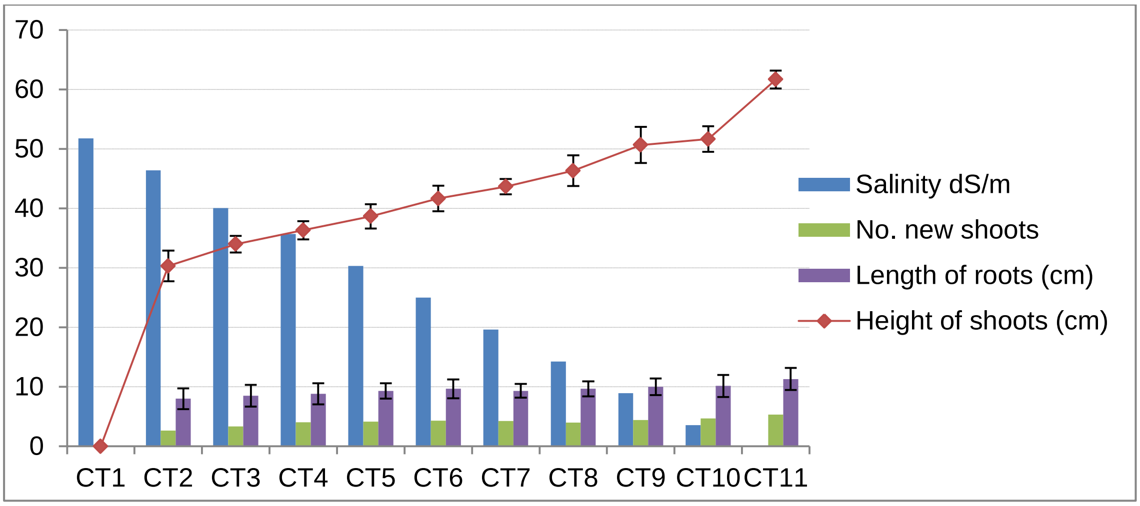

Figure 2. *Effect of salinity on the growth of vetiver*

According to Truong (Truong and Baker, 1996), when planting *Chrysopogon zizanioides*; *Chloris guyana* and *Paspalum vaginatum* to reclaim soil affected by salinity in the Warril View, Queensland, Australia, results showed that among the tested species, the vetiver grass can survive and grow better in high salinity conditions (Table 3), the height of shoots reached 60 cm in 8 weeks.

Table 3. *Salt tolerance of some grass species*

Species	Soil Salinity (dS/m)	
	0-5cm	10-20cm
Chloris Guyana	4.83	9.59
Paspalum vaginatum	9.73	11.51
Chrysopogon zizanioides	18.27	18.06

This result illustrated that the growth of vetiver grass in saline soil medium is better than in saline water medium. This can be due to higher nutrient levels in the soil than those in water, which would promote better growth to cope with disadvantaged conditions of high salinity. In addition, vetiver species possesses long and dense root system and potentially reaching deeper horizon to obtain more nutrients and possibly less saline water.

In a pilot studies for saline land rehabilitation due to the mining activities, Radloff (Radloff, Walsh et al. 1995) have used 5 plant species including *Chrysopogon zizanioides; Sporobolus virginicus; Typha domingensis; Phragmites australis; C. glauca* and *Sarcocornia* sp. The results indicated that vetiver grass gave excellent establishment and growth. Complete mortality was recorded after 210 days for all species, except *C. zizanioides* and *S. virginicus*. Vetiver survival was significantly increased by mulching and was unaffected by fertilisation. In particular, vetiver biomass reached 2 tons/ha, nearly 10 times as high as the biomass of *Sporobolus virginicus*.

These studies showed that extensive experimental studies of salinity tolerance of vetiver grass have been conducted in the soil medium, and experimental studies in the aquatic environment have been very few.

3.2. The growth of vetiver grass after 30 days

The results in terms of the height of shoots and roots and the number of new shoots of vetiver grass after 30 days are showed in Table 4.

Table 4. *Effects of salinity on the growth of vetiver grass after 30 days.*

Formula	Salinity		Height of shoots (cm)	No. new shoots	Length of roots (cm)	Changes in length	
	‰	dS/m				Shoots	Roots
CT1	29	51.79	-	-	-		
CT2	26	46.43	-	-	-		
CT3	23	40.07	-	-	-		
CT4	20	35.72	16.67±2.29	1.33±0.58	9±1.32	-	+
CT5	17	30.35	19.67±3.12	2.00±1.00	9.67±1.78	-	+
CT6	14	25	19.33±2.15	2.67±1.15	13.00±1.70	-	++
CT7	11	19.64	45.83±3.76	4.33±0.58	13.83±2.58	+	++
CT8	8	14.28	53.67±3.18	5.33±0.87	15.33±2.04	++	+++
CT9	5	8.92	66.33±3.55	5.33±1.08	15.50±1.50	+++	+++
CT10	2	3.57	73.67±4.15	5.67±1.15	15.83±2.29	++++	+++
CT11	0	0	80.17±4.29	6.67±1.15	16.50±2.51	++++	+++

changes in height of shoots (cm):
< 0 → –; 0 – 5 → +; 6 – 15 → ++; 16 - 30 → +++; and > 30 → ++++

changes in length of roots (cm):
≤ 2 → +; 3 – 7 → ++; and > 7 → +++

After 30 days the results revealed that vetiver grass can only grow at the salinity lower than 35.72dS/m, with shoot height reaching 16.67 to 80.17 cm; the number of new shoots ranges from 1.33 - 6.67 and root length is from 9.00 to 16.50 cm *($p \leq 0.05$)*.

Overall, after 30 days, the growth of vetiver grass tends to increase gradually as salinity reduced from 35.72 to 25dS/m but increased sharply as salinity reduced from 25 to 0dS/m and vetiver died at salinity higher than 35.72dS/m.

Figure 3. *Vetiver grass after 30 days, treatments 1(L) - 11(R)*

Research conducted under dry land salinity conditions indicated that vetiver grass has good salt tolerance because its deep root system can reach less saline and more nutrients at a deeper soil horizon. For instance, the study by Truong (Truong, Gordon et al. 2002), (Truong 1999) reported that, the saline threshold of Monto vetiver is ECse= 8 dS/m and soil ECse values of 10 and 20 dS/m would reduce yield by 10% and 50% respectively (Figure 5 and Figure 6).

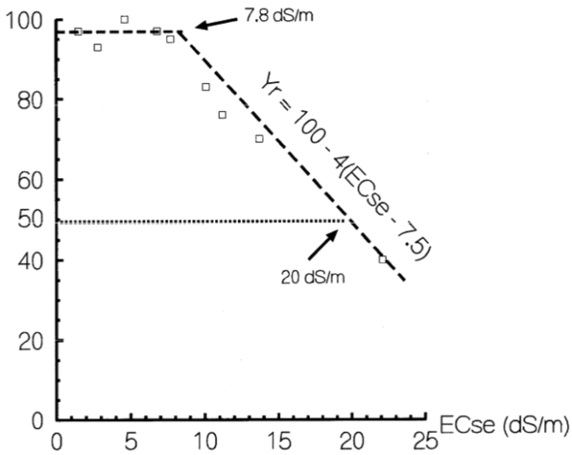

Figure 4. *Saline threshold level of vetiver grass (Truong and Gordon et al. 2002)*

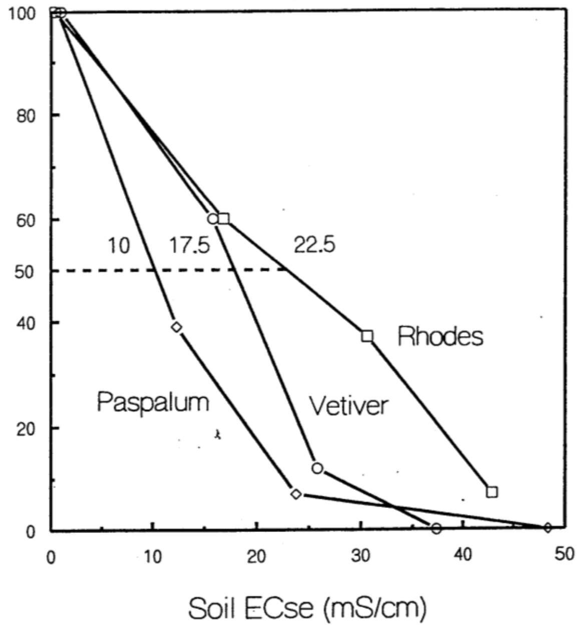

Figure 5. *Saline threshold level of vetiver grass, Rhodes grass (Chloris guyana) and paspalum (Paspalum dilatatum) (Truong, Gordon et al. 2002)*

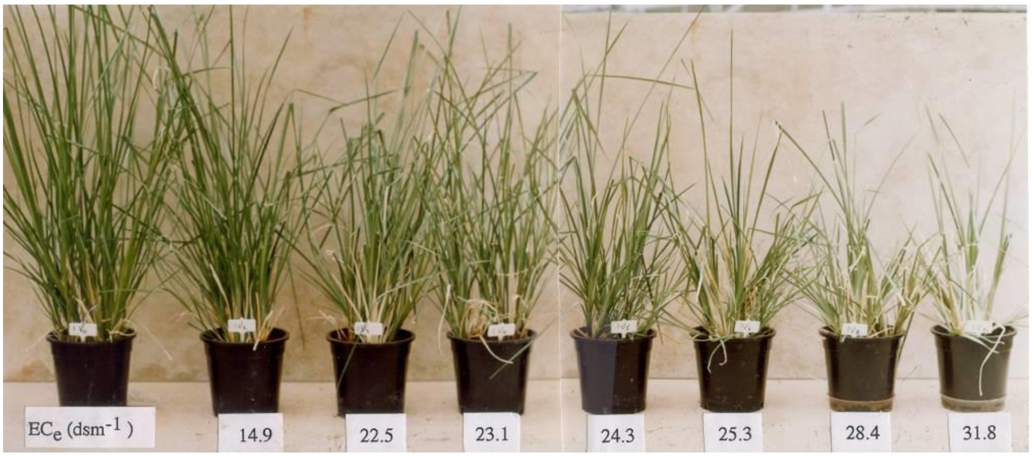

Figure 6. *Salt tolerance level of vetiver grass grown in Australia (Truong, Gordon et al. 2002)*

Pongvichian (Pongvichian, P. et al. 2005) found that 'Kamphaeng Phet 2' ecotype and 'Sri Lanka' cultivar of *C. zizanioides*, and 'Prachuap Khiri Khan' and 'Kamphaeng Phet 1' of *Chrysopogon nemoralis* have better salt tolerance than the others, and can grow in 20dS/m solution; the salt contents have direct effect on the growth, biomass, and root development of vetiver.

The results of this study, testing the salt tolerance of vetiver in aquatic medium, showed that the vetiver grass continues to grow in water salinity ranging from 0-19.64dS/m, and at salinity levels greater than 19.64dS/m, the growth of vetiver grass is much reduced. Thus, the treatment of saline wastewater at the coastal estuaries by using vetiver grass can be very effective.

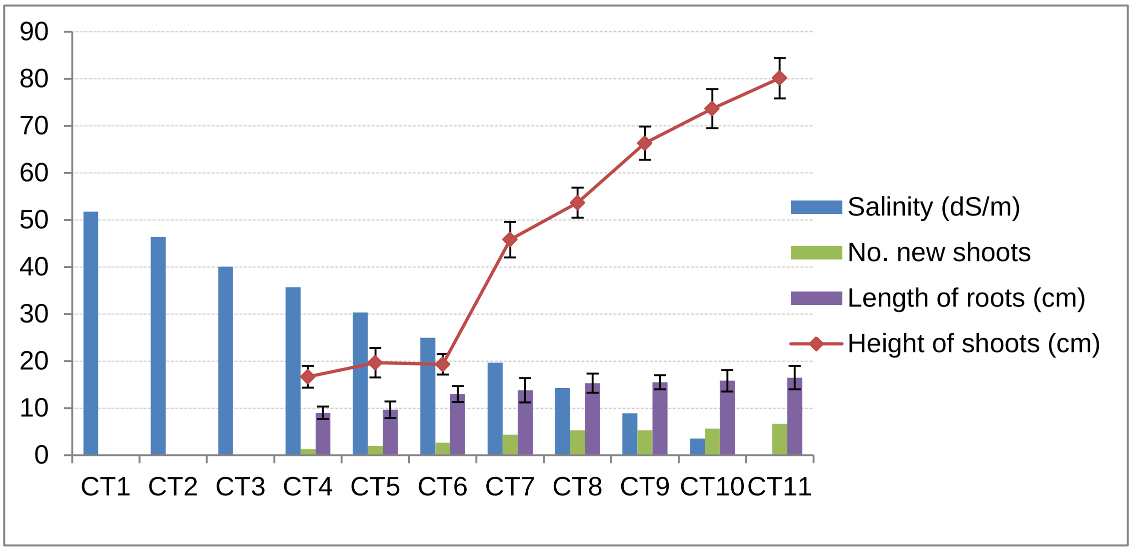

Figure 7. *Effects of salinity on the growth of vetiver grass after 30 days*

4. Conclusion

From the results above, vetiver grass is quite suitable for treating polluted water under moderate saline aquatic environment. For successful application of using vetiver to treatment of saline wastewater at coastal estuaries, a full understanding of the chemical properties of the pollutants requiring treatment is needed for best results.

References

Huaiman, C. (1999). Vetiver for metal mine rehabilitation and sea water tolerance. Annual Report. Nanjing, China Vetiver Development Foundation.

Irabien, M. J., et al. (2008). "A 130 year record of pollution in the Suances estuary (southern Bay of Biscay): Implications for environmental management." Marine Pollution Bulletin **56**(10): 1719-1727.

Koyro, H.-W., et al. (2008). Salt Tolerance of *Chenopodium quinoa* Willd., Grains of the Andes: Influence of Salinity on Biomass Production, Yield, Composition of Reserves in the Seeds, Water and Solute Relations. Mangroves and Halophytes: Restoration and Utilisation. H. Lieth, M. Sucre and B. Herzog, Springer Netherlands. **43:** 133-145.

Pongvichian, P., et al. (2005). "The role of salt on the growth and development of vetiver." Bhumivarin **19**: 22-26.

Potter, I. C., et al. (2010). "The concept of an estuary: A definition that incorporates systems which can become closed to the ocean and hypersaline." Estuarine, Coastal and Shelf Science **87**(3): 497-500.

Radloff, B., et al. (1995). Direct revegetation of coal tailings at BHP-Saraji mine (Central

Queensland). The 20th Annual Environmental workshop. Australia, Minerals Council of Australia , Dickson, ACT**:** 129-143.

Truong, P. (1994). Vetiver grass, its potential in the stabilisation and rehabilitation of degraded saline land. Halophytes as a resource for livestock and for rehabilitation of degraded lands. V. Squires and A. Ayoub, Springer Netherlands. **32:** 293-296.

Truong, P. (1999). Vetiver Grass technology for mine tailings rehabilitation. The First Asia Pacific Conference on Ground and Water Bioengineering for Erosion Control and Slope Stabilisation, Manila, Philippines.

Truong, P. and Baker. D. (1996). Vetiver grass for the stabilisation and rehabilitation of acid sulphate soils. The Second National Conf. Acid Sulfate Soils, Coffs Harbour, Australia.

Truong, P., et al. (2002). Vetiver grass for saline land rehabilitation under tropical and mediterrranean climate. Productive Use and Rehabilitation of Saline Lands National Conference, Fremantle, Australia.

Weiguo, S., et al. (1999). Preliminary Report on the introduction of vetiver in Tianjing. Nanjing, China Vetiver Development Foundation.